Can't shake it off. Earthquakes and social cohesion in Italy

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Abstract

(DO NOT CIRCULATE WITHOUT PERMISSION)

This paper examines how earthquakes affect social cohesion using the 2012 major Italian earthquake as a case study. While some theories suggest that disasters strengthen social bonds, others indicate social disintegration. Recent research, however, points to more complex dynamics, where disasters simultaneously strengthen in-group ties while eroding connections with diverse groups. We address the limited causal evidence on this phenomenon using the 2012 Northern Italy earthquake and exploiting a unique dataset that captures multiple dimensions of social cohesion through behavioural measures: racial hate incidents (out-group hostility), hit-and-run accidents (general individualism), marriages (in-group individualism), voluntary tax donations to community-based organizations (community orientation), and to local councils (linking social capital). Employing difference-in-difference and event study designs with continuous exposure measures —perception of shaking (PGA) and economic damage—we find that the earthquake initially shifted behaviour toward self-preservation and individualism across both in-group and out-group dimensions. Racial hate and hit-and-run accidents increased significantly in the first two years before returning to baseline, while marriages showed persistent declines. Critically, economic damage had stronger and more persistent effects than the physical sensation of shaking, suggesting that visible, measurable destruction has a more profound impact on social cohesion. These findings advance our understanding of post-disaster social dynamics by demonstrating that different dimensions of social cohesion respond distinctly to disasters, with varying recovery patterns depending on the characteristics of the earthquake.

Keywords: disasters, earthquake, social norms, social cohesion, individualism
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1 Introduction

While earthquakes can devastate communities by disrupting physical infrastructure, social networks, and economic systems, research shows that resilient communities —those with strong adaptive and copying capacities— can better withstand and recover from these shocks (Townshend et al., 2015).

Scholars suggest that social cohesion, a multidimensional attribute that measures the community's collective togetherness, might favour community resilience (Schiefer & van der Noll, 2017). As the definition suggests, social cohesion comprises several dimensions, including trust, mutual tolerance, cooperation, responsibility for the common good, compliance to the social norms and identification with a social entity, and stronly relates to the concepts of bonding, bridging and linking social capital (Aldrich & Meyer, 2015a).

While evidence shows that high social cohesion correlates with rapid post-disaster recovery (Townshend et al., 2015), our understanding of how earthquakes themselves transform social cohesion is limited, and existing research is contradictory. Some studies suggest that earthquakes can foster social cohesion as communities bring together in the face of shared adversity, leading to cooperation, altruism and mutual support among affected individuals (Behlendorf et al., 2020; Kaniasty, 2020). Other research indicates the opposite by speculating that the earthquake-induced stress and the perception of hardship may lead to adverse behavioural changes, such as increased selfishness, individualism, social fragmentation and violence (K. Tierney, 2019; Vardy & Atkinson, 2019).

This prior research has often examined disasters' effects on social cohesion through a narrow lens, focusing on a single dimension, like trust or crime. This approach overlooks the multidimensional nature of social cohesion and neglects recent developments in disaster studies that suggest natural disasters (including earthquakes) might alter the social fabric in ways that are not uniform but rather multifaceted and potentially polarised (Savage, 2019; K. Tierney, 2019). These conceptual developments are grounded in existing qualitative and descriptive research that supports the coexistence of both rivalry and support within affected communities (Aldrich, 2014; Behlendorf et al., 2020). Such studies document how natural disasters can simultaneously strengthen bonds between members of the same social group, fostering mutual support, while also potentially leading to increased discrimination of minority groups. Factors such as stress, resource scarcity, and a heightened instinct for group self-preservation can exacerbate pre-existing social divisions. Consequently, while certain social groups become more cohesive internally, they may become more exclusionary towards others (K. Tierney, 2019). This dual effect challenges the simplified narratives of disaster response and highlights the need for a more sophisticated understanding of social dynamics in post-disaster contexts (Savage, 2019), particularly in designing inclusive recovery strategies that benefit all community members as societies grow culturally diverse.

More evidence capable of solving this conflict is crucial for research and policy, given the speculated role of social cohesion on immediate disaster recovery (Bourdeau-Brien & Kryzanowski, 2020; Noy & Strobl, 2023) and on long-term socioeconomic outcomes (Acemoglu & Jackson, 2017; Cortinovis et al., 2017). This paper contributes to this effort by providing, for the first time in our knowledge, causal estimates of the effect of a major earthquake on community cohesion, focusing on behaviours linked to individualism, violence, and cooperation.

Existing quantitative research on this topic is scarce and conflicting due to several factors. First, ethical restrictions prevent experimental studies with distressed participants, methodological challenges limit survey data collection during crises, and the unpredictable nature of most disasters typically makes pre-event baseline measurements impossible (Pancotto et al., 2024). Second, causal studies have focused on economic consequences and reconstruction policies after disasters (Acconcia et al., 2020; Carvalho et al., 2021; Cavallo et al., 2013; Deryugina et al., 2018; Johar et al., 2022), as well as the institutional factors that mediate these impacts (Barone & Mocetti, 2014; Buonanno et al., 2023; Cerqua et al., 2023).[1] Third, among the few studies that move beyond small-scale samples and descriptive evidence to examine the earthquake effects on social cohesion, the focus has been exclusively on crime, yielding mixed results (García Hombrados, 2020; Silverio-Murillo et al., 2024).

Our study represents a significant advancement in this direction by providing the first causal, multidimensional investigation of how earthquakes impact social cohesion. Unlike earlier research that often relied on small-scale samples, descriptive evidence, or single outcome measures, we examine multiple behavioural manifestations of social cohesion spanning both in-group and out-group dynamics. Specifically, we investigate how the 2012 Northern Italy earthquake (magnitude 5.9) affected four key dimensions of social behaviour: (1) racial hate incidents capturing out-group hostility, (2) hit-and-run accidents reflecting general individualism, (3) voluntary tax donations to community-based organizations indicating bonding engagement with local communities, and (4) voluntary tax donations to local councils measuring linking social capital—the vertical connections between citizens and formal government institutions. To further illuminate the nature of earthquake-induced individualism, we complement the analysis on hit-and-run accidents by examining same-nationality marriage rates as an indicator of in-group couple formation.

Our methodological approach offers several innovations. First, we focus on behavioural manifestations rather than self-reported attitudes, providing revealed preference measures that are less susceptible to social desirability bias. Second, we move beyond binary treatment indicators to ex-

[1] Other causal evidence has explored disaster-driven changes in economic behaviours, such as risk preferences and consumption patterns (Filipski et al., 2019; Hanaoka et al., 2018; Kuroishi & Sawada, 2024; Modica, Zoboli, et al., 2021).

amine two different exposure measures: the human perception of shaking intensity and the economic impact. This enables us to investigate which earthquake characteristics most significantly impact various dimensions of social cohesion. Third, our identification strategy exploits the quasi-exogenous, unexpected, and spatially limited nature of earthquakes to implement difference-in-difference and event study designs, comparing affected and unaffected municipalities before and after the disaster.

Our findings reveal complex, multidimensional social responses that challenge mono-directional narratives of disaster impacts on social cohesion. Rather than substituting out-group connections (bridging social capital) for in-group ties (bonding social capital)—as parochial altruism theories might predict—or strengthening social ties -as speculated by the 'disaster as galvaniser' hypothesis- the 2012 Italian earthquake triggered a multi-phase transformation with distinct temporal patterns across different dimensions of social life.

In the immediate aftermath (years 1-2), we observe a sharp shift toward self-preservation and individualism. Racial hate incidents increased by 7.34% and hit-and-run accidents by 9.66% in areas moving from low to high exposure based on actual building damage. However, voluntary tax donations to local councils increased significantly, suggesting that affected communities initially turned to formal government institutions for support and coordination even as interpersonal social bonds fractured. Analysis of marriage rates—examined to further understand the nature of post-disaster individualism—reveals that this shift extended to in-group intimate bonds, with marriages declining by 8.92%.

Recovery patterns differed markedly across outcomes, revealing differential resilience of social cohesion dimensions. While racial hate and hit-and-run accidents returned to baseline by year 3—indicating that out-group hostility and opportunistic individualism proved temporary—marriage reductions persisted throughout the entire study period, suggesting lasting damage to intimate in-group bonds. Additionally, years 6-7 witnessed delayed decreases in voluntary tax donations to both community-based organisations and local councils, indicating a late-stage erosion of civic engagement across both horizontal (community) and vertical (linking) dimensions of social capital. This pattern suggests that while immediate antisocial behaviours may be transient responses to acute crisis, economic damage from disasters produces cumulative effects that progressively undermine both community bonds and collective civic structures.

The differential persistence of effects across earthquake characteristics—with economic damage showing stronger and more lasting impacts than ground motion intensity—suggests that visible, measurable destruction and ongoing reconstruction burdens have more profound effects on social cohesion than the shared experience of shaking alone.

Results are confirmed through a broad set of robustness checks, which include considering alternative control groups and addressing compositional differences between treated and control municipalities.

Critically, we find that economic damage—measured as actual destruction to private buildings—had substantially stronger and more persistent effects on social cohesion than ground motion intensity (PGA). Racial hate increased by 7.34% from damage versus 3.43% from ground motion; hit-and-run accidents increased by 9.66% from damage versus 3.12% from ground motion. This suggests that visible, measurable destruction has a more profound impact on the social fabric, while the physical sensation of shaking alone has a more limited impact differential effects have important implications: social cohesion may rebuild relatively quickly after the shared experience of ground shaking, but struggles more to overcome the persistent burden of economic damage. This interpretation aligns with findings that economic hardship can strain social bonds and increase intergroup competition.

Our research makes several important contributions. Theoretically, we provide the first causal evidence supporting recent frameworks that move beyond the binary 'galvaniser versus divider' debate to show how disasters can simultaneously affect different dimensions of social cohesion in divergent ways. Methodologically, we demonstrate the importance of examining multiple behavioural outcomes and continuous exposure measures rather than relying on binary treatment indicators or single outcome dimensions. For policy, our findings suggest that recovery planning must address social cohesion alongside physical reconstruction, particularly in areas with severe economic damage. Policymakers should protect vulnerable groups during recovery, track multiple behavioural indicators of social cohesion, and extend monitoring beyond officially designated impact zones since effects vary by the actual extent of damage.

The paper proceeds as follows. We begin with a review of relevant literature in Section 2. Section 3 outlines our case study, detailing the major earthquake that hit a portion of Italy in 2012 (3.1) the data and metrics used to measure the different domains of social cohesion (3.2), and our identification approach (3.3). We then describe our empirical methodology in Section 4. Section 5 presents our main findings, while Section 6 validates their robustness before the concluding Section 8.

2 Background

Conceptual frameworks on social cohesion responses to earthquakes reveal two main opposing views. One line of research suggests that disasters, including earthquakes, can stimulate social cohesion (Behlendorf et al., 2020; Vardy & Atkinson, 2019). This perspective argues that the common experience of a natural disaster enhances empathy, altruism and community connections (Kaniasty, 2020) while reducing violence and crime (Fritz, 1996).[2] In contrast, another perspective indicates that shocks may exacerbate existing social tensions, leading to negative behavioural changes such as increased selfishness, social fragmentation, discrimination and violence against minorities (Aldrich & Crook, 2008; Aldrich & Meyer, 2015b; Vardy & Atkinson, 2019).[3] This research suggests that perceived threats and hardship can enhance individualism and push dominant social groups to discriminate against and marginalise minority groups (Andrighetto et al., 2016).

The evidence supporting these contrasting perspectives tends to focus on a specific dimension of social cohesion, producing mixed results. Often, evidence has been drawn on small-scale samples, relying on focus groups, surveys, and experiments using hypothetical scenarios (Cassar et al., 2017; Pancotto et al., 2024; Vardy & Atkinson, 2019). Larger-scale, primarily descriptive evidence is more scarce and presents conflicting results. For instance, increases in marriage rates were observed after major natural disasters in Italy, the US, and India (Cicatiello et al., 2022; Cohan & Cole, 2002; Khanna & Kochhar, 2023), suggesting a strengthening of emotional connections. Conversely, decreases in marriage rates were found in other contexts (Ahmed, 2018; Prati & Pietrantoni, 2014), suggesting an increase in individualism post-disaster. [4]

Mixed descriptive findings also characterise the investigation on the effect of natural disasters on community engagement. Studies in Indonesia (Bai & Li, 2021), Japan (Hanaoka et al., 2018; Ye & Aldrich, 2021), Thailand (Cassar et al., 2017) and Italy (Buonanno et al., 2023) show that affected individuals engage more with community life after exposure to a disaster. Among the few causal studies, research in Chile (García Hombrados, 2020) found no increase in property crimes in communities hit by a major earthquake, suggesting these communities coordinated property protection while institutions focused on other priorities. However, other data support a more negative outlook. Exposure to natural disasters correlates to individualism and pessimistic behaviours in the Philippines (Brown et al., 2018), Thailand (Cassar et al., 2017), and the US (Bourdeau-Brien & Kryzanowski, 2020). Systematic reviews show that exposure to natural disasters has a strong correlation with increased fear, stress, and anxiety (Kano et al., 2016; Neria et al., 2008). A large-scale review by Xu et al. (2016) found that nearly 39% of reviewed papers reported an association between the occurrence of natural disasters, social unrest and conflict. This finding is supported by figures that document hostility towards ethnic minorities after natural disasters (Andrighetto

[2] Conceptual frameworks supporting this perspective include 'altruism born of suffering' (**Staub2005TheSuffering**), 'therapeutic community' (Fritz, 1996), 'attachment theory' (Cohan & Cole, 2002) and 'disaster-as-a-galvaniser' (Vardy & Atkinson, 2019).

[3] Theories supporting this perspective include the 'disaster-as-a-divider' hypothesis (Vardy & Atkinson, 2019) and 'parochial altruism' theory (Döring & Hall, 2023).

[4] Among these studies, Cicatiello et al. (2022) and Ahmed (2018) used difference-in-difference estimation, although facing challenges due to small samples and limited identification.

et al., 2016; Chung & Rhee, 2022; Döring & Hall, 2023; Vardy & Atkinson, 2019). Causal evidence is provided by Anderson et al. (2017), who show that a historical temperature shock increased the persecution of Jewish people, a result that is in line with recent studies suggesting that shocks can facilitate the manifestation of existing prejudices, as authorities prioritise crisis management over monitoring social transgressions (Bauer et al., 2021; Bursztyn et al., 2022). Descriptive evidence also indicates an increase in gender-based violence after disasters in various countries (Fisher, 2010; Harville et al., 2011; Rao, 2020; Schumacher et al., 2010; Sekhri & Storeygard, 2014; Vigna et al., 2009), as confirmed by comprehensive systematic reviews (Murphy et al., 2023; van Daalen et al., 2022).

This wealth of mixed evidence, although mainly descriptive, suggests a more nuanced effect of natural disasters, including earthquakes, on social cohesion. It underscores the importance of expanding empirical research to consider the post-disaster in-group/out-group dynamics, as suggested by recent theoretical developments. According to these new approaches, an increase in in-group solidarity does not necessarily translate to universal altruism or cohesion across different social groups (Savage, 2019; K. Tierney, 2019). Also, natural disasters may stimulate cooperation within each social group to implement safety and support systems that compensate for disrupted formal institutions (Vardy & Atkinson, 2019), while simultaneously leading to hostility against out-group individuals, as perceived resource scarcity intensifies inter-group competition and the need for stress release and scapegoating emerges (Andrighetto et al., 2016; K. J. Tierney, 2007).

These developments highlight the importance of expanding the investigation of disaster-induced changes to social cohesion by considering behaviours that can shed some light on the post-disaster in-group/out-group dynamics. Descriptive evidence from India provides initial support for these theoretical predictions, showing that natural disasters can have divergent effects on social cohesion: while they strengthen bonds and cooperative behaviours within dominant social groups, they simultaneously exacerbate discrimination and social exclusion of out-group members (Aldrich, 2014; Behlendorf et al., 2020). This suggests that disasters might reinforce existing social boundaries rather than fostering universal solidarity. Particularly relevant to our study is the finding from Italy, where a small survey conducted after the 2012 earthquake indicated that affected Italians strengthened in-group collaboration while developing more discriminatory attitudes toward non-Italians in their communities (Andrighetto et al., 2016). Despite these preliminary insights, comprehensive causal evidence remains scarce (K. J. Tierney, 2007).

This paper addresses this gap by providing causal evidence of the effects of the 2012 Italian earthquake on behaviours that contribute to social cohesion, specifically accounting for in-group and out-group dynamics. The main focus of our investigation is on racial hate incidents, hit-and-run accidents, marriage rates, engagement with local Community-Based Organisations and engagement with local authorities. Racial hate incidents serve as a direct measure of out-group hostility, allowing us to assess whether earthquake exposure exacerbates discrimination against minority groups, as suggested in the literature (i.a., Andrighetto et al., 2016; Vardy & Atkinson, 2019).

Hit-and-run accidents reflect changes in individualistic behaviour, disregarding group membership after an earthquake. As a two-stage crime involving an involuntary 'hit' and a voluntary 'run' under stressful conditions, hit-and-run accidents proxy individualism, indicating prioritisation of personal interests over collective welfare even within the same social group (Denti & Modica, 2024; Leviton & Factor, 2022). Post-disaster increases in hit-and-run accidents could suggest a breakdown of social cohesion and a shift toward self-preservation, even against in-group members, while decreases might indicate strengthened community bonds and a collective sense of responsibility.

We complement individualistic behaviour, disregarding group membership, with individualism within the same in-group, considering marriage rates within the dominant social group. Extant research has shown mixed responses to disasters (i.a., Cicatiello et al., 2022; Prati & Pietrantoni, 2014), but it has not discriminated between marriage types (Cohan & Cole, 2002; Prati & Pietrantoni, 2014).

Beyond these behaviours, we also examine bonding engagement (Aldrich & Meyer, 2015a) through voluntary tax designations to local Community-Based Organisations (CBOs), which capture whether individuals choose to support local collective action and community welfare. Finally, we consider linking social capital (Aldrich & Meyer, 2015b)—the vertical connections between citizens and formal government institutions—proxied by voluntary tax designations to the local council (Aldrich & Meyer, 2015a). When taxpayers voluntarily direct funds to their local municipality rather than to other eligible organisations (or do nothing), they reveal trust in and willingness to empower local government institutions. Since municipalities have formal authority over citizens, directing funds to them represents a form of voluntary engagement with institutions across the power hierarchy. Post-disaster changes in these contribution patterns can thus illuminate how earthquakes affect both horizontal ties within communities and vertical ties to governing authorities, providing insight into the evolution of social cohesion beyond antisocial behaviours and bonding relationships.

Rather than relying on surveys, which often underestimate socially undesirable attitudes as respondents tend to provide socially accepted answers[5], we measure behaviours through their observable manifestations (Stephens-Davidowitz, 2014).

We also consider multiple dimensions of earthquake severity, as different characteristics may influ-

[5] The tendency of survey respondents to mask socially sensitive attitudes behind socially correct answers is called the 'social desiderability bias' (Stephens-Davidowitz, 2014)

ence the post-disaster balance between cohesion and discrimination in distinct ways (K. Tierney, 2019). We distinguish between the immediate human experience of ground shaking—measured through Peak Ground Acceleration (PGA)—and the resulting economic damage to buildings and infrastructure.

On one hand, intense shaking and severe damage could erode social cohesion through several pathways. High-intensity earthquakes may induce significant post-traumatic stress (Bourdeau-Brien & Kryzanowski, 2020), strengthening self-preservation instincts and individualistic behaviour even toward in-group members. The resulting physical destruction and economic hardship may intensify resource competition, potentially increasing discrimination against out-group members as dominant groups seek scapegoats and attempt to monopolise scarce recovery resources (Andrighetto et al., 2016; Vardy & Atkinson, 2019).

On the other hand, severe earthquakes could strengthen social bonds through shared adversity. The common experience of intense shaking may magnify emotional connections among survivors, fostering the 'altruism born of suffering' and therapeutic community effects described in disaster literature (Cohan & Cole, 2002). Additionally, massive destruction of physical capital may increase incentives for cooperation and collective action, as communities must work together to overcome economic hardship and rebuild (Bai & Li, 2021; Buonanno et al., 2023). By examining both ground motion intensity and actual damage, we can better understand which earthquake characteristics drive changes in social cohesion and through which mechanisms.

3 Case study and identification strategy

3.1 The 2012 Italian earthquake

Italy is situated on the junction of the Eurasian and African tectonic plates, the so-called 'Gloria Fault' (Omira et al., 2019), which is the source of its seismic activity. Seismic events are primarily microearthquakes that are not felt by people, while major tremors occur infrequently. However, in 2012, a major earthquake with 5.9 magnitude occurred in an area comprised within three regions in Northern Italy: Emilia-Romagna, Lombardy and Veneto (Rovida et al., 2017).

The 2012 earthquake sequence was characterised by two main shocks occurring on May 20 and May 29, 2012. The first had a magnitude ML 5.9 (MW 5.86) with an epicentre in the town of Finale Emilia about 30 km west of Ferrara in the Emilia-Romagna region (Scognamiglio et al., 2012). The second major shock struck on May 29 with a magnitude ML 5.9 (Mw 5.66) located about 20 km east of the first (Scognamiglio et al., 2012). The shallow depth of the epicentres, ranging from 6.3 to 9.6 km, contributed to the severity of the surface impacts (INGV, 2022). These primary events were followed by numerous aftershock tremors that continued for several weeks. As of July 19, 2012, approximately 2,800 seismic events had been recorded in the affected area. The aftershock zone extended over 50 km, with hypocentres primarily concentrated in the upper 10 km of the crust, and these extensive weeks of tremors contributed to maintaining disruption in the affected area (INGV, 2022).

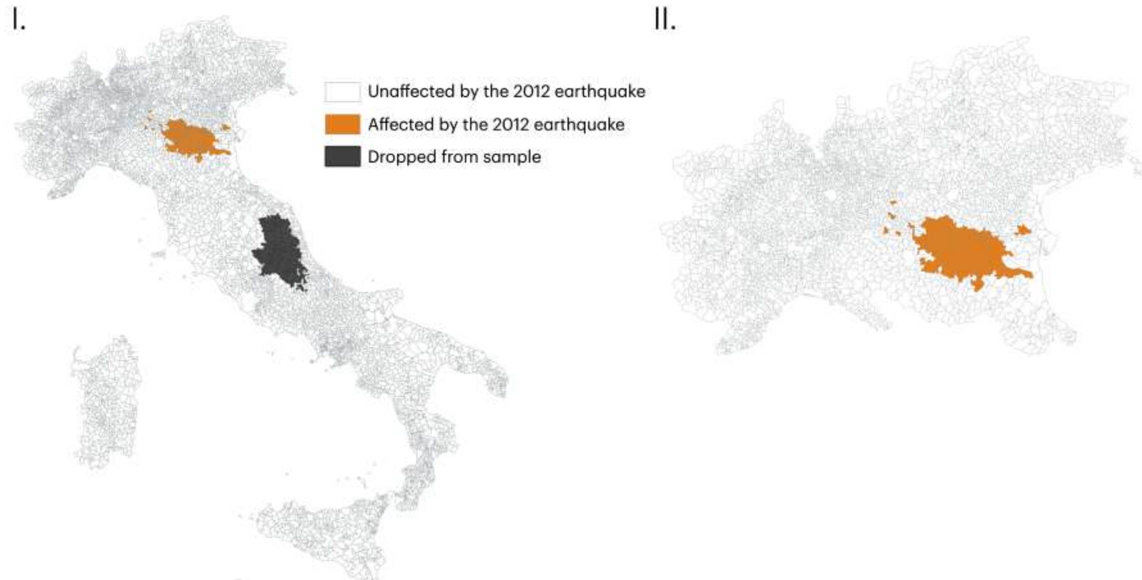
The earthquake primarily affected the provinces of Modena, Ferrara, Bologna in Emilia-Romagna, Mantua in Lombardy and Rovigo in Veneto. The affected area was large and densely populated, with 550,000 inhabitants distributed across a continuum of medium-sized towns and 5 cities, and approximately 48,000 productive activities, employing 190,000 people. The earthquake caused 28 deaths and more than 300 injuries. Nearly 19,000 households, corresponding to 45,000 people, had to leave their homes, and more than 14,000 residential dwellings were damaged. The economic damage was estimated at 13.2 billion euros (ERVET, 2015; Istituto Regionale Emiliano-romagnolo, 2014).[6]

Post-earthquake measures were swift and comprehensive. Immediately after the earthquake, a state of emergency was declared with the Prime Ministerial Decree (DPCM) of 22 May 2012. The Decree defined the so-called 'seismic crater' which delimited the epicentral area where the emergency measures for reconstruction were to be applied (area in orange in Figure 1 - I). The inclusion criteria were primarily based on the assessment of damages, considering factors such as the number of damaged buildings and infrastructures, effects on economic activities, and the need for population assistance (Italian Parliament, 2012). The area encompassed 124 municipalities situated in the regions of Emilia-Romagna, Lombardy, and Veneto. 59 municipalities were in Emilia-Romagna, distributed in 5 provinces (17 municipalities in the Province of Bologna, 8 in the Province of Ferrara, 19 in the Province of Modena, 15 in the Province of Reggio Emilia).[7] Lombardy had 44 municipalities, which were located in the Province of Mantua (37 municipalities), the Province of Cremona (6 municipalities) and the Province of Brescia (1 municipality). The Veneto region had 21 municipalities, all in the Province of Rovigo (Figure 1 - II. provides a closer view of the municipalities impacted by the 2012 earthquake). At the end of 2017, as reconstruction proceeded, a new perimeter of the 'seismic crater' was identified in Emilia-Romagna, by reducing the number of

[6] Two other major seismic events occurred in Italy between 2009 and 2019: the 2009 L'Aquila earthquake and the 2016 - 2017 Central Italy earthquake. L'Aquila earthquake impacted an urban environment, while the Central Italy earthquake impacted a rural environment. This contrasts with the strong industrial vocation of the 2012 earthquake-impacted area (Di Bucci et al., 2023). The events differ also in terms of geography, as the 2012 earthquake struck a plain area, while the 2009 and 2016-2017 seismic events occurred in mountainous areas (Modica, Urso, & Faggian, 2021). The demographic and geographic differences limit the extension of the investigation to these other major events, which will be included as a robustness check in future research stages.

[7] Two municipalities hit by the 2012 earthquake merged in 2017 (Mirabello and Sant'Agostino).

Figure 1: The area impacted by the 2012 earthquake



Note: Figure 1 - I: area in orange corresponds to the municipalities affected by the 2012 major earthquake as defined by the official list included in Law 122/2012 enacted immediately after the earthquake (Italian Parliament, 2012). Areas in white correspond to the municipalities not affected by major earthquakes between 2009 and 2019. The areas in grey are the municipalities that were affected by a major earthquake between 2009 and 2019. Figure 1 - II offers a closer view to the municipalities affected by the 2012 earthquake.

municipalities to 30 (the so-called 'restricted crater'). Lombardy and Veneto did not reduce their crater perimeter.

In the aftermath of the earthquake, immediate measures were implemented to address the emergency. These included providing initial assistance and rescue to the affected population, setting up temporary accommodation, and quickly restoring essential infrastructure and public services. Temporary structures were rapidly constructed for schools, municipal offices, and churches to ensure continuity of education, administration, and religious services (Emilia-Romagna Region, 2014). The authorities managed the relocation of about 45,000 displaced people through various housing solutions, including camps and prefab modules, which were closed in autumn 2012. The healthcare and welfare services were immediately reactivated, ensuring continuous care for patients. Essential public services such as water, electricity, and waste management were quickly restored (ERVET, 2014).

Financial support was provided to businesses through subsidies to help them pay taxes and other obligations. The reduction in the number of business units was marginal and consistent with regional patterns (-1.0%), but a more pronounced drop was in employment (-3.2%). To mitigate this, social safety nets were established, including around 10.4 million hours of the special wage guarantee fund ('CIG in deroga'), which supported 17,530 employees in 3,525 local units, predominantly in the months following the earthquake. Since January 2013, the number of claimants decreased to less than 600 (ERVET, 2014).

We leverage newly available and rich figures on behavioural outcomes, as well as detailed information on the heterogeneous impact of the earthquake, to investigate aspects of the earthquake's impact that were not previously measurable.

3.2 Data and measures

This section presents our data sources and key measures. Our dataset combines information from multiple domains: social cohesion indicators (racial hate incidents, traffic accidents, marriages); seismic measures (epicentral area classification, building damage, Peak Ground Acceleration and Velocity); and controls (population demographics, including foreign residents and refugees).

Data. Municipal-level racial hate data come from 'Cronache di Ordinario Razzismo', a database managed by Lunaria, an Italian advocacy group. This source is recognized as reliable by various institutions, including the OSCE Office for Democratic Institutions and Human Rights and the European Commission (Siragusa et al., 2020). By collecting and cross-checking data from multiple sources, including Italian newspapers and NGOs, the database aligns to recommendations on how to alleviate bias in measuring hate (Siragusa et al., 2020).[8] For each racial hate event (property damage, threats, assault, and murder) we retrieved the date and the location, which were then used to plot hate events across Italian municipalities. This data are available for the period 2009-2019.[9] Municipal-level figures on hit-and-run accidents, total road accidents and road traffic are provided by ISTAT, the Italian National Statistics Office, and Emilia-Romagna Region. Figures for marriages and unmarried couples are supplied by ISTAT. We consider figures for Italian non-mixed (both spouses are Italians) marriages, since a 2009-2011 policy that imposed stricter eligibility requirements for foreign spouses pushed many mixed and all-foreign couples to marry abroad instead of in Italy (ISTAT, 2013). As this policy change occurred within our study period, it introduces temporal inconsistencies that make these marriage data unsuitable for analysis.

Data on voluntary tax designations come from the Italian Ministry of Finance's '5 per mille' (five

[8] Evidence advises against measuring hate through police records, since 70% of hate victims in Europe do not report the crime to the police. Conversely, existing evidence corroborates the more extensive coverage of hate events provided by databases which collect and cross-check several sources (Dancygier et al., 2022).

[9] We stop the investigation in 2019 since the COVID-19 years posed specific challenges and restrictions to people's behaviours.

per thousand) system, which allows taxpayers to allocate 0.5‰of their income tax to eligible voluntary organisations or municipalities since 2006. Regarding voluntary tax designations to voluntary organisations, we count only designations to organisations operating exclusively at the municipal level, excluding those with supra-municipal scope, to ensure we capture connections with community-based organisations (bonding engagement).

The perimeter of the municipalities affected by the 2012 earthquake is defined by the official list included in Law 122/2012, which was enacted immediately after the earthquake (Italian Parliament, 2012), as well as the subsequent decrees[10] that have adjusted the perimeter based on ongoing reconstruction efforts (the area in orange in Figure 1 corresponds to the perimeter specified in Law 122/2012). We then use other relevant data on the characteristics of the earthquake to describe its intensity. We use the US Geological Survey information on the Peak Ground Acceleration (PGA)[11] data to represent human perception of earthquake shaking motion, a standard approach in seismology (Wald et al., 1999). Additionally, we use building-level data on actual damage to private dwellings from the Emilia-Romagna region to calculate the average private damage for affected municipalities. This data is derived from the post-earthquake technical assessments that determined immediate usability or necessary repairs for impacted buildings (Italian Government, 2014a). In Italy, these assessments follow the AeDES methodology, which categorised the 2012 earthquake damage to private buildings into six levels: 'no damage' (AeDES class A); 'light damage' (AeDES class B/C); 'moderate-severe damage' (E0); 'severe damage' (E1); 'considerably severe damage' (E2); 'extremely severe damage' (E3) (Emilia-Romagna Region, 2024a; Italian Government, 2014a) (more details in Appendix, Table A.5. The AeDES data for the 2012 earthquake are available only for municipalities in the Emilia-Romagna region. Consequently, the analysis of the earthquake's effects based on actual damage is restricted to a smaller subset of the affected municipalities, focusing specifically on those in Emilia-Romagna. Finally, the US Geological Survey provides Peak Ground Velocity (PGV)[12] figures that serve to design the instrumental variable for actual dwelling damage, as it provides a vetted physical indicator of the potential for structural damage (Wald et al., 1999) while being exogenous to social outcomes.

As part of our robustness checks, we also estimate the main econometric specification by adding control variables. We design them using several data sources. Municipal data on population are retrieved from ISTAT. Regarding confounders that might be particularly relevant for racial hate, we consider ISTAT data on foreign residents and data on refugees from the Italian Ministry of Interior SPRAR database, the Openpolis CAS database and the OpenPolis-Centri d'Italia CAS database. Data sources and summary statistics are summarized in Tables A.1-A.4 in the Appendix.

[10]Lombardy Region (2019) Decree 19/2019 and Emilia Romagna Region (2017) Decree 34/2017

[11]PGA refers to the amplitude of the highest peak acceleration captured on an accelerogram at a location during a specific earthquake (Douglas, 2003).

[12]PGV is the maximum speed of ground movement during a particular earthquake (Wald et al., 1999).

Measures. We use this data to develop metrics for behavioural outcomes and earthquake characteristics. Racial hate is measured by incidents per 100,000 residents, while hit-and-run incidence is calculated as the ratio of hit-and-runs to total road accidents resulting in fatalities or injuries. For marriages, we focus solely on Italian-Italian unions per 10,000 Italian residents, as the 2009-2011 policy change affecting foreign spouses (ISTAT, 2013) prevents consistent measurement of mixed marriages. To handle non-negligible zeros in these measures, we apply the Inverse Hyperbolic Sine (IHS) transformation.[13]. Voluntary tax designations to local community-based organisations (CBOs) and local councils are calculated as the number of taxpayers who designated 5‰of their income taxes to each one of these categories of entities per 1,000 residents, allowing for comparability across municipalities of different sizes.

We employ two main continuous treatment measures of exposure: Peak Ground Acceleration (PGA) and private dwelling damage. We compute PGA as the municipal averages of its maximum values during the tremors. Higher PGA values indicate stronger perceived shaking (with values below 0.1%g being imperceptible) (Wald et al., 1999).[14] The private dwelling damage is a measure of the earthquake's actual damage to private buildings, which is given by the municipal average of the individual building damages resulting from AeDES data and covers Emilia-Romagna municipalities only due to data limitations. Finally, we include a third treatment measure, which is the municipal average of their maximum Peak Ground Velocity (PGV) values during the tremors. We use this additional treatment to instrument private dwelling damage in a two-stage model, as higher PGV values correlate with increased building risk (Wald et al., 1999).

Each continuous treatment allows us to capture both the extensive margin (whether a municipality was affected) and the intensive margin (how strongly it was affected) of earthquake impact in a single variable.

3.3 Identification and descriptive analysis

We employ a quasi-experimental design to assess the impact of the 2012 earthquake on social cohesion behaviours in Italian municipalities. Leveraging the exogeneity of the occurrence of earthquakes, we divide municipalities into 'treated' (affected by the 2012 earthquake) and 'control' (unaffected). Our treated group comprises the 124 municipalities affected by the 2012 earthquake, defined using the official government designation in Law 122/2012 and subsequent decrees (Emilia Romagna Region, 2017; Lombardy Region, 2019). These decrees were issued in response to the

[13] The IHS transformation approximates the natural logarithm while retaining zero-valued observations (Bellemare & Wichman, 2020)

[14] Appendix, Figure A.1 shows PGA-tremor perception relationships.

earthquake and updated throughout the reconstruction efforts, creating a staggered treatment setting. While all treated municipalities initiated treatment simultaneously in 2012, 23% of them exited the treatment (official perimeter) by 2017. This official designation ensures our treated group encompasses all municipalities that experienced significant earthquake impacts, minimising potential selection bias. Figure 1 - I illustrates the officially designated affected area.

The control group comprises all municipalities outside the officially defined impacted areas that are also unaffected by significant earthquakes during 2009-2019. We exclude three sets of earthquake-affected municipalities from the control group: (i) the 57 municipalities impacted by the 2009 L'Aquila earthquake due to absence of pre-treatment data, and (ii) the 136 municipalities affected by the 2016-17 Central Italy earthquake due to distinctive geographic characteristics (Di Bucci et al., 2023; Modica, Urso, & Faggian, 2021) and data limitations regarding damage heterogeneity and road infrastructure impacts (iii) the 1,368 municipalities that experienced ground motion due to the 2012 earthquake but were not included in the officially designated impacted area. The resulting sample includes 6,360 municipalities (124 treated and 6,236 control) between 2009 and 2019.

Recognising Italy's persistent North-South divide (Barone & Mocetti, 2014; Guiso et al., 2016) and the northern location of the 2012 earthquake-impacted municipalities, we conduct robustness checks using an alternative control group of 3,126 unaffected northern municipalities (Figure 1 - II). In the robustness check, we consider two alternative control groups: the 122 municipalities bordering the officially designated impacted area and the 1,278 municipalities that experienced ground motion but were excluded from the officially designated impacted area.

All samples exhibit balanced outcomes and parallel trends between treatment and control groups in pre-treatment periods (Figures A.7 and A.8). Post-earthquake, treated municipalities show distinct patterns: racial hate and hit-and-run accidents spiked in 2012 before gradually declining but remaining elevated; voluntary tax donations to local councils peaked in 2013, then declined sharply, falling below control levels; voluntary tax donations to community-based organisations tracked upward with controls until declining in the final years. These patterns persist regardless of control group composition (Figure A.8). The consistency of road traffic in affected municipalities post-earthquake (Appendix, Figure A.10b) confirms that the hit-and-run spike reflects behavioral change rather than traffic pattern changes.

We examine the effects of key earthquake impact characteristics: human experience of ground shaking and actual damage. For the human experience of ground shaking, as treatment, we use the continuous PGA gradient, which measures the rate of change in peak ground acceleration, being 0 where there is no PGA and non-zero where it varies spatially. This gradient captures the spatial variation in seismic acceleration intensity. Our initial analysis compares treated municipalities (PGA > 0 within the official impact area) to control municipalities (PGA $= 0$), excluding areas with minimal seismic activity outside the impact zone (see Appendix, Figures A.3 - I) (Wald et al., 1999). Two robustness checks later exploit these excluded municipalities as alternative control and treatment groups, respectively.

The damage analysis focuses on municipalities within Emilia-Romagna's official impact area due to data availability, excluding Veneto and Lombardy municipalities. The control group comprises municipalities without damage from major earthquakes between 2009 and 2019 (Appendix, Figure A.5 - I). Additional robustness checks include seven municipalities that experienced damage in 2012, but fell outside the official perimeter.

This approach enables us to more precisely assess the earthquake's impact by considering the geographical designation of affected areas, as well as the specific ground motion characteristics and resulting damage. Additionally, this analysis has significant policy implications, as it enables us to assess the effectiveness of the criteria used by institutions to determine impacted areas. If our findings reveal that significant behavioural changes occur in areas experiencing certain levels of ground motion, even if these areas fall outside the officially designated impact zones, it would suggest a need to refine the criteria for identifying affected communities.

While certain confounders (population, foreign residents) exhibit pre-2012 imbalances between treated and control municipalities (Figure A.9), these imbalances are balanced within treated municipalities across the pre- and post-periods (Figure A.10a), allowing us to include them as control variables in robustness specifications (Imbens & Rubin, 2015).

4 Empirical Strategy

4.1 Event study and difference-in-difference with continuous treatment

To explore which characteristics of the earthquake drive changes in social cohesion behaviours (if any), we employ a difference-in-difference model with continuous treatment intensity (de Chaisemartin & D'Haultfœuille, 2024; de Chaisemartin et al., 2023) in a staggered setting to account for 'switcher' municipalities. While all treated municipalities initiate the treatment simultaneously, in 2012, 23% of them exited the treatment in 2017.

We design two distinct continuous treatments, each based on a different seismic measure, to capture various dimensions of earthquake impact. The first treatment uses Peak Ground Acceleration

(PGA), which captures the ground acceleration of the tremor and correlates with the perceived strength of shaking experienced by residents (Wald et al., 1999). The second relies on the actual damage to private buildings, providing a direct measure of the earthquake's impact by quantifying structural impairment and subsequent reconstruction needs (Italian Government, 2014a).

The 2012 earthquake produced specific geographies of PGA and damage to private buildings (Appendix, Figure A.2). PGA and damages were higher in municipalities within the officially defined impact area. However, the 2012 earthquake caused damages and ground acceleration in other municipalities, albeit to a lesser extent.[15] We exploit this geographical variation in an empirical estimation to assess whether and which of these characteristics had a significant impact on our social cohesion outcomes. By examining this, we can identify which aspects of the earthquake experience (if any) are associated with behavioural changes.

Empirically, we rely on the approach proposed by de Chaisemartin and D'Haultfœuille (2024) and de Chaisemartin et al. (2023), which allows the comparison between the outcome evolution of treated and control with a continuous treatment in a staggered setting, by estimating a weighted average of the slopes of the treated potential outcome function, between each pair of consecutive period(de Chaisemartin & D'Haultfœuille, 2022). Under parallel trends assumptions and with a positive count of untreated, estimates identify a weighted average of the effect, across all treated, of moving their treatment from a period to the next one, scaled by the difference between these two values (de Chaisemartin & D'Haultfœuille, 2022). Formally, we consider the following event study

$$y_{it} = \sum_{j=-k}^{k} \gamma_{1j}\, Dose_i \times\ D_{i,t+j} + \theta_i + \phi_t + \epsilon_{it} \tag{1}$$

$$y_{it} = \rho_0 + \rho_1\, Dose_{it} + \tau_i + \chi_t + \xi_{it} \tag{2}$$

Equations 1 and 2 are estimated for the following behaviours (y_{it}) in municipality *i* at time *t*: $hate_{it}$ (the Inverse Hyperbolic Sine transformation of the incidence of racial hate); HR_{it} (the Inverse Hyperbolic Sine transformation of the incidence of hit-and-run accidents); $LCOB_{it}$ (the log transformation of the tax donors to Local Community-Based Organisations); and MUN_{it} (the log transformation of the tax donors to Local Councils) $Dose_i$ measures the treatment intensity in munic-

[15]The perceived shaking in these municipalities is in the categories 'Light' and 'Weak' (Appendix, Figure A.1).

ipality i, i.e., a fixed attribute of each municipality hit by the 2012 earthquake until it stays in the institutionally-defined perimeters of impacted municipalities (0 otherwise). In equation 1, $D_{i,t+j}$ is the lead/lag dummy variable referring to municipality i in year $t+j$ before or after the earthquake. θ_i are municipal fixed effects, and ϕ_t are year fixed effects and errors are clustered at municipal level (de Chaisemartin & D'Haultfœuille, 2022). In equation 2, τ_i are municipal fixed effects and ϕ_t are year fixed effects. Errors are clustered at municipal level.

Given that several municipalities in Emilia-Romagna moved out of treatment status during the considered time span, we draw on the estimation procedure developed by de Chaisemartin and D'Haultfœuille (2020), which accounts for treatment switching.

We use equations 1 and 2 to assess the two treatment intensity measures ($Dose_i$) mentioned earlier: PGA and actual damage to private buildings. Regarding PGA, the main estimation divides municipalities into two groups. The treatment group contains municipalities within the institutionally defined impacted area. Municipalities unaffected by changes in PGA and spared by major earthquakes since 2009 are in the control group. Municipalities that experienced weak or minor PGA are excluded to evaluate the influence of levels of ground motion intensity that are recognised as high enough to impact the human experiences of earthquake (Appendix, Figures A.3 - I describes the sample). Regarding damage to buildings, our main estimation divides municipalities into treated if they are within the institutionally-defined impacted area and control if they had no damages and did not experience major earthquakes since 2009. All municipalities in the officially designated impact area had damage, but data are available only for those in Emilia-Romagna. Therefore, we exclude affected municipalities in Lombardy and Veneto from this analysis (Appendix, Figures A.5 - I describes the sample). To address potential sample selection bias and strengthen the validity of our findings, we conduct robustness checks using alternative sample definitions for all models with continuous treatment to test the validity of our findings.

Among robustness, we add a vector of controls, X_{it}, which includes population and the share of foreigners —the two variables that showed pre-treatment imbalance between treated and control municipalities, but were balanced for treated pre-post earthquake. Additionally, we estimate a non-staggered specification to account for non-absorbing earthquake impact, also for municipalities that exited the officially recognised impacted area.

As a further robustness check, we evaluate the reliability of the estimates in relation to sample selection by estimating the model using smaller control groups, starting from a control group that includes only municipalities that did not experience any ground shaking in 2012 and are situated in Northern regions. This allows us to estimate the effect of the 2012 earthquake comparing affected municipalities (treated) with spared municipalities (controls) within regions that share relevant socioeconomic and institutional similarities (Barone & Mocetti, 2014; Guiso et al., 2016). We complement this by considering an alternative control group made of municipalities bordering with the official impacted area acknowledged by institutions Also, given the small number of treated municipalities (124) compared to the control group in the main estimation (7,604), among robustness checks we estimate a Synthetic Difference-in Difference (SDID) model (Arkhangelsky et al., 2021)[16] summarised by

$$y_{it} = \delta_1 D_{it} + \delta_{2i} \upsilon_t^T + \varepsilon_{it} \quad (3)$$

where y_{it} represents the IHS-transformed outcomes from equations **??** - **??** in municipality i at time t. D_{it} is a binary treatment indicator that equals 1 if municipality i is treated in year t (0 otherwise). υ_t^T captures unit-specific and time-varying latent factors.

4.2 CF-IV model: damage as a channel for the impact of ground rolling on social cohesion

To address concerns about endogeneity, which suggests that the relationship between actual building damage and social cohesion may be confounded by unobserved municipal characteristics that affect both structural vulnerability and social outcomes, we employ an instrumental variables approach using Peak Ground Velocity (PGV) as an instrument for private dwelling damage.

PGV, which measures the maximum rate of ground displacement during seismic shaking, satisfies the instrumental variable requirements for two key reasons. First, it strongly predicts structural damage risk, since higher ground velocity is strongly correlated to building damage (Wald et al., 1999). Second, it satisfies the exclusion restriction: PGV is determined solely by the earthquake's physical characteristics, rather than by municipal socioeconomic conditions or pre-existing social cohesion levels. This means PGV affects social cohesion only through its impact on structural damage, not through other channels.

We employ a control function approach (Abdulkadiroğlu et al., 2016; Wooldridge, 2015), which enables us to isolate the causal effect of structural damage on social cohesion, purged of potential correlations with pre-existing municipal vulnerabilities. The approach consists of two stages. In the first stage, we estimate how the earthquake's ground motion (PGV) translates into actual building

[16] SDID estimation is a good complement for DID estimation also because it relaxes key assumptions, like the need for parallel trends and treatment exogeneity assumptions (Arkhangelsky et al., 2021).

damage:

$$\text{damage}_{it} = \pi_0 + \pi_1 \text{Post}_t \times \text{PGV}_i + \chi_i + \xi_t + u_{it} \quad (4)$$

where PGV_i is the municipal average of maximum Peak Ground Velocity values during the tremors, Post_t is a dummy for the post-earthquake period, χ_i and ξ_t are municipality and year fixed effects, and u_{it} captures the residual variation in damage not explained by ground motion. This residual represents the component of damage potentially correlated with unobserved municipal characteristics. In the second stage, we estimate the effect of damage on social cohesion outcomes while controlling for this residual correlation:

$$y_{it} = \alpha + \beta_1 \widehat{\text{damage}}_{it} + \beta_2 \hat{u}_{it} + \eta_i + \mu_t + v_{it} \quad (5)$$

where $\widehat{\text{damage}}_{it}$ is the predicted damage from the first stage and $\hat{u}_{it}$ is the estimated residual included as a control function term. The coefficient β_1 identifies the causal effect of structural damage on social cohesion, conditional on the control function $\hat{u}_{it}$ that accounts for the endogenous component of damage.

5 Results

Figure 2 presents event study estimates comparing two earthquake characteristics: Peak Ground Acceleration (PGA), which captures the human perception of shaking intensity, and actual damage to private buildings, which measures the economic impact. For each characteristic, we examine five dimensions of social cohesion: racial hate incidents (out-group hostility), hit-and-run accidents (general individualism), marriages (in-group individualism), voluntary tax donations to community-based organisations (bonding engagement), and voluntary tax donations to local councils (linking social capital).

5.1 Peak Ground Acceleration - Human perception of shaking intensity

The top panel of Figure 2 shows the effects of the earthquake's Peak Ground Acceleration (PGA), comparing municipalities inside the official perimeter of the impacted area with those with no PGA variation (detailed estimates and post-diagnostics in the Appendix, column 1 in Tables A.7, A.8, A.9, A.10 and A.11; sample map in the Appendix, Figure A.3 - I; sample details in the Appendix, TableA.4).

Regarding racial hate, estimates show that incidents rose significantly in years 1-2 post-earthquake, then returned to baseline by year 3 (Figure 2a.). Hit-and-run accidents showed a notable increase in the immediate post-earthquake period. Unlike racial hate, the effect becomes insignificant from year 2 onwards, indicating a more short-lived impact (Figure 2b1.). Marriage rates among Italians decreased significantly immediately after the event, with reductions persisting across multiple years, reflecting sustained changes in in-group couple formation (Figure 2b2.). Voluntary tax donations to local Community-Based Organisations showed no significant immediate effects, but exhibited a significant decline in years 6-7, indicating delayed erosion of bonding social capital (Figure 2b3.). Finally, voluntary tax donations to local councils showed a significant increase in year 2 post-earthquake, suggesting that affected communities initially turned to formal government institutions for support and coordination during the crisis period. However, this increase did not persist (Figure 2c.). In all cases, pre-earthquake period estimates are small and insignificant, and the joint test of nullity of the placebos is always greater than 0.88, supporting the validity of the event study design.

Considering cumulative effects scaled by the interquartile range (moving from low to high exposure based on PGA), racial hate increased by 3.43%, hit-and-run accidents by 3.12%, and marriages decreased by 6.30% (Table 1). The effects on voluntary tax donations were not statistically significant in cumulative terms for PGA.

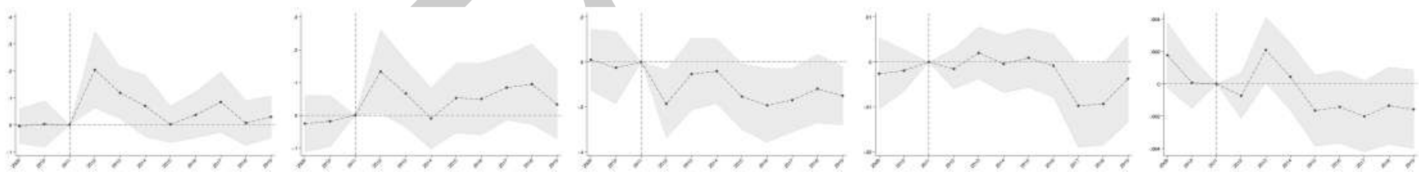
5.2 Actual damage to private buildings - Economic impact

The bottom panel of Figure 2 describes the effects of actual damage to private buildings caused by the 2012 earthquake (detailed estimates and post-diagnostics in Appendix, column 2 in Tables A.7, A.8,A.9, A.10 and A.11; sample map in the Appendix, Figure A.5 - I; sample details in the Appendix, Table A.4). In this case, the estimation considers as treated the 59 Emilia-Romagna municipalities inside the officially designated impacted area due to data limitations. The control group comprises all municipalities with no PGA variation.

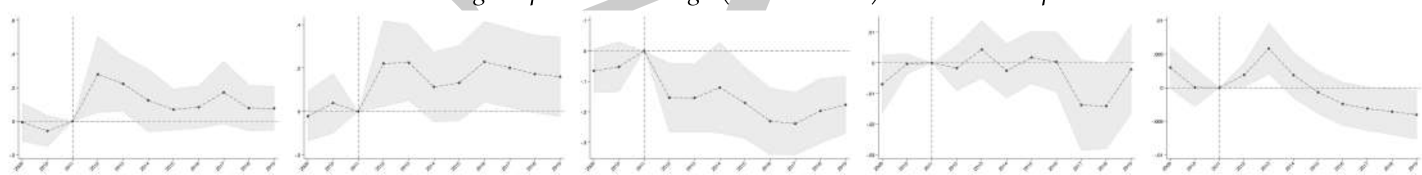
Figure 2: Event study. Impact heterogeneity by earthquake characteristics

Peak Ground Acceleration (PGA) - Human perception of shaking intensity

Out-group attitude	**Individualism**			**Linking social capital**
a. Racial hate	b1. Hit & run	b2. Marriages	b3. Vol. tax to CBOs	c. Vol. tax to council



Actual damage to private buildings (AeDES scale) - Economic impact



Note: Event study estimates of the effect of the 2012 earthquake on (a.) racial hate (out-group attitude), (b1.) hit-and-run accidents (general individualism), (b2.) marriages (in-group individualism), (b3.) voluntary tax donations to community-based organisations (bonding engagement), and (c.) voluntary tax donations to local councils (linking social capital). Estimation using the de Chaisemartin and D'Haultfœuille (2024)'s approach. Grey dots: point estimates; gray bands: 90% confidence intervals, municipal-clustered standard errors. **Top panel**: PGA measure (continuous; 0 for unaffected areas); excludes 2009/2016 earthquake zones and 2012 earthquake areas with PGA $>$ 0 outside official impact area. Appendix, Table **??** columns 1-5 for detailed estimates; Tables **??** and A.4 for sample details and summary statistics; Figure A.3 - I for sample map. **Bottom panel**: actual private building damage (AeDES scale, continuous; 0 for unaffected areas); excludes Lombardy/Veneto (data limits), 2009/2016 earthquake zones and 2012 earthquake areas with damage $>$ 0 outside the official impact area. Appendix, Table **??** columns 6-10 for detailed estimates; Tables **??** and A.4 for sample details and summary statistics; Figure A.5 - I for sample map.

The actual damage to private buildings shows more pronounced, and in some cases more persistent, effects than PGA. Racial hate increased significantly in years 1-2 post-earthquake, then returned to baseline by year 3 (Figure 2a.). Hit-and-run accidents showed significant increases in years 1-2, then again in years 5-6, revealing a more complex temporal pattern than with ground motion measures (Figure 2b1.). Marriages decreased significantly immediately after the earthquake, and this reduction persisted throughout most of the entire post-earthquake period (Figure 2b1.) Voluntary tax donations to community-based organisations showed a significant decline in year 7, indicating delayed erosion of bonding social capital (Figure 2b3.). Voluntary tax donations to local councils showed significant increases in years 1-2, confirming that affected communities initially turned to formal institutions. However, by years 7-8, these donations had declined significantly below baseline (Figure 2c.)

The cumulative effects scaled by the interquartile range (moving from low to high damage exposure) were substantially larger than for ground motion: racial hate increased by 7.34%, hit-and-run accidents by 9.66%, and marriages decreased by 8.92% (Table 1).

5.3 Comparing ground motion and structural damage

The post-earthquake evolution of social cohesion reveals both common patterns and important differences between the effects of ground shaking intensity and structural damage.

Both earthquake characteristics trigger similar initial responses in affected communities. Racial hate incidents increased significantly in years 1-2 post-earthquake under both measures, before returning to baseline levels by year 3. Hit-and-run accidents showed immediate post-earthquake increases regardless of the measure used. Marriage rates among Italians decreased significantly after the earthquake in both cases. Additionally, both exposure measures revealed an initial increase in voluntary tax donations to local councils during the crisis period, followed by delayed decreases in voluntary tax donations to Local Community-Based Organisations in years 6-7.

Despite these common patterns, actual structural damage shows substantially stronger and more persistent effects than ground motion measures (Table 1). Considering cumulative effects scaled by the interquartile range (moving from low (25th percentile) to high (75th percentile) exposure), damage increased racial hate by 7.34% compared to 3.43% for ground motion; hit-and-run accidents by 9.66% compared to 3.12% for ground motion; and decreased marriages by 8.92% compared to 6.30% for ground motion (see Appendix, Table A.6 for more details).

The temporal patterns also differ substantially. While ground motion effects on racial hate and

Table 1: Ground motion vs. structural damage immediate and cumulative effects

	Ground Motion		**Structural Damage**	
	Immediate	*Cumulative*	*Immediate*	*Cumulative*
Racial hate	+	+3.43%	+	+7.34%
Hit-and-run	+	n.s.	+	+9.66%
Marriages	+	-6.30%	+	-8.92%
Voluntary tax to LCBOs	n.s.	n.s.	n.s.	n.s.
Voluntary tax to council	n.s.	n.s.	n.s.	n.s.

Note: Treatment effects are scaled by the interquartile range (IQR) → change from low (25th percentile) to high (75th percentile) exposure. Immediate effects refer to statistically significant impacts in year 1 post-earthquake.

Table 2: Dynamic post-treatment effects by outcome and treatment

Outcome	**Treatment**	1	2	3	4	5	6	7	8
Racial hate	PGA	+**	+**	n.s	n.s.	n.s.	n.s.	n.s.	n.s.
	Dwelling damage	+**	+**	n.s	n.s.	n.s.	n.s.	n.s.	n.s.
Hit-and-run	PGA	+*	n.s	n.s.	n.s.	n.s	n.s.	n.s.	n.s.
	Dwelling damage	+*	+**	n.s	n.s.	+**	+*	n.s.	n.s.
Marriages	PGA	-**	n.s	n.s	-*	-*	-**	n.s	-*
	Dwelling damage	-**	-**	n.s	-**	-***	-***	-***	-***
Voluntary Tax to LCBOs	PGA	n.s.	n.s.	n.s.	n.s.	n.s.	−*	−*	n.s.
	Dwelling damage	n.s	n.s	n.s	n.s.	n.s.	n.s.	−**	n.s.
Voluntary Tax to Council	PGA	n.s	+*	n.s	n.s	n.s.	n.s.	n.s.	n.s.
	Dwelling damage	+*	+**	n.s.	n.s.	n.s.	n.s.	−*	−*

Note: + / − = effect direction, n.s. = not significant, *** p<0.01, ** p<0.05, * p<0.1

hit-and-run were largely confined to years 1-2, damage effects persisted longer, with hit-and-run accidents showing renewed increases in years 5-6. Marriage reductions, though present under both measures, were more consistently significant throughout the post-earthquake period under the damage measure. Most notably, voluntary tax donations to local councils, which initially increased under both measures, showed a significant late-stage decline (years 7-8) only under the damage measure, suggesting cumulative effects of prolonged reconstruction burdens on linking social capital (Table 2).

These patterns suggest that the visible and measurable impacts of the earthquake—damaged buildings and ongoing reconstruction burdens have a stronger influence on social cohesion than the physical earth movements and shared experience of shaking itself. Social cohesion may rebuild relatively quickly after the shared experience of ground shaking, but struggles more to overcome the persistent burden of economic damage.

The multi-phase evolution reveals a complex trajectory. Initially, the earthquake appears to trigger self-preservation and individualistic instincts, leading to spikes in both in-group and out-group antisocial behaviours (hit-and-run accidents and racial hate) and a sharp decline in marriages. Simultaneously, affected communities turned to formal government institutions, with voluntary tax donations to local councils increasing significantly. As time progresses and the acute sense of danger subsides, a divergence emerges. Hit-and-run accidents and racial hate returned to baseline by year 3, while marriage reductions persisted throughout the study period, particularly under the damage measure. The delayed decreases in voluntary tax donations in years 6-7 suggest that while communities initially sought institutional coordination during acute crisis, the cumulative burden of reconstruction gradually undermined civic engagement across both bonding and linking social capital.

The swift return of hit-and-run accidents to pre-earthquake levels could reflect people recognising the collective benefit of maintaining a secure environment, making individualistic motivations converge with prosocial behaviour, as the personal desire for safety reinforces adherence to community-protective norms. In contrast, the persistence of racial hate—though temporary—suggests that social norms about multicultural coexistence may not be deeply ingrained. The limited experience with demographic changes resulting from recent immigration in the affected communities (Emilia-Romagna Region, 2015) may have contributed to this phenomenon, favouring exclusionary behaviours against out-groups during times of stress (Dinesen et al., 2020). Without rooted norms of multicultural coexistence, the dominant group might have excluded ethnic minorities due to fears of hardship and the perceived costs of cooperating with unfamiliar individuals (Chung & Rhee, 2022; Dinesen et al., 2020). Ethnic minorities, being less integrated into community networks, could have become scapegoats for stress relief (Allport, 1988). Additionally, the post-earthquake disruption may have created opportunities to express prejudices with less risk of penalties (Bursztyn et al., 2022).

The sustained reduction in marriages indicates a lasting change in personal priorities and risk assessment also among members of the same social group. It appears that individuals maintained a focus on personal autonomy and individual resource management.

This resulted in a community where basic safety concerns were addressed (hit-and-run accidents), institutional support was initially mobilised (voluntary tax to councils), but longer-term in-group commitments (marriages) decreased, intergroup tensions (racial hate) persisted temporarily, and eventually civic engagement across both bonding and linking dimensions eroded. This complex picture underscores the multifaceted nature of social cohesion in the face of natural disasters and suggests that while certain core societal norms can quickly reassert themselves, other aspects of social cohesion—particularly those involving long-term commitments, intergroup relations, or sustained civic participation—may require more targeted interventions to fully recover.

5.4 DID-IV estimates

Our Control Function Instrumental Variable (CF-IV) results (Table 3) focus on municipalities that experienced positive Peak Ground Velocity (PGV) from the 2012 earthquake, exploiting PGV's exogeneity with respect to municipal characteristics and its strong correlation with building damage (Wald et al., 1999).

Table 3: Damage and social cohesion - CF-IV estimates

	Damage (1)	Racial hate (2)	Hit-and-Run (3)	Marriage (4)	Vol tax to LCBOs (5)	Vol Tax to Council (6)
			Panel A. Northern sample			
Post × Quake	0.414***					
	(0.016)					
Damage		0.170***	0.102**	-0.142***	-0.001	0.002***
		(0.089)	(0.051)	(0.042)	(0.004)	(0.0009)
Observations	48,136	48,136	48,136	48,136	48,136	48,136
Municipalities	4,376	4,376	4,376	4,376	4,376	4,376
			Panel B. Neighbouring sample			
Post × Quake	0.372***					
	(0.014)					
Damage		0.191***	0.025	-0.135**	-0.009	0.007***
		(0.073)	(0.062)	(0.062)	(0.006)	(0.001)
Observations	1,991	1,991	1,991	1,991	1,991	1,991
Municipalities	181	181	181	181	181	181
Municipality FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓

Note: *** p<0.01, ** p<0.05, * p<0.1. 1,000-replication bootstrapped SE (Wooldridge, 2015)

The estimates in column (1) correspond to the first-stage, showing that PGV is a good predictor of dwelling damage. Those in columns (2)-(6), instead, reproduce the impact of an increase in dwelling damage, induced by PGV, on racial hate, hit-and-run accidents, marriages, voluntary tax donation to Local Community-Based-Organisations and voluntary tax donation to Local Council. They confirm estimates from the event-study and difference-in-difference setting.

6 Robustness check and alternative explanations

6.1 Robustness check

As a preliminary robustness check, we evaluate the sensitivity of the estimates to sample selection by estimating equation 1 for the specified outcomes by replacing the broad control group —comprising all municipalities unaffected by a recent significant earthquake— with alternative control groups.

We start focusing on the subgroup of unaffected municipalities situated in the Northern regions. This test is useful for checking whether the results remain valid when comparing municipalities that share similar socioeconomic and cultural outlooks (Barone & Mocetti, 2014; Guiso et al., 2016), and it supports our main results (detailed estimates in the Appendix, columns 3-4 in Tables A.7, A.8, A.9, A.10 and A.11; event study plots in Figure A.11; sample map in Figure 1 - II; sample details in Tables A.3 panel b. and A.4 panel b.). Additionally, we consider a control group that comprises only the municipalities bordering the perimeter of the officially impacted area, to see that results are again confirmed (detailed estimates in the Appendix, columns 5-6 in Tables A.7, A.8, A.9, A.10 and A.11; event study plots in Figure A.12)

To address potential selection concerns, we re-estimate all specifications controlling for population and foreign share—the two variables that showed pre-treatment imbalance, but were balanced pre/post-treatment for the treated group. Results are nearly identical with and without controls, suggesting that our findings are not driven by compositional differences between treated and control municipalities (Appendix, Figures A.13-A.15).

Next, we consider the Synthetic Difference-in-Difference as an alternative model specification to account for the relatively small size of the treated group, although in this case, we have to consider a binary treatment specification. This alternative model specification allows us to see whether our results are confirmed when relaxing concerns of selection bias, accounting for the small number of treated municipalities compared to control, including covariates, relaxing the parallel trend assumption and constructing the control group through a weighted combination of untreated units that closely match the pre-treatment characteristics and trends of the treated units. By improving the counterfactual, SDID estimates provide insightful evidence regarding the internal validity of our results with respect to the control group definition. Estimates confirm the dynamics that we observed in our main estimation (Appendix, Figure A.16, Tables A.12 A.13 A.14).

We then estimate a model specification that assumes a non-absorbing treatment for the 23% of impacted municipalities which were removed from the official impacted perimeter in 2017, to see that our main results are confirmed (Appendix, Tables A.15-A.16 and Figures A.17-A.19).

Another robustness check accounts for the role of persistency, considering that previous work in Italy suggests that areas with previous experience of major earthquakes might strengthen their propensity to pay taxes, attend church, and donate blood (Buonanno et al., 2023). We perform two tests. First, we exclude from our main control group those municipalities that experienced a major earthquake between 1900 and 2008, complementing the exclusion of those hit by the 2009 and 2016 earthquakes, as well as those that experienced ground shaking in 2012. As the second test, we consider only those municipalities that experienced a major earthquake between 1900 and 2008 as the control group. Both tests confirm our main estimates (Appendix, Figures A.20-A.21).

Next, we consider alternative definitions of treatment and control groups which account for the fact that ground motions extended beyond the administrative boundaries of the official designation of affected areas. Hence, we test whether our results remain stable when accounting for municipalities that experienced earthquake effects but were excluded. This approach allows us to address potential sample selection bias and provide a more comprehensive understanding of the earthquake's impact across a broader range of affected areas.

Our first robustness check broadens the treatment definition. For ground motions, we include all municipalities with PGA > 0 due to the 2012 earthquake expanding our sample to over 1,000 municipalities (sample maps in the Appendix, Figures A.3 - II and A.4 - II, sample description in Tables A.3 panel e. and A.4 panel e.). The control group comprises all municipalities with PGA $= 0$ in 2012, excluding those affected by the 2009 and 2016 earthquakes. This broader analysis suggests that changes in social cohesion are attenuated with lower seismic intensity (Appendix, Figure A.22-top panel).

Our second robustness check compares municipalities that experienced only weak seismic activity to unaffected ones (Figures A.6 shows the considered samples). In these lightly affected areas, we find only minor effects (Appendix, Figure A.22-bottom panel).

Our final robustness check compares municipalities within the officially designated impact zone against the municipalities that experienced only weak or light seismic activity outside the zone (sample maps in Figures A.3 - III and A.4 - III; sample description in Table A.3 panel f. and A.4 panel f.).[17]. Results confirm significantly higher racial hate and hit-and-run incidents, and fewer marriages in the more strongly affected official impact zone (Appendix, Figures **??** - **??** and Table **??**). This pattern of relevant effects in areas that experienced noticeable ground motion and dam-

[17] PGA values are normalized by subtracting the mean PGA observed outside the official zone from each observation within the zone. Observations outside the official zone are assigned a PGA value of zero. The maximum PGA values recorded outside the official perimeter were 0.02g, corresponding to 'light'-'moderate' shaking (Wald et al., 1999)

ages provides additional support for the earthquake's role in driving the observed changes in social cohesion.

Overall, this final evidence suggests that while severe seismic activity triggered immediate and substantial changes in social cohesion, mere exposure to weak shaking produced only minor and delayed effects.

6.2 Alternative explanation

We rule out alternative compositional mechanisms in the treated areas which could explain our results, by finding no significant pre–post changes in population dynamics or mobility patterns (Appendix, Figure A.10).

We then check whether our results regarding marriages could be explained by couples substituting cohabitation for formal marriages. Having to rely on Census data for unmarried couples, the pre-post analysis can only be conducted over a two-year period (2011-2021). Nonetheless, we find that municipalities hit by the 2012 earthquake had significant decreases in unmarried couples compared to the spared municipalities (Appendix, Figure A.23.

7 Discussion

The evidence presented in the previous sections reveals distinct changes in social cohesion in communities impacted by the 2012 earthquake. Our findings show that the initial shock appears to have activated immediate self-preservation in affected municipalities, with simultaneous increases in antisocial behaviour (racial hate and hit-and-run accidents) and decreases in social bonds (marriages). This suggests that the initial shock eroded social cohesion.

The subsequent years showed divergent recovery patterns. While hit-and-run accidents, governed by social norms and legal enforcement, quickly returned to pre-earthquake levels, behaviours with greater individual discretion —racial hate and marriage decisions— showed more persistent changes towards increased individualism, suggesting that the earthquake's disruption to social cohesion endured particularly in domains where personal choices faced fewer institutional or normative constraints.

The comparison across different measures of earthquake exposure provides additional insights into how the disaster affected social cohesion. Municipalities that experienced tangible damage to buildings had substantially larger and more enduring changes to racial hate, hit-an-run accidents and marriages.

This difference suggests that visible, measurable and lasting signs of the earthquake's destruction, rather than the temporary experience of ground motion, played a crucial role in eroding social cohesion. The stronger response to actual damage likely reflects both the persistent physical reminders of community vulnerability and the concrete economic challenges of rebuilding and recovery. This interpretation suggests that the erosion of social cohesion may be driven more by the material challenges of post-disaster recovery (damaged properties, financial strain, and resource competition) than by the temporary psychological shock of experiencing seismic movements, highlighting how economic pressure on individuals and communities can strain social bonds more durably than the shared experience of natural disaster itself.

8 Conclusion

Using the 2012 major earthquake that affected Northern Italy, this paper provides novel causal evidence on how natural disasters impact social cohesion. Our findings reveal that earthquakes erode different aspects of social cohesion, challenging simplified narratives.

The results demonstrate that the earthquake triggered an immediate shift toward self-preservation, manifesting as increased antisocial behaviours (racial hate and hit-and-run accidents) and decreased social bonds (marriages). However, while hit-and-run accidents quickly returned to pre-earthquake levels, higher racial hate and reduced marriage rates persisted, indicating more durable changes in domains governed by higher individual discretion.

Our analysis of different measures of earthquake exposure provides crucial insights into underlying mechanisms. While experiencing the earthquake itself had consistent effects regardless of tremor intensity, municipalities that suffered tangible building damage showed substantially larger and more persistent behavioural changes. This suggests that visible destruction and its associated economic challenges played a more significant role in eroding social cohesion than the temporary experience of ground motion.

These findings have three key implications for disaster policy. First, recovery efforts must extend beyond physical reconstruction to actively preserve social cohesion, particularly in communities with substantial structural damage. Second, assessment frameworks should incorporate multiple behavioural indicators to capture the complex dynamics of post-disaster social change. Third, vulnerable groups require targeted protection during recovery periods when institutional oversight may be reduced.

Our results advance the theoretical understanding of earthquake impacts on social dynamics, supporting recent conceptual developments about simultaneous strengthening and weakening of different aspects of social cohesion. The finding that visible damage had more persistent effects than the earthquake experience itself suggests that economic recovery challenges may strain social bonds more durably than the shared trauma of the disaster.

Future research could build on these findings in three directions. First, examining how the duration and quality of reconstruction efforts influence the recovery of social cohesion. Second, investigating the long-run persistence of behavioural changes to determine if they represent permanent shifts in social dynamics or gradually revert to pre-disaster patterns. Third, studying whether communities with repeated earthquake exposure develop different patterns of social response may potentially offer insights into adaptation mechanisms and resilience building. Such research would enhance our understanding of how to preserve community cohesion in the face of increasingly frequent natural disasters.

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Appendix

A Data and estimation samples description

Table A.1: Variables description

Variable	Description	Source
Outcomes		
racial hate	racial hate events per 100,000 inhabitants (Inverse Hyperbolic Sine)	Lunaria
hit and run	percentage of Hit&Run accidents on total road accidents with dead &/or injured people (Inverse Hyperbolic Sine)	ISTAT
marriages	marriages between Italians per 10,000 Italians (Inverse Hyperbolic Sine)	ISTAT
property crimes	thefts per 1,000 inhabitants (logs)	ISTAT
intimate partner violence (IPV)	female access to specialised support for gender-based violence per 10,000 inhabitants (logs)	Emilia-Romagna Anti-Violence Centres & Casa delle Donne; Emilia-Romagna Region; Tuscany Region; Marche Region
Treatment		
2012 earthquake affected area	Dummy = 1 for the municipalities affected by the 2012 earthquake officially recognised as such by national authorities (0 otherwise)	Emilia-Romagna Region; Lombardy Region, Italian Parliament
Treatment intensity		
2012 PGA	municipal average of maximum peak ground acceleration during earthquake in the municipalities affected by the 2012 earthquake officially recognised as such by national authorities	USGS
2012 PGV	municipal average of maximum peak ground velocity during earthquake in the municipalities affected by the 2012 earthquake officially recognised as such by national authorities	USGS
2012 damage to private buildings	municipal average of the ordinal values of the AeDES scale of actual post-earthquake damages to private buildings for the Emilia-Romagna municipalities affected by the 2012 earthquake officially recognised as such by national authorities (logs) (0 otherwise)	Emilia-Romagna Region

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Table A.2: Variables description

Variable	Description	Source
Controls		
foreign population	share of foreign population on total population	ISTAT
population	resident population in thousands	ISTAT
refugee presence	hosted refugees per 10,000 inhabitants (logs)	OpenPolis-Centri d'Italia

Table A.3: Estimation samples for racial hate, hit-and-run accidents and marriages

Treated	Control
panel a. 0/1 treatment main sample (Figure 1 - I)	
124 municipalities in the officially designated area affected by the 2012 earthquake	7,604 municipalities outside officially designated areas impacted by major earthquake between 2009 and 2019
panel b. 0/1 treatment robustness sample I (Figure 1 - II)	
124 municipalities in the officially designated area affected by the 2012 earthquake	4,317 Northern municipalities outside officially designated areas between 2009 and 2019
panel c. PGA & PGV (continuous) treatments main sample (Figure A.3 - I; Figure A.4 - I)	
124 municipalities in the official designated area affected by the 2012 earthquake	6,326 municipalities: unaffected by a major earthquake between 2009 and 2019 or PGA (PGV) $= 0$ in 2012
panel d. damage (continuous) treatments main sample (Figure A.5 - I)	
59 municipalities in the official designated area affected by the 2012 earthquake	7,597 municipalities: unaffected by a major earthquake between 2009 and 2019 or 0 damages to private buildings in 2012
panel e. PGA & PGV (continuous) treatments robustness sample I (Figure A.3 - II; Figure A.4 - II)	
1,402 municipalities: PGA (PGV)> 0 due to the 2012 earthquake	6,326 municipalities: unaffected by a major earthquake between 2009 and 2019 or PGA (PGV) $= 0$ in 2012
panel f. PGA & PGV (continuous) treatments robustness sample II (Figure A.3 - III; Figure A.4 - III)	
124 municipalities in the official designated area affected by the 2012 earthquake	1,278 municipalities: PGA (PGV) > 0 but outside the official designated area
panel g. PGA & PGV (continuous) treatments robustness sample III (Figure A.6 - I; Figure A.6 - II)	
1,278 municipalities: PGA (PGV) > 0 outside the official designated area	6,326 municipalities: unaffected by a major earthquake between 2009 and 2019 or PGA (PGV) $= 0$ in 2012
panel h. damage (continuous) treatments robustness sample I (Figure A.5 - II)	
66 municipalities: damage > 0 due to the 2012 earthquake	7,597 municipalities: unaffected by a major earthquake between 2009 and 2019 or 0 damages to private buildings in 2012
panel i. damage (continuous) treatments robustness sample II (Figure **??** *- ???)*	
59 municipalities in the officially designated area affected by the 2012 earthquake	7 municipalities: damage $= 0$ but outside the officially designated area
panel j. damage (continuous) treatments robustness sample III (Figure **??** *- ???)*	
7 municipalities outside the officially designated area with damage> 0	7,597 municipalities: unaffected by a major earthquake between 2009 and 2019 or 0 damages to private buildings in 2012

Table A.4: Summary statistics

Variables	n	mean	sd	min	max
panel a. 0/1 treatment main sample					
Outcomes					
racial hate (IHS)	85,008	0.083	0.508	0	7.849
hit & run (IHS)	85,008	0.071	0.0392	0	5.298
marriages (IHS)	85,008	3.767	1.323	0	7.943
property crimes (logs)	1,133	3.233	0.472	1.517	4.404
intimate partner violence (logs)	240	2.891	0.586	0.730	5.308
Control variables					
population	85,008	7.676	42.249	0.028	2820.22
foreign population	85,008	0.063	0.043	0	0.397
panel b. 0/1 treatment robustness sample I					
racial hate (IHS)	48,851	0.085	0.523	0	7.849
hit & run (IHS)	48,851	0.077	0.417	0	5.298
marriages (IHS)	48,851	3.701	1,363	0	7.943
property crimes (logs)	517	3.378	0.4398	2.063	4.384
intimate partner violence (logs)	100	2.968	0.396	1.529	3.633
Control variables					
population	48,851	6.261	29.203	0.028	1406.242
foreign population	48,851	0.077	0.042	0	0.397
panel c. PGA & PGV (continuous) treatments main sample.					
Outcomes					
racial hate (IHS)	70,950	0.072	0.476	0	7.849
hit & run (IHS)	70,950	0.063	0.370	0	5.298
marriages (IHS)	70,950	3.748	1.388	0	7.943
property crimes (logs)	924	3.172	0.481	1.517	4.404
intimate partner violence (logs)	140	2.912	0.568	1.327	5.308
Treatment intensity					

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Table A.4 continued

Variables	n	mean	sd	min	max
PGA	70,950	0.001	0.006	0	0.15
PGV	70,950	0.045	0.424	0	10
panel d. damage (continuous) main sample					
racial hate (IHS)	84,216	0.083	0.508	0	7.849
hit & run (IHS)	84,216	0.071	0.391	0	5.298
marriages (IHS)	84,216	3.769	1.326	0 7.9423	
property crimes (logs)	1,122	3.228	0.471	1.517	4.404
intimate partner violence (logs)	240	2.891	0.586	0.7230	5.308
Treatment intensity					
damage to private buildings (logs)	84,216	0.005	0.0734	0	1.705
panel e. PGA & PGV (continuous) treatments robustness sample I					
Outcomes					
racial hate (IHS)	85,008	0.083	0.508	0	7.849
hit & run (IHS)	85,008	0.071	0.392	0	5.298
marriages (IHS)	85,008	3.767	1.323	0	7.943
property crimes (logs)	1,133	3.233	0.472	1.517	4.404
intimate partner violence (logs)	240	2.891	0.568	0.730	5.308
Treatment intensity					
PGA	85,008	0.002	0.006	0	0.15
PGV	85,008	0.205	0.528	0	10
panel f. PGA & PGV (continuous) treatments robustness sample II					
racial hate (IHS)	15,422	0.141	0.637	0	5.943
hit & run (IHS)	15,422	0.118	0.494	0	5.298
marriages (IHS)	15,422	3.849	0.907	0	7.617
property crimes (logs)	264	3.564	0.322	2.798	4.335
intimate partner violence (logs)	140	2.898	0.532	0.730	3.749
Treatment intensity					
PGA	15,422	0.002	0.011	0	0.15

Continued on next page

Table A.4 continued

Variables	n	mean	sd	min	max
PGV	15,422	0.146	0.759	0	10
panel g. PGA & PGV (continuous) robustness sample III					
racial hate (IHS)	83,644	0.08197	0.0506	0	7.849
hit & run (IHS)	83,644	0.069	0.388	0	5.298
marriages (IHS)	83,644	3.769	1.3298	0	7.943
property crimes (logs)	1,078	3.204	0.462	1.517	4.404
intimate partner violence (logs)	200	2.871	0.634	0.7296	5.308
Treatment intensity					
PGA	83,644	0.002	0.004	0	0.02
PGV	83,644	0.1695	0.379	0	2
panel h. damage (continuous) treatment robustness sample I					
Outcomes					
racial hate (IHS)	84,293	0.083	0.508	0	7.849
hit & run (IHS)	84,293	0.071	0.392	0	5.298
marriages (IHS)	84,293	3.769	1.325	0	7.943
property crimes (logs)	1,122	3.228	0.471	1.517	4.404
intimate partner violence (logs)	240	2.891	0.568	0.730	5.308
Treatment intensity					
damage to private buildings (logs)	84,293	0.006	0.077	0	1.705
panel i. damage (continuous) treatment robustness sample II					
Outcomes					
racial hate (IHS)	726	0.229	0.705	0	3.889
hit & run (IHS)	726	0.295	0.687	0	3.507
marriages (IHS)	726	3.796	0.433	0	4.664
property crimes (logs)	44	3.826	0.243	3.379	4.335
intimate partner violence (logs)	40	2.9897	0.206	2.347	3.392
Treatment intensity					
damage to private buildings (logs)	726	0.639	0.538	0	1.705

Continued on next page

Table A.4 continued

Variables	n	mean	sd	min	max
panel j. damage (continuous) treatment robustness sample III					
Outcomes					
racial hate (IHS)	83,644	0.082	0.506	0	7.849
hit & run (IHS)	83,644	0.069	0.388	0	5.298
marriages (IHS)	83,644	3.787	1.3298	0	7.042
property crimes (logs)	1.078	3.204	0.462	1.517	4.404
intimate partner violence (logs)	200	2.871	0.634	0.7296	5.308
Treatment intensity					
damage to private buildings (logs)	83,644	0.002	0.069	0	3.5

Table A.5: Post-earthquake building damage assessment. AeDES scale (Emilia-Romagna Region, 2024b; Italian Government, 2014b)

AeDES category	damage type	value
A	none	0
B-C	light	1
E0	moderate-severe	2
E1	severe	3
E2	considerably severe	4
E3	extremely severe	5

Figure A.1: National Institute of Geophysics and Volcanology Shake Map of Peak Ground Acceleration and Peak Ground Velocity for the 2012 earthquake (INGV, 2022)

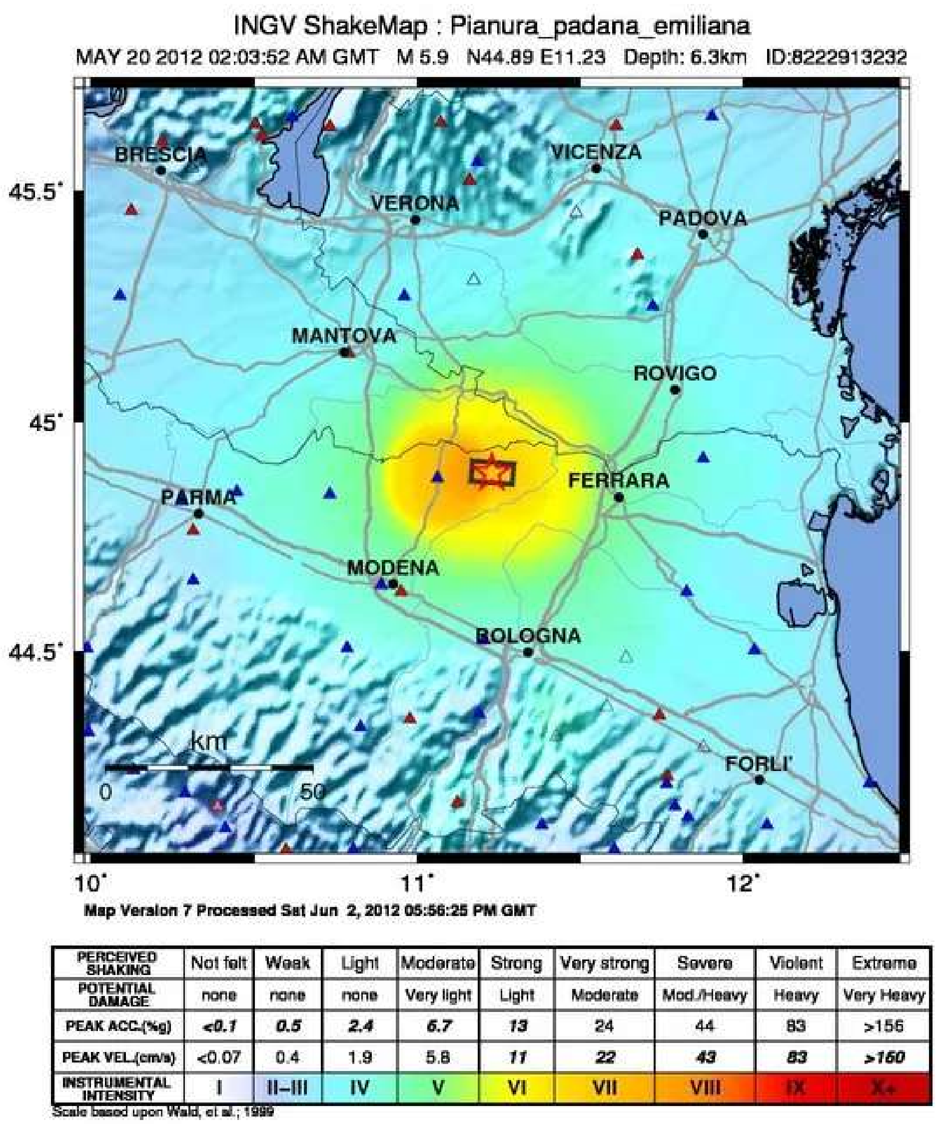


Figure A.2: Peak Ground Acceleration (PGA), Peak Ground Velocity (PGV) and private buildings damage due to the 2012 earthquake

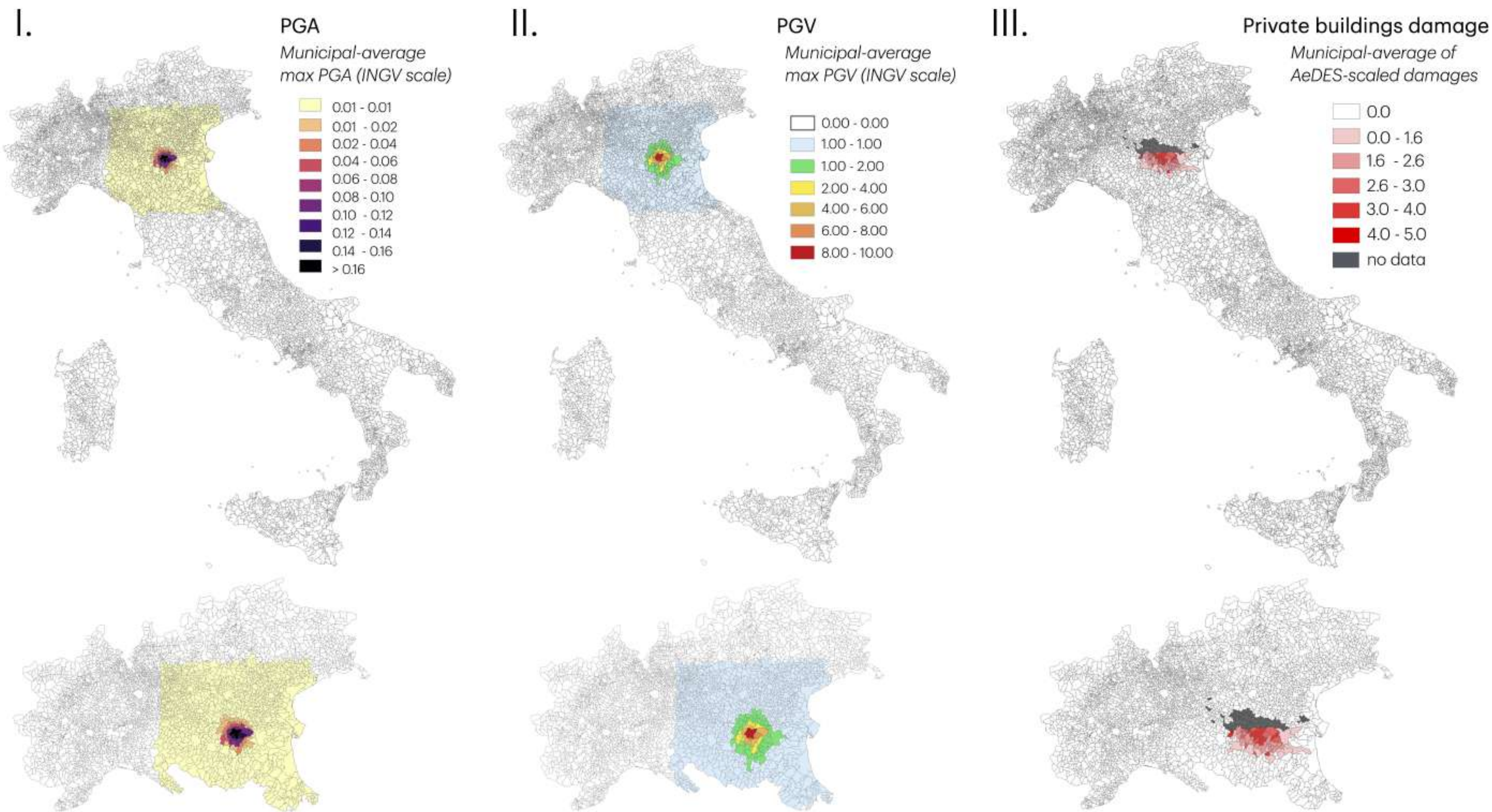
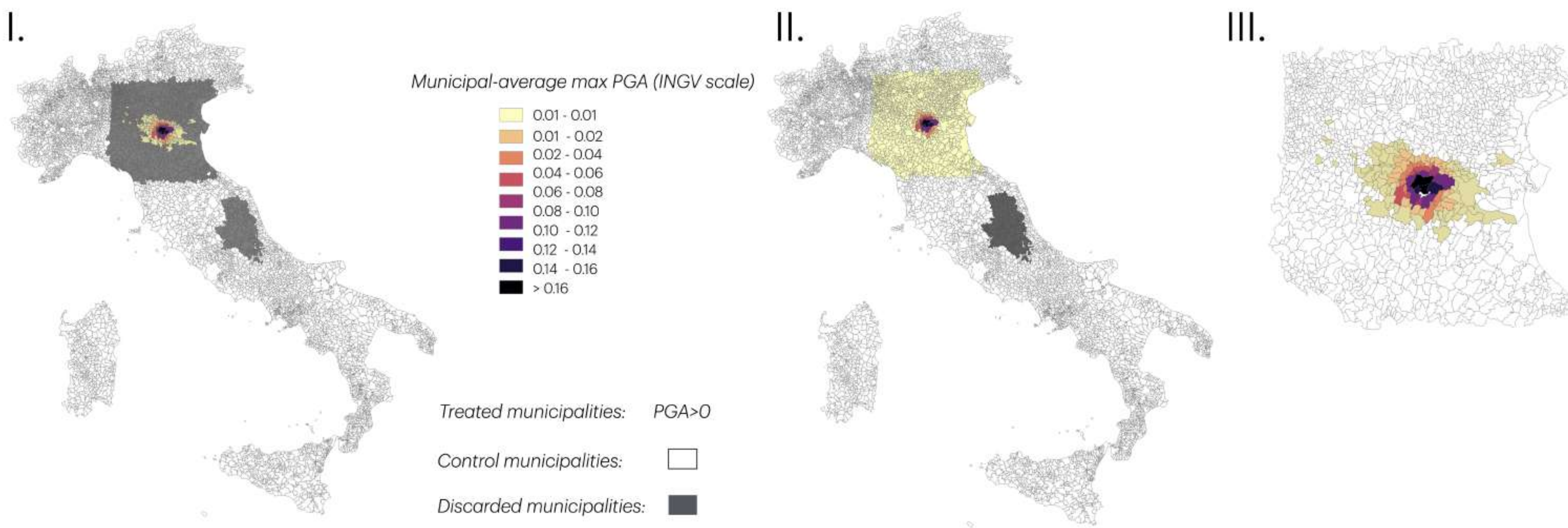
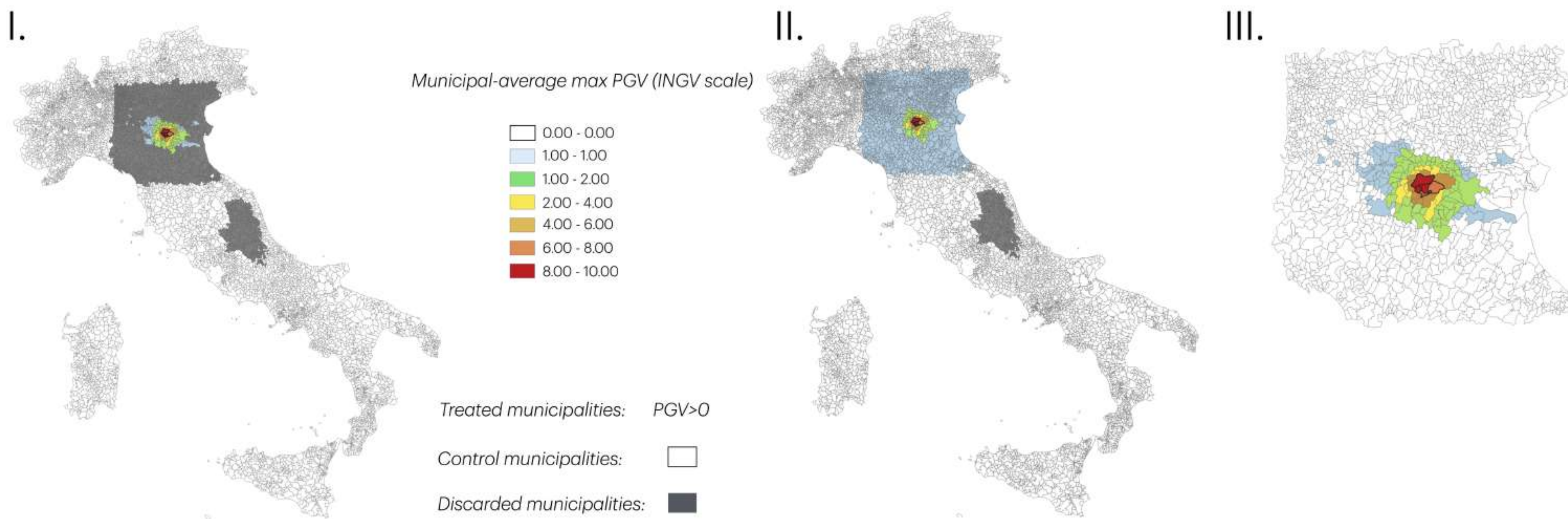


Figure A.3: Classification of municipalities to estimate the 2012 earthquake Peak Ground Acceleration (PGA) impact



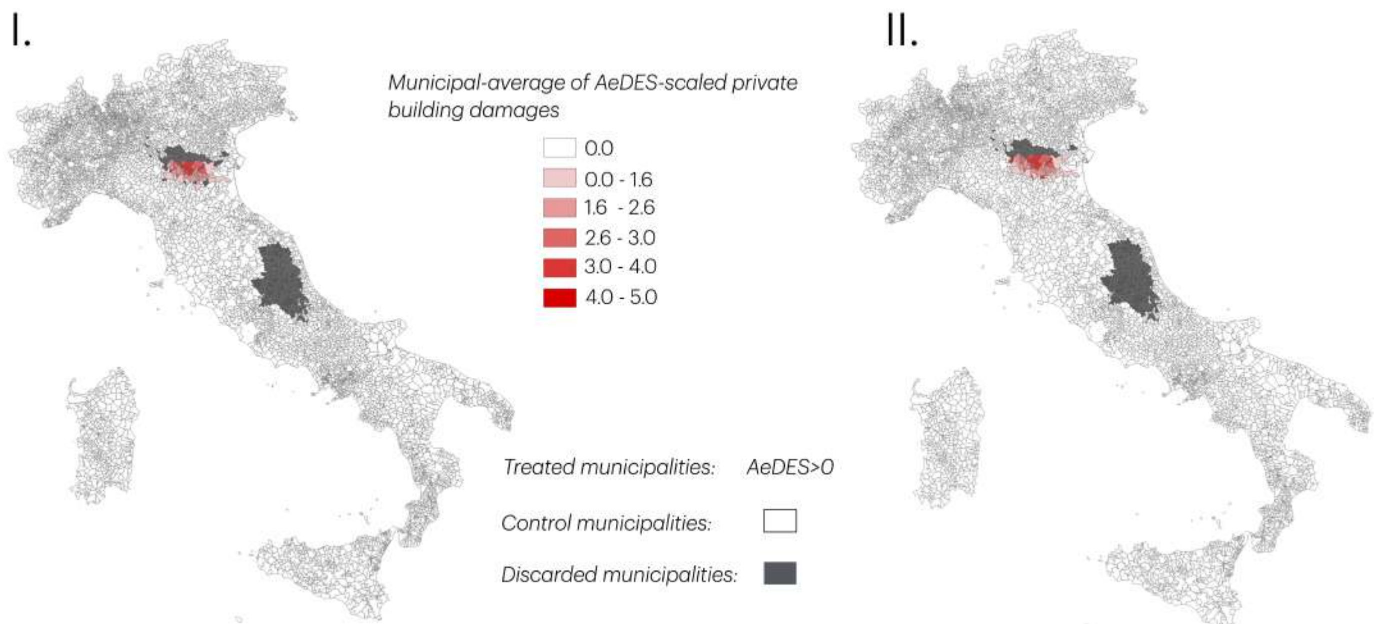
Note: **Figure A.3 - I**: main sample for estimating the 2012 earthquake PGA effect. Treated municipalities (coloured areas) are those within the official 2012 earthquake perimeter. Control municipalities (white areas) experienced no major earthquakes between 2009 and 2019. Discarded municipalities (grey areas) either experienced a major earthquake between 2009 and 2019 or had PGA>0 in 2012 but were outside the official earthquake perimeter. **Figure A.3 - II**: sample for a robustness check. Treated municipalities (coloured areas) are all those with PGA>0 due to the 2012 earthquake. Control municipalities (white areas) experienced no major earthquakes between 2009 and 2019. Discarded municipalities (grey areas) experienced a major earthquake between 2009 and 2019. **Figure A.3 - III**: sample for an alternative robustness check. Treated municipalities (colored areas) are those within the official 2012 earthquake perimeter. Control municipalities (white areas) had PGA>0 in 2012 but were outside the official earthquake perimeter.

Figure A.4: Classification of municipalities to estimate the 2012 earthquake Peak Ground Velocity (PGV) impact



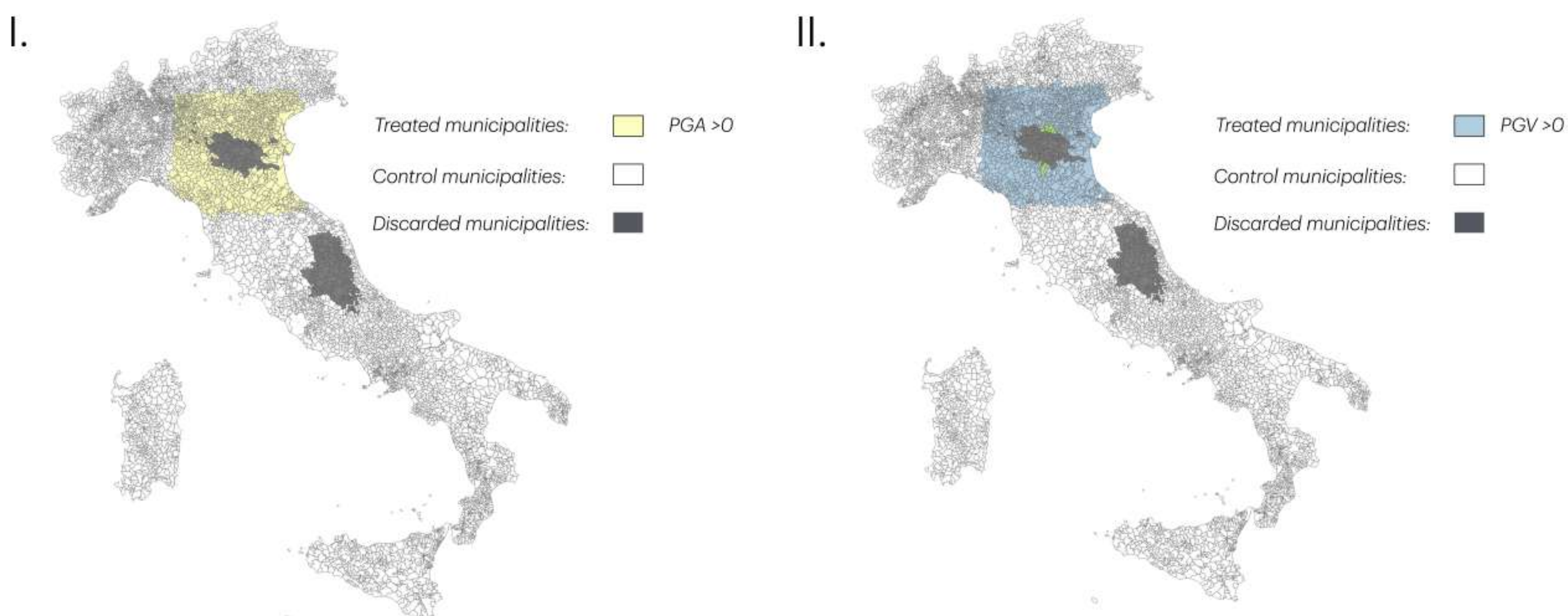
Note: **Figure A.4 - I**: main sample for estimating the 2012 earthquake PGV effect. Treated municipalities (coloured areas) are those within the official 2012 earthquake perimeter. Control municipalities (white areas) experienced no major earthquakes between 2009 and 2019. Discarded municipalities (grey areas) either experienced a major earthquake between 2009 and 2019 or had PGV$>$ 0 in 2012 but were outside the official earthquake perimeter. **Figure A.4 - II**: sample for a robustness check. Treated municipalities (coloured areas) are all those with PGV$>$ 0 due to the 2012 earthquake. Control municipalities (white areas) experienced no major earthquakes between 2009 and 2019. Discarded municipalities (grey areas) experienced a major earthquake between 2009 and 2019. **Figure A.4 - III**: sample for an alternative robustness check. Treated municipalities (coloured areas) are those within the official 2012 earthquake perimeter. Control municipalities (white areas) had PGV$>$ 0 in 2012 but were outside the official earthquake perimeter.

Figure A.5: Classification of municipalities to estimate the 2012 earthquake damage to private buildings [TO BE COMPLETED, MISSING III]



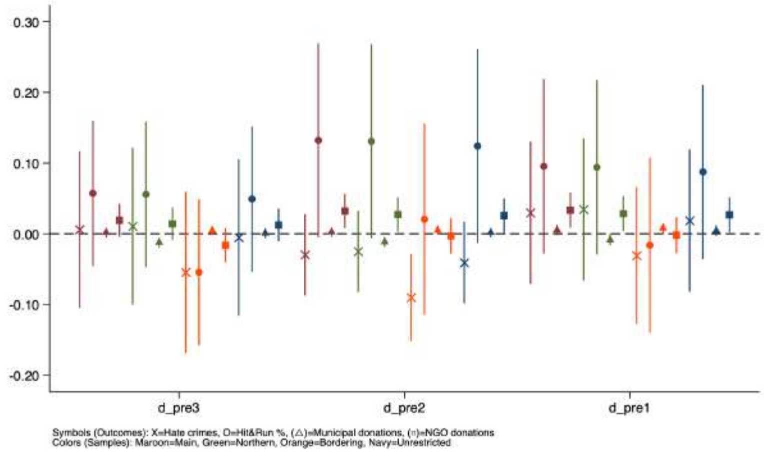
Note: **Figure** A.5 **- I**: main sample for estimating the 2012 earthquake damage to private building effect. Treated municipalities (coloured areas): the Emilia-Romagna municipalities within the official 2012 earthquake perimeter. Control municipalities (white areas): experienced no major earthquakes between 2009 and 2019. Discarded municipalities (grey areas): either experienced a major earthquake between 2009 and 2019 or had damages in 2012 but were outside the official earthquake perimeter, or we lack data. **Figure** A.5 **- II**: sample for a robustness check. Treated municipalities (coloured areas): all the Emilia-Romagna municipalities with damage to private buildings due to the 2012 earthquake. Control municipalities (white areas): experienced no major earthquakes between 2009 and 2019. Discarded municipalities (grey areas): either experienced a major earthquake between 2009 and 2019 or had damages in 2012 but were outside the official earthquake perimeter, or we lack data.

Figure A.6: Classification of municipalities to estimate the 2012 earthquake PGA and PGV impact. Treatment group: light and weak PGA (PGV); Control group: PGA $= 0$ [TO BE COMPLETED: MISS DAMAGES]



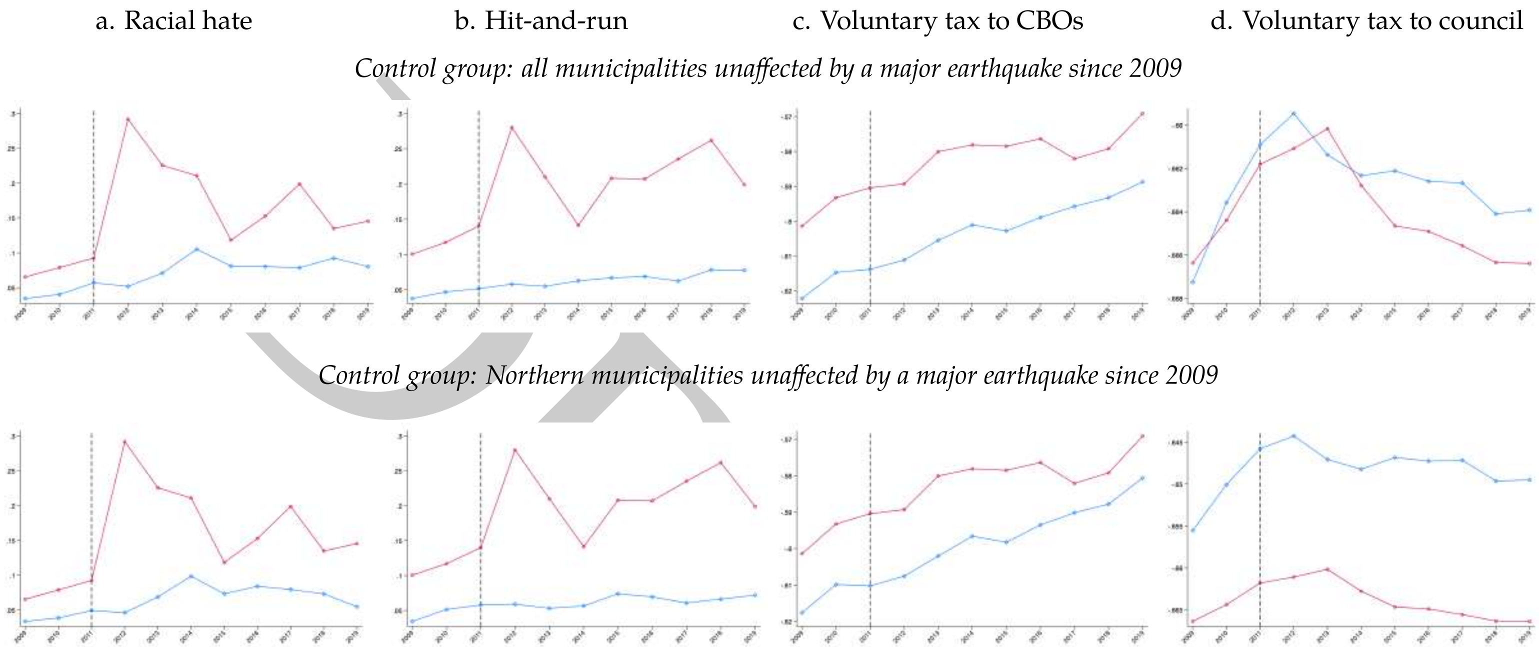
Note: **Figure** A.6 **- I (II)**. Treated municipalities (coloured areas): municipalities with PGA$>$ 0 outside the official 2012 earthquake perimeter. Control municipalities (white areas): experienced no major earthquakes between 2009 and 2019. Discarded municipalities (grey areas): either experienced a major earthquake between 2009 and 2019 or were inside the official earthquake perimeter.

Figure A.7: Pre-earthquake comparisons in outcomes (treated vs. control groups)



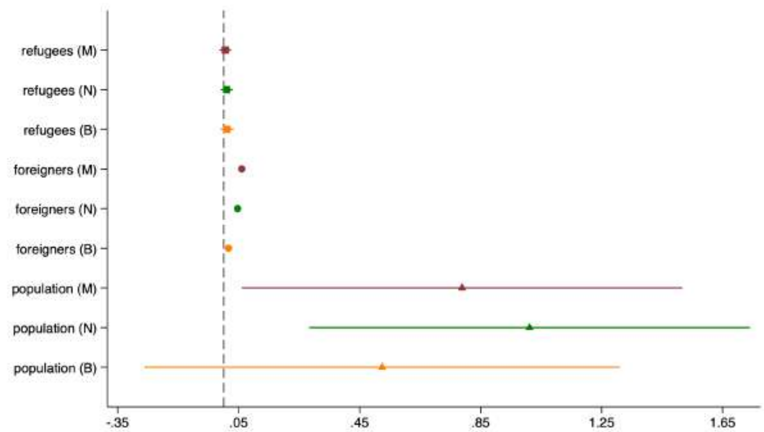
Notes: The figure displays pre-treatment balance tests comparing outcome variables between treated and control municipalities across different sample specifications. Symbols indicate variables: (□) = refugees per inhabitant; (O) = foreign population share; (△) = population (log). Colors indicate samples: Maroon = Main; Green = Northern; Orange = Bordering; Navy = Unrestricted.

Figure A.8: Pre-post behaviour trends - treated vs. control municipalities



Note: Observed outcome means (raw means) over time for earthquake-affected ('treated'- red line with hollow circles) and unaffected ('control' - blue line with hollow diamonds) municipalities. Dependent variables: racial hate (IHS) (Fig.A.8a.), hit-and-run (IHS) (Fig.A.8b.), voluntary tax designations to community-based organisations per 1,000 residents (Fig.A.8c.), and voluntary tax designations to local councils per 1,000 residents (Fig.A.8d.). In both panels, treated municipalities are those affected by the 2012 earthquake. Control municipalities in the top panel are those unaffected by a major earthquake since 2009. Control municipalities in the bottom panel are those unaffected by a major earthquake since 2009 and located in Northern regions.

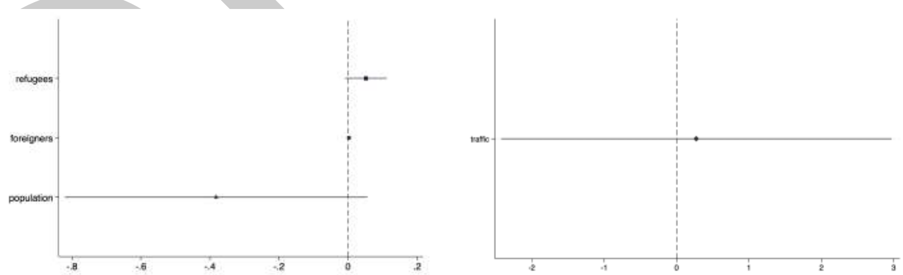
Figure A.9: Pre-treatment balancing tests in potential confounders



Notes: The figure displays coefficient plots from pre-treatment balance tests for potential confounding variables. Symbols indicate variables: (□) = refugees per inhabitant; (O) = foreign population share; (△) = population (log). Colours indicate samples: Maroon = Main; Green = Northern; Orange = Bordering.

Figure A.10: Pre-post comparisons in affected municipalities (2012 earthquake)

a. Demographic variables b. Road traffic



Note: Coefficient plots display pre-post treatment comparisons for demographic characteristics and traffic patterns in treated municipalities. Panel (a) shows refugees, foreign residents, and total population; panel (b) shows total road traffic.

B Continuous treatments detailed estimates and robustness checks

Table A.6: Average total effects

Outcome	β	Range (P25→P75)	$\beta\times$ Range	Effect (%)
Panel A: PGA (scaled g)				
Racial Hate	2.249*	0.015	0.034	+3.43%
Hit-and-Run	2.050	0.015	0.031	+3.12%
Voluntary Tax to LCBOs	−0.092	0.015	−0.001	−0.14%
Voluntary Tax to Council	−0.025	0.015	−0.0004	−0.04%
Panel B: Dwelling damage				
Racial Hate	0.156***	0.46	0.072	+7.34%
Hit-and-Run	0.205**	0.46	0.095	+9.66%
Voluntary Tax to LCBOs	−0.004	0.46	−0.002	−0.18%
Voluntary Tax to Council	−0.001	0.46	−0.0005	−0.05%

Note: Treatment effects are scaled by the interquartile range (IQR) → change from low (25th percentile) to high (75th percentile) exposure. *** p<0.01, ** p<0.05, * p<0.1. Municipal-level clustered SE (de Chaisemartin, 2024)

Table A.7: Event study estimates. Racial hate across samples and treatments

	Main Sample		*Northern Sample*		*Bordering Sample*	
	PGA	Dwelling	PGA	Dwelling	PGA	Dwelling
	(1)	(2)	(3)	(4)	(5)	(6)
Placebo 2	-0.005	-0.006	-0.011	-0.013	0.091*	-0.027
	(0.039)	(0.069)	(0.040)	(0.069)	(0.052)	(0.089)
Placebo 1	0.003	-0.057	-0.003	-0.063	-0.028	0.084
	(0.053)	(0.057)	(0.053)	(0.057)	(0.065)	(0.092)
Effect 1	0.204**	0.280**	0.202**	0.278**	0.217**	0.420***
	(0.086)	(0.138)	(0.086)	(0.138)	(0.091)	(0.149)
Effect 2	0.119**	0.223**	0.113*	0.218**	0.128*	0.299**
	(0.058)	(0.101)	(0.059)	(0.101)	(0.070)	(0.121)
Effect 3	0.070	0.124	0.069	0.123	0.092	0.178
	(0.070)	(0.114)	(0.070)	(0.114)	(0.081)	(0.137)
Effect 4	0.002	0.070	0.002	0.070	0.062	0.092
	(0.041)	(0.075)	(0.042)	(0.075)	(0.056)	(0.102)
Effect 5	0.037	0.084	0.025	0.072	0.094	0.149
	(0.052)	(0.077)	(0.053)	(0.077)	(0.065)	(0.105)
Effect 6	0.085	0.172	0.076	0.163	0.095	0.250*
	(0.068)	(0.114)	(0.069)	(0.114)	(0.077)	(0.132)
Effect 7	0.007	0.079	0.018	0.090	0.082	0.228*
	(0.051)	(0.084)	(0.051)	(0.084)	(0.065)	(0.139)
Effect 8	0.030	0.077	0.047	0.095	0.070	0.179
	(0.047)	(0.079)	(0.048)	(0.080)	(0.058)	(0.118)
Observations	51,600	51,080	26,000	25,480	1,968	1,390
Municipal FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
	Average cumulative (total) effect per treatment unit					
β_1	2.249*	0.156***	2.251*	0.156***	5.051**	0.232***
	(1.170)	(0.059)	(1.183)	(0.059)	(2.234)	(0.077)
	Test of joint nullity of the placebos					
p-value	0.986	0.501	0.956	0.465	0.072	0.340

Note: Staggered difference-in-difference estimation following de Chaisemartin and D'Haultfœuille (2024). Bootstrapped and municipal-clustered standard errors; *** p<0.01, ** p<0.05, * p<0.1. PGA = Peak Ground Acceleration. Dwelling = Dwelling damage (AEDES scale). Time to treat = 0 omitted as reference period. **Main Sample**: Treatment: municipalities in official 2012 earthquake zone (n=124); Control: municipalities with PGA=0 (n=6,236). **Northern Sample**: Treatment: municipalities in official 2012 earthquake zone (n=124); Control: Northern municipalities with PGA=0 (n=3,126). **Bordering Sample**: Treatment: municipalities in official 2012 earthquake zone (n=124); Control: municipalities bordering the earthquake zone (n=122).

Table A.8: Event study estimates. Hit-and-run accidents across samples and treatments

	Main Sample		*Northern Sample*		*Bordering Sample*	
	PGA	Dwelling	PGA	Dwelling	PGA	Dwelling
	(1)	(2)	(3)	(4)	(5)	(6)
Placebo 2	-0.026	-0.022	-0.016	-0.012	-0.031	-0.024
	(0.052)	(0.070)	(0.053)	(0.070)	(0.058)	(0.097)
Placebo 1	-0.018	0.039	-0.017	0.041	-0.034	-0.064
	(0.048)	(0.084)	(0.048)	(0.084)	(0.055)	(0.083)
Effect 1	0.133*	0.221*	0.139*	0.226*	0.061	0.123
	(0.078)	(0.121)	(0.078)	(0.121)	(0.084)	(0.130)
Effect 2	0.066	0.225**	0.075	0.233**	-0.063	0.151
	(0.062)	(0.107)	(0.063)	(0.107)	(0.069)	(0.116)
Effect 3	-0.010	0.113	0.003	0.125	-0.052	-0.007
	(0.057)	(0.099)	(0.057)	(0.099)	(0.064)	(0.112)
Effect 4	0.053	0.132	0.052	0.131	-0.071	0.030
	(0.065)	(0.106)	(0.065)	(0.106)	(0.072)	(0.119)
Effect 5	0.050	0.229**	0.055	0.234**	-0.029	0.170
	(0.067)	(0.114)	(0.067)	(0.114)	(0.072)	(0.121)
Effect 6	0.084	0.201*	0.092	0.209*	-0.052	0.088
	(0.061)	(0.111)	(0.061)	(0.112)	(0.069)	(0.124)
Effect 7	0.095	0.173	0.113	0.191*	-0.035	0.148
	(0.075)	(0.109)	(0.075)	(0.110)	(0.083)	(0.145)
Effect 8	0.033	0.160	0.045	0.172	-0.043	0.198
	(0.064)	(0.112)	(0.065)	(0.112)	(0.072)	(0.170)
Observations	51,600	51,080	26,000	25,480	1,968	1,390
Municipal FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
	Average cumulative (total) effect per treatment unit					
β_1	2.050	0.205***	2.328	0.214***	-1.712	0.106
	(1.477)	(0.081)	(1.487)	(0.081)	(2.318)	(0.073)
	Test of joint nullity of the placebos					
p-value	0.879	0.738	0.933	0.793	0.793	0.742

Note: Staggered difference-in-difference estimation following de Chaisemartin and D'Haultfœuille (2024). Bootstrapped and municipal-clustered standard errors; *** p<0.01, ** p<0.05, * p<0.1. PGA = Peak Ground Acceleration. Dwelling = Dwelling damage (AEDES scale). Time to treat = 0 omitted as reference period. **Main Sample**: Treatment: municipalities in official 2012 earthquake zone (*n*=124); Control: municipalities with PGA=0 (*n*=6,236). **Northern Sample**: Treatment: municipalities in official 2012 earthquake zone (*n*=124); Control: Northern municipalities with PGA=0 (*n*=3,126). **Bordering Sample**: Treatment: municipalities in official 2012 earthquake zone (*n*=124); Control: municipalities bordering the earthquake zone (*n*=122).

Table A.9: Event study estimates. In-group marriages across samples and treatments

	Main Sample		*Northern Sample*		*Bordering Sample*	
	PGA	Dwelling	PGA	Dwelling	PGA	Dwelling
	(1)	(2)	(3)	(4)	(5)	(6)
-2	0.010	-0.066	0.082	0.006	-0.078	-0.180*
	(0.082)	(0.044)	(0.086)	(0.049)	(0.094)	(0.098)
-1	-0.026	-0.052	0.032	0.006	-0.057	-0.095
	(0.098)	(0.050)	(0.101)	(0.055)	(0.101)	(0.073)
1	-0.186**	-0.153**	-0.147	-0.114	-0.269***	-0.285***
	(0.092)	(0.069)	(0.095)	(0.072)	(0.100)	(0.102)
2	-0.054	-0.154**	0.040	-0.060	-0.155	-0.235**
	(0.097)	(0.068)	(0.101)	(0.071)	(0.110)	(0.117)
3	-0.041	-0.120	0.019	-0.061	-0.181*	-0.170
	(0.088)	(0.090)	(0.091)	(0.092)	(0.099)	(0.127)
4	-0.154*	-0.171**	-0.158*	-0.175**	-0.154	-0.184
	(0.089)	(0.072)	(0.092)	(0.075)	(0.104)	(0.122)
5	-0.193*	-0.231***	-0.175*	-0.213***	-0.261**	-0.287***
	(0.100)	(0.067)	(0.103)	(0.070)	(0.108)	(0.103)
6	-0.170**	-0.239***	-0.109	-0.178***	-0.071	-0.150
	(0.086)	(0.062)	(0.090)	(0.065)	(0.102)	(0.116)
7	-0.119	-0.197***	-0.076	-0.154**	-0.101	-0.218*
	(0.093)	(0.065)	(0.096)	(0.068)	(0.102)	(0.126)
8	-0.150*	-0.177***	-0.079	-0.106*	-0.127	-0.225*
	(0.080)	(0.058)	(0.084)	(0.061)	(0.092)	(0.128)
	Average cumulative (total) effect per treatment unit					
β_1	-4.335*	-0.203***	-2.788	-0.149**	-7.927**	-0.224**
	(2.224)	(0.058)	(2.303)	(0.059)	(3.650)	(0.084)
	Test of joint nullity of the placebos					
p-value	0.886	0.315	0.576	0.991	0.710	0.147

Note: Staggered difference-in-difference estimation following de Chaisemartin and D'Haultfœuille (2024). Bootstrapped and municipal-clustered standard errors; *** p<0.01, ** p<0.05, * p<0.1. PGA = Peak Ground Acceleration. Dwelling = Dwelling damage (AEDES scale). Time to treat = 0 omitted as reference period. **Main Sample**: Treatment: municipalities in official 2012 earthquake zone (n=124); Control: municipalities with PGA=0 (n=6,236). **Northern Sample**: Treatment: municipalities in official 2012 earthquake zone (n=124); Control: Northern municipalities with PGA=0 (n=3,126). **Bordering Sample**: Treatment: municipalities in official 2012 earthquake zone (n=124); Control: municipalities bordering the earthquake zone (n=122).

Table A.10: Event study estimates. Voluntary tax to local Community-Based-Organisations across samples and treatments

	Main Sample		*Northern Sample*		*Bordering Sample*	
	PGA	Dwelling	PGA	Dwelling	PGA	Dwelling
	(1)	(2)	(3)	(4)	(5)	(6)
Placebo 2	-0.003	-0.007	-0.004	-0.008	0.006	0.002
	(0.005)	(0.006)	(0.005)	(0.006)	(0.007)	(0.003)
Placebo 1	-0.002	-0.000	-0.003	-0.002	-0.001	0.012
	(0.003)	(0.002)	(0.003)	(0.002)	(0.003)	(0.010)
Effect 1	-0.002	-0.002	-0.002	-0.002	-0.003	-0.005
	(0.003)	(0.005)	(0.003)	(0.005)	(0.003)	(0.005)
Effect 2	0.002	0.004	0.002	0.005	-0.004	-0.003
	(0.004)	(0.006)	(0.004)	(0.006)	(0.004)	(0.007)
Effect 3	-0.000	-0.003	-0.001	-0.003	-0.003	-0.005
	(0.004)	(0.005)	(0.004)	(0.006)	(0.005)	(0.007)
Effect 4	0.001	0.002	-0.000	0.001	-0.001	0.002
	(0.004)	(0.005)	(0.004)	(0.005)	(0.005)	(0.007)
Effect 5	-0.001	0.000	-0.003	-0.002	-0.004	-0.002
	(0.004)	(0.006)	(0.004)	(0.006)	(0.005)	(0.008)
Effect 6	-0.010*	-0.014	-0.012**	-0.016*	-0.016**	-0.020*
	(0.006)	(0.009)	(0.006)	(0.009)	(0.007)	(0.011)
Effect 7	-0.009*	-0.014*	-0.011**	-0.016*	-0.012*	-0.012
	(0.006)	(0.008)	(0.006)	(0.009)	(0.007)	(0.011)
Effect 8	-0.004	-0.002	-0.008	-0.007	-0.011	-0.010
	(0.006)	(0.009)	(0.006)	(0.009)	(0.007)	(0.011)
Observations	51,600	51,080	26,000	25,480	1,968	1,390
Municipal FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
	Average cumulative (total) effect per treatment unit					
β_1	-0.092	-0.004	-0.141	-0.006	-0.330*	-0.007
	(0.117)	(0.006)	(0.121)	(0.006)	(0.204)	(0.006)
	Test of joint nullity of the placebos					
p-value	0.790	0.464	0.540	0.381	0.458	0.491

Note: Staggered difference-in-difference estimation following de Chaisemartin and D'Haultfœuille (2024). Bootstrapped and municipal-clustered standard errors; *** p<0.01, ** p<0.05, * p<0.1. PGA = Peak Ground Acceleration. Dwelling = Dwelling damage (AEDES scale). Time to treat = 0 omitted as reference period. **Main Sample**: Treatment: municipalities in official 2012 earthquake zone (*n*=124); Control: municipalities with PGA=0 (*n*=6,236). **Northern Sample**: Treatment: municipalities in official 2012 earthquake zone (*n*=124); Control: Northern municipalities with PGA=0 (*n*=3,126). **Bordering Sample**: Treatment: municipalities in official 2012 earthquake zone (*n*=124); Control: municipalities bordering the earthquake zone (*n*=122).

Table A.11: Event study estimates. Voluntary tax to local council across samples and treatments

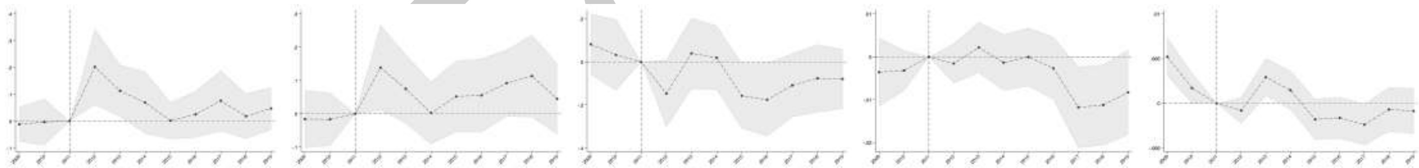
	Main Sample		*Northern Sample*		*Bordering Sample*	
	PGA	Dwelling	PGA	Dwelling	PGA	Dwelling
	(1)	(2)	(3)	(4)	(5)	(6)
Placebo 2	0.002	0.003	0.005***	0.006***	-0.696	-0.614
	(0.001)	(0.002)	(0.001)	(0.002)	(0.706)	(1.000)
Placebo 1	0.000	0.000	0.002*	0.002	-0.394	-0.545
	(0.001)	(0.002)	(0.001)	(0.002)	(0.545)	(1.157)
Effect 1	-0.001	0.002*	-0.001	0.002	0.119	1.222
	(0.001)	(0.001)	(0.001)	(0.001)	(0.549)	(0.817)
Effect 2	0.002*	0.006**	0.003**	0.007***	1.195*	2.529**
	(0.001)	(0.002)	(0.001)	(0.002)	(0.708)	(1.282)
Effect 3	0.000	0.002	0.001	0.003	0.701	0.928
	(0.001)	(0.002)	(0.001)	(0.002)	(0.718)	(1.209)
Effect 4	-0.002	-0.001	-0.002	-0.001	-0.856	-0.620
	(0.001)	(0.002)	(0.001)	(0.002)	(0.813)	(1.280)
Effect 5	-0.001	-0.002	-0.002	-0.003	-1.120	-1.542
	(0.001)	(0.002)	(0.001)	(0.002)	(0.806)	(1.241)
Effect 6	-0.002	-0.003	-0.002*	-0.004*	-1.433*	-2.237*
	(0.001)	(0.002)	(0.001)	(0.002)	(0.799)	(1.268)
Effect 7	-0.001	-0.004*	-0.001	-0.003	-1.185	1.187
	(0.001)	(0.002)	(0.002)	(0.002)	(0.843)	(1.347)
Effect 8	-0.002	-0.004*	-0.001	-0.003	-1.790**	0.316
	(0.001)	(0.002)	(0.002)	(0.002)	(0.855)	(1.433)
Observations	51,600	51,080	26,000	25,480	1,968	1,390
Municipal FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
	Average cumulative (total) effect per treatment unit					
β_1	-0.025	-0.004	-0.015	-0.006	-26.260	0.152
	(0.038)	(0.006)	(0.039)	(0.006)	(31.645)	(1.036)
	Test of joint nullity of the placebos					
p-value	0.155	0.463	0.0001	0.382	0.613	0.827

Note: Staggered difference-in-difference estimation following de Chaisemartin and D'Haultfœuille (2024). Bootstrapped and municipal-clustered standard errors; *** p<0.01, ** p<0.05, * p<0.1. PGA = Peak Ground Acceleration. Dwelling = Dwelling damage (AEDES scale). Time to treat = 0 omitted as reference period. **Main Sample**: Treatment: municipalities in official 2012 earthquake zone (n=124); Control: municipalities with PGA=0 (n=6,236). **Northern Sample**: Treatment: municipalities in official 2012 earthquake zone (n=124); Control: Northern municipalities with PGA=0 (n=3,126). **Bordering Sample**: Treatment: municipalities in official 2012 earthquake zone (n=124); Control: municipalities bordering the earthquake zone (n=122).

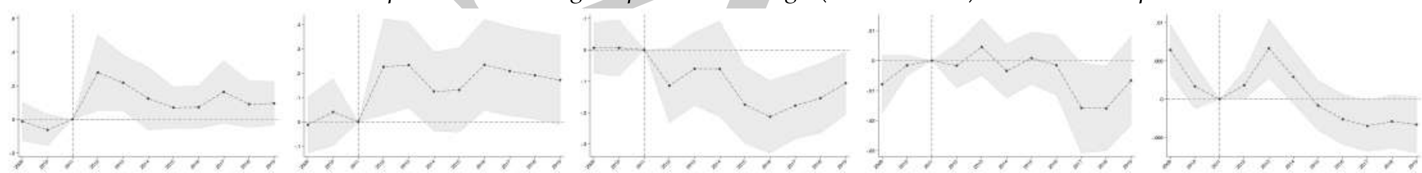
Figure A.11: Northern sample. Event study. Impact heterogeneity by earthquake characteristics

Northern sample. Peak Ground Acceleration (PGA) - Human perception of shaking intensity

Out-group attitude		**Individualism**		**Linking social capital**
a. Racial hate	b1. Hit & run	b2. Marriages	b3. Vol. tax to CBOs	c. Vol. tax to council



Northern sample. Actual damage to private buildings (AeDES scale) - Economic impact

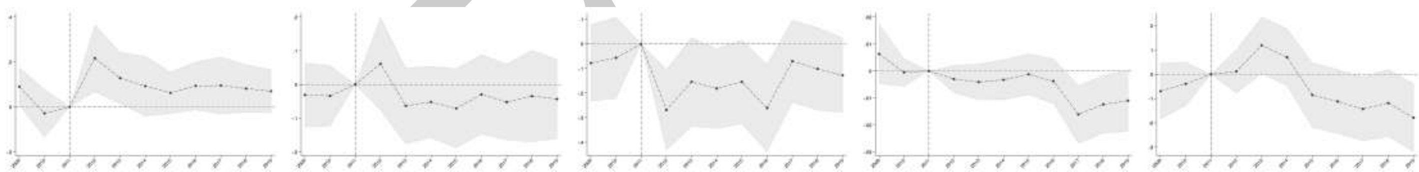


Note: Event study estimates of the effect of the 2012 earthquake on (a.) racial hate (out-group attitude), (b1.) hit-and-run accidents (general individualism), (b2.) marriages (in-group individualism), (b3.) voluntary tax donations to community-based organisations (bonding engagement), and (c.) voluntary tax donations to local councils (linking social capital). Estimation using the de Chaisemartin and D'Haultfœuille (2024)'s approach. Grey dots: point estimates; gray bands: 90% confidence intervals, municipal-clustered standard errors. **Top panel**: PGA measure (continuous; 0 for unaffected areas); control groups includes only 2012 earthquake Northern areas with PGA = 0 outside official impact area. Appendix, Table **??** columns 1-5 for detailed estimates; Tables **??** and A.4 for sample details and summary statistics; Figure A.3 - I for sample map. **Bottom panel**: actual private building damage (AeDES scale, continuous; 0 for unaffected areas); excludes Lombardy/Veneto (data limits); control groups includes only Northern earthquake areas with PGA = 0 outside the official impact area. Appendix, columns 3-4 of Tables A.7, A.8, A.9; A.10 and A.11 for detailed estimates; Tables **??** and A.4 for sample details and summary statistics; Figure A.5 - I for sample map.

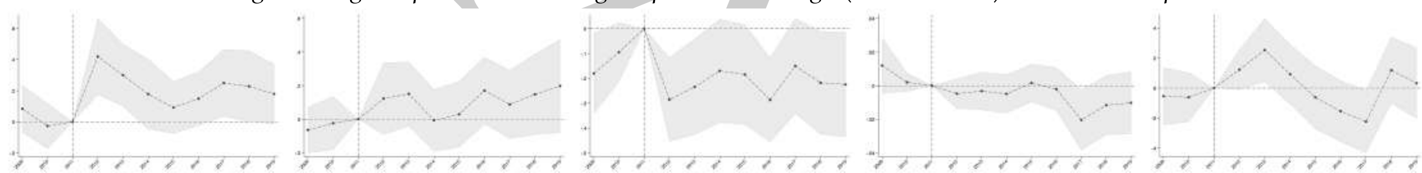
Figure A.12: Neighbouring sample. Event study. Impact heterogeneity by earthquake characteristics

Neighbouring sample. Peak Ground Acceleration (PGA) - Human perception of shaking intensity

Out-group attitude	**Individualism**			**Linking social capital**
a. Racial hate	b1. Hit & run	b2. Marriages	b3. Vol. tax to CBOs	c. Vol. tax to council



Neighbouring sample. Actual damage to private buildings (AeDES scale) - Economic impact

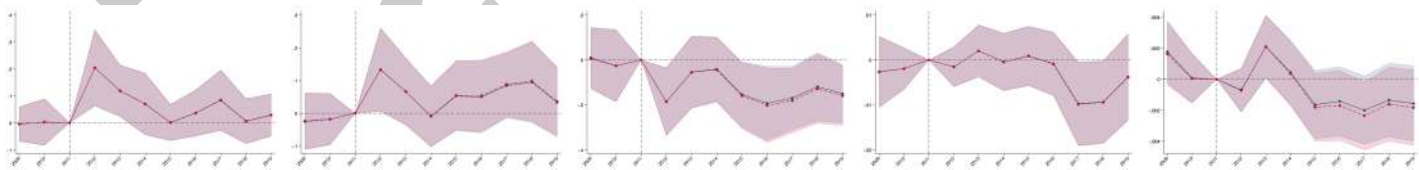


Note: Event study estimates of the effect of the 2012 earthquake on (a.) racial hate (out-group attitude), (b1.) hit-and-run accidents (general individualism), (b2.) marriages (in-group individualism), (b3.) voluntary tax donations to community-based organisations (bonding engagement), and (c.) voluntary tax donations to local councils (linking social capital). Estimation using the de Chaisemartin and D'Haultfœuille (2024)'s approach. Grey dots: point estimates; gray bands: 90% confidence intervals, municipal-clustered standard errors. **Top panel**: PGA measure (continuous; 0 for unaffected areas); control groups includes only 2012 earthquake Northern areas with PGA = 0 outside official impact area. Appendix, Table **??** columns 1-5 for detailed estimates; Tables **??** and A.4 for sample details and summary statistics; Figure A.3 - I for sample map. **Bottom panel**: actual private building damage (AeDES scale, continuous; 0 for unaffected areas); excludes Lombardy/Veneto (data limits) and 2012 Northern earthquake areas with damage > 0 outside the official impact area. Appendix, columns 5-6 of Tables A.7, A.8, A.9; A.10 and A.11 for detailed estimates; ; Tables **??** and A.4 for sample details and summary statistics; Figure A.5 - I for sample map.

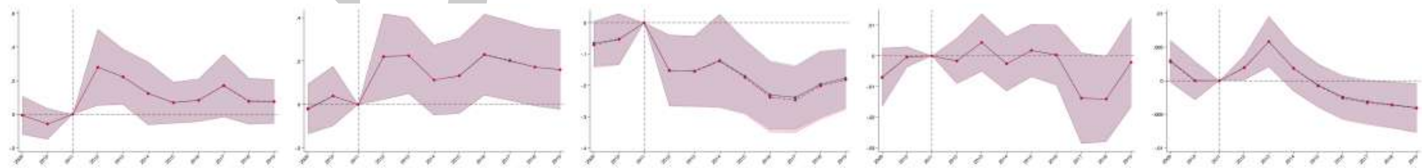
Figure A.13: Main sample. Event study with control variables.

Main sample. Peak Ground Acceleration (PGA) - Human perception of shaking intensity

Out-group attitude	**Individualism**			**Linking social capital**
a. Racial hate	b1. Hit & run	b2. Marriages	b3. Vol. tax to CBOs	c. Vol. tax to council



Main sample. Actual damage to private buildings (AeDES scale) - Economic impact

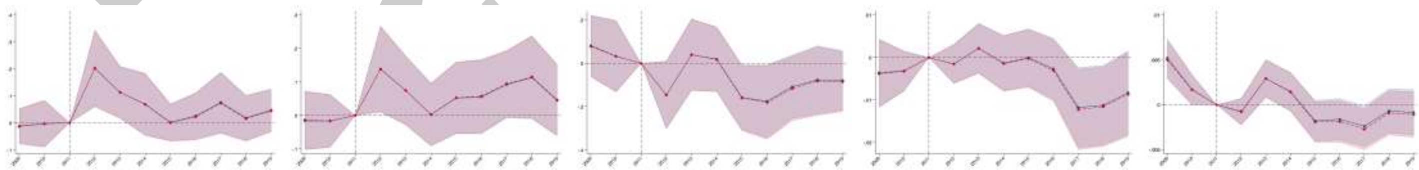


Note: Event study estimates of the effect of the 2012 earthquake on (a.) racial hate (out-group attitude), (b1.) hit-and-run accidents (general individualism), (b2.) marriages (in-group individualism), (b3.) voluntary tax donations to community-based organisations (bonding engagement), and (c.) voluntary tax donations to local councils (linking social capital). Estimation using the de Chaisemartin and D'Haultfœuille (2024)'s approach. Grey dots: point estimates; gray bands: 90% confidence intervals, municipal-clustered standard errors. **Top panel**: PGA measure (continuous; 0 for unaffected areas). **Bottom panel**: actual private building damage (AeDES scale, continuous; 0 for unaffected areas). Control variables are population and foreign population.

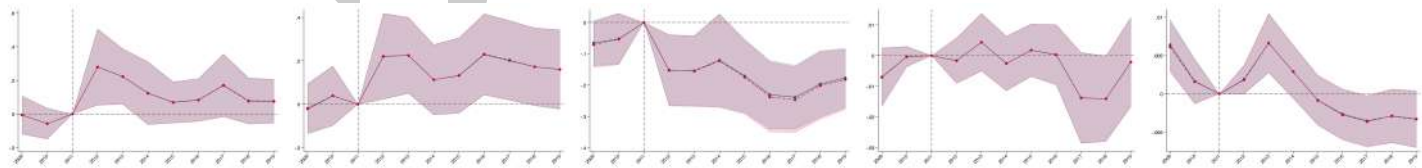
Figure A.14: Northern sample. Event study with control variables.

Northern sample. Peak Ground Acceleration (PGA) - Human perception of shaking intensity

Out-group attitude		**Individualism**		**Linking social capital**
a. Racial hate	b1. Hit & run	b2. Marriages	b3. Vol. tax to CBOs	c. Vol. tax to council



Northern sample. Actual damage to private buildings (AeDES scale) - Economic impact

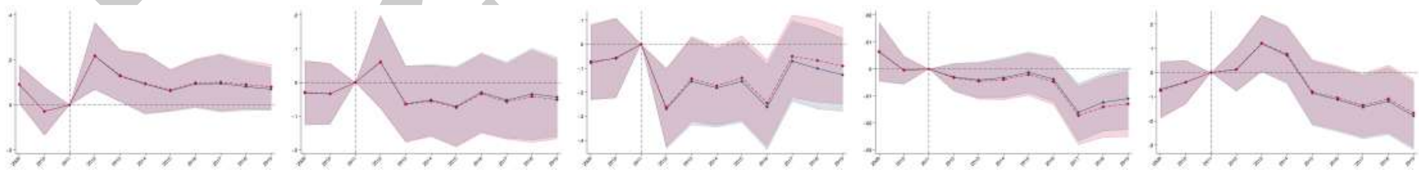


Note: Event study estimates of the effect of the 2012 earthquake on (a.) racial hate (out-group attitude), (b1.) hit-and-run accidents (general individualism), (b2.) marriages (in-group individualism), (b3.) voluntary tax donations to community-based organisations (bonding engagement), and (c.) voluntary tax donations to local councils (linking social capital). Estimation using the de Chaisemartin and D'Haultfœuille (2024)'s approach. Grey dots: point estimates; gray bands: 90% confidence intervals, municipal-clustered standard errors. **Top panel**: PGA measure (continuous; 0 for unaffected areas). **Bottom panel**: actual private building damage (AeDES scale, continuous; 0 for unaffected areas). Control variables are population and foreign population.

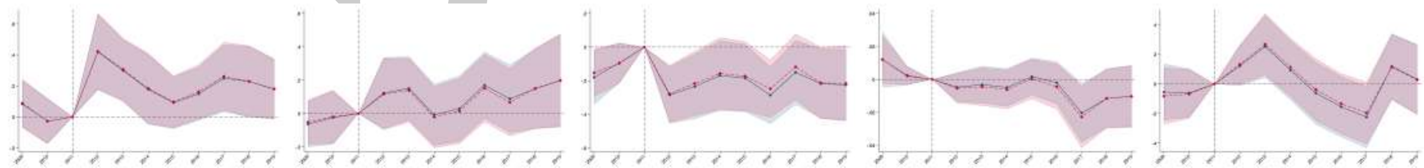
Figure A.15: Neighbouring sample. Event study with control variables.

Northern sample. Peak Ground Acceleration (PGA) - Human perception of shaking intensity

Out-group attitude		**Individualism**		**Linking social capital**
a. Racial hate	b1. Hit & run	b2. Marriages	b3. Vol. tax to CBOs	c. Vol. tax to council



Northern sample. Actual damage to private buildings (AeDES scale) - Economic impact

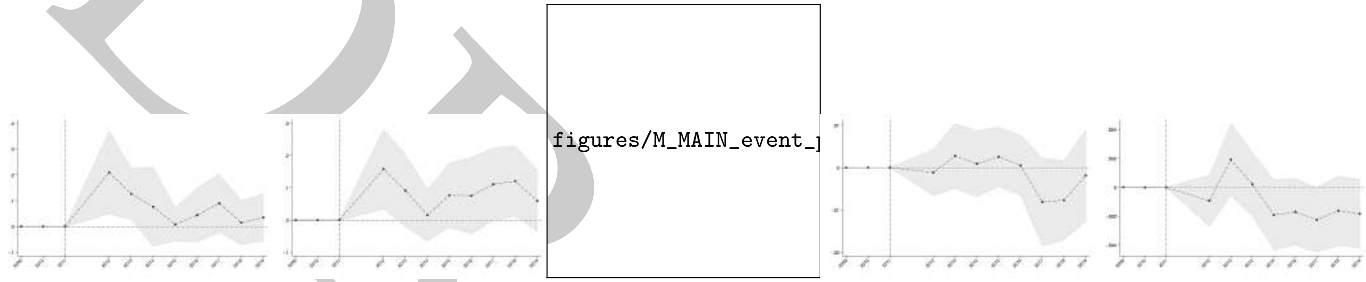


Note: Event study estimates of the effect of the 2012 earthquake on (a.) racial hate (out-group attitude), (b1.) hit-and-run accidents (general individualism), (b2.) marriages (in-group individualism), (b3.) voluntary tax donations to community-based organisations (bonding engagement), and (c.) voluntary tax donations to local councils (linking social capital). Estimation using the de Chaisemartin and D'Haultfœuille (2024)'s approach. Grey dots: point estimates; gray bands: 90% confidence intervals, municipal-clustered standard errors. **Top panel**: PGA measure (continuous; 0 for unaffected areas). **Bottom panel**: actual private building damage (AeDES scale, continuous; 0 for unaffected areas). Control variables are population and foreign population.

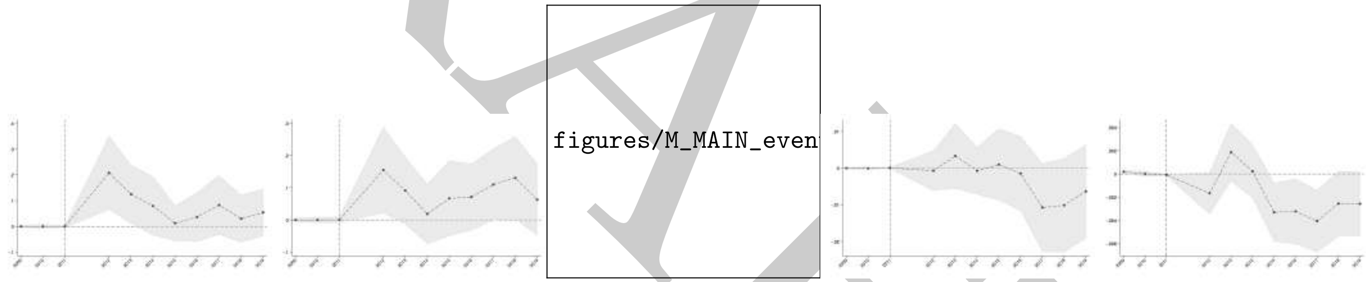
Figure A.16: Synthetic Difference-in-Difference. Event study estimates across samples.

Main sample. Synthetic Difference-in-difference. 0/1 treatment

a. Racial hate | b1. Hit & run | b2. Marriages | b3. Vol. tax to LCBOs | c. Vol. tax to council



Northern sample. Synthetic Difference-in-difference. 0/1 treatment



Note: 95% confidence interval

Table A.12: Synthetic Difference-in-Difference. Average Treatment Effects across samples and outcomes

	Main Sample		*Northern Sample*	
Outcome	ATT	Impact (%)	ATT	Impact (%)
Racial Hate	0.076*** (0.029)	+7.84	0.078*** (0.028)	+8.15
Hit & Run	0.089*** (0.028)	+9.25	0.088*** (0.033)	+9.23
Vol. tax to LCBO	-0.002 (0.003)	-0.15	-0.003 (0.004)	-0.32
Vol. tax to Local Council	-0.001 (0.001)	-0.10	-0.002* (0.001)	-0.19

Note: Notes: Standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. Standard errors based on placebo inference. ATT = Average Treatment Effect on the Treated. Impact (%) shows the percentage change relative to baseline.

Table A.13: Synthetic Difference-in-Difference. Event Study Estimates: Main Sample

Year	Racial Hate	Hit & Run	Marriages	LCBO tax	Mun. tax
2009	0.000	-0.000	0.000	0.000	0.000
	(0.001)	(0.002)	(0.000)	(0.000)	(0.000)
2010	0.000	-0.000	-0.000	-0.000	-0.000
	(0.002)	(0.002)	(0.001)	(0.000)	(0.000)
2011	-0.000	0.000	0.000	0.000	-0.000
	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)
2012	0.209**	0.158**	-0.184**	-0.001	-0.001
	(0.082)	(0.063)	(0.077)	(0.003)	(0.001)
2013	0.127**	0.091	-0.051	0.003	0.002
	(0.051)	(0.057)	(0.075)	(0.004)	(0.001)
2014	0.076	0.015	-0.034	0.001	0.000
	(0.079)	(0.041)	(0.080)	(0.004)	(0.001)
2015	0.008	0.077	-0.151**	0.003	-0.002
	(0.033)	(0.051)	(0.067)	(0.004)	(0.001)
2016	0.044	0.076	-0.190***	0.001	-0.002
	(0.054)	(0.061)	(0.071)	(0.004)	(0.001)
2017	0.090	0.111*	-0.171***	-0.008	-0.002**
	(0.058)	(0.057)	(0.059)	(0.005)	(0.001)
2018	0.015	0.121**	-0.121	-0.008	-0.002
	(0.044)	(0.056)	(0.074)	(0.005)	(0.001)
2019	0.035	0.059	-0.150**	-0.002	-0.002
	(0.047)	(0.049)	(0.063)	(0.006)	(0.001)

Note: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Years 2009-2011 are pre-treatment placebos.

Table A.14: Synthetic Difference-in-Difference. Event Study Estimates: Northern Sample

Year	Racial Hate	Hit & Run	Marriages	LCBO tax	Mun. tax
2009	-0.000	-0.000	0.002	-0.000	0.000***
	(0.003)	(0.003)	(0.002)	(0.000)	(0.000)
2010	0.000	-0.000	-0.000	-0.000	0.000
	(0.004)	(0.004)	(0.002)	(0.000)	(0.000)
2011	0.000	0.000	-0.002	0.000	-0.000**
	(0.002)	(0.005)	(0.003)	(0.000)	(0.000)
2012	0.208***	0.155**	-0.184**	-0.001	-0.002*
	(0.073)	(0.068)	(0.084)	(0.003)	(0.001)
2013	0.125**	0.091*	-0.000	0.003	0.002
	(0.058)	(0.053)	(0.086)	(0.005)	(0.001)
2014	0.079	0.018	-0.023	-0.001	0.000
	(0.058)	(0.048)	(0.089)	(0.003)	(0.001)
2015	0.012	0.067	-0.196**	0.001	-0.003**
	(0.035)	(0.060)	(0.083)	(0.005)	(0.001)
2016	0.037	0.071	-0.214**	-0.001	-0.003**
	(0.049)	(0.053)	(0.085)	(0.005)	(0.001)
2017	0.083	0.110*	-0.155***	-0.011*	-0.004***
	(0.059)	(0.057)	(0.057)	(0.006)	(0.001)
2018	0.030	0.131**	-0.125	-0.010	-0.003*
	(0.047)	(0.065)	(0.080)	(0.007)	(0.001)
2019	0.054	0.063	-0.122	-0.006	-0.003*
	(0.047)	(0.057)	(0.077)	(0.007)	(0.001)

Note: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Years 2009-2011 are pre-treatment placebos.

Table A.15: Average Treatment Effects. Non-absorbing PGA

	(1) Racial Hate	(2) Hit & Run	(3) Marriages	(4) NGO Don.	(5) Mun. Don.
Panel A: Main Sample					
ATET	2.585**	1.564*	-2.649***	-0.056	0.052***
	(1.124)	(0.899)	(0.834)	(0.106)	(0.020)
Observations	70,235	70,235	70,235	70,235	70,235
Panel B: Northern Sample					
ATET	2.639**	1.617*	-2.582***	-0.067	0.033
	(1.128)	(0.904)	(0.852)	(0.106)	(0.021)
Observations	35,035	35,035	35,035	35,035	35,035
Panel C: Neighbouring Sample					
ATET	2.504*	-0.260	-2.250*	-0.193	0.111***
	(1.446)	(0.944)	(1.140)	(0.133)	(0.023)
Observations	1,991	1,991	1,991	1,991	1,991

Note: Standard errors clustered at the municipal level in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. Continuous treatment: Peak Ground Acceleration.

Table A.16: Average Treatment Effects. Non-absorbing damage

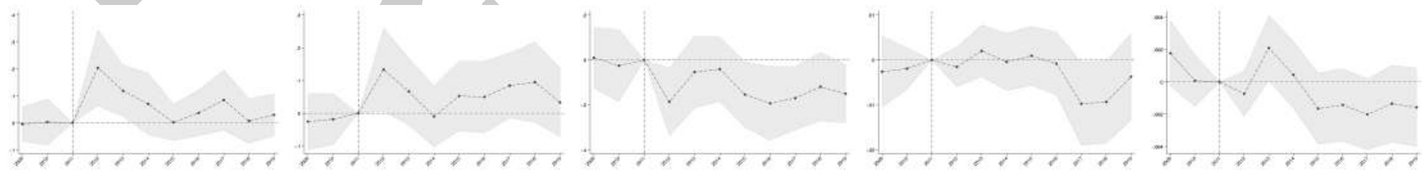
	(1) Racial Hate	(2) Hit & Run	(3) Marriages	(4) NGO Don.	(5) Mun. tax
Panel A: Main Sample					
ATET	0.145***	0.150***	-0.147***	-0.003	0.000
	(0.043)	(0.043)	(0.034)	(0.005)	(0.002)
Observations	70,235	70,235	70,235	70,235	70,235
Panel B: Northern Sample					
ATET	0.149***	0.154***	-0.143***	-0.004	0.001
	(0.043)	(0.043)	(0.036)	(0.005)	(0.002)
Observations	35,035	35,035	35,035	35,035	35,035
Panel C: Neighbouring Sample					
ATET	0.168***	0.083*	-0.132**	-0.014*	0.002
	(0.054)	(0.050)	(0.057)	(0.007)	(0.002)
Observations	1,991	1,991	1,991	1,991	1,991

Note: Standard errors clustered at the municipal level in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.Continuous treatment: private dwelling damage measured using the AeDES scale

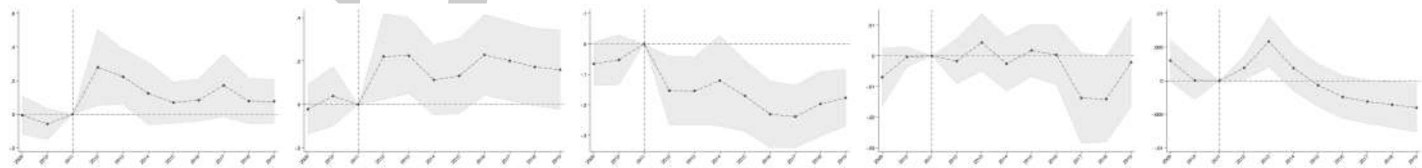
Figure A.17: Main sample. Event study with non-absorbing treatment.

Main sample. Peak Ground Acceleration (PGA) - Human perception of shaking intensity

Out-group attitude		**Individualism**		**Linking social capital**
a. Racial hate	b1. Hit & run	b2. Marriages	b3. Vol. tax to CBOs	c. Vol. tax to council



Main sample. Actual damage to private buildings (AeDES scale) - Economic impact

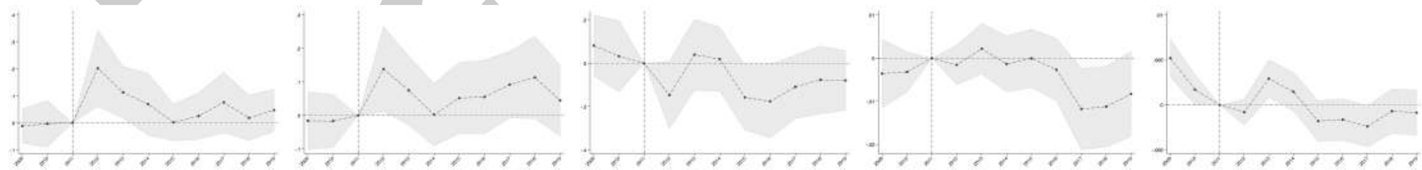


Note: Event study estimates of the effect of the 2012 earthquake on (a.) racial hate (out-group attitude), (b1.) hit-and-run accidents (general individualism), (b2.) marriages (in-group individualism, placeholder acr), (b3.) voluntary tax donations to community-based organisations (bonding engagement), and (c.) voluntary tax donations to local councils (linking social capital). Grey dots: point estimates; gray bands: 90% confidence intervals, municipal-clustered standard errors. **Top panel**: PGA measure (continuous; 0 for unaffected areas). **Bottom panel**: actual private building damage (AeDES scale, continuous; 0 for unaffected areas).

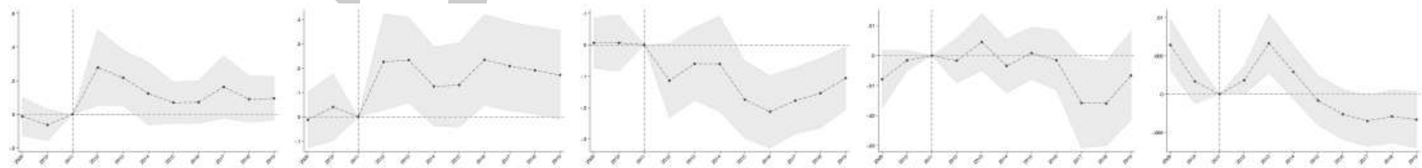
Figure A.18: Northern sample. Event study with non-absorbing treatment.

Northern sample. Peak Ground Acceleration (PGA) - Human perception of shaking intensity

Out-group attitude		**Individualism**		**Linking social capital**
a. Racial hate	b1. Hit & run	b2. Marriages	b3. Vol. tax to CBOs	c. Vol. tax to council



Northern sample. Actual damage to private buildings (AeDES scale) - Economic impact

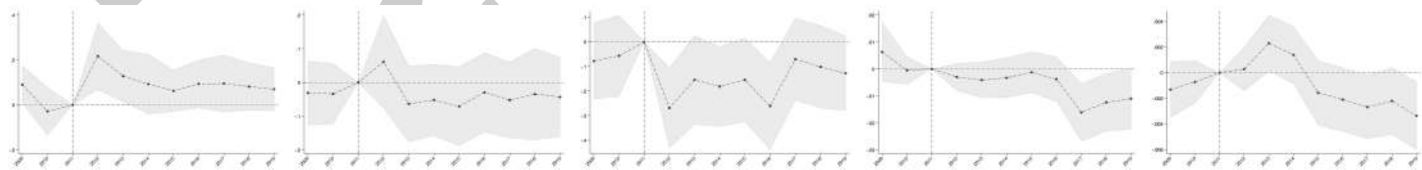


Note: Event study estimates of the effect of the 2012 earthquake on (a.) racial hate (out-group attitude), (b1.) hit-and-run accidents (general individualism), (b2.) marriages (in-group individualism, placeholder acr), (b3.) voluntary tax donations to community-based organisations (bonding engagement), and (c.) voluntary tax donations to local councils (linking social capital). Grey dots: point estimates; gray bands: 90% confidence intervals, municipal-clustered standard errors. **Top panel**: PGA measure (continuous; 0 for unaffected areas). **Bottom panel**: actual private building damage (AeDES scale, continuous; 0 for unaffected areas). Control variables are population and foreign population.

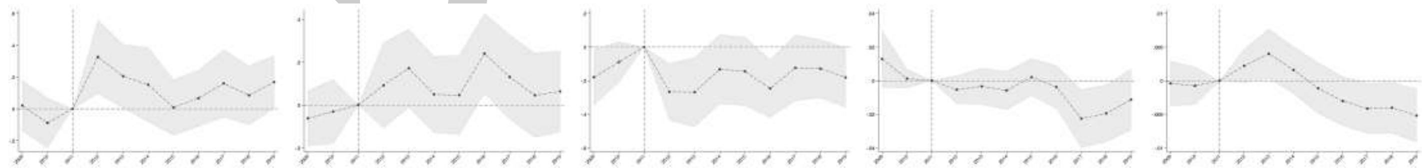
Figure A.19: Neighbouring sample. Event study with non-absorbing treatment

Neighbouring sample. Peak Ground Acceleration (PGA) - Human perception of shaking intensity

Out-group attitude		**Individualism**		**Linking social capital**
a. Racial hate	b1. Hit & run	b2. Marriages	b3. Vol. tax to CBOs	c. Vol. tax to council



Neighbouring sample. Actual damage to private buildings (AeDES scale) - Economic impact

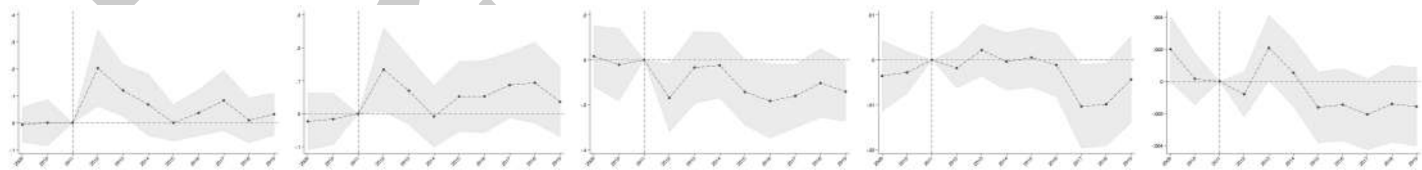


Note: Event study estimates of the effect of the 2012 earthquake on (a.) racial hate (out-group attitude), (b1.) hit-and-run accidents (general individualism), (b2.) marriages (in-group individualism, placeholder acr), (b3.) voluntary tax donations to community-based organisations (bonding engagement), and (c.) voluntary tax donations to local councils (linking social capital). Grey dots: point estimates; gray bands: 90% confidence intervals, municipal-clustered standard errors. **Top panel**: PGA measure (continuous; 0 for unaffected areas). **Bottom panel**: actual private building damage (AeDES scale, continuous; 0 for unaffected areas)

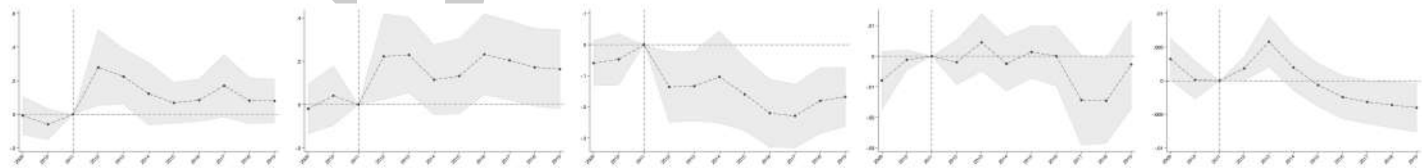
Figure A.20: Historical outer sample. Event study estimates

Historical outer sample. Peak Ground Acceleration (PGA) - Human perception of shaking intensity

Out-group attitude		**Individualism**		**Linking social capital**
a. Racial hate	b1. Hit & run	b2. Marriages	b3. Vol. tax to CBOs	c. Vol. tax to council



Historical outer sample. Actual damage to private buildings (AeDES scale) - Economic impact

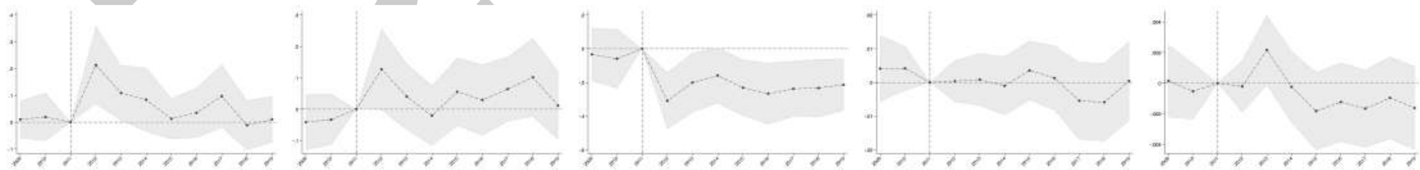


Note: Event study estimates of the effect of the 2012 earthquake on (a.) racial hate (out-group attitude), (b1.) hit-and-run accidents (general individualism), (b2.) marriages (in-group individualism, placeholder M), (b3.) voluntary tax donations to community-based organisations (bonding engagement), and (c.) voluntary tax donations to local councils (linking social capital). Grey dots: point estimates; gray bands: 90% confidence intervals, municipal-clustered standard errors. **Top panel**: PGA measure (continuous; 0 for unaffected areas). **Bottom panel**: actual private building damage (AeDES scale, continuous; 0 for unaffected areas).

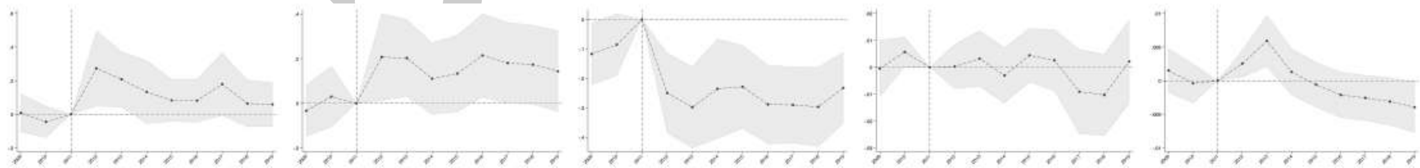
Figure A.21: Historical sample. Event study estimates

Historical sample. Peak Ground Acceleration (PGA) - Human perception of shaking intensity

Out-group attitude		**Individualism**		**Linking social capital**
a. Racial hate	b1. Hit & run	b2. Marriages	b3. Vol. tax to CBOs	c. Vol. tax to council



Historical sample. Actual damage to private buildings (AeDES scale) - Economic impact



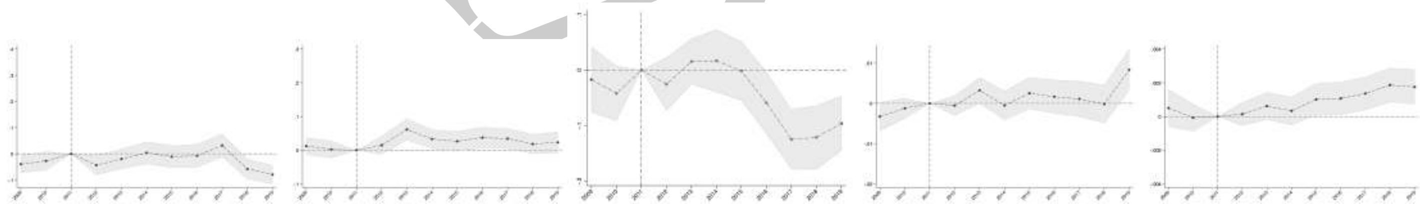
Note: Event study estimates of the effect of the 2012 earthquake on (a.) racial hate (out-group attitude), (b1.) hit-and-run accidents (general individualism), (b2.) marriages (in-group individualism, placeholder M), (b3.) voluntary tax donations to community-based organisations (bonding engagement), and (c.) voluntary tax donations to local councils (linking social capital). Grey dots: point estimates; gray bands: 90% confidence intervals, municipal-clustered standard errors. **Top panel**: PGA measure (continuous; 0 for unaffected areas). **Bottom panel**: actual private building damage (AeDES scale, continuous; 0 for unaffected areas).

Figure A.22: Alternative treated and control groups. Event study estimates

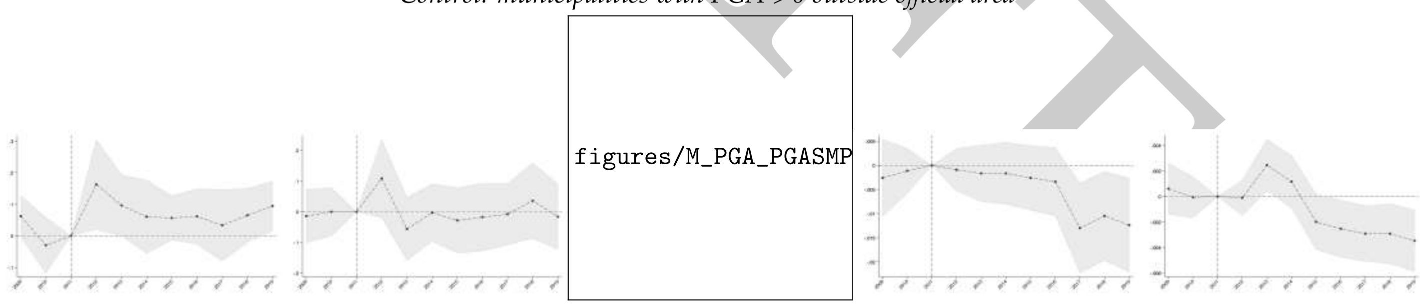
Treated: all municipalities with PGA>0

Out-group attitude		**Individualism**		**Linking social capital**
a. Racial hate	b1. Hit & run	b2. Marriages	b3. Vol. tax to CBOs	c. Vol. tax to council

Treated: municipalities with PGA >0 outside official area



Control: municipalities with PGA >0 outside official area



Note: Event study estimates of the effect of the 2012 earthquake on (a.) racial hate (out-group attitude), (b1.) hit-and-run accidents (general individualism), (b2.) marriages (in-group individualism, placeholder M), (b3.) voluntary tax donations to community-based organisations (bonding engagement), and (c.) voluntary tax donations to local councils (linking social capital). Grey dots: point estimates; gray bands: 90% confidence intervals, municipal-clustered standard errors.

Figure A.23: Unmarried couples. Difference-in-difference estimates for different samples