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INTERNATIONAL MIGRATION RESPONSES TO
MODERN EUROPE'S MOST DESTRUCTIVE EARTHQUAKE:
MESSINA AND REGGIO CALABRIA, 1908

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International Migration Responses to Modern Europe's Most Destructive Earthquake: Messina and Reggio Calabria, 1908

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ABSTRACT

The Messina-Reggio Calabria Earthquake (1908) was one of the most devastating natural disasters 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 readily available option for relief. We study the effects of this disaster on international migration. We find that there was no large positive impact on emigration on average. There were, however, heterogeneous responses, with a more positive effect where agricultural day laborers comprised a larger share of the labor force, suggesting that attachment to the land limited an emigration response.

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A data appendix is available at <http://www.nber.org/data-appendix/w27506>

1 Introduction

The Messina-Reggio Calabria Earthquake of December 1908 was the most destructive earthquake, and one of the most devastating and deadly natural disasters, in modern European history.¹ An estimated 90,000–120,000 people—mostly in the municipalities closest to the earthquake’s epicenter, including the region’s urban centers of Messina and Reggio Calabria—were killed by the earthquake itself and by the ensuing tsunami.² The earthquake also caused widespread destruction to a substantial fraction of buildings and infrastructure (Dickie 2008; Dickie and Sayer 2005; Parrinello 2015; Risk Management Solutions 2008).

The historical importance of this earthquake is compounded by the setting in which it struck. It 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 cheap transatlantic transportation, and drawn by high expected returns (Abramitzky et al. 2012). Italy was a leading country in this movement, sending hundreds of thousands of migrants each year to the Americas, 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 2023). The earthquake-affected regions of Sicily and Calabria had just come to the forefront of this movement, with extremely high rates of emigration by any historical standard (average annual rates of 26 and 36 per thousand, respectively, in the four years prior to the earthquake). They thus had sufficient prior exposure to migration to develop thick networks of prior migrants (Spitzer and Zimran 2023). These factors made international migration a familiar, attractive, and relatively easy disaster-relief option for the affected population.

In this paper, we ask whether, and under what circumstances, this earthquake affected international migration. The expected effect of natural disasters on international migration is theoretically 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 through a variety of mechanisms, including tightened liquidity constraints (Cattaneo and Peri 2016), greater economic opportunities or needs at home (Halliday 2006), and remittances or other financial inflows to affected areas (Yang 2008a). As a result, empirical evidence from a diverse array of events is important. Although each natural disaster is unique, studying them helps to better understand

¹Other events, such as the Great Irish Famine or the harvest failures in the wake of the 1815 eruption of Mount Tambora were deadlier, and can, at least in part, be considered natural disasters. But the Messina-Reggio Calabria Earthquake was likely the deadliest and most destructive relative to other sudden, localized, and purely natural disasters.

²We will show below that the true death toll was probably closer to the lower end of this range.

the mechanisms and circumstances that govern their effects, in addition to helping to better understand the specific event in question. We contribute to this understanding by asking, in the context of the Messina-Reggio Calabria Earthquake, whether emigration was a relief valve for the population or a hindrance to migration and what made communities more likely to react in one way or the other.

Our analysis is based on a dataset of annual emigration rates for every municipality (*comune*) in Italy for the pre-World War I period, focusing on the period 1905–1912.³ This dataset is based on two main sources—passenger manifests of Italians arriving at the Port of New York (Spitzer and Zimran 2018) and official Italian emigration statistics (Spitzer and Zimran 2023). We combine these data with municipality-level measures of damage from the earthquake (Guidoboni et al. 2007) and with an extensive dataset of characteristics of Italian municipalities and districts that we compiled from censuses and other official historical sources.⁴ We use difference-in-differences and event study specifications to determine whether the emigration trends of severely damaged municipalities in Sicily and Calabria differed from those of other municipalities in those regions following the earthquake.

Our main finding is that there is no evidence of a large positive impact of severe damage from the earthquake on emigration from affected municipalities as a whole. Our preferred point estimates, though imprecise, suggest a small and transitory *decline* in emigration of about 10 percent in the first year after the shock in municipalities experiencing severe damage relative to other municipalities in Sicily and Calabria. We are able to conclude that the impact of the earthquake was small as compared to some relevant benchmarks. For instance, the Panic of 1907, though not a natural disaster, provides a temporally and spatially proximate gauge against which to understand the magnitude of the earthquake’s effect. This financial crisis, which led to a recession in the United States and sharp declines in US immigration from all sources, was associated with at least a 75-percent decline in Italian emigration in the following year. We can easily rule out such a magnitude for the estimated effect of the earthquake. That is, the effect of the earthquake as a push factor was far less than that of the Panic of 1907 as a pull factor on migration from the same places.⁵ Our estimates are also small when compared to the estimated increase in migration in response to more recent events, such as modern hurricanes (Mahajan and Yang 2020). This finding is striking in light of the extreme toll of the

³There were approximately 8,000 municipalities in Italy, of which about 390 were in Calabria and 350 were in Sicily.

⁴We use the term “district” to refer to the Italian units of *circondario* or *distretto*. These were the next highest administrative unit above the municipality, and there were 284 such units in Italy in the study period. The two earthquake-affected regions had only *circondari*, with 24 in Sicily and 11 in Calabria. Above that, there were 69 provinces (3 in Calabria and 7 in Sicily) and 16 regions.

⁵This result contributes to the 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).

earthquake in human lives and physical 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 both before and after the shock.

To better understand the reasons for the limited aggregate earthquake response, we test a number of explanations for limited and non-positive migration responses to natural disasters that have been proposed in the literature. The degree of attachment to the land appears to be the most robust factor differentiating between the response of different places. We find that municipalities from districts with a greater share of the labor force employed as agricultural day laborers (as opposed to owner-occupiers, renters, sharecroppers, etc.), whose lack of property or contractual obligation to the land would have made them most readily able to quickly decide to emigrate, experienced a greater increase in emigration. Although we cannot definitively rule out that this result reflects heterogeneity with respect to employment in agriculture more broadly, the evidence strongly suggests that it was specifically the unattached day laboring portion of the agricultural labor force that was prone to react by migration.

In principle, this result is consistent with the *greater exigencies* explanation for reduced migration after natural disasters (Halliday 2006)—that damage to individuals’ property incentivizes them and their family members to remain at home to rebuild. However, to the extent that we can test this explanation with information on the distribution of property owners, we find that such a channel is not borne out by the data. Instead, we argue that the relationship between individuals and the land *per se* was likely the root cause that prompted those who (among the agricultural classes) were most weakly attached to the land to react quickly through overseas emigration and prevented those who were economically invested and contractually tied to the land from responding with the same ease.⁶ This finding is consistent with prior work, which has identified attachment to the land as a factor limiting emigration during the Age of Mass Migration (e.g., Hatton 2010; Hatton and Williamson 1998) as well as in contemporary migration (e.g., Valsecchi 2014). Ours is the first evidence, to our knowledge, that it can also hinder short-term adjustment in the face of shocks.

Another common explanation for a lack of migration increases in response to disasters is that the economic repercussions exacerbate liquidity constraints faced by households with limited access to credit, thus inhibiting them from funding emigration. To test whether this explanation applies in our context, we collected a variety of municipality-level measures of access to financial services and local savings, ranging from large joint stock banks and credit unions to local branches of postal savings banks, pledge banks (forms of charitable pawnbrokers), and mutual aid societies. None of these measures appear to be consistently associ-

⁶Difficulties in liquidating connections to a prior place of residence has also been identified as a possible hindrance to migrating in response to shocks by Blanchard et al. (1992).

ated with an increased migration response to the earthquake, nor is the size of the migrant network, another potential source for liquidity under stress. These results suggest that even if liquidity constraints impeded migration, they did not become a relatively stronger inhibiting force in severely damaged municipalities in the aftermath of the earthquake. We also provide evidence suggesting that our findings do not result from a surge in demand for reconstruction labor that might have diverted a potential flow of emigration, and we argue that increased financial inflows are an unlikely explanation as well.

This paper contributes to three main literatures. First, it contributes to the literature on the effects of natural and man-made disasters on migration and thus to the literature on climate- and disaster-driven migration (Myers 2002), as well as to the broader literature on the effects of natural disasters.⁷ Interest in understanding the effect of natural disasters on international migration has grown recently, in part due to increased attention to the dangers of climate change. A number of recent studies have found that international migration may be unaffected or even reduced by natural disasters (e.g., Beine et al. 2019; Beine and Parsons 2015; Cattaneo and Peri 2016; Gröschl and Steinwachs 2017; Halliday 2006; Hunter et al. 2013; Nawrotzki and DeWaard 2018; Shakya et al. 2022). But this evidence comes almost entirely from studies of events occurring in recent decades—a period characterized by stringent legal restrictions on international migration that potentially add a distorting filter to economic incentives. Evidence from events that occurred in the absence of such barriers has been lacking.

This paper, as with many others focusing on the Age of Mass Migration, can inform the economics of migration by studying a setting in which such barriers were absent (e.g., Abramitzky and Boustan 2017). Our finding, that a shock as cataclysmic as the Messina-Reggio Calabria earthquake had no meaningfully positive impact on international migration even in a context of widespread and unhindered mass migration, is therefore an important addition to the recent accumulation of evidence demonstrating no or negative effects of natural disasters and other climatic shocks on international 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. Yet the effects of such shocks may be more nuanced than simple intuition implies. Moreover, since natural disasters of the magnitude that we study are rare and no two are alike, it is important to understand what mechanisms modulate the migration response and under what conditions. Our exploration of an array of proposed mechanisms, and in particular our evidence regarding attachment to the land as an obstacle to adjustment through migration, also adds to the possible

⁷This broader literature includes Andrabi et al. (2023), Belasen and Polachek (2009), Boustan et al. (2021), Figlio and Özek (2019), Franklin and Labonne (2019), Groen et al. (2020), Johar et al. (2022), Karbownik and Wray (2019), Kim et al. (2017), Kleemans and Magruder (2018), Kocornik-Mina et al. (2020), Pereira (2009), and Testa (2021).

explanations for such non-response.

This paper also adds to the literature on the effects of the Messina-Reggio Calabria Earthquake. This event has been the object of repeated scholarly investigations over more than a century (e.g., Bertolaso et al. 2008; 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 internal population movements in its wake (e.g., Caminiti 2009; Mortara 1913b; Parrinello 2012; Restifo 1995). One contribution of our analysis is to shed light on these debates by lending quantitative support to the revisionist view, arguing that death tolls and internal population movements in the aftermath of the shock have been overstated. Furthermore, 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 earthquake, and subsequently of the historical literature and of the popular memory of the event, has focused on the experience of the city of Messina and to a lesser extent of Reggio Calabria. But these cities were just two of the many affected (and 110 severely damaged) municipalities. The responses of the remaining smaller municipalities, on the other hand, are poorly documented and understood. Our analysis sheds more light on the aftermath of the earthquake beyond the major cities. Finally, to our knowledge, we are the first to study international migration in response to this disaster—a potentially important margin of response in this context given the high levels of migration prior to the shock. Understanding such a response to the shock is fundamental to a complete history of this momentous event.

Finally, this paper adds to the literature on the economics of the Age of Mass Migration. Since Hatton and Williamson’s (1998) canonical study (see also Baines 1995), there has been a surge in this literature that has benefited from improved empirical methods and large individual-level data sets (Abramitzky and Boustan 2017; Hatton and Ward 2019). However, advances in understanding the determinants of migration within this literature have been more limited (c.f., Beck Knudsen 2022; Boberg-Fazlić et al. 2023; Gray et al. 2019; Karadja and Prawitz 2019; Obolensky et al. 2023; Spitzer 2021; Spitzer and Zimran 2023). We advance the literature’s understanding of the causes and the dynamics of pre-World War I mass migration by studying the effect of a shock to the home economy on emigration—a topic that, with the exception of Irish migration around the Great Famine (e.g., Ó Gráda 2019; Ó Gráda and O’Rourke 1997), and to a lesser extent Swedish migration after weather shocks in the 1860s (Andersson et al. 2022; Karadja and Prawitz 2019), has received little attention.

2 Background

2.1 The earthquake and its aftermath

The 7.1-magnitude Messina-Reggio Calabria Earthquake struck the Strait of Messina and its surroundings on December 28, 1908. It was followed by a severe tsunami, with waves as high as 40 feet (Risk Management Solutions 2008), which ravaged coastal communities along the strait. The earthquake is regarded as one of the most destructive natural disasters in modern European history (Dickie 2008). The area’s main cities, Messina and Reggio Calabria, on opposite sides of the strait, were almost entirely destroyed (Baratta 1910; Mercalli 1909), and many smaller communities in the regions of Sicily and Calabria were also reduced to rubble (Baratta 1910; Liberti 1993).

In total, the earthquake and tsunami are estimated to have caused between 90,000 and 120,000 deaths, most of which were concentrated in the two urban centers. In the municipality of Messina alone (i.e., in the city of Messina and in some outlying *frazioni* within the *comune*), an estimated 30,000 to 60,000 inhabitants were killed relative to a 1901 population of just under 150,000 (Caminiti 2009; Dickie 2008; Guidoboni and Mariotti 2008; Parrinello 2012; Restifo 1995, 2008)—a mortality rate of 20–40 percent. The city of Reggio Calabria also suffered enormous casualties, with an estimated 8,000 inhabitants killed relative to a 1901 population of about 44,000—approximately an 18 percent mortality rate. Similarly, 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 injured; 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 even these were badly damaged (Baratta 1910, pp. 198–207).

Although it was, understandably, a central part of the narrative arising from the event, such a high-mortality experience of the earthquake was atypical even among severely damaged municipalities. Of 110 municipalities that we define below as being severely damaged, only 11 had mortality rates of 5 percent or greater. Instead, most severely damaged municipalities experienced the earthquake largely as massive shock to infrastructure with a more limited effect on population. Figures for Sicily are lacking, but detailed data are available on damage for all municipalities in the province of Reggio Calabria. In the average municipality 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 Online Appendix Figure B.1 for a map of districts in the affected area). Indeed, the damage in some municipalities was so severe, that, after surveying it, the renowned seismologist Giuseppe Mercalli added a new intensity degree to his eponymous scale to describe it—XI, *catastrofe* (Tertulliani 2014).

Immediately following the earthquake, at least 66,000 refugees are estimated to have left Messina, traveling mainly to other large Sicilian cities and to Naples. But there are indications that this flow was short-lived, such that “immediately following the exodus from the scene of the disaster, a counter-exodus began” (Restifo 1995, p. 562). Consistent with this claim, the population of the cities of Messina and Reggio Calabria rebounded quickly, as shown in Table 1 (see also Mortara 1913a,b; Parrinello 2012; Restifo 1995). But according to the traditional view of the *Messinesi*, this demographic recovery was largely due to an inflow of newcomers from the hinterland (Dickie and Sayer 2005). Such an inflow, if true, is important for our case, as it potentially would have captured individuals who would otherwise have emigrated in response to the shock. But a more detailed examination of Italian census figures from 1901 and 1911 and of data on emigration, return migration, births, and deaths reveals that the local myth of population replacement cannot be correct, and that the inflow of newcomers to the cities of Messina and Reggio Calabria was likely small.

Table 1 presents data on the population of the cities of Messina and Reggio Calabria by place of birth from 1901 and 1911 population censuses.⁸ 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 1901.⁹ Thus, in 1911 the number of non-native residents in these cities was too small to be consistent with any large inflow of new internal migrants in the wake of the earthquake. To provide more concrete bounds on the inflow of newcomers that can be attributed to the earthquake, we combine these census figures with annual data on 1901–1911 births, deaths, and emigrants for the municipalities of Messina and Reggio Calabria, and information on return migration to their respective provinces. The rationale of this exercise is that internal migration and the death toll from the earthquake can be inferred from the unexplained residual from a calculation of the total population change, taking into account international net migration, births, and deaths. The details of these computations and the underlying assumptions are presented in Appendix A and we report the main findings here.

First, as a by-product of these calculations, we compute alternative upper bounds to the death tolls

⁸Unfortunately, similar data are not available for smaller towns.

⁹We are not able to rule out that the replacement was by residents of outlying *frazioni* within the municipality of Messina, who would have counted as natives of the municipality in the census but might have been considered outsiders by themselves and by natives of the city. We are not aware of any historical evidence suggesting that this is the explanation for the divergence between the folk history and official statistics.

from the earthquake for the two cities: 35,193 in Messina and 9,298 in Reggio Calabria. The upper bound for Messina is well short of the official but long-suspected statistic of over 60,000 fatalities, increasing our skepticism of the official count and lending more credibility to the lower range of estimates. For Reggio Calabria, however, the upper bound exceeds somewhat the official estimate of 8,000, suggesting that the official toll is plausible. This is consistent with most of the uncertainty coming from questions over the death toll for Messina itself.

Our estimated upper bound for the net internal migration to these major cities over the *entire period 1901–1911* is 10,581 for Messina and 7,623 for Reggio Calabria. These estimates pale in comparison to the size of international emigration flows, which averaged over 15,600 *per year* from the province of Messina over the period 1905–1908 (of which over 13,000 per year were from municipalities other than Messina) and over 14,300 emigrants per year from the province of Reggio Calabria over the same period. Moreover, as we point out in Appendix A, these upper bounds include both internal migration in response to the earthquake as well as the internal churn of population that would have occurred even in the absence of the earthquake. In fact, our preferred estimate of the true net internal inflow of Italians who were not natives of the city in response to the earthquake is as low as -562 in Messina (i.e., the number of non-native residents of Messina who left the city to another Italian destination slightly *exceeded* the number of new incomers) and 3,492 in Reggio Calabria. Thus, local folk history notwithstanding, internal migration to the two major cities, fueled as it may have been by demand for reconstruction labor, was not sufficiently large to reroute significant flows that would have constituted a positive international migration response had they been directed abroad.

Surprisingly, little is known about international migration as a response to the earthquake, despite the facts that the area was in the midst of an unprecedented episode of mass emigration at the time of the shock and that emigration potentially provided cheap and readily available access to relief. Whether the affected population responded to the disaster through international migration remains an open question with important implications for a complete understanding of this event, for the economics of the Age of Mass Migration, and for the economics of disaster-induced migration. Importantly, there is no evidence that the earthquake itself directly hindered migration by disrupting travel: Messina’s importance as a point of embarkation for transatlantic migration was negligible relative to that of Palermo, Naples, and Genoa.¹⁰

¹⁰From the Ellis Island data that we describe below, we were able to determine that only about 3.9 percent of passengers from Sicily and Calabria arriving at Ellis Island between 1904 and 1908 embarked in Messina. From the provinces of Messina and Reggio Calabria, the comparable figure is 11.3 percent.

2.2 The economy of the Strait of Messina after the earthquake

Beyond the human tragedy that it caused, the earthquake ravaged the local economy. As mentioned above, tens of thousands of people were killed, reducing the local labor force in the worst affected places. Many more were dislocated, and there was widespread destruction of residential structures, which meant a massive loss of household wealth as well as a deterioration in living standards. Importantly, there is little evidence of substantial reconstruction efforts in the immediate aftermath of the earthquake, either in the two major cities or in the smaller affected towns. Instead, all indications are that recovery and reconstruction were extremely slow, with little progress made even by the 1930s (Farinella and Saitta 2019; Teti 2008),¹¹ meaning that the earthquake likely constituted a long-run economic shock.

The economy of the area around the Strait of Messina was largely based on agriculture, and primarily specialized in grains. However, the export of tree crops such as olives, vines, and citrus had become increasingly important in the area's economy by the time of the earthquake. Citrus in particular was an export staple with a significant subsidiary industry. This trade was disrupted, however, by the damage to the port of Messina, which had been the main outlet for the citrus trade.¹²

It is difficult to quantify precisely the severity and the duration of the economic consequences of the earthquake, particularly outside of the city and province of Messina. The best account of these effects is probably that produced by the young economist, statistician, and demographer Giorgio Mortara (1913a,b).¹³ He documented a severe economic downturn due to the destruction and the diversion of trade. This downturn lasted about two years before partial recovery began in 1911. For example, even though citrus shipments through Messina had resumed within two weeks of the earthquake (Farinella and Saitta 2019; Royal Society for the Encouragement of Arts and Commerce 1910), the value of trade passing through Messina in 1909 was less than half its 1907 value, with a more pronounced decline (70 percent) in exports than in imports; even in 1911 the value of exports was still one-third lower than the 1901–1907 average (Mortara 1913b, p. 269). Some of this decline was offset by trade diversion, however, with citrus exports from Catania increasing by 51 percent from 1907 to 1909, and continuing to rise thereafter. Indicators of banking activity were generally reduced by more than 50 percent, with profits of credit institutions slashed by an order of magnitude (Mortara

¹¹In a sense, the reconstruction remains incomplete: as of September 2021, some of the supposedly temporary wooden shelters constructed in the earthquake's aftermath were still occupied due to a lack of suitable alternative housing (Bubola 2021).

¹²Tree crops were also dependent on irrigation systems, which, in principle, may have been damaged by the earthquake. Such a channel, if it existed, would potentially impact even places where structures were not directly damaged by the earthquake. In a study of the available sources on the earthquake, however, we found no systematic evidence that this was a major cause of lower output. Moreover, we provide evidence below based on data on crop acreage and distance to the earthquake epicenter that is inconsistent with such a channel for the effect of the earthquake on emigration.

¹³Mortara had just started his first academic position at the University of Messina in 1909 and would later become one of the leading Italian social scientists.

1913b, pp. 283–284). The agricultural processing sector was also badly damaged—notably the citrus sector, but also mills, pasta factories, and tanneries, among others. A similar impression is provided by the report of the committee charged with overseeing the distribution of funds in the area, which cited substantial damage to local industry that in turn necessitated aid and loans for reconstruction.¹⁴

If trends in taxable income are informative of trends in overall income and economic activity, then the municipality of Messina was indeed devastated (Mortara 1913b, pp. 260, 298).¹⁵ Taxable capital income fell by two thirds in 1909 and 1910 and taxable mixed labor-capital income fell by four fifths. Even as late as 1912, revenues in both categories remained well below their 1908 levels. Highly paid labor income also fell by two thirds in the first two years after the earthquake, but recovered to above its previous level by 1912, as did public workers’ income, the decline of which was more moderate, though still substantial (40 percent and 26 percent in 1909 and 1910, respectively). All in all, these measures suggest that communities most affected by the earthquake suffered an economic downturn comparable to events such as the Great Depression or the Dust Bowl, and that these impacts were felt for several years before recovery began. It is likely that the shock to commercial hubs, such as the city of Messina, had wider economic implications in the region, also affecting municipalities not severely damaged by the earthquake—an issue that we tackle below.

2.3 Natural disasters and migration: theory and evidence

We think of the Messina-Reggio Calabria Earthquake as an exemplary case of a large-scale, sudden, and localized natural disaster, comparable to floods, hurricanes, and volcanic eruptions (and, of course, other earthquakes). Such events are distinct from, although not unrelated to, other types of natural and man-made disasters such as prolonged drought, crop destruction, famine, war, or societal or state collapse. The predicted impact of such natural disasters on migration is theoretically ambiguous. Consequently, much of our understanding of the effects of natural disasters on migration comes from an empirical literature that has identified several mechanisms by which natural disasters affect migration. Much of this literature is motivated by the goal of understanding the effects of climate change on population movements in developing countries in recent decades (Berleemann and Steinhardt 2017; Black et al. 2013).

The simplest mechanism by which natural disasters can impact migration is by augmenting push factors.

¹⁴This report is available in the *Archivio Centrale dello Stato* in Rome.

¹⁵Unfortunately, we were not able to locate the underlying data on taxable income from mobile wealth (*Imposta di Ricchezza Mobile*), the official publication of which was discontinued in the 1890s. We are thus unable to shed light on economic activity outside of Messina. Moreover, the annual provincial series of real wages compiled by Federico et al. (2019) are unfortunately of little use in revealing local income shocks, since most of the raw data for Messina and Reggio Calabria are missing for the years 1909–1910 (as well as some of the data for 1911). We believe that the absence of raw wage data may be a result of the earthquake itself. Our understanding, following personal communication with the authors, is that the figures in their series are constructed using geographic imputations.

By destroying productive capital, buildings, and infrastructure and by displacing labor, natural disasters hamper productive activity and trade, reducing household income in the place of origin (Baez and Santos 2008; Banerjee 2007; Cai et al. 2016; Gröger and Zylberberg 2016).¹⁶ The destruction of residential capital—probably the most notable feature of the Messina-Reggio Calabria Earthquake outside of the loss of life—amounts to a major shock to standards of living and household wealth; 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 incomes 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 et al. 2013; Robalino et al. 2015)—and permanent long-distance internal migration (Boustan et al. 2012; Hornbeck 2012; Hornbeck and Naidu 2014; Sichko 2021; Sichko et al. 2023). Some studies have also found similar positive effects on international migration (e.g., Drabo and Mbaye 2014; Murathanoğlu 2023; Reuveny and Moore 2009). The most comprehensive evidence for such a positive effect comes from Mahajan and Yang’s (2020) study of the effect of hurricanes on migration to the United States over the period 1980–2000.¹⁷

Positive effects on international migration do not characterize all cases 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 et al. 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 et al. 2013), and it gives rise to the notions of *trapped populations* (Nawrotzki and DeWaard 2018) and an *immobility paradox* (Beine et al. 2019), describing a state in which poor populations would have wanted to react through migration, but are locked in by liquidity constraints that are exacerbated by the shock. Findings

¹⁶More broadly, there is evidence that these shocks have persistent long-run negative effects on individual standards of living (Caruso 2017), on regional economic trajectories (Ager et al. 2020; Hornbeck 2012), and on national economic growth (Hsiang and Jina 2014; Skidmore and Toya 2002).

¹⁷Disasters in the destination can also make a place less attractive for in-migration. For instance, Ager et al. (2020) show that places that had been affected by the 1906 San Francisco Earthquake received less in-migration, probably due to the disruption of migration networks. Long and Siu (2018) also find evidence of falling in migration in response to the Dust Bowl. Although effects on in-migration from shocks in the destination are a related phenomenon, it differs from our focus on the effects of shocks in the origin on emigration in two important ways. First, studying the effects on emigration of a shock in the origin is informative of the response of the population that actually experienced the shock, whereas studying the effects of a shock in the destination is not. Moreover, the interruption of networks that characterized the San Francisco Earthquake is less likely to be applicable in our case, since the friends and relatives in the destination would not have been directly affected.

of heterogeneous effects of shocks on migration with respect to income, wealth, or human capital, and specifically 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 2021; c.f., Halliday 2006), are consistent with such a mechanism.

Another mechanism that could offset the push effect of natural disasters is that reconstruction may increase local demand for labor. Part of this effect would be realized through self-employment within the household, such as by repairing or rebuilding damaged property, which becomes 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 (c.f., Yang 2008b). The effect might also come through demand for construction workers in the local and regional labor markets. Moreover, reconstruction efforts are often fueled by remittances and other forms of financial flows to the affected places (Bettin and Zazzaro 2018; David 2011; Mohapatra et al. 2009; Murathanoğlu 2023; Paul 2005; Yang 2008a; c.f., Lueth and Ruiz-Arranz 2008).

Two issues in the literature on the relationship between natural disasters and migration highlight the contribution of this paper. First, 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 that are sudden and yet cause damage at that scale is scarce (c.f., Gignoux and Menéndez 2016; Halliday 2006; Yang 2008b). Second, virtually all studies of international migration have explored events that have occurred since 1960—a period of stringent restrictions on international migration (Hatton and Williamson 2005). 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 effectively 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. Our case study is unique in focusing on a massive shock whose survivors were familiar with a relatively cheap option of legally unconstrained overseas migration and were linked to a large proportion of their communities that had already relocated abroad and could assist their migration.

2.4 Italian emigration

By the 1890s, Italy had become one of the main sources of international migrants (Foerster 1919; Gomellini and Ó Gráda 2013; Spitzer and Zimran 2023). In 1901, the rate of emigration from the entire country exceeded 15 per thousand and subsequently peaked in 1913 at over 25 per thousand (Ferenczi and Willcox 1929; Hatton and Williamson 1998, p. 97). Altogether, this made the Italian transatlantic migration one of the largest free flows of population in history. In the earthquake-affected regions of Sicily and Calabria, the main destination was North America (primarily the United States), to which the rate of emigration regularly exceeded 20 per thousand after 1900. In total, 71 percent of migrants from these regions traveled to North America from 1901 to 1914. The next largest major destination was South America, with just over 22 percent of migrants from these regions.¹⁸

Three important patterns characterized the Italian migration. First, a relatively large share of this flow consisted of repeat and temporary migrants (Bandiera et al. 2013; Gomellini and Ó Gráda 2013; Hatton and Williamson 1998; Spitzer and Zimran 2018). 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 et al. 2014).

The second feature 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; Jerome 1926; 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—was followed by a decline in Italian emigration to the United States from over 300,000 in calendar year 1907 to about 130,000 in calendar year 1908, before resurging to 289,000 in calendar year 1909.¹⁹ To evaluate the effects of the earthquake on migration, it is crucial that we account for such volatility.

The third important pattern in Italian migration is its spatial expansion. Following Gould (1980), Spitzer and Zimran (2023) 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 the expansion of immigrants’ social networks.²⁰ In Sicily and Calabria, the nearest *epicenter* districts were Corleone in the province of Palermo (about 200 kilometers west of the Strait of Messina) and Sala Consilina in the province of Salerno (about 250 kilometers north), from which the sources of mass

¹⁸The figures on emigration by province of origin and destination country are calculated from Table V of the *Statistica della Emigrazione Italiana per l’Estero*, which we describe in more detail below.

¹⁹Such decline and resurgence around 1907–1909 occurred in most European countries of origin.

²⁰There were similar patterns for migration to South America and to Europe, but with different initial epicenters and starting points in time.

emigration expanded gradually beginning in the 1870s.²¹ By the time of the earthquake, the area around the Strait of Messina had already achieved high rates of emigration. Municipalities within a radius of 150 kilometers from the earthquake’s epicenter experienced an average annual emigration rate of over 35 per thousand in the period 1905–1908—extraordinarily high by any standard. 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 who could aid them in migration. Emigration trends from saturated areas were reaching a plateau, albeit with considerable volatility around this level. But the provinces of Catania and Siracusa in southeastern Sicily, farther from the emigration epicenters, had lagged behind the rest of Sicily and Calabria, and achieved saturation only in the early 1910s. This meant that the emigration of this area was on a rising trend relative to the area around the Strait of Messina in the period that we analyze (Spitzer and Zimran 2023). 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 analysis.

Roughly three-quarters of Italian migrants were male (Hatton and Williamson 1998, p. 102). 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 migration also consisted primarily of individuals employed in unskilled occupations (Federico et al. 2021; Pérez 2021; 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.²²

Internal migration within Italy may also have been an important margin of response to the earthquake, potentially constituting a substitute for international migration. Although data sources on internal migration are very limited in comparison to international migration, we know that, at least in southern Italy in our study period, this was a far less common phenomenon than was international migration (Gallo 2012), probably because returns to migration and employment opportunities were far greater in overseas destinations. As discussed above, there is also no evidence of a large inflow to the cities of Messina and Reggio Calabria, indicating that the draw of reconstruction labor to these cities was unlikely to capture any substantial part of the potential international migration flow. There is little doubt that the primary outside option for the earthquake-affected population was overseas migration.

²¹The other epicenters identified by Spitzer and Zimran (2023) are Pozzuoli in Naples, Isernia in Campobasso, and Albenga and Chiavari in Genoa.

²²As we discuss in footnote 63 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, the share of migrants who worked in agriculture was smaller, but there were large shares of migrants who were employed in construction, and these individuals were likely unskilled and landless.

Return migration, which was substantial in the period that we study, might also have provided households with a margin on which to adjust to the earthquake. For instance, individuals in the United States who had intended to return to Italy might have delayed their returns as a result of the damage to the area. We regard return migration as a related yet separate phenomenon that is different from the response of the local population, and due to the paucity of the available data on return migration we cannot reliably estimate the magnitude of its response to the earthquake; we discuss what empirical evidence we can glean on the relationship between the earthquake and return migration in Online Appendix C.²³

3 Data

3.1 Sources and construction

Data on earthquake severity are taken from Guidoboni et al. (2007). This source, based largely on descriptions of earthquake damage provided by Baratta (1910), reports Mercalli severity scores for various latitude-longitude pairs in the affected region. Whereas the more commonly referenced Richter scale is based on the amount of energy released by the earthquake, the Mercalli scale is defined on the basis of the damage suffered. It ranges from I (not felt) to XII (extreme), with the definitions listed in Online Appendix Table B.1. In some cases, our data include intermediate measures such as IX–X or X–XI, which we score as 9.5 or 10.5. The Mercalli score 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 into damage differently in different areas. Guidoboni et al. (2007) also provide information on the number of deaths at each latitude-longitude pair.²⁴

We assigned the point-based severity measures to the municipalities into which they fall.²⁵ For municipalities with no severity measures, we used an inverse-distance-weighted imputation of Mercalli scores. Our benchmark treatment variable is a binary indicator for severe damage from the earthquake: we assigned a municipality to the severe group if its severity score was VIII or higher,²⁶ and assigned all other munic-

²³Data on return migration are only available at the province level. We find that return migration after the earthquake was approximately one third lower in the provinces of Messina and Reggio Calabria relative to the trend for the regions of Sicily and Calabria.

²⁴As discussed above, these estimates remain the subject of debate to the present, particularly in the case of the city of Messina. We use the official death toll for this city (67,307 when including some outlying towns that have since been incorporated into Messina) although, as discussed above, we believe that the true toll may be less than half this number. In Online Appendix D we show that our results are robust to a number of approaches to addressing potential inaccuracies in the death counts.

²⁵In the absence of a map of Italian municipalities for the early 20th century, we relied on a shape file of municipalities as of January 1, 2018 (ISTAT 2018), which resulted in a small number of historical municipalities being combined with one another to form larger municipalities, primarily through the incorporation of adjacent municipalities into the municipalities of Messina or Reggio Calabria. In cases where a modern municipality had multiple points of severity measures, we first attempted to identify the city center; in other cases, we use the maximum severity recorded in the municipality.

²⁶This cutoff typically corresponds to a Richter scale reading of 7.0 (US Geological Survey 2019).

papalities to the non-severe group. In practice, all municipalities for which we imputed a severity measure fell into the non-severe category (i.e., their imputed Mercalli scores were below VIII), which is consistent with the absence of severity information indicating little or no earthquake damage and with the inclusion of all severely affected areas in the damage data. Our choice of the VIII cutoff is based on the fact that this severity level entails substantial damage to ordinary buildings, whereas a VII cutoff implies considerable damage only to poorly built structures. Recognizing that many structures in the study area may have been poorly built, we also explore the consequences of changing the severity cutoff, using dose-response models, or using distance from the earthquake epicenter as an alternative treatment measure.

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. In total, there are records of 4.8 million passengers with Italian origin or nationality compiled from passenger manifests. In the case of Italian passengers, the information provided in these manifests appears highly accurate, probably as a result of the requirement by Italian authorities to travel abroad with a passport (Foerster 1919, pp. 10–22), which was an official document identifying migrants’ municipalities of origin.

To identify the last place of residence of each passenger arriving at Ellis Island,²⁷ 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 and that the subset of individuals whose location could be determined from the algorithm is representative of all passengers. In total, specific latitude and longitude coordinates could be assigned to 1,445,096 passengers arriving 1905–1912. These were then linked to a municipality of last residence and we then used a variety of sources to determine the historical district and province of this municipality.²⁸ The ultimate product is an annual count of passengers from each municipality. The transcribed passenger lists also contain a limited number of individual migrant characteristics, including age and gender.²⁹ We use these data to construct each municipality-year’s average

²⁷The passenger manifests also include the passenger’s place of birth, but this field was not digitized by the Statue of Liberty-Ellis Island foundation. Spitzer and Zimran (2018, p. 229, fn 14) show that the last place of residence and birth place agree in approximately 98 percent of cases in 1907 and 1912 (when an auxiliary source transcribing birth place is available).

²⁸More details of this component of the data cleaning process are presented in Online Appendix E.

²⁹The 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-municipality-year comparison of individuals characteristics is infeasibly large. Therefore, we restrict our analysis to the variables that are available for all individuals.

emigrant characteristics, as well as a count of prime-aged (18–65) male passengers, 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 municipality-level emigration counts published in the *Statistica della Emigrazione Italiana per l'Estero*. This source, which was digitized and described in detail by Spitzer and Zimran (2023),³⁰ indicates the number of international emigrants from each municipality 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 by covering all destinations (rather than just the United States) and ports of entry (rather than just New York), they suffer from some disadvantages. First, lack any information on migrants' demographics. Second, records 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.³¹ Most important is 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 as an alternative the same results using the official emigration data for robustness. The two sources are largely consistent with each other, as are the outcomes of the empirical analysis. Where they are not, we point this out.

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 were low, as discussed above. Further reassurance is provided by sampling and manually inspecting passenger lists for a mismatch between the last place of residence and the place of birth. This search yields no systematic evidence of Messina-born individuals listing a different locality as the last place of residence.³²

Finally, we collected data on the characteristics of Italian municipalities and districts from a variety of official sources. The most important is the 1901 Italian census of population, the last before the earthquake.

³⁰See also Fontana et al. (2021).

³¹The 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.”

³²We 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 important 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.

This source provides municipality-level population counts,³³ which enable us to compute rates of emigration, as well as district-level occupational distributions.³⁴ We are particularly interested in the distribution of the different types of contractual attachment to the land of agricultural workers, which was likely the most important factor differentiating the status of the rural working class that formed the majority of the population and of those who migrated. The least attached were the agricultural day laborers (*giornalieri di campagna*). Other categories indicate a more rigid attachment: 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. Important as well is employment in construction and in credit and banking—sectors whose size might modulate the effect of the earthquake, as we discuss in section 5.4. We also use district-level information from the 1901 census on the rates of ownership of real estate in the form of land and buildings,³⁵ as well as literacy and the fraction of the population under age 15.³⁶ Finally, we collected municipality-level indicators on the presence of post offices, telegraphs, and police stations.³⁷

To evaluate the suspected role of liquidity constraints in muting a potential earthquake response, we collected and digitized municipality-level information on various tiers of the Italian financial system to complement our data on district-level employment in credit and banking. First, from the Historical Archive of Credit in Italy (Natoli et al. 2016) we have data on the assets of and the short- and long-duration loans provided by banks of various levels. This includes data on the upper and middle tiers of the banking system—ordinary credit or joint-stock banks (*Società Ordinarie di Credito*), cooperative banks (*Banche Popolari*), and savings banks (*Casse di Risparmio Ordinarie*).³⁸ These institutions were typically located in district capitals and sometimes hard to access by the southern peasantry; moreover, the data are informative of their main locations, potentially to the exclusion of smaller branches.³⁹ Lower-tier institutions, on the other hand, were prevalent in many small localities and the degree of their development was likely a good

³³The population data that we use are originally from the 1901 census, but were reported in the *Statistica della Emigrazione Italiana per l'Estero*.

³⁴1901 Census, Volume III, Table C.

³⁵1901 Census, Volume IV, Table VIII.B.

³⁶1901 Census, Volume II, Table III.B.

³⁷*Dizionario dei Comuni del Regno d'Italia*

³⁸The Natoli et al. (2016) data do not include, and we were not able to locate, data on the *Casse Rurali*, which were at a level similar to the cooperative banks (*Banche Popolari*). Galassi and Cohen (1994) show that, with the exception of the Province of Palermo, the *Casse Rurali* were largely absent from Sicily and Calabria, meaning that their omission from our data likely does not obscure a significant potential source of credit in the earthquake-affected region.

³⁹We are grateful to an anonymous referee for pointing this out.

indicator for access to credit, savings, and mutual assistance. Natoli et al. (2016) provide data on one such type of institution—pledge banks (*Monti di Pietà*). These pawn shops, which operated as charitable religious institutions, were widely diffused, particularly in less developed areas such as Sicily and Calabria, and handled much of the country’s small scale credit (Carboni and Fornasari 2019; Pascali 2016). The most recent year with complete coverage prior to the earthquake is 1905, and we use the data to compute each municipality’s log assets per capita and log credit per capita, as well as analogs of these measures capturing assets and credit within a 25-kilometer radius of each municipality. Access to household funds is measured using data on postal savings banks (*Casse Postali di Risparmio*), which were perhaps the most important destination for the savings of the working classes.⁴⁰ Similar to the *Monti di Pietà*, their branches were ubiquitous in small-sized localities, and they are informative of highly localized access to savings that could have funded emigration. We collected data on these banks, but the most recent available source relative to the earthquake was in 1887.⁴¹ Again, we use this source to produce local and 25-kilometer radius per capita measures. Another important institution was Mutual Aid Societies (*Società di Mutuo Soccorso*), for which we collected data on membership and endowment in each municipality in 1904.⁴² These may have been an instrument for raising funds under stress, and, more broadly, an indicator for high social capital that could be used for the same end.⁴³

3.2 Summary statistics

Table 2 presents summary statistics for earthquake exposure and emigration for severely damaged and non-severely damaged municipalities in Calabria and Sicily, as well as for the whole of Italy. The table also includes tests of whether the differences in each of these characteristics between severely damaged and non-severely damaged municipalities are statistically significant. As for the damage caused by the earthquake, severely damaged municipalities were, unsurprisingly, closer to the epicenter of the earthquake—just under 40 kilometers on average—and by definition they experienced more damage as measured by the Mercalli

⁴⁰*Relazione intorno al servizio delle Casse Postali di Risparmio durante l’anno 1887.*

⁴¹We also digitized data on pledge banks in 1896 and savings banks in 1875, which we use for robustness checks.

⁴²*Le Società di Mutuo Soccorso in Italia al 31 Dicembre 1904.*

⁴³Additional sources enable us to collect data that we use for robustness checks, on municipalities’ agriculture, industry, and transportation. The Jacini Inquiry (1877–1886) published data on agricultural activity for Sicily from 1885 (*Atti della Giunta per la inchiesta agraria e sulle condizioni della classe agricola*, Roma, 1881–1886). We use this source to compute the fraction of a municipality’s land devoted to agriculture, the share of trees (citrus, olives, and vineyards) in total cultivated land, and the cultivated hectares per capita. Ciccarelli and Groote (2017) provide data on the Italian rail network, which we use to determine each municipality’s rail linkage status in 1908. The 1911 Industrial census provides information on total horsepower in manufacturing in each municipality, which we use to produce a per capita measure. A clear concern with this source is that it is from after the earthquake, but no earlier measure is available and we believe that this source provides a stock measure of municipalities’ industrialization which is unlikely to be drastically changed within a short period of time. Finally, we have GIS data on municipality area from the Italian statistical agency ISTAT, which we use to compute population density.

score. By contrast, the average non-severely damaged municipality in the regions of Sicily and Calabria had a Mercalli severity of about VI.⁴⁴ Severely damaged municipalities also registered considerably more deaths per capita, on average 17.5 deaths per thousand. This figure emphasizes that Messina’s official death toll (445 per thousand) was an extreme outlier, and that in most cases earthquake deaths were unlikely to cause a meaningful change in emigration rates by reducing the denominator (though we verify this explicitly in our analysis). Figure 1 maps the data on damage from the earthquake. Panel (a) presents the Mercalli score for each municipality (excluding those without data in Guidoboni et al. 2007). Panel (b) maps the indicator for whether each municipality experienced damage of a Mercalli severity of VIII or greater. Severity is clearly a decreasing function of distance from the earthquake’s epicenter (indicated by the large dot), but there is still considerable local variation.

Emigration rates according to the Ellis Island data are approximately half those reported in the official emigration data, reflecting their incomplete coverage in terms of international destinations (e.g., migration to South America is not captured by the Ellis Island data), the minority of passengers whose municipality of origin could not be determined, and to a lesser degree the absence of data from other ports of entry to the United States. Figure 2 presents the spatial distribution of our main outcome variable—average annual emigration rates at the municipality 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 its greater distance from the early origins of migration (section 2.4 and Spitzer and Zimran 2023). Panel (b) 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 again 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. There is no clear relationship between proximity to the earthquake epicenter and the change in emigration rates.

Figure 3 plots the average annual municipality-level emigration rate over the period 1905–1912 for severely damaged and non-severely damaged municipalities in Sicily and Calabria. The dominant pattern in these trends is the large decline in average emigration rates in 1908 following the Panic of 1907, from over 15 per thousand to about 5 per thousand in the Ellis Island data (panel a) and from over 40 per thousand to about 20 per thousand in the official statistics over 1906–1908 (panel b). Conversely, the trends for both

⁴⁴The 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.

⁴⁵Online Appendix Figure B.2 presents analogous figures based on the Italian official statistics.

the severely damaged and other municipalities in Sicily and Calabria appear similar both before and after the earthquake at the end of 1908—with severely damaged municipalities always exhibiting slightly lower emigration rates than non-severely damaged ones.

Finally, the bottom panel of Table 2 tests for differences in the characteristics of migrants in the pre-earthquake period between severely damaged and non-severely damaged municipalities. These figures reveal statistically significant differences between migrant characteristics between these two groups. For instance, migrants from severely damaged municipalities in Calabria were substantially older than those from non-severely damaged municipalities, even before the shock.

Table 3 presents summary statistics for characteristics of municipalities and districts, and also includes tests for statistical significance of differences between severely damaged and non-severely damaged municipalities.⁴⁶ Severely damaged municipalities were, on average, farther from emigration epicenters than were non-severely damaged municipalities, and were in districts with a greater share of employment in construction and with fewer property owners per capita. Municipalities of both groups were in districts with, on average, similar levels of employment in credit and agricultural day labor. Severely damaged municipalities were also in districts with somewhat lower property ownership. There are some substantial differences in measures of financial development and social capital, but the signs of the differences vary and no group clearly dominates the other.

All of these summary statistics suggest that severely damaged and non-severely damaged municipalities differed in important ways prior to the earthquake. This difference is likely the product of the fact that the earthquake epicenter was near the major cities of Messina and Reggio Calabria, and thus that severely damaged municipalities were both closer to the coast and to the major cities. This emphasizes the importance of including municipality fixed effects in our empirical specifications, absorbing any level differences between severely damaged and non-severely damaged municipalities and rendering any such imbalances not concerning *per se*. The main remaining concern, however, is that the differences in municipality characteristics between the two groups might suggest that emigration from the two groups would have evolved along different trends in the counterfactual without an earthquake shock. As pointed out above, the most concrete source for such non-parallel trends is distance from emigration epicenters, for which we control directly, but we cannot rule out the existence of others *a priori*, though we find it unlikely that differing characteristics would drive differing emigration trends after the earthquake but, as our event study specifications will show, not prior to it. We address this concern below by repeating our main results allowing for differential trends based on

⁴⁶This table focuses on our main variables of interest. Summary statistics for additional variables are presented in Online Appendix Table B.2.

a large set of observable covariates and find that our results are robust.

Finally, our summary statistics provide the first indications of our main finding. Table 2 shows that emigration rates in both severely damaged and non-severely damaged municipalities declined somewhat over time, but did so slightly more in municipalities experiencing severe damage. In panel (b) of Figure 2 there is little apparent impact of the earthquake. In Figure 3 the trends both before and after the event are nearly indistinguishable, and certainly so relative to the large temporal fluctuations in migration, such as around the Panic of 1907. Finally, Figure 4 plots the ratio of the post-to-pre (i.e., 1909–1912 to 1905–1908) emigration rates against the pre-earthquake average annual emigration rates, separately for each group. It appears that any impact of the earthquake was of secondary importance as compared to the patterns of convergence in emigration rates discussed above. There is a clear downward slope in the plots, reflecting β -convergence in migration rates, but there is little difference between the trends of the two groups and the trend of the severe group is nowhere higher.

4 Empirical strategy

Our empirical analysis is based on emigration data at the municipality-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 benchmark sample is limited to the regions of Sicily and Reggio Calabria, in which all affected municipalities are located. We also report results in which we limit attention to one region in particular or expand it to all of Italy.

Our benchmark empirical approach is the generalized difference-in-differences equation

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

where α_{pt} are province-year fixed effects, α_i are municipality fixed effects, and e_{it} is the emigration rate of municipality i in year t . 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 the post-earthquake period according to the estimated death toll. The municipality fixed effects capture time-invariant differences in emigration rates and other characteristics across municipalities. The province-year fixed effects capture province-specific year-to-year variations, controlling for time trends,

volatility across the study area, and, at least in part, for the regional economic fallout of the earthquake.⁴⁷ The coefficient of interest is β , which estimates the interaction between an indicator for whether a municipality was severely damaged by the earthquake (s_i) and an indicator for the post period of years 1909 and later (q_t). With the economic fallout of the earthquake likely affecting the entire region, the coefficient β can be interpreted as the additional effect of experiencing severe damage on top of the effects of such exposure.⁴⁸ Equation (1) also includes an interaction between the distance from the nearest emigration epicenter (d_i) and the post indicator (q_t) to account for differential trends stemming from distance from the early sources of emigration. We also adapt equation (1) into an event study specification of the form

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

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

We take several different approaches to inference. The treatment varies at the level of the municipality and it might be natural to cluster standard errors at this level. But such an approach would rule out cross-municipality correlation, which we find implausible. Conley (1999) standard errors address this issue by permitting such a correlation. In later analyses, however, we will use variables that vary only at the district level, requiring that we cluster at this more conservative level. Thus, although the online appendix includes a version of our results with municipality-clustered and Conley (1999) standard errors (the latter allowing correlation within 3 lags and 150 kilometers), our preferred approach is to cluster at the higher level of the district, which also permits correlation between municipalities in the same district over different years. Since there are only 35 districts in the regions of Sicily and Calabria, we use Roodman et al.’s (2019) wild bootstrap approach.⁴⁹ Clustering at a higher level, which generally yields wider confidence intervals, works against our argument that there was no large positive effect. While wider confidence intervals eliminate the statistical significance of a wider range of positive effects, they also raise the upper bounds of our confidence intervals, such that for any given estimate, it is harder to rule out large positive effects.

The nature of earthquakes is such that the treatment itself is very geographically clustered, which is one of the important motivations for conservative clustering. It also suggests an additional randomization inference method that explicitly incorporates the geographic structure of the shock. Complete details of

⁴⁷That is, insofar as the economic effects of the earthquake varied across provinces rather than within them, the province-year fixed effects would capture any impact of these economic effects on migration, leaving the comparison to be solely between places experiencing severe damage and those not experiencing severe damage within the same province.

⁴⁸Some of the economic impacts of the earthquake, such as the destruction in the commercial hubs were felt throughout the affected area and therefore any identification strategy based on making comparisons within the affected area cannot capture the combined effects of severe damage and the economic effects of the earthquake relative to the counterfactual of no effect.

⁴⁹The bootstrap is not necessary for specifications including all of Italy since there are 284 districts in this case.

this method are presented in Online Appendix F. In brief, we simulate 500 randomly placed earthquakes in Sicily and Calabria with the distance-damage relationship estimated from the Messina-Reggio Calabria Earthquake. We then re-estimate our regressions for each of the simulated events. This approach enables us to determine whether the estimates that we derive for the actual earthquake differ from those of the random earthquakes—essentially a placebo analysis that takes into account the spatial distributions of the treatment and the outcome. This exercise produces what we call a *tail-mass value*, which is the share of estimates in the randomization inference that are more extreme than the true estimate relative to the median of these estimates.⁵⁰ The tail-mass value is a close analog to the ordinary one-sided p -value.

In all of our analyses we weight each municipality equally rather than by its population, its share of aggregate emigration, or some other measure of size. Each municipality thus constitutes a separate instance. 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 municipalities (and we show in Online Appendix D that our results are not sensitive to excluding them). Weighting by population would cause us to derive much of our identification from these two cities, in which the effects of the earthquake may have been idiosyncratic and unrepresentative.⁵¹ Our equal-weighting approach corresponds to the motivation to understand how a typical municipality was affected by the earthquake rather than to quantify the total effect of the earthquake.

5 Results

5.1 Aggregate effects of the earthquake

Our benchmark results point toward the conclusion that there was no large positive impact of the earthquake on subsequent emigration flows, and moreover, although imprecise, our estimates suggest that any effect was negative. Table 4 presents the results of estimating the difference-in-differences specification of equation (1) for a variety of geographic scopes and definitions of the outcome.⁵² Our preferred estimates, based on the Ellis Island data with no adjustments and focusing on Sicily and Calabria as the study regions, are in column (1) of Panel A. The estimated coefficient of -0.071 indicates a small relative decline in emigration from affected municipalities of about 7 percent,⁵³ and is both statistically insignificant according to the district-clustered

⁵⁰For instance, if 5 percent of the random earthquakes produce a coefficient smaller than the estimate for the true earthquake, the tail mass value would be 0.05. Similarly, if 5 percent of the random earthquakes produce a coefficient larger than the estimate for the true earthquake, the tail mass value would also be 0.05.

⁵¹When we do weight our observations by population, there are strong differential pre-trends between severely damaged and non-severely damaged municipalities, limiting our ability to determine an earthquake effect.

⁵²Online Appendix Table B.3 repeats these results with municipality-clustered and Conley (1999) standard errors. These results are also statistically insignificant, but the implied confidence intervals are all smaller than those in Table 4.

⁵³This corresponds to about 6 percent of a standard deviation of the outcome.

wild bootstrap ($p > 0.50$) and does not stand out according to the randomization inference exercise, with more than one-quarter of the placebo estimates more negative than our estimate (and, conversely, nearly three-quarters more positive). The remaining specifications of Table 4 show that this qualitative result is not driven by the source of the emigration data, by the inclusion or exclusion of earthquake deaths in computing emigration rates, or by the geographic scope; the estimated effect in all specifications ranges from a decline of 15 log points to a zero impact, and no estimate is statistically significant.⁵⁴

Figure 5 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 4, the sample includes all municipalities in Sicily and Calabria. First, these specifications lend support to the parallel trends assumption underlying the difference-in-differences analysis. They also show how any effect of the earthquake evolved over time. Our preferred results are presented in panel (a), which uses emigration counts from Ellis Island without adjustments. The point estimates show no evidence of meaningfully different emigration trends of severely damaged and other municipalities prior to the earthquake. In the first year after the shock, there was a slight (just under 10 log points) relative decline in emigration in the severely damaged municipalities, but this change was not statistically significant. This decline then diminished considerably by the second year after the earthquake, remaining small and statistically insignificant thereafter, suggesting that any effect was short-lived. Notably, there is no resurgence in emigration in the years after the initial decline that would suggest that many individuals had simply delayed migration.

The lack of a large positive impact of the earthquake is not due to an idiosyncrasy of our choice of how to measure earthquake damage or emigration. First, both the difference-in-differences results of Table 4 and the event study results of Figure 5 are qualitatively robust to changing the definition of the outcome variable. Second, we repeat the results of Table 4 using either the Mercalli score (Online Appendix Table B.5) or the negative distance (in hundreds of kilometers) from the earthquake epicenter (Online Appendix Table B.6) instead of the severe indicator.⁵⁵ Although the coefficients are occasionally statistically significant, mostly hovering just below zero, the interpretation of the point estimates is similar to that of Table 4.⁵⁶ Finally,

⁵⁴Online Appendix Table B.4 repeats the estimation of equation (1) with the demographic characteristics of migrants as the outcome. These specifications enable us, for instance, to test if the earthquake led older individuals, who might have been less likely to emigrate in general, to leave severely damaged municipalities. For all four characteristics—age, male, prime-aged male, and child (i.e., less than 16 years old)—we find no evidence of a statistically significant effect of the earthquake.

⁵⁵Since the earthquake epicenter was very near Messina, distance from the earthquake epicenter is informative of distance from the port. Insofar as places closer to the port were more reliant on it, and thus more likely to be affected by its disruption, this analysis can be thought of as capturing the combined effect of the two forces. That the results are similar in interpretation to those in Table 4 is reassuring.

⁵⁶As shown in Table 2, the difference in the severity of the average severely damaged and average non-severely damaged municipality was about 2.5, which according to column (1) panel A of Online Appendix Table B.5 corresponds to a negative effect of severity of about 15 log points. We present these results with the caveat that there is no reason to believe that the Mercalli scores are cardinal and that Online Appendix Figure B.3 shows that some of this estimate may be driven by lower

Figure 6 explores the consequences of changing the definition of severe damage to various Mercalli score cutoffs.⁵⁷ Given the small number of municipalities with a severity of IX or greater (25 municipalities) and our understanding that a Mercalli score of VI or less indicates only negligible damage, the natural alternative cutoff to VIII is VII. In no case does changing the definition of severe damage from VIII to VII materially affect our results.⁵⁸ Although in some cases the earthquake effect for a cutoff of VII, which is always negative, is marginally significant, the magnitude of the point estimate is not appreciably different, and the tighter confidence intervals strengthen the case for no large positive effect. Nonetheless, since it is our view that VIII is the most appropriate cutoff, we continue to use it throughout the analysis. Online Appendix G presents results for an alternative severity definition based on a Mercalli cutoff of VII. Consistent with Figure 6, the results are all similar to, and in some cases are stronger than, those based on the Mercalli cutoff of VIII.

On the whole, we conclude that, regardless of the definition of treatment, the extent of the sample, the source of emigration data, or the approach to inference, there is no statistically significant evidence of a meaningful positive effect of the earthquake on migration. At most, the point estimates attribute to the disaster a small and short-lived relative *decline* in emigration from severely damaged municipalities.

5.2 Statistical power and economic significance

Perhaps the greatest challenge to our interpretation of these results as indicating a lack of a large positive effect of the earthquake on migration is that our estimates are statistically imprecise. In the benchmark specification (Table 4, Panel A, column 1), the 95-percent confidence interval for the earthquake effect ranges from a decrease in emigration of 45 log points to an increase of 39 log points.⁵⁹ This raises the question of whether we can rule out an economically significant positive migration response to the earthquake. In part, this imprecision is a product of our conservative approach to inference based on the wild bootstrap clustered at the district level. When we use a more liberal approach to inference, as in Online Appendix Table B.3, the confidence intervals are considerably narrower. The upper bound of the 95-percent confidence interval is an increase of 9 log points when using municipality-clustered standard errors. When using Conley (1999)

severity levels, where we do not expect to find an effect due to the lack of damage. Similarly, according to Table 2, the difference in the average distance to epicenter between the severely damaged and non-severely damaged municipalities was 99.5 kilometers, implying that Online Appendix Table B.6's panel A column (1) estimate also corresponds to a negative severe coefficient of about 15 log points. The confidence intervals of the estimates of Online Appendix Tables' B.5 and B.6 are also somewhat tighter than those of Table 4 when converted similarly, again strengthening the case for no large positive effect.

⁵⁷In Figure 6, all municipalities with missing severity data are set to non-severe. Online Appendix Figure B.4 performs an analogous exercise imputing missing scores before applying the cutoff, again finding no evidence of large positive effects.

⁵⁸Due to the small number of municipalities experiencing severity of IX or above, setting the cutoff to IX or greater results in confidence intervals that are an order of magnitude greater, rendering any inference largely meaningless.

⁵⁹The 90-percent confidence interval for the same estimate ranges from a decline of 36 log points to an increase of 28 log points.

standard errors, which are plausible in this case since we do not use district-level variables, the upper bound of the confidence interval is an increase of 20 log points. The conclusion also depends on the yardstick for economic significance. To be sure, the upper bound of the most conservative confidence interval, a 39-log point increase, is not negligible. But it is important to keep in mind the unprecedented magnitude of the disaster 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.

Recent studies and related historical events offer reasonable yardsticks to gauge economic significance. The closest temporally and spatially is the decline in emigration following the Panic of 1907, just one year before the earthquake. 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. Municipalities severely damaged by the earthquake experienced a decline in average rates of emigration from 1907 to 1908 of 129.3 log points, from 15 per thousand to 4 per thousand (panel a of Figure 3).⁶⁰ This is far outside even our most conservative confidence intervals,⁶¹ meaning that any likely effect of the earthquake is far smaller, in absolute size, relative to this benchmark effect of a large but not unheard-of temporary downturn in the US business cycle.⁶²

Another useful yardstick for the effect of the earthquake on migration is provided by Mahajan and Yang’s (2020) study of the effects of hurricanes on migration to the US, which emphasizes the role of the stock of previous immigrants in the destination. Applying their estimates (Tables 3 and 5) to a rough estimate of the size of the Calabrian and Sicilian population already present in the US at the end of 1908, the implied effect of what Mahajan and Yang (2020) call a “one standard deviation” hurricane—a far smaller shock than the Messina-Reggio Calabria earthquake—ranges from 43.9 percent to 106 percent increase in annual migration, again outside of our confidence intervals for the effect of the earthquake. The details of how we computed these figures are presented in Online Appendix H, where we also argue that our estimated effect of the earthquake is precise enough to conclude that it was small relative to estimates of declines in migration in response to recent earthquakes (Halliday 2006; Shakya et al. 2022).

In sum, although a conservative approach to inference leads to rather wide confidence intervals around

⁶⁰In the official data, the decline over 1906-1908 is from over 45 per thousand to just over 20 per thousand—79 log points lower. Over 1907–1908, the decline is from about 34 per thousand to just over 20 per thousand (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 31 log points to a rise of 13 log points.

⁶¹The 1907–1908 change also exceeds the bounds of our conservative confidence interval for the one-year impact of the earthquake (Figure 5, panel a).

⁶²Our estimated effect of the earthquake is also small relative to seasonal variation in migration in this context. From 1904 to 1908, the average difference between the high-migration season (March-June) and the remainder of the year was 63.9 log points. This comparison must be interpreted with caution, however, because of the predictability of seasonal changes.

our estimates, hindering our ability to definitively conclude that there was no positive effect of the earthquake on international migration, our estimates are nevertheless sufficiently precise to conclude that any likely true increase in migration in response to the earthquake was small as compared to those of comparable or weaker shocks, whether economic or other natural disasters, that have been studied in prior research.

5.3 Labor force composition and heterogeneous responses to the earthquake

What could explain the absence of a large aggregate positive impact of the earthquake? We approach this question by looking for local characteristics that were associated with heterogeneous responses to severe earthquake damage. Such responses may have been meaningful in magnitude and duration, even if they canceled each other out in the aggregate. Guided by the competing hypotheses in the literature discussed in section 2.3 and by the features of the southern Italian economy, we focus on what we consider to be the most likely factors that would limit a positive emigration response to the earthquake—attachment to the land, liquidity constraints, greater exigencies, and demand for reconstruction labor.

We first turn to understanding the role of the composition of the agricultural working class, which formed the majority of both the labor force and of the migrants themselves.⁶³ Peasants in the different categories of agricultural labor differed in both their standards of living and in their tenancy status, and moving up the tenancy ladder by leasing or purchasing land was a primary goal of Italian migrants and their households (MacDonald and MacDonald 1964, p. 85). It is likely that a worker’s position in this hierarchy affected his ability and his incentive to respond quickly to a shock through migration. Renters, lessees, and owner-occupiers, who had at least some stake in cultivating and improving the land to which they were attached, could not abandon it costlessly on short notice (see also Blanchard et al. 1992), and they may have experienced the greater exigency of an incentive to invest in rebuilding and repairing their own property after the earthquake. Day laborers, who comprised about half of the agricultural labor force, were relatively unfettered by contractual obligations or vested capital and, for this reason, potentially were better able to react quickly to unexpected shocks.⁶⁴ On the other hand, being at the bottom of the socio-economic scale, agricultural day laborers may have faced a greater tightening of their financial constraints to migration. To evaluate these possibilities, we test whether districts where agricultural day laborers were a greater share of

⁶³There 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. Moreover, it is very likely that those listing an occupation of “laborer” were in fact farm laborers; see also Pérez’s (2021, pp. 13–14) argument that the distinction between farmers and unskilled laborers in passenger manifests is not particularly informative.

⁶⁴Hatton (2010), Hatton and Williamson (1998), and Vianello (2014) also argue that attachment to the land might have hindered migration in general.

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

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

where x_i is some characteristic of municipality i and π is the interaction coefficient of interest. We standardize the interaction characteristics such that x_i always has mean 0 and standard deviation 1 in the estimation sample for each specification. Similarly, we adjust the event study specification of equation (2) to the form

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

In Table 5, we estimate equation (3) using unadjusted emigration data for Sicily and Calabria, taking the 1901 district-level share of employment as agricultural day laborers as x_i .⁶⁵ Column (1) repeats the result of Table 4.⁶⁶ Column (2) reports a statistically significant and strongly positive relationship between a district's share of employment in agricultural day labor and the response of municipalities in that district to the earthquake. A municipality with an agricultural day labor share one standard deviation above the mean experienced a relative increase in emigration of over 35 log points in response to the earthquake shock.

To more easily see the differential reaction, Figure 7 estimates the event study specification of equation (4). Rather than using the actual agricultural day labor share as the interaction, as in Table 5, this figure uses an indicator for being in a district above the sample median in terms of this share as the interaction variable x_i .⁶⁷ This enables us to present the effect of severe earthquake damage separately for each group (above or below the median), easing interpretation. Panels (a) and (c), which use the Ellis Island data, show that neither group exhibits any differential pre-trend, and that there is a readily apparent divergence in the effect of the earthquake on severely damaged districts. In the above-median group, there was a relative increase in emigration of 19 log points in 1909, whereas municipalities in the below-median group share show a relative decrease of 39 log points. The divergence persisted in later years, though it was of a somewhat smaller magnitude, indicating that differences in the agricultural labor share had an enduring effect in shaping emigration responses to the earthquake rather than simply delaying or slowing an emigration response. However, we treat these results with some skepticism: based on the official emigration data, the interaction with the share of agricultural laborers is weaker, though still statistically significant (Table 5,

⁶⁵Results for other dependent variables and geographic scopes are presented in Online Appendix Table B.7.

⁶⁶Because of the randomization involved in the wild bootstrap, the p -values and confidence intervals will not be identical.

⁶⁷In Calabria, 7 districts were above the median and 4 below. In Sicily, 10 districts were above and 14 were below.

column 6) and the event study patterns are no longer as neat as with the Ellis Island data (panels b and d of Figure 7).⁶⁸ Online Appendix Figure G.3, however, presents results defining severe damage at a Mercalli cutoff of VII with neater event study results for the official statistics.

Was this heterogeneity indeed linked to the composition of the agricultural labor force, or merely to its size relative to that of other sectors? In column (3) of Table 5, we estimate equation (3) with the standardized share of a district’s male labor force employed in agriculture in 1901 as x_i . In column (3), the coefficient is positive, but it is also smaller and its statistical significance weaker. Column (4) allows for heterogeneous earthquake responses by both characteristics, effectively “horse-racing” the two. In column (4), the coefficient on the interaction with general agricultural labor is reduced to zero, while the coefficient on the interaction with the share in agricultural day labor is only slightly reduced and remains statistically significant. Again, performing the same exercise with the official statistics (columns 7 and 8) gives less conclusive results, with estimates that point in the same direction, but which are weaker and statistically insignificant in the horse-race specification.

On the whole, we conclude that the results of Table 5 and Figure 7 indicate that the lack of an average effect of the earthquake masks a more complex heterogeneous response in which individuals from municipalities with the least attached peasants experienced higher rates of emigration after the earthquake, while other municipalities experienced a decline. This result suggests that the response to the earthquake consisted of the least attached peasants reacting by migrating overseas, whereas the rest remained.

5.4 Liquidity, greater exigencies, and labor demand shocks

Another potential explanation for the lack of a discernible aggregate positive impact of the earthquake on migration is that the devastation from the disaster led to a tightening of liquidity constraints that offset any strengthening of push factors arising from the earthquake. Such a mechanism is not easily reconcilable with our finding above that a greater share of agricultural day laborers, who were likely most sensitive to tightening liquidity constraints, was associated with the most positive reactions to this shock. But it is possible to test such a mechanism directly using our data on financial institutions, mutual aid societies, pre-existing migrant networks, and district-level employment in credit. As described above, some of these indicators are highly local. We do this by estimating versions of equation (3) in which the normalized interaction characteristic x_i is one of these measures, presenting our results for the interaction coefficient π in Table 6. In general, these results do not support the notion that liquidity constraints were important in

⁶⁸Results for alternative dependent variables are presented in Online Appendix Figure B.5.

determining migration responses. Measures of financial development in rows a–g of this table are, as a rule, not statistically significantly associated with earthquake responses, and the estimated coefficients are nearly all negative—the opposite of what we would expect from a liquidity constraints mechanism.

We also focus on two measures of social capital that would provide access to more informal support for migration. These are the prevalence of mutual aid societies and the size of the local migration network,⁶⁹ which is both a migration-specific measure of local social capital and a potential source of liquidity in the form of remittances and paid tickets. Indeed, there is evidence that the pre-existing migration network was likely the main determinant of whether the option of migration was available to an individual (e.g., Spitzer 2021; Spitzer and Zimran 2023). If increasingly binding liquidity constraints were responsible for limiting a migration response, we would expect a more positive reaction to the earthquake where mutual aid societies and migrant networks were more prevalent. Some of the results in rows h–j of Table 6 are not inconsistent with this view, but overall they are weak and mixed. The coefficients on the interaction with membership in mutual benefit associations in row h are positive when using the Ellis Island data, large in comparison to the results of Table 4, and statistically significant according to the randomization inference. But, they are negative and significant when using the official emigration statistics, and in row i, the coefficient on the alternative measure, these associations’ per capita assets, is negative and insignificant in all specifications. The interaction coefficients of the size of the migrant network in row j hover around zero and are statistically insignificant.⁷⁰ We conclude that overall, there is no consistent evidence that municipalities that had better access to credit and social capital were more likely to react to the earthquake by overseas migration, and therefore that liquidity constraints are unlikely to have been the cause for the non-positive average effect of the earthquake.

Another potential explanation for a lack of a response is a rise in reconstruction labor demand that provided an increasingly lucrative alternative to overseas migration. This explanation is inconsistent with the absence of a large population inflow from the hinterland to the heavily damaged cities (Table 1) and with the lengthy delays in reconstruction after the earthquake.⁷¹ It is also somewhat inconsistent with our findings of more positive responsiveness of areas with more agricultural day laborers, who were likely the first candidates to switch to unskilled construction jobs. Although we lack detailed data on internal migration and

⁶⁹We define this as the ratio of the cumulative flow from the municipality over the years prior to 1908 according to each source of emigration data to the 1901 population of a municipality.

⁷⁰This finding is not inconsistent with Mahajan and Yang’s (2020) finding of a positive 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.

⁷¹Indeed, the refugees returning to these cities, especially Messina, were likely out of work and could have absorbed a considerable portion of the new demand for reconstruction labor.

wages, we can test this argument by looking for a heterogeneous earthquake response according to the share of employment in construction in 1901. Notwithstanding the potential shift of labor into construction after the shock, a lesser migration response by areas with a greater construction share would be consistent with a reconstruction mechanism. We estimate equation (3) with a district’s standardized share of construction labor as the interaction characteristic x_i , presenting our results in columns (1) and (2) of Table 7.⁷² In column (1), the interaction coefficient is negative, consistent with the hypothesized mechanism, but the coefficient is small (approximately -0.1) and approaches statistical significance only using the official emigration data (Panel B). Moreover, this negative estimate could simply be the product of a negative correlation between employment in construction and in agriculture. In column (2), we “horse race” the two interaction terms, finding that our agricultural day labor result is qualitatively robust whereas the construction labor interaction becomes zero or slightly positive and statistically insignificant, inconsistent with the suspected mechanism of construction labor absorbing would-be migrants.⁷³

Bettin and Zazzaro (2018), David (2011), Mohapatra et al. (2009), Paul (2005), and Yang (2008a) attribute a non-positive migration response to remittances and other financial inflows to the affected area. We have not been able to locate municipality-level data on remittances that would enable us to test this mechanism, though our results for heterogeneity by the size of the migrant network do point against it.⁷⁴ Moreover, it appears that governmental financial aid to the affected area, though initially present, was limited.⁷⁵ Instead, the primary channel through which government aid flowed into the area was reconstruction spending (Farinella and Saitta 2019), which as we argued above, was unlikely to shape migration responses.

Finally, returning to the role of tenancy status, were unattached workers more positively reactive because they were not fettered by contractual obligations, or because they were not affected by the greater exigencies faced by workers who had stakes in the capital with which they were working? To tackle this question, columns (3)–(6) of Table 7 estimate equation (3) and analogs of it with the following characteristics interacted with a severe earthquake shock: the share of building owners, the share of land owners, both shares together, and both shares alongside the share of agricultural day laborers.⁷⁶ The greater exigencies theory suggests that owners of buildings, which were the main capital damaged by the earthquake, would be incentivized to

⁷²Results for other dependent variables are provided in Online Appendix Table B.8.

⁷³As in Table 5, in the official emigration data the coefficient on the share of agricultural laborers is positive yet smaller and not statistically significant. The important point here is that the interaction with construction workers is neither large nor statistically significant.

⁷⁴Suggestive analysis based on province-level remittance data, reported in Online Appendix Figure B.6 show no evidence of a dramatic divergence between the severely affected provinces and the rest of Sicily and Calabria.

⁷⁵For instance, only 866 of 30,000 businesses that applied were granted subsidies in the first 4 months after the earthquake (Di Paola and Savasta 2005), and the head of the relief committee forbade allocating funds to individuals (Bosworth 1981).

⁷⁶Results for other dependent variables are provided in Online Appendix Table B.9.

dedicate their own labor to rebuilding or repairing their own property, and thus a greater share of building owners would be associated with a lesser migration response to the shock. Land, on the other hand, was less likely to be damaged and in need of repair. Thus, although both variables measure the prevalence of household wealth, the greater exigencies explanation predicts that the interaction coefficient with ownership of buildings would be more negative than that of ownership of land. In fact, the results of Table 7 appear to show the opposite. When included as the sole interaction characteristic, ownership of either type has a strongly positive and often statistically significant coefficient (columns 3 and 4). But these results can potentially confound the two different types of property. When both measures are included together in column (5), the coefficient on building ownership is made more positive and approaches statistical significance more closely, whereas the coefficient for land ownership is negative. Even when the share of agricultural day laborers is added as an additional interaction variable in column (6), the interaction coefficients of buildings remains highly positive in the Ellis Island specifications and zero in the official statistics, while that for land ownership remains negative in the Ellis Island specifications.⁷⁷

In sum, assessing to the best of our ability the common explanations for limited migration responses to disasters, the most consistent finding that helps explain variation in this reaction is that attachment to the land hindered a short-term reaction. This does not appear to be attributable to the possibility that the earthquake created greater exigencies for the owners of real property in the form of buildings. Instead, our evidence is consistent with contracts, tenancy relations, and ownership of land limiting an emigration response in the short-run, whereas day laborers, unfettered by these obligations, could react quickly to the shock.

5.5 Summary of robustness checks

Online Appendix D tests the sensitivity of the results to dropping the main cities of Messina and Reggio Calabria from our analysis to exclude their potentially unique conditions and large death tolls, tests the sensitivity to sequentially dropping municipalities in order of the share of deaths to further ensure that potentially inaccurate death counts or the unique experiences of municipalities with high earthquake mortality do not drive our results, and tests the sensitivity of the results to re-assigning internal migrants in the main cities to other municipalities to address potential internal migration. Online Appendix I tests robustness to including the interaction of time with various controls. Online Appendix J addresses potential spillovers of

⁷⁷The positive coefficient for the interaction coefficient for buildings also points away from the possibility that the destruction of physical capital might have exacerbated liquidity constraints by reducing the extent to which individuals could sell property to finance passage.

treatment from severely damaged to non-severely damaged municipalities, in part by changing the unit of analysis from the municipality to the district.⁷⁸ In all cases, our main results are robust to these checks. In Online Appendix Table B.10, we assess the robustness of our findings regarding heterogeneous responses to the earthquake shock by “horse racing” the interaction of severe \times post with the agricultural labor share against analogous interactions with various characteristics studied above, such as the various measures of liquidity. Online Appendix Table B.11 tests for heterogeneous responses to the earthquake on a variety of additional municipality characteristics not discussed above and “horse races” them with the agricultural labor share. In all cases, the interaction of the agricultural labor share remains largely unchanged.⁷⁹

6 Conclusion

How was emigration affected by major destructive shocks experienced by the populations of prospective migrants during the Age of Mass Migration? This paper answers this question in the context of the most devastating earthquake to strike modern Europe, and one of the most destructive natural disasters 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. Our answer is that, on average, there was no large positive response of migration, and indeed that there is no clear evidence of any aggregate effect, though our point estimates do indicate a short-lived and mild negative average effect. However, this does not mean that the earthquake had no effect at all on emigration. Instead, we find that a greater share of agricultural day laborers was associated with increased migration, which we interpret as evidence that attachment to the land acted as a barrier to responding to shocks through migration. Explanations that have been cited for non-positive migration responses in other contexts, such as tightening liquidity constraints or labor demand generated by reconstruction efforts, do not seem to have played a role in this case.

As a changing climate has increased the likelihood of natural disasters (Intergovernmental Panel on

⁷⁸Our results based on distance to the earthquake epicenter also speak to the possible role of spillovers. The district-level analysis also enables us to capture the combined impact of severe damage and the economic shock: it is more likely that the magnitude of the economic shock varied across districts than within them. That the results of this analysis are similar to those of Table 4 is thus reassuring.

⁷⁹Among these is an analysis that permits heterogeneous responses on the basis of the share of land devoted to the cultivation of tree crops in general or of citrus in particular—data that are only available for Sicily. Given the importance of citrus exports to the local economy and the impacts of the earthquake on citrus exports (Mortara 1913a,b), this analysis enables us to ensure that the heterogeneity that we document according to agricultural labor shares is not simply the product of the economic fallout from trade disruption or of damage to agricultural infrastructure. It also speaks to the role of these channels themselves in shaping the migration response based on the logic that places specialized in these crops would be expected to respond differently than places not specialized in these crops to damage from the earthquake if they were affected by either damage to infrastructure or to the disruption of trade. We find no evidence of a heterogeneous response by the share in tree crops, and the results for the citrus share are too unstable across specifications to be given a strong interpretation. In neither case is there a substantial impact on the interaction of the severe damage indicator with the agricultural labor share.

Climate Change 2012), particularly in the developing world, concern has grown over the degree to which individuals will be displaced in the aftermath of such events (World Bank 2018). It remains an open question whether and under what circumstances individuals in the affected region can find relief through migration, and specifically, whether such shocks will lead to an influx of refugees to developed countries. The case that we study demonstrates that even when borders are open and the magnitude of the disaster is enormous, the reaction can be a complex outcome of both positive and negative effects that aggregate to a seemingly unremarkable total. Altogether, the effects of such events are far more nuanced than simple intuition would suggest.

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Tables

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

<i>Birthplace</i>	Messina		Reggio Calabria	
	1901	1911	1901	1911
Same municipality	127,017 (0.848)	106,025 (0.838)	37,175 (0.837)	32,530 (0.754)
Other municipality in same province	9,888 (0.066)	7,838 (0.062)	3,927 (0.088)	4,872 (0.113)
Elsewhere in Sicily	4,244 (0.028)	6,167 (0.049)	824 (0.019)	1,826 (0.042)
Elsewhere in Calabria	3,833 (0.026)	2,386 (0.019)	668 (0.015)	755 (0.017)
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. Fractions of total population in parentheses.

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 for earthquake exposure and emigration

<i>Variable</i>	Sicily and Calabria		Calabria		Sicily		Italy
	Severe (1)	Not (2)	Severe (3)	Not (4)	Severe (5)	Not (6)	All (7)
<i>Earthquake exposure</i>							
Distance to epicenter (km)	39.148 ^a (20.557)	138.634 (57.250)	39.484 ^a (21.917)	128.431 (46.338)	38.209 ^a (16.474)	148.335 (64.566)	701.232 (312.131)
Mercalli intensity	8.364 ^a (0.704)	5.868 (1.185)	8.395 ^a (0.732)	6.198 (0.747)	8.276 ^a (0.621)	5.554 (1.417)	1.248 (2.209)
Deaths per thousand	17.473 ^b (57.465)	0.012 (0.124)	18.087 ^c (45.970)	0.014 (0.122)	15.759 (82.543)	0.011 (0.127)	0.277 (7.509)
<i>Emigrants per thousand</i>							
Ellis Island, 1905–1908	13.177 (16.242)	14.035 (14.625)	11.816 (16.278)	13.282 (12.585)	16.978 (15.588)	14.756 (16.312)	5.893 (11.001)
Ellis Island, 1909–1912	11.665 (12.871)	13.378 (11.732)	9.925 (12.392)	12.663 (10.931)	16.526 (12.989)	14.062 (12.416)	5.338 (8.828)
Ellis Island, prime, 1905–1908	9.717 (11.776)	8.504 (8.923)	9.212 (12.250)	8.702 (8.674)	11.124 (10.260)	8.314 (9.154)	3.762 (7.098)
Ellis Island, prime, 1909–1912	7.997 (8.347)	7.698 (7.064)	7.249 (8.452)	8.242 (7.384)	10.086 (7.705)	7.178 (6.705)	3.268 (5.599)
Official, 1905–1908	34.146 (19.560)	36.296 (21.662)	35.196 (19.579)	38.948 (19.194)	31.030 (19.242)	33.710 (23.545)	27.614 (26.933)
Official, 1909–1912	31.899 (18.184)	34.195 (19.185)	30.740 ^b (17.328)	37.742 (17.778)	35.340 (20.200)	30.735 (19.871)	26.343 (26.674)
<i>Migrant Characteristics, 1905–1908</i>							
Age	26.572 ^c (3.989)	25.262 (3.806)	27.227 ^a (4.280)	25.735 (3.965)	24.969 (2.549)	24.818 (3.596)	25.667 (5.541)
Male	0.873 ^a (0.136)	0.773 (0.172)	0.896 ^a (0.135)	0.808 (0.172)	0.818 ^b (0.122)	0.741 (0.167)	0.797 (0.228)
Prime-aged male	0.750 ^a (0.183)	0.635 (0.215)	0.786 ^a (0.173)	0.674 (0.211)	0.664 ^c (0.179)	0.599 (0.213)	0.677 (0.277)
Child	0.117 ^a (0.109)	0.181 (0.139)	0.100 ^a (0.106)	0.156 (0.133)	0.158 ^c (0.103)	0.205 (0.141)	0.140 (0.170)
Observations	879	5,056	647	2,472	232	2,584	55,743
Municipalities	110	632	81	309	29	323	6,971

Notes: Standard deviations in parentheses. Observations are at the municipality-year level. Mercalli measures are imputed where missing. Observation numbers are the minimum with observations for migration, distance from earthquake epicenter, deaths, and population in the Ellis Island-based dataset. Municipality numbers are the number of distinct municipalities among these observations. Emigration rates are expressed per thousand population for clarity, but we use the (logarithm of the) decimal rate (i.e., migrants per capita) for analysis. Prime-aged defined as ages 18–65.

Significance levels, district-clustered b.s.: Columns (1), (3), and (5) indicate whether the differences between the severe and non-severe groups are statistically significant based on the district-clustered bootstrap. Notation is ^a $p < 0.01$, ^b $p < 0.05$, ^c $p < 0.1$. For instance, an ^a in column (1) indicates that the value in column (1) is statistically significantly different from the value in column (2) at the 1-percent level.

Table 3: Summary statistics for municipality and district characteristics

<i>Variable</i>	Sicily and Calabria		Calabria		Sicily		Italy
	Severe (1)	Not (2)	Severe (3)	Not (4)	Severe (5)	Not (6)	All (7)
<i>Municipality characteristics</i>							
Population (1901, 1,000)	5.861 (15.954)	6.684 (15.171)	4.545 (8.543)	3.219 (3.169)	0.158 (27.627)	9.979 (20.441)	4.460 (15.275)
Distance to emigration epicenter (km)	210.730 ^a (25.821)	126.660 (60.018)	223.090 ^b (15.647)	157.615 (47.628)	176.205 ^b (14.815)	97.224 (55.661)	152.175 (93.997)
<i>District characteristics (1901)</i>							
Agricultural day laborer share	0.303 (0.055)	0.308 (0.078)	0.315 (0.037)	0.320 (0.075)	0.267 (0.078)	0.297 (0.079)	0.166 (0.098)
Agricultural employment share	0.622 (0.115)	0.645 (0.109)	0.653 (0.082)	0.698 (0.045)	0.535 (0.145)	0.595 (0.127)	0.625 (0.140)
Finance employment share	0.006 (0.004)	0.006 (0.004)	0.004 (0.002)	0.003 (0.001)	0.010 (0.005)	0.008 (0.004)	0.007 (0.005)
Construction employment share	0.055 (0.040)	0.038 (0.016)	0.044 (0.035)	0.029 (0.007)	0.086 (0.037)	0.047 (0.018)	0.052 (0.043)
Building owners per cap.	0.183 (0.041)	0.196 (0.055)	0.180 (0.027)	0.184 (0.038)	0.191 (0.067)	0.208 (0.064)	0.198 (0.089)
Land owners per cap.	0.157 (0.048)	0.174 (0.056)	0.149 (0.034)	0.163 (0.042)	0.180 (0.070)	0.184 (0.065)	0.216 (0.114)
<i>Municipality financial development</i>							
Bank credit (l./cap., 1905)	5.955 (31.940)	4.659 (35.392)	7.853 (37.037)	4.501 (46.639)	0.654 ^c (3.525)	4.810 (19.338)	0.516 (11.472)
Bank credit (l./cap., 1905, 25km)	0.463 (0.328)	0.680 (0.912)	0.543 (0.332)	0.886 (1.104)	0.241 (0.182)	0.485 (0.624)	
Bank assets (l./cap., 1905)	4.347 (23.732)	4.646 (44.082)	5.561 (27.430)	5.142 (60.432)	0.957 ^c (5.151)	4.172 (17.725)	0.490 (13.665)
Bank assets (l./cap., 1905, 25km)	0.380 (0.284)	0.785 (1.203)	0.406 (0.299)	1.035 (1.419)	0.305 (0.223)	0.547 (0.893)	
Postal credit (l./cap., 1887)	1.698 ^a (3.276)	3.233 (5.267)	1.221 (2.762)	2.163 (4.496)	3.029 (4.183)	4.256 (5.735)	
Postal credit (l./cap., 1887, 25km)	0.135 (0.092)	0.140 (0.079)	0.106 (0.077)	0.108 (0.051)	0.216 (0.081)	0.171 (0.087)	
Mutual aid membership per cap. (1904)	0.004 ^b (0.011)	0.009 (0.019)	0.005 (0.012)	0.006 (0.017)	0.003 (0.007)	0.011 (0.021)	
Mutual aid assets (l./cap., 1904)	0.137 (0.397)	0.149 (0.538)	0.175 (0.453)	0.134 (0.563)	0.032 (0.119)	0.163 (0.515)	
Observations	110	632	81	309	29	323	6,968

Notes: Standard deviations in parentheses. Observations are at the municipality level. Observation numbers are the minimum with observations for all variables in the Ellis Island-based dataset. Financial measures are expressed in levels for clarity but we use logs for analysis, adding one to each measure before dividing by population to address zeroes. The abbreviation l./cap. in the municipality financial development measures denotes lire per capita.

Significance levels, district-clustered b.s.: Columns (1), (3), and (5) indicate whether the differences between the severe and non-severe groups are statistically significant based on the district-clustered bootstrap. Notation is ^a p<0.01, ^b p<0.05, ^c p<0.1. For instance, an ^a in column (1) indicates that the value in column (1) is statistically significantly different from the value in column (2) at the 1-percent level.

Table 4: Difference-in-differences results

	Ellis Island				Official Data	
	(1)	(2)	Prime-Age Only		(5)	(6)
			(3)	(4)		
	All	Deaths	All	Deaths	All	Deaths
<i>Panel A: Sicily and Calabria</i>	-0.071	-0.054	-0.086	-0.070	-0.085	-0.053
District-Clustered b.s. p	(0.577)	(0.597)	(0.548)	(0.551)	(0.456)	(0.665)
Randomization Inference tail mass	{0.266}	{0.314}	{0.228}	{0.278}	{0.224}	{0.310}
District-Clustered b.s. 95% CI	[-0.446 0.393]	[-0.416 0.394]	[-0.463 0.382]	[-0.415 0.370]	[-0.305 0.129]	[-0.292 0.125]
Observations	5,604	5,604	5,543	5,543	6,109	6,109
R-squared	0.751	0.751	0.741	0.741	0.618	0.617
Districts	35	35	35	35	35	35
<i>Panel B: Italy</i>	-0.057	-0.040	-0.076	-0.060	-0.068	-0.037
District-Clustered p	(0.662)	(0.746)	(0.553)	(0.627)	(0.393)	(0.645)
Randomization Inference tail mass	{0.212}	{0.274}	{0.120}	{0.166}	{0.200}	{0.320}
District-Clustered 95% CI	[-0.311 0.198]	[-0.285 0.204]	[-0.326 0.175]	[-0.300 0.181]	[-0.223 0.088]	[-0.194 0.121]
Observations	39,525	39,525	37,333	37,333	61,160	61,160
R-squared	0.799	0.799	0.795	0.795	0.788	0.788
Districts	284	284	284	284	284	284
<i>Panel C: Sicily</i>	-0.123	-0.105	-0.124	-0.106	-0.069	-0.037
District-Clustered b.s. p	(0.567)	(0.589)	(0.616)	(0.630)	(0.651)	(0.805)
Randomization Inference tail mass	{0.158}	{0.188}	{0.152}	{0.180}	{0.282}	{0.352}
District-Clustered b.s. 95% CI	[-0.854 0.562]	[-0.811 0.555]	[-0.712 0.544]	[-0.680 0.549]	[-0.548 0.230]	[-0.491 0.227]
Observations	2,708	2,708	2,678	2,678	2,815	2,815
R-squared	0.767	0.767	0.752	0.752	0.672	0.672
Districts	24	24	24	24	24	24
<i>Panel D: Calabria</i>	-0.035	-0.022	-0.065	-0.052	-0.145	-0.117
District-Clustered b.s. p	(0.690)	(0.814)	(0.452)	(0.612)	(0.499)	(0.707)
Randomization Inference tail mass	{0.252}	{0.296}	{0.190}	{0.224}	{0.068}	{0.106}
District-Clustered b.s. 95% CI	[-0.203 0.136]	[-0.182 0.149]	[-0.231 0.120]	[-0.212 0.120]	[-0.655 0.687]	[-0.643 0.702]
Observations	2,896	2,896	2,865	2,865	3,294	3,294
R-squared	0.733	0.733	0.728	0.728	0.516	0.512
Districts	11	11	11	11	11	11

Significance levels, district-clustered b.s.: ^a p<0.01, ^b p<0.05, ^c p<0.1

Notes: This table presents difference-in-differences coefficients for severe-times-post. P-values from a wild bootstrap clustering at the district level are in parentheses. Tail mass values from a randomization inference test are in curly braces. Ninety-five percent confidence intervals from the wild bootstrap clustered at the district level are in square braces. In panel B, the district-clustered p-values and confidence intervals are based on large-sample approximations, not the bootstrap. Columns (1), (3), and (5) use unadjusted base populations to compute migration rates; columns (2), (4), and (6) use populations adjusted for earthquake deaths. All regressions include municipality fixed effects, province-year indicators, and distance from the nearest emigration epicenter-times-post. Observations limited to 1905–1912.

Table 5: Heterogeneous responses with respect to agricultural day labor

Variables	Ellis Island				Official			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Severe x Post	-0.071	0.003	-0.001	0.007	-0.085	-0.041	-0.100	-0.079
District-Clustered b.s. p	(0.569)	(0.977)	(0.996)	(0.959)	(0.430)	(0.443)	(0.400)	(0.294)
Randomization Inference tail mass	{0.266}	{0.488}	{0.436}	{0.436}	{0.224}	{0.392}	{0.294}	{0.262}
District-Clustered b.s. 95% CI	[-0.452 0.393]	[-0.184 0.311]	[-0.161 0.328]	[-0.221 0.305]	[-0.307 0.127]	[-0.188 0.074]	[-0.323 0.124]	[-0.194 0.095]
Severe x Post x Ag Lab Share		0.351 ^a		0.339 ^b		0.143 ^a		0.155
District-Clustered b.s. p		(0.004)		(0.045)		(0.007)		(0.574)
Randomization Inference tail mass		{0.004}		{0.012}		{0.102}		{0.156}
District-Clustered b.s. 95% CI		[0.095 0.599]		[0.014 0.831]		[0.042 0.381]		[-0.265 0.555]
Severe x Post x Ag Share			0.195	0.002			0.154 ^c	0.064
District-Clustered b.s. p			(0.144)	(0.985)			(0.053)	(0.642)
Randomization Inference tail mass			{0.108}	{0.338}			{0.138}	{0.178}
District-Clustered b.s. 95% CI			[-0.030 0.464]	[-0.331 0.392]			[-0.003 0.282]	[-0.432 0.308]
Observations	5,604	5,604	5,604	5,604	6,109	6,109	6,109	6,109
R-squared	0.751	0.752	0.752	0.752	0.618	0.619	0.621	0.623
Districts	35	35	35	35	35	35	35	35

Significance levels, district-clustered b.s.: ^a p<0.01, ^b p<0.05, ^c p<0.1

Notes: Sample includes all municipalities 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. P-values from a wild bootstrap clustering at the district level are in parentheses. Tail mass values from a randomization inference test are in curly braces. Ninety-five percent confidence intervals from the wild bootstrap clustered at the district level are in square braces. 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 municipality fixed effects, province-year indicators, and distance from the nearest emigration epicenter-times-post. Observations limited to 1905–1912.

Table 6: Heterogeneous responses with respect to liquidity

	Ellis Island				Official Data	
			Prime-Age Only		(5) All	(6) Deaths
	(1) All	(2) Deaths	(3) All	(4) Deaths		
a. Severe x Post x District Credit Employment Share	-0.182	-0.168	-0.181	-0.167	-0.138 ^c	-0.110 ^c
District-Clustered b.s. p	(0.166)	(0.225)	(0.220)	(0.243)	(0.068)	(0.097)
Randomization Inference tail mass	{0.034}	{0.044}	{0.046}	{0.052}	{0.112}	{0.126}
District-Clustered b.s. 95% CI	[-0.472 0.049]	[-0.395 0.064]	[-0.418 0.054]	[-0.448 0.064]	[-0.377 0.018]	[-0.329 0.034]
b. Severe x Post x Credit per capita	-0.111 ^b	-0.089	-0.111 ^b	-0.089	-0.072 ^b	-0.057
District-Clustered b.s. p	(0.014)	(0.154)	(0.045)	(0.268)	(0.036)	(0.160)
Randomization Inference tail mass	{0.050}	{0.084}	{0.056}	{0.106}	{0.034}	{0.076}
District-Clustered b.s. 95% CI	[-0.199 -0.045]	[-0.162 0.068]	[-0.190 -0.006]	[-0.188 0.093]	[-0.124 -0.021]	[-0.091 0.045]
c. Severe x Post x Credit per capita (25km)	-0.273	-0.262	-0.234	-0.223	-0.135	-0.115
District-Clustered b.s. p	(0.468)	(0.480)	(0.474)	(0.531)	(0.766)	(0.896)
Randomization Inference tail mass	{0.004}	{0.006}	{0.022}	{0.024}	{0.012}	{0.016}
District-Clustered b.s. 95% CI	[-1.408 0.640]	[-1.293 0.590]	[-1.160 0.545]	[-1.088 0.540]	[-0.636 0.676]	[-0.888 0.757]
d. Severe x Post x Assets per capita	-0.108 ^b	-0.085	-0.105 ^c	-0.082	-0.072 ^b	-0.057
District-Clustered b.s. p	(0.014)	(0.169)	(0.066)	(0.309)	(0.036)	(0.161)
Randomization Inference tail mass	{0.052}	{0.092}	{0.062}	{0.116}	{0.028}	{0.070}
District-Clustered b.s. 95% CI	[-0.194 -0.040]	[-0.161 0.065]	[-0.185 0.007]	[-0.182 0.088]	[-0.126 -0.021]	[-0.091 0.043]
e. Severe x Post x Assets per capita (25km)	-0.291	-0.278	-0.253	-0.240	-0.138	-0.114
District-Clustered b.s. p	(0.442)	(0.449)	(0.412)	(0.455)	(0.631)	(0.852)
Randomization Inference tail mass	{0.002}	{0.004}	{0.018}	{0.020}	{0.008}	{0.016}
District-Clustered b.s. 95% CI	[-1.253 0.749]	[-1.169 0.651]	[-1.058 0.594]	[-1.020 0.610]	[-0.443 0.599]	[-0.749 0.766]
f. Severe x Post x Postal Credit per capita	-0.028	-0.015	-0.048	-0.034	0.005	0.010
District-Clustered b.s. p	(0.587)	(0.759)	(0.392)	(0.571)	(0.927)	(0.816)
Randomization Inference tail mass	{0.414}	{0.480}	{0.310}	{0.368}	{0.388}	{0.364}
District-Clustered b.s. 95% CI	[-0.128 0.085]	[-0.121 0.095]	[-0.168 0.056]	[-0.162 0.083]	[-0.077 0.154]	[-0.073 0.150]
g. Severe x Post x Postal Credit per capita (25km)	-0.094	-0.077	-0.077	-0.060	-0.048	-0.015
District-Clustered b.s. p	(0.438)	(0.516)	(0.492)	(0.611)	(0.230)	(0.648)
Randomization Inference tail mass	{0.410}	{0.444}	{0.466}	{0.488}	{0.384}	{0.436}
District-Clustered b.s. 95% CI	[-0.476 0.347]	[-0.438 0.254]	[-0.456 0.364]	[-0.412 0.257]	[-0.103 0.068]	[-0.084 0.132]
h. Severe x Post x MA Members per capita	0.139	0.152	0.130	0.144	-0.082	-0.073
District-Clustered b.s. p	(0.121)	(0.136)	(0.201)	(0.198)	(0.118)	(0.124)
Randomization Inference tail mass	{0.022}	{0.014}	{0.012}	{0.010}	{0.026}	{0.046}
District-Clustered b.s. 95% CI	[-0.044 0.439]	[-0.044 0.445]	[-0.066 0.458]	[-0.077 0.564]	[-0.254 0.110]	[-0.234 0.126]
i. Severe x Post x MA Assets per capita	-0.028	-0.007	-0.024	-0.003	-0.055	-0.039
District-Clustered b.s. p	(0.573)	(0.914)	(0.759)	(0.960)	(0.169)	(0.246)
Randomization Inference tail mass	{0.334}	{0.474}	{0.382}	{0.482}	{0.056}	{0.116}
District-Clustered b.s. 95% CI	[-0.129 0.113]	[-0.129 0.176]	[-0.176 0.156]	[-0.169 0.257]	[-0.117 0.075]	[-0.094 0.106]
j. Severe x Post x Network	0.059	0.061	0.017	0.019	-0.009	-0.014
District-Clustered b.s. p	(0.753)	(0.737)	(0.817)	(0.811)	(0.880)	(0.858)
Randomization Inference tail mass	{0.346}	{0.340}	{0.356}	{0.356}	{0.486}	{0.498}
District-Clustered b.s. 95% CI	[-0.209 0.217]	[-0.205 0.210]	[-0.265 0.172]	[-0.286 0.176]	[-0.156 0.137]	[-0.184 0.102]

Significance levels, district-clustered b.s.: ^a p<0.01, ^b p<0.05, ^c p<0.1

This table presents the coefficient on the interaction listed in each row from estimating equation (3) with the listed dimension of heterogeneity as x_i , standardizing it to have mean zero and standard deviation one. Sample includes all municipalities in Sicily and Calabria. P-values from a wild bootstrap clustered at the district level in parentheses. Tail mass values from the randomization inference test are in curly braces. Ninety-five percent confidence intervals from the wild bootstrap clustered at the district level are in square braces. All regressions include municipality fixed effects, province-year indicators, and distance from the nearest emigration epicenter-times-post. Observations limited to 1905–1912.

Table 7: Additional difference-in-differences results with share of district employment in construction, district property owners per capita, and share of district employment in agricultural day labor

	(1)	(2)	(3)	(4)	(5)	(6)
<i>Panel A: Ellis Island</i>						
Severe x Post	0.018	0.010	-0.031	-0.042	-0.027	-0.005
District-Clustered b.s. p	(0.957)	(0.933)	(0.528)	(0.612)	(0.615)	(0.936)
Randomization Inference tail mass	{0.428}	{0.444}	{0.366}	{0.310}	{0.396}	{0.448}
District-Clustered b.s. 95% CI	[-0.196 0.460]	[-0.233 0.295]	[-0.155 0.106]	[-0.264 0.151]	[-0.150 0.088]	[-0.156 0.141]
Severe x Post x Ag Lab Share		0.360 ^b				0.184 ^b
District-Clustered b.s. p		(0.026)				(0.038)
Randomization Inference tail mass		{0.008}				{0.084}
District-Clustered b.s. 95% CI		[0.063 0.922]				[0.034 0.330]
Severe x Post x Constr Share	-0.068	0.041				
District-Clustered b.s. p	(0.276)	(0.583)				
Randomization Inference tail mass	{0.186}	{0.378}				
District-Clustered b.s. 95% CI	[-0.165 0.111]	[-0.151 0.265]				
Severe x Post x Building Owners per capita			0.336		0.748	0.506
District-Clustered b.s. p			(0.138)		(0.228)	(0.144)
Randomization Inference tail mass			{0.002}		{0.016}	{0.064}
District-Clustered b.s. 95% CI			[-0.051 0.666]		[-0.994 2.287]	[-0.383 2.161]
Severe x Post x Land Owners per capita				0.252	-0.410	-0.281
District-Clustered b.s. p				(0.250)	(0.294)	(0.227)
Randomization Inference tail mass				{0.008}	{0.058}	{0.152}
District-Clustered b.s. 95% CI				[-0.107 0.616]	[-1.322 0.570]	[-1.585 0.564]
Observations	5,604	5,604	5,604	5,604	5,604	5,604
R-squared	0.751	0.752	0.752	0.752	0.752	0.753
Districts	35	35	35	35	35	35
<i>Panel B: Official Data</i>						
Severe x Post	-0.082	-0.069	-0.080	-0.084	-0.074	-0.048
District-Clustered b.s. p	(0.643)	(0.555)	(0.415)	(0.299)	(0.537)	(0.304)
Randomization Inference tail mass	{0.250}	{0.246}	{0.106}	{0.104}	{0.136}	{0.218}
District-Clustered b.s. 95% CI	[-0.393 0.237]	[-0.286 0.369]	[-0.276 0.083]	[-0.247 0.073]	[-0.257 0.094]	[-0.177 0.068]
Severe x Post x Ag Lab Share		0.148				0.119
District-Clustered b.s. p		(0.444)				(0.391)
Randomization Inference tail mass		{0.138}				{0.106}
District-Clustered b.s. 95% CI		[-0.269 0.434]				[-0.094 0.367]
Severe x Post x Constr Share	-0.129 ^c	-0.089				
District-Clustered b.s. p	(0.079)	(0.400)				
Randomization Inference tail mass	{0.030}	{0.058}				
District-Clustered b.s. 95% CI	[-0.509 0.311]	[-0.478 0.121]				
Severe x Post x Building Owners per capita			0.196 ^b		0.220	0.044
District-Clustered b.s. p			(0.017)		(0.612)	(0.880)
Randomization Inference tail mass			{0.146}		{0.154}	{0.352}
District-Clustered b.s. 95% CI			[0.074 0.331]		[-0.951 0.600]	[-1.223 1.298]
Severe x Post x Land Owners per capita				0.177 ^b	-0.028	0.067
District-Clustered b.s. p				(0.044)	(0.918)	(0.804)
Randomization Inference tail mass				{0.162}	{0.442}	{0.356}
District-Clustered b.s. 95% CI				[0.008 0.321]	[-0.378 0.884]	[-1.101 0.920]
Observations	6,109	6,109	6,109	6,109	6,109	6,109
R-squared	0.620	0.621	0.621	0.621	0.621	0.622
Districts	35	35	35	35	35	35

Significance levels, district-clustered b.s.: ^a p<0.01, ^b p<0.05, ^c p<0.1

Notes: Sample includes all municipalities in the regions of Sicily and Calabria. The construction labor share, agricultural labor share, building owners share, and land owners share are all at the district level and are both standardized to have mean zero and standard deviation one. P-values from a wild bootstrap clustered at the district level in parentheses. Tail mass values from the randomization inference test are in curly braces. Ninety-five percent confidence intervals from the wild bootstrap clustered at the district level are in square braces. All regressions include municipality fixed effects, province-year indicators, and distance from the nearest emigration epicenter-times-post. Observations limited to 1905–1912. Panel A of this table uses Ellis Island-based migration rates unadjusted for deaths as the outcome. Panel B of this table uses Official Data-based migration rates unadjusted for deaths as the outcome.

Figures

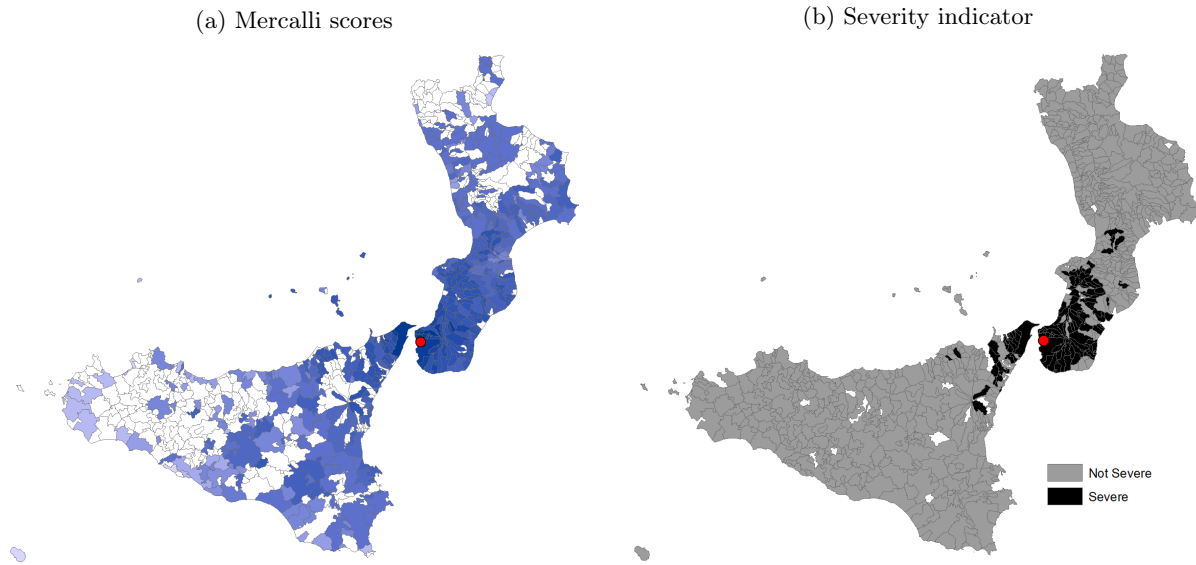


Figure 1: Earthquake damage

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 municipalities have no data. Panel (b) presents the severity indicator, which takes a value of one for municipalities with Mercalli severity of VIII or greater. White municipalities in panel (b) are those that were created in the 1920s or later. In some cases, there are migrants assigned to these municipalities (based on geographic location), but they are reassigned to the original municipality, which is necessary due to the absence of population data for these new municipalities.

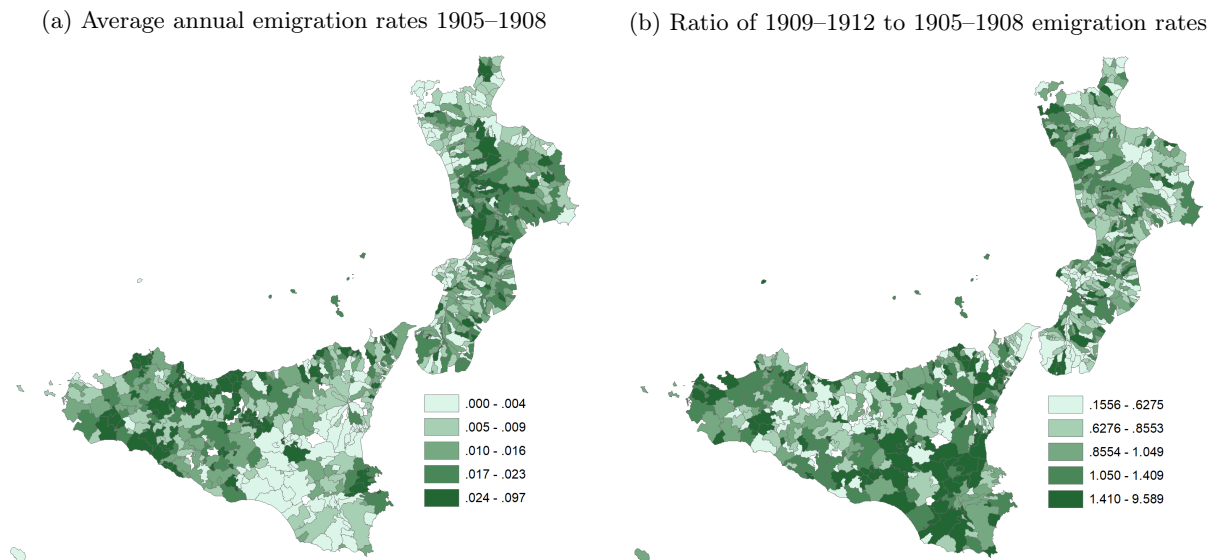


Figure 2: Municipality-level emigration rates

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.

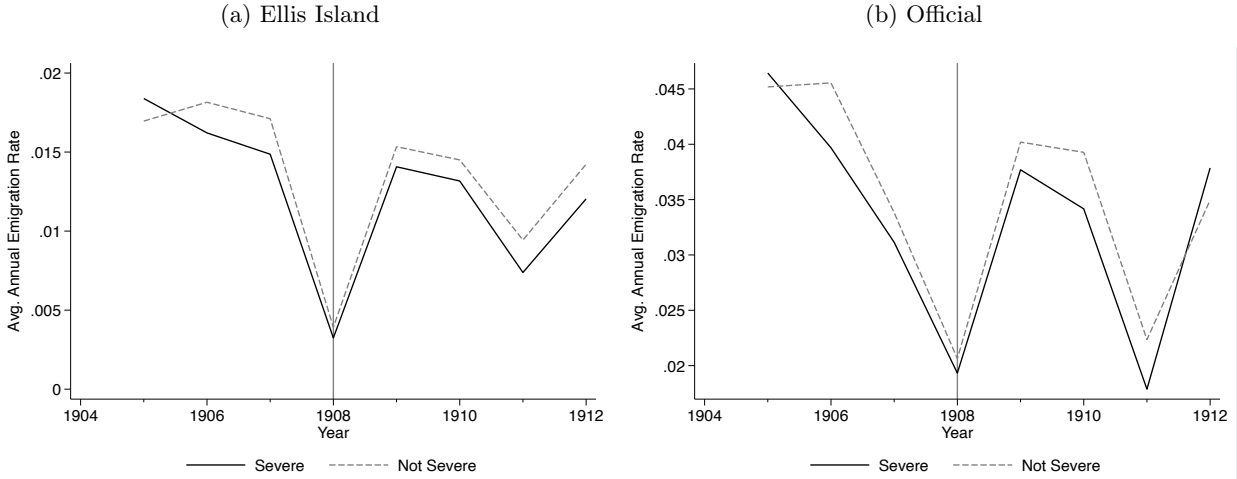


Figure 3: Emigration trends for Sicily and Calabria

Note: “Severe” indicates municipalities experiencing severe damage from the earthquake. “Not Severe” indicates all municipalities in Sicily and Calabria not experiencing severe damage from the earthquake. These are average annual emigration rates across municipalities (i.e., they are not weighted by municipality population).

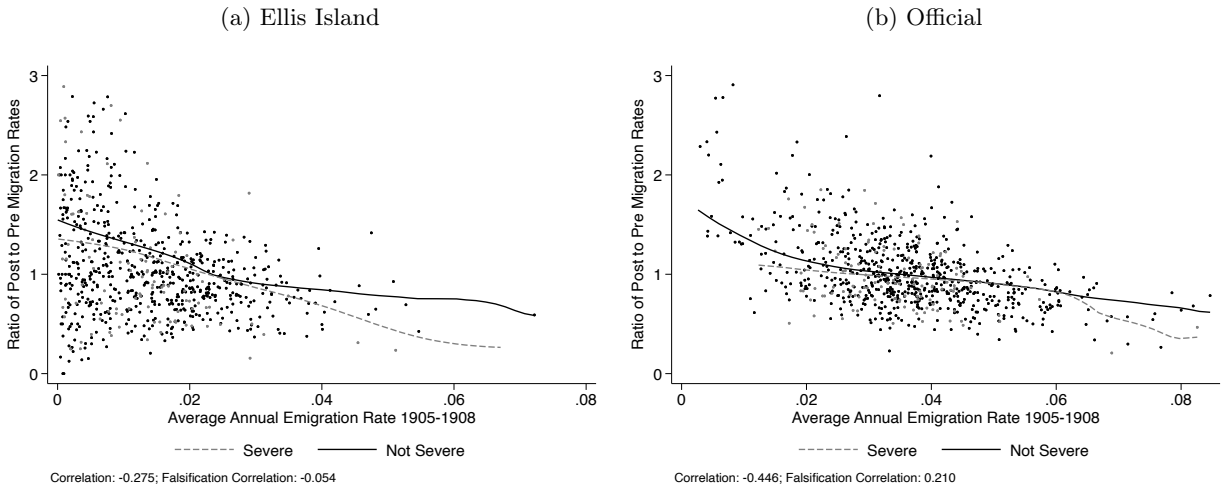


Figure 4: β -convergence in emigration rates

Note: “Severe” indicates municipalities experiencing severe damage from the earthquake. “Not Severe” indicates all municipalities 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 municipality level using data from Ellis Island. Municipalities 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 municipality in panel (a) with a 1905–1908 migration rate over 0.08 is also omitted from the scatter plot for clarity. 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 (2021) and Spitzer and Zimran (2023) 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 this figure is spurious.

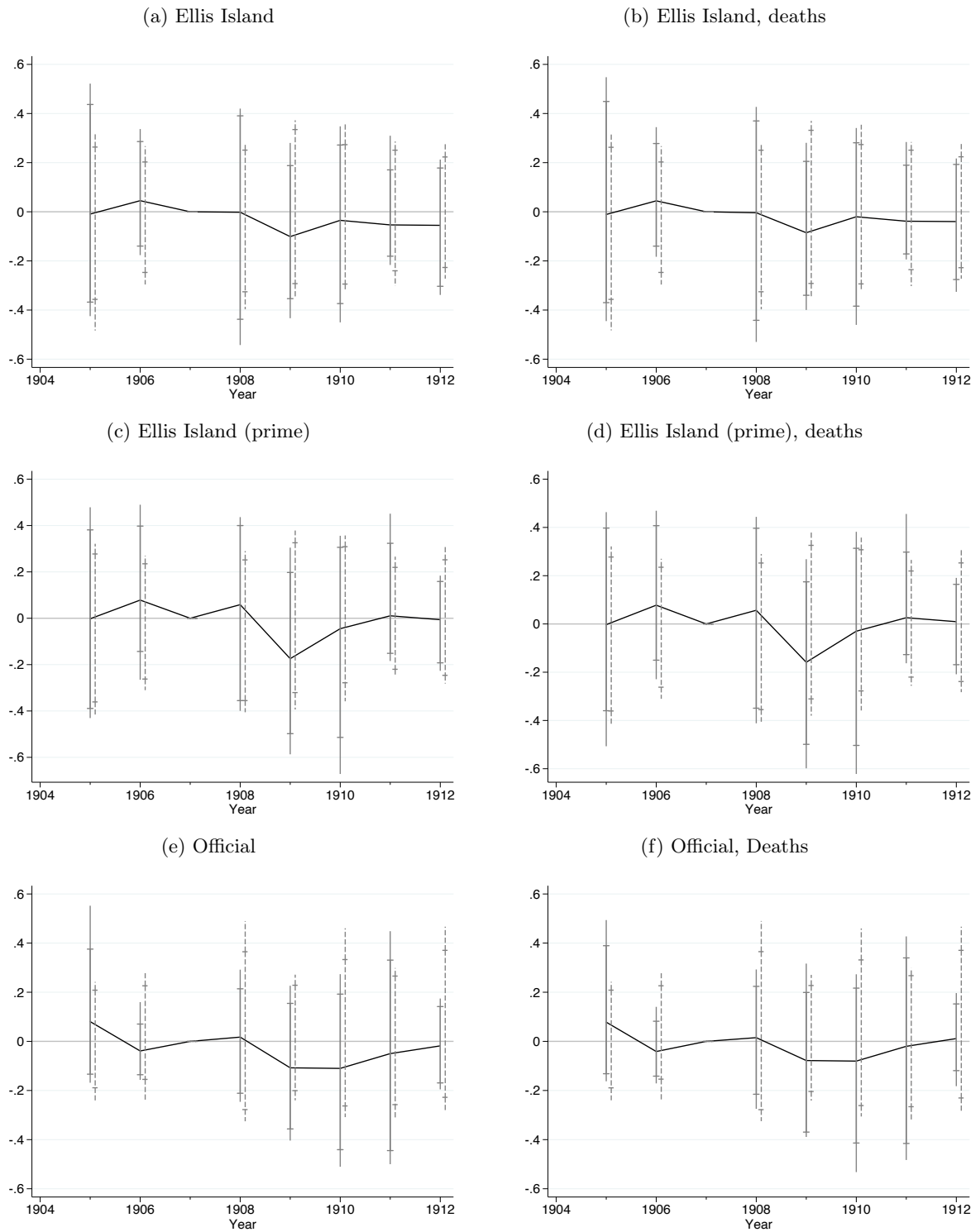


Figure 5: Event studies for the effect of the earthquake on migration

Note: Sample includes all municipalities in the regions of Sicily and Calabria. All event studies control for a year-specific function of distance from the nearest emigration epicenter and have 1907 as the base year. Solid bars are 90- and 95-percent confidence intervals from a wild bootstrap clustered on the district level. dashed bars are the middle 90 and 95 percent of randomization inference replications. The measure on the y -axis is the effect in logs.

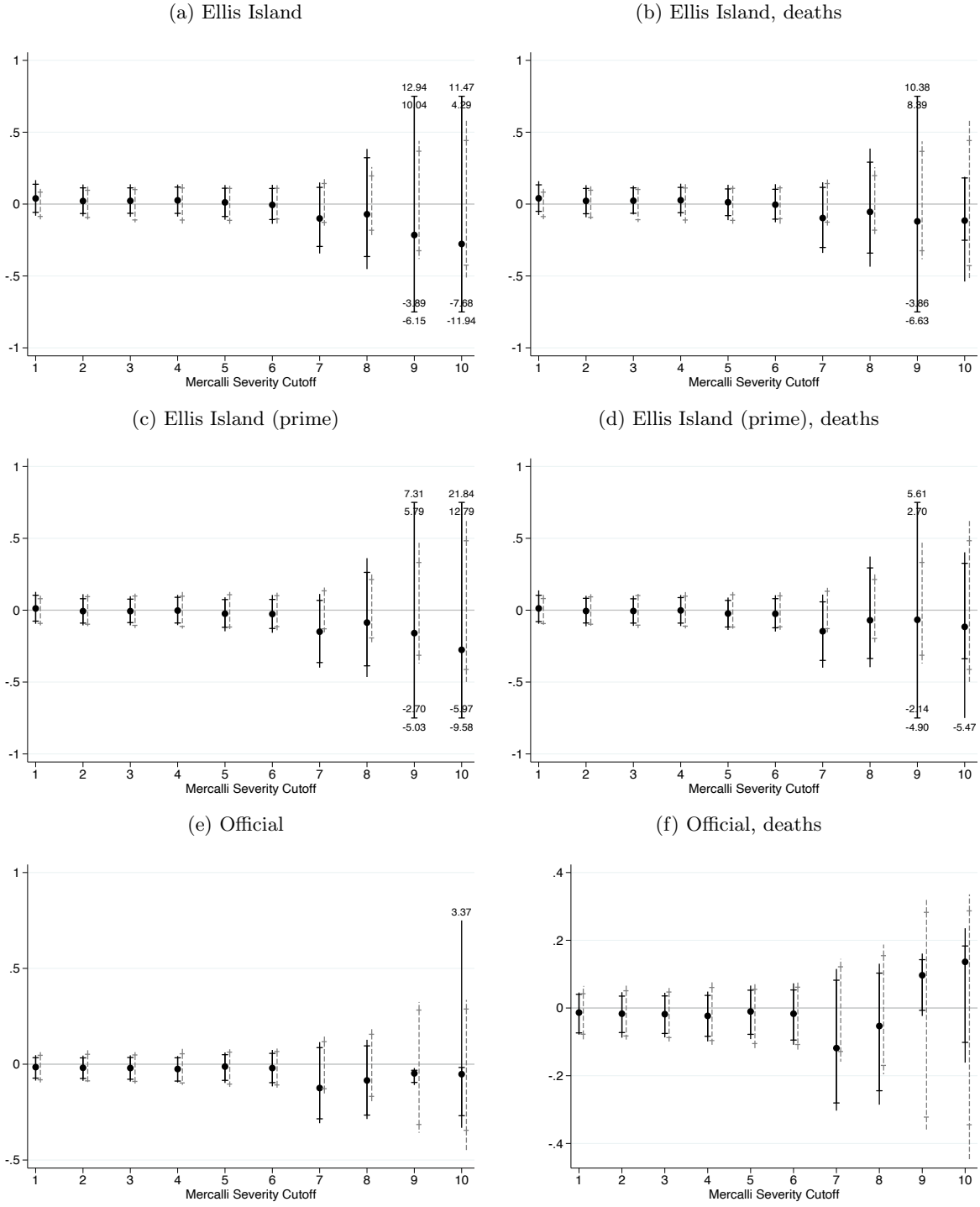


Figure 6: Difference-in-differences results varying Mercalli cutoffs for severity

Note: These figures present the estimated difference-in-differences coefficient from estimating equation (1) with the value listed on the x -axis as the Mercalli score cutoff for defining severe damage. Sample includes all municipalities in the regions of Sicily and Calabria. Solid bars are 90- and 95-percent confidence intervals from the wild bootstrap, clustered on the district level. Dashed bars are the middle 90- and 95-percent of results from the randomization inference permutations. When the absolute value of the extreme of a confidence interval exceeds 0.75, the interval is truncated and the true value listed either outside the interval (95-percent) or inside the interval (90-percent).

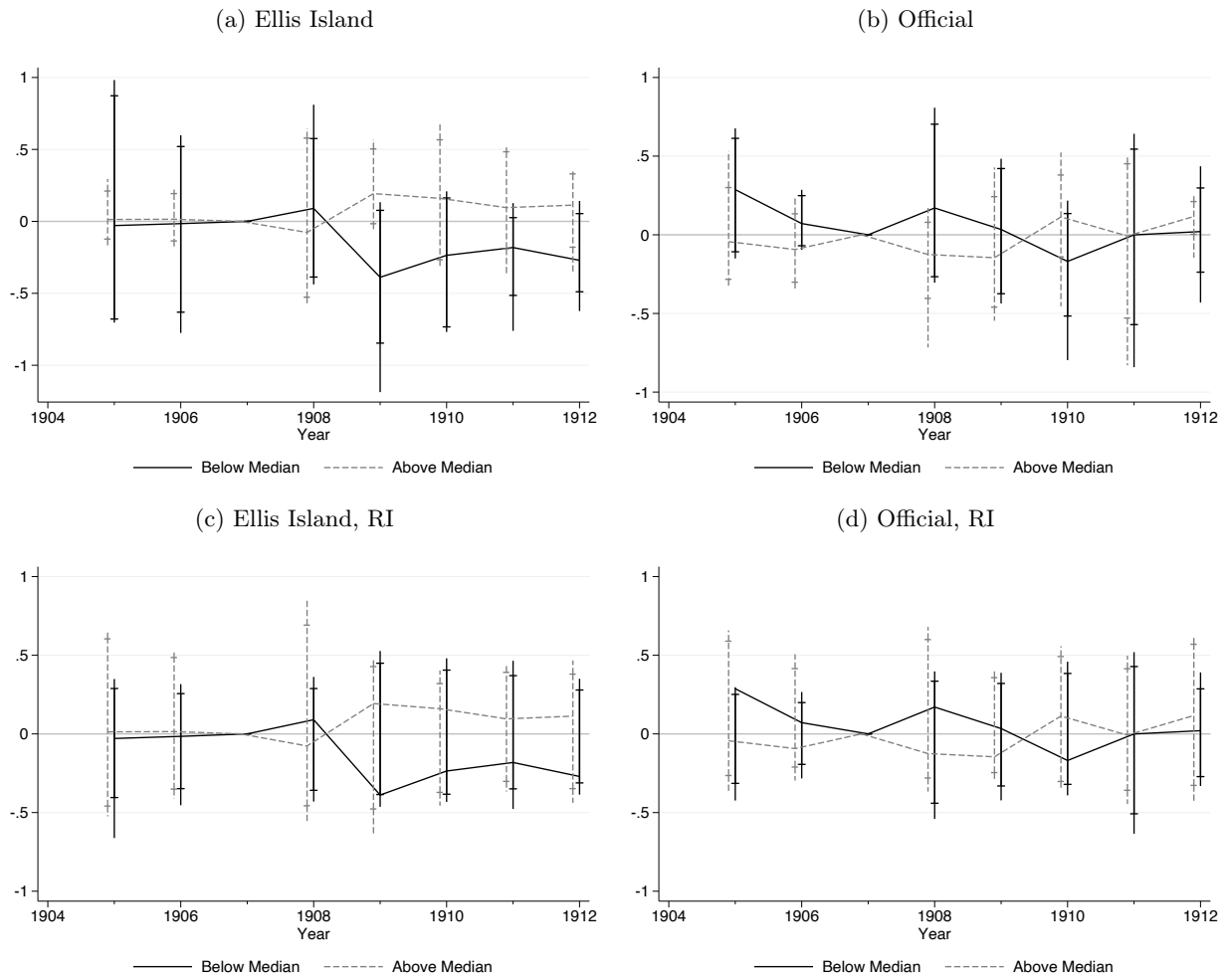


Figure 7: Event studies divided by share of district employment in agricultural day labor

Note: Sample includes all municipalities in the regions of Sicily and Calabria. All event studies control for a year-specific function of distance from the nearest emigration epicenter and have 1907 as the base year. In panels (a) and (b), bars indicate 90- and 95-percent confidence intervals clustered on the district level, computed by a wild bootstrap. In panels (c) and (d), bars indicate the middle 90 and 95 percent of estimates from the randomization inference exercise. 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 logs.

A Demographic accounting for Messina and Reggio Calabria

In this section, we use data on births, deaths, and emigration from the municipalities of Messina and Reggio Calabria to compute a plausible upper bound for the possible internal migration to Messina and Reggio Calabria following the earthquake. This analysis has the additional benefit of providing new estimates of death tolls from the earthquake for these two municipalities.

We begin by observing that the 1911 local-born population of a municipality can be written as

$$n_{1911}^{\ell} = n_{1901}^{\ell} + b^{\ell} - d_{ne}^{\ell} - e^{\ell} + r^{\ell} + i^{\ell} - d_e^{\ell}, \quad (\text{A.1})$$

where n_{1911}^{ℓ} is the local-born population in 1911, n_{1901}^{ℓ} is the local-born population in 1901, b^{ℓ} represents total births in the municipality in 1901–1911, d_{ne}^{ℓ} represents total non-earthquake deaths of local-born individuals in 1901–1911, e^{ℓ} is the total international emigration of local-born individuals in 1901–1911, r^{ℓ} is the total return international migration of local-born individuals over 1901–1911, i^{ℓ} represents net in-migration of Messina-born individuals from domestic sources, and d_e^{ℓ} is the death toll of local-born individuals from the earthquake. The local-born population in 1901 and 1911, n_{1901}^{ℓ} and n_{1911}^{ℓ} is known from the census. Total births are known from the *Movimento dello Stato Civile* for years 1911–1911, which also provides information on total non-earthquake deaths, which we assign to the local-born and non-local-born groups according to their shares of 1901 population. Emigration data are from the *Statistica della Emigrazione Italiana per l'Estero* and are assigned to local-born and non-local-born groups in the same manner as deaths. Data on return migration are available from the *Annuario Statistico della Emigrazione Italiana dal 1876 al 1925*, but are only at the province-level and only for the period 1905–1911; we estimate the number of return migrants by using the province-level ratio of return migrants to emigrants over this period.

Table A.1 presents these figures. The remaining missing pieces in equation (A.1) are the domestic in-migrants i^{ℓ} and the earthquake deaths d_e^{ℓ} . In Table A.1, we impose the assumption that $i^{\ell} = 0$; that is, that there was no net in-migration or out-migration of local-born individuals.⁸⁰ We view this as an upper bound on the true in-migration flow. In reality, we expect that this figure was negative, reflecting a net movement of individuals out of their birth municipalities. Indeed, this must be the case unless there were a substantial flow of, for instance, Messina-born individuals living outside Messina back to their hometown after the earthquake, and similarly for Reggio Calabria. This upper bound on i^{ℓ} implies an upper bound on earthquake deaths d_e^{ℓ} , which we estimate as 29,845 for Messina-born individuals living in Messina and 7,782

⁸⁰To be concrete, this means that there was no net movement of Messina-born individuals to Messina from elsewhere in Italy and similarly for Reggio Calabria.

for Reggio Calabria-born individuals living in Reggio Calabria.

We observe next that the non-local-born population of a municipality can be written in a manner similar to equation (A.1), but omitting births. This yields a demographic law of motion of the form

$$n_{1911}^f = n_{1901}^f - d_{ne}^f - e^f + r^f + i^f - d_e^f, \quad (\text{A.2})$$

where all terms are defined and computed analogously to those in equation (A.1). Our goal in equation (A.2) is to determine an upper bound for i^f , the net inflow of individuals born in other municipalities. To do this, we use the estimated death toll from Table A.1 and the assumption that deaths were randomly distributed between local-born and non-local born individuals according to their 1901 population shares to produce estimates of 5,348 deaths in Messina and 1,516 deaths in Reggio Calabria. These figures yield estimates of total deaths from the earthquake—35,193 in Messina, well short of the official count, and 9,298 in Reggio Calabria, above the official count. Note that, since these are upper bounds, they show that the official Messina death count, as suspected, is dramatically overstated, while that for Reggio Calabria is plausible.

We compute our estimates of i^f in Table A.2, arriving at 10,581 for Messina and 7,623 for Reggio Calabria. Note that these are also upper bounds. Moreover, it is important to realize that these are estimates of the total rate of in-migration over the entire period 1901–1911. Nonetheless, these figures are small relative to the 1901 province populations of 543,809 in Messina and 428,714 in Reggio Calabria, corresponding to average annual rates of about 2 per thousand (relative to average international emigration rates of over 25 per thousand).

Not all of these in-migrants, however, would have come in response to the shock of the earthquake. Indeed, there was likely some base level of population movement that would have occurred in the absence of the shock. Table A.2 also includes rough estimates of how many of these internal migrants were excess internal migrants driven by the earthquake. One reasonable approximation of the population inflow that would have occurred in the absence of the earthquake is that in-migration would have occurred to replace (non-earthquake) deaths and net international emigration of foreign-born individuals. The estimate \hat{i}^f in Table A.2 provides an estimate of in-migration after removing such replacements. This estimate is considerably smaller than the previous one, yielding a total in-migration of only 3,119 for Messina and 4,908 for Reggio Calabria.

Even these, however, are likely over-estimates of excess internal migration arising from the earthquake. Even if there were an internal migrant to replace each non-local-born resident of a city that died or emigrated,

natural growth of the local population would have led to a reduction in the share of the non-local-born population. Another reasonable assumption is to assume that, in the absence of the earthquake, the share of non-local-born individuals in total population would have remained constant. Under this assumption we produce the estimate $\hat{i}^{f''}$ in Table A.2, which indicates a *negative* inflow of individuals from outside of Messina into it—that is, a small net out-migration of 562 individuals—and an inflow to Reggio Calabria of only 3,492 individuals, again small as compared to the province population of over 400,000.

Table A.1: Demographic accounting for Messina and Reggio Calabria, 1901–1911, locally born

		(1)	(2)
		Messina	Reggio Calabria
n_{1901}^{ℓ}	Population 1901	127,017	37,175
b^{ℓ}	Total births 1901–1911	50,495	17,074
d_{ne}^{ℓ}	Non-earthquake deaths 1901–1911*	29,954	9,805
e^{ℓ}	Total emigrants, 1901–1911**	18,399	6,554
r^{ℓ}	Return migration based on provincial rates 1905–1911†	6,711	2,422
i^{ℓ}	Assumed net domestic in-migration	0	0
\hat{n}_{1911}^{ℓ}	Implied population absent earthquake 1911‡	135,870	40,312
n_{1911}^{ℓ}	Actual population 1911	106,025	32,530
\hat{d}_e^{ℓ}	Estimated earthquake deaths§	29,845	7,782

*: computed as $d_{ne} \times \frac{n_{1901}^{\ell}}{n_{1901}^{\ell} + n_{1901}^f}$, where d_{ne} represents total deaths regardless of birthplace

** : computed as $e \times \frac{n_{1901}^{\ell}}{n_{1901}^{\ell} + n_{1901}^f}$, where e represents total emigrants from the municipality regardless of birthplace

†: return migrants are the product of e^{ℓ} and the province-level ratio of return migration to emigration for 1905–1911

‡: computed as $\hat{n}_{1911}^{\ell} = n_{1901}^{\ell} + b^{\ell} - d_{ne}^{\ell} - e^{\ell} + r^{\ell}$

§: computed as $\hat{d}_e^{\ell} = \hat{n}_{1911}^{\ell} - n_{1911}^{\ell}$

Sources: The total population by birthplace data are from Table 1. The birth and death figures are from the *Movimento dello Stato Civile* for 1901–1911. The emigration data are from the *Statistica della Emigrazione Italiana per l'Estero* for the municipality level and from the *Annuario Statistico della Emigrazione Italiana dal 1876 al 1925* for the province level. The return migration data, which are available only beginning in 1905, are from the *Annuario Statistico della Emigrazione Italiana dal 1876 al 1925*.

Table A.2: Demographic accounting for Messina and Reggio Calabria, 1901–1911, non-locally born

		(1)	(2)
		Messina	Reggio Calabria
n_{1901}^f	Population 1901	22,761	7,240
d_{ne}^f	Non-earthquake deaths 1901–1911*	5,368	1,910
e^f	Total emigrants, 1901–1911**	3,297	1,277
r^f	Return migration based on provincial rates 1905–1911†	1,203	472
\hat{d}_e^f	Estimated earthquake deaths‡	5,348	1,516
\hat{n}_{1911}^f	Implied population absent in-migration, 1911§	9,951	3,009
n_{1911}^f	Actual population 1911	20,532	10,632
\hat{i}^f	Estimated domestic in-migration, 1901–1911	10,581	7,623
$\hat{i}^{f'}$	Net of replacement¶	3,119	4,908
$\hat{i}^{f''}$	Net of replacement and population growth#	-562	3,492

*: computed as $d_{ne} \times \frac{n_{1901}^f}{n_{1901}^e + n_{1901}^f}$, where d_{ne} represents total deaths regardless of birthplace

** : computed as $e \times \frac{n_{1901}^f}{n_{1901}^e + n_{1901}^f}$, where e represents total emigrants from the municipality regardless of birthplace

†: return migrants are the product of e^f and the province-level ratio of return migration to emigration for 1905–1911

‡: computed as $\hat{d}_e^f = \hat{d}_e^l \times \frac{n_{1901}^f}{n_{1901}^l}$

§: computed as $\hat{n}_{1911}^f = n_{1901}^f - d_{ne}^f - e^f + r^f - \hat{d}_e^f$

||: computed as $\hat{i}^f = n_{1911}^f - \hat{n}_{1911}^f$

¶: computed as $\hat{i}^{f'} = \hat{i}^f - d_{ne}^f - e^f + r^f$

#: computed as $\hat{i}^{f''} = \hat{i}^{f'} - \frac{b^l - a_{ne}^l}{n_{1901}^l} n_{1901}^f$

Sources: The total population by birthplace data are from Table 1. The birth and death figures are from the *Movimento dello Stato Civile* for 1901–1911. The emigration data are from the *Statistica della Emigrazione Italiana per l'Estero* for the municipality level and from the *Annuario Statistico della Emigrazione Italiana dal 1876 al 1925* for the province level. The return migration data, which are available only beginning in 1905, are from the *Annuario Statistico della Emigrazione Italiana dal 1876 al 1925*.