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Abstract

We analyze the response of municipalities to the occurrence of natural disasters (earthquakes) in Italy, in terms of spending behavior, use of upper tier transfers and recovery. We find evidence of increasing expenditure for about 12 years after the shock, with asymmetric responses between matching (earthquake-related) and unconditional grants, and heterogeneous flypaper effects across the country. While in Northern municipalities expenditure tends to regress to pre-treatment levels, i.e., before the earthquake occurrence, Southern municipalities react to the drop of grants showing inertia in expenditure levels. This evidence is coupled with a faster recovery of private income and housing prices in Northern municipalities. Our analysis exploits balance sheet data of about 8000 municipalities for the period 2000-2015 and encompasses the universe of earthquake events defined using alternative intensity measures. We apply a matching approach to disentangle earthquake-related grants (mostly matching grants) from other grants, and to define a control group of non-treated municipalities. The spatial and temporal variation in expenditure and transfers between treated and not-treated governments are then examined using panel data models on the universe of municipalities as well as on a matching sample of municipalities.

Keywords: Natural disasters, Local expenditure, Intergovernmental transfers, Matching grants, Flypaper effect, Economic growth

JEL codes: H52, H72, R7

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1 Introduction

Natural disasters have several implications on affected economies and society. Infrastructures get damaged and need to be repaired, people get injured or die, economic activities are unable to operate and inequalities may worsen (Bui et al., 2014; Kahn, 2005; Strömberg, 2007). Whether it is because of legal rules, solidarity or to raise the consensus of the electorate, public authorities commonly intervene by means of higher spending levels and transfers of financial resources from the central government to disaster areas (Barone and Mocetti, 2014; Noy and Nualsri, 2011).¹ It has been noted that expenditure on post-disaster relief is generally less efficient and effective than expenditure on prevention (Healy and Malhotra, 2009; Skoufias, 2003). However, governments prefer to deal with disaster relief measures since the electorate is more likely to perceive (or misperceive) the benefits and, therefore, to provide political consensus (Zaman et al., 2010). Despite the involvement of local authorities and their role as the main channel of interaction between citizens and regional/central governments to face natural disasters, there is lacking evidence on the response of local public expenditure in terms of resources use and timing, and the subsequent impact on recovery (Bevan and Cook, 2015).

This paper investigates the response of local government expenditure to natural disasters exploiting detailed data on expenditure and transfers from the universe of Italian municipalities for a 16-year period (2000-2015), and a large historic data set of seismic events since 1000 AD. To this aim, we estimate expenditure variation following earthquake occurrence using panel data regression models on the universe of municipalities as well as on a matching sample, focusing on immediate and medium-run effects of earthquakes. Further, we exploit the variability in transfers received for earthquake damage recovery to identify a possible source of inefficiency in post-disaster interventions, i.e., the overreaction to transfers from upper tiers to lower government levels that can offset the growth of income - the so called *flypaper effect* (see e.g., Gennari and Messina, 2014; Hamilton, 1983). Due to their essential matching-grants nature and their duration, the response to earthquake-specific transfers may be more pronounced as compared to other sources of transfers, implying both an income and a substitution effect (Bailey and Connolly, 1998) and leading to persistent path-dependency of local governments expenditure over time.

¹In Italy - a country frequently struck by earthquakes - the central government allocated almost 100 billion Euro at 2014 prices to fund disaster relief just for the five largest seismic events that occurred between 1968 and 2002 (Di Giacomo, 2014).

We apply a matching procedure to disentangle different types of grants and explore differences in the response to earthquake-specific and general grants. Then, we investigate the asymmetric responses to increasing and decreasing grants and between Northern and Southern municipalities in terms of resources allocation and recovery.

We find that an earthquake increases local government expenditure immediately after the shock by about 2%, following an inverse U-shaped trend, which persists for about 11-12 years since the disaster. This increase is mainly driven by transfers of financial resources from the central and regional governments. Further, we find evidence of flypaper effects with asymmetric responses to matching (earthquake-related) and unmatching grants and to increasing and decreasing grants. Finally, we testify differences in the response of Northern and Southern municipalities, suggesting that the less efficient use of earthquake-specific grants by Southern municipalities lead to poor economic outcomes.

Despite the size of public resources employed in the recovery from losses of natural disasters and the long-lasting effort of public authorities, only a few studies analyze the response of public expenditure to natural disasters and its impact. Melecky and Raddatz (2011) investigate the effect of natural disasters on fiscal sustainability using data on a number of high and middle-income countries for the period 1975-2008, and show that public expenditure grows to allow for recovery. Noy and Nualsri (2011) find that governments of developed countries tend to support more disaster areas by means of transfers of financial resources, while governments in developing countries are less committed or even contract the resources transferred to disaster areas. Other studies focus on the impact of natural disasters on economic growth and show that economic gains are context related (e.g. Barone and Mocetti, 2014; Cavallo et al., 2013; Skidmore and Toya, 2002). Looking at two Italian regions struck by severe earthquakes in 1976 and 1980, Barone and Mocetti (2014) show that in the medium-run (i.e., the first 5 years after the disaster) transfers from the central government allow to entirely cover the losses, but remarkable differences are observed between the two regions in terms of ability to recover. Hornbeck and Keniston (2017) find that Boston city reconstruction after the 1872 fire is an example of successful recovery with beneficial effects on land and house values and urban growth, while Horwich (2000) finds that the port of Kobe in Japan, struck by a severe earthquake in 1995, was able to recover from damages within one year, but economic growth slowed down because part of economic activities moved to other port cities.²

²Note that Horwich (2000) uses information on 19 months after the disaster. This does not exclude that the area could have recovered from economic damages in the long-run, as found by Davis and Weinstein

Our analysis contributes to a deeper knowledge of the effects of post-disaster public spending, which helps policy makers to design more effective and efficient relief measures. Usually, natural disasters affect a limited area of a country and, even if an event is not catastrophic, damages may be remarkable at local level. Hence, observing the consequences of these events from a within-country perspective may improve the precision of the analysis. The large majority of studies mentioned above focus at country level and analyze the economic impact of the largest natural disasters, neglecting smaller but harmful disasters. Clearly, cross-country studies can only exploit a limited number of rare and big events, which may undermine the validity of the results. Our approach allows to capture the effects of relatively small events since we exploit data for the universe of Italian municipalities and a unique historic data set of all seismic events. Italy is an ideal setting because the country was struck by several hundreds of earthquakes over the last decades, out of which only 19 were large catastrophic events.³ Moreover, local governments are responsible for housing services, urban road maintenance, economic development, social protection and education, all aspects that are likely affected by catastrophes.

The rest of the paper is structured as follows. Section 2 describes the institutional setting and how public authorities respond to natural disasters. Section 3 presents the data and some descriptive evidence on the incidence of earthquakes and changes in public expenditure. Section 4 defines the empirical strategy and Section 5 presents the main results on expenditure behavior and provide some robustness checks. In Section 4.2, we extend the analysis to investigate the role of transfers, and in Section 5.3 we explore differences in the response to earthquakes, i.e. asymmetric responses to increasing and decreasing grants and heterogeneous flypaper effects across municipalities. Finally, in Section 5.4, we further explore differences in the response of Northern and Southern local governments in terms of timing and spending composition, and the effects on economic growth. Section 6 concludes.

(2002) after city bombings in Japan during World War II.

³Our elaboration on data provided by the Center for Research on the Epidemiology of Disasters (CRED) (Guha-Sapir et al., 2017).

2 Institutional and seismic background in Italy

2.1 Exposure to earthquake risk

Italy is a country with a high frequency of earthquakes. The country is almost continuously exposed to minor earthquakes and several large events occurred both recently and in the past. However, it is necessary to distinguish the physical strength of an earthquake from the damages it causes. A very strong earthquake that occurs in a not populated area without infrastructures may not cause any damage, while a mild earthquake that strikes a town with weak infrastructures may cause human losses and large damages. The 2017 earthquake of Ischia was a relatively weak earthquake (moment magnitude 4), but very destructive because of poor building standards present in the area. This distinction is of relevance also because Italy is rich in cultural heritage, which is difficult to protect against natural disasters.

Figure 1 illustrates the frequency of earthquakes with intensity equal or bigger than 5 at municipality level for the period 1985-2015. Intensity 5 is the lowest level at which damages occur (see Section 3.2 on earthquake measurement for details). The map highlights that earthquakes occur across the entire country. One-third of municipalities were struck at least once by a seismic event over the considered period and almost half of them in the period 2000-2015. The areas most frequently affected are the regions Emilia-Romagna in the North, Umbria, Marche, and the municipality Rome in the Center, Abruzzo, Basilicata, Northern Puglia and Eastern Sicily in the South.

The exposure to earthquake risk leads to the classification of municipalities into seismic zones. In 2004, the Italian Institute for Geophysics and Volcanology (INGV), a unit of the Civil Protection with the task to increase the knowledge on the Earth system and its phenomena and to monitor seismic and volcanic events, analyzed the probability to face large earthquakes based on the movement speed of the ground and defined, accordingly, 4 seismic zones. A more detailed classification with sub-categories was realized in 2015. This classification is of interest for the central government because it allows to address policies to the most exposed areas. One of these policies defines building standards that must be fulfilled in high-risk seismic zones. Moreover, the central government allocates funds for infrastructure maintenance to prevent disaster damages based on the classification.

2.2 Administrative organization and response to natural disasters

Italy is a decentralized country where the public administration consists of 4 levels: the central government, the region, the province, and the municipality. The main task of regions is the provision of services in the health care sector. Provinces are responsible for the maintenance of non-urban roads, environmental protection and secondary education. Municipal governments are required to offer a number of services, among which the most relevant are local transports, urban road maintenance, waste disposal, housing, social protection, and primary education.

Since the early '90s, the administrative organization has changed. The Law 142/1990 started a decentralization process of powers from the central government towards local authorities with the attempt to increase the autonomy of local governments. This implied a change in the composition of funding sources. Since 1992, an increasing share of local government revenues derived from the withholding of tax revenues, mainly from property taxes and surcharges on income taxes, and from the revenues generated by local service provision. However, decisions on local tax rates are constrained by national regulation that limits the extent to which local governments can leverage on taxation. The central government reallocate resources among local governments with the purpose to grant equal access to essential services across the country. In 2002, a fund for equalization was established. The resources are distributed to local governments, both directly and through regional governments, so that governments with insufficient own resources are able to provide the necessary services to the population.⁴ To grant equal access to basic services across the country, the central government funds up to 70% of the expenditure reported in the balance sheet of the year before.⁵ The other services need to be funded with own resources.

In 2015, local governments spent 83 billion Euro, which is 10% of total public expenditure in Italy. Transfers of financial resources from the central and regional governments and from other public institutions account for 14% of current revenues. These transfers are mainly unconditional. Current transfers represent on average 70% of total transfers and

⁴The benchmark adopted by the central government is the average revenue of municipalities of a given demographic class. Decree Law 267/2000 (*Testo unico delle leggi sull'ordinamento degli enti locali*) classified municipalities into 12 demographic classes based on the size of the resident population and defined regulation accordingly, because population size determines differences in needs.

⁵Since 2009, services provided by local governments are divided into basic services and other services. Basic services are general administration, local police, education, local transport, social protection and local services. Local services are housing, Civil Protection, waste disposal, water services, and services for environmental protection.

they are generally non-earmarked transfers, while the remaining share represents capital transfers, which are generally distributed for specific projects, such as the construction of infrastructures. The remaining 86% of local government revenues is composed of own resources. Almost half of own resources are produced by local taxation (ISTAT, 2017).

The response of public authorities to natural disasters consists of two phases. Immediate aid is provided to meet short-run needs, such as the provision of food and medicals, the preparation of emergency camps, and the inspection and evaluation of damages to infrastructures. Later on, effort is put in the recovery from losses and in the prevention of future disasters. Generally, funds for recovery from damages are matching grants, i.e., they meet spending requirements for specific projects proposed by local public authorities.

Although central authorities are not obliged to intervene in the case of natural disasters, usually they offer immediate support through the Civil Protection Department.⁶ Moreover, the law empowers the central government to claim the state of emergency and define its duration and the involved area (Art. 5 of Law 225/1992). This claim has two main implications. First, the central government can recur to decrees to face the situation notwithstanding the current regulation. In this way, public authorities can intervene immediately without the need to recur to legislative procedures, which could impede a prompt and proper response to the catastrophe. The second implication is that the state of emergency allows to transfer financial resources from the fund of the Civil Protection to the affected areas. However, this procedure can have a drawback in terms of timing. The central government can claim the state of emergency only upon request from regional governments through the Civil Protection. Commonly, regional governments decide whether to ask for the state of emergency based on the size of damages. They delegate the collection of information from the citizens to local governments, a procedure that could delay effective intervention.⁷

For medium and long-run support to disaster areas, the central government needs to follow ordinary legislative procedures. Based on the size of damages resulting from inspections, financial resources for the reconstruction of capital and the recovery of economic

⁶The Civil Protection Department, which is administered by the Presidency of the Council of Ministers, guides the prevention, response, forecast and risk monitoring activities related to both natural and man-made disasters through central and local units across the country.

⁷In 2002 and 2003, further regulation was introduced in order to reduce the time of response and the exposure to seismic risk. In case of extreme events that threaten lives of individuals, the government can assign special powers to a delegate even before claiming the state of emergency (Art. 3 of Law 245/2002). Also, an additional fund, managed directly by the premiership, was established to transfer resources to regional and local governments for both prevention and disaster relief (Art. 32-bis of Decree Law 269/2003).

activities are allocated by means of decree laws. A final tool at government disposal is the yearly financial law, which allows to allocate additional resources to the areas affected by catastrophic events.

3 Data and descriptive evidence

3.1 Data

In this study we use 3 main data sets: (1) local government balance sheet data, (2) data on earthquake occurrence, and (3) data on municipality characteristics. Data on local government expenditure are available for 7997 Italian municipalities observed for 16 years (2000-2015).⁸ The panel data set is obtained from the Italian Ministry of the Interior and contains detailed information on expenditure as well as revenues of local governments for each year.⁹ Our measure of expenditure (revenues) is the sum of current and capital expenditures (revenues) registered in the competence and residual accounts in each year.^{10,11}

We gathered data on earthquakes from two databases available from INGV that collects information on earthquake occurrence between 1000 and 2014.¹² The first database is the parametric catalog of earthquakes CPTI15 (Rovida et al., 2016) that includes detailed information on each earthquake (e.g., magnitude, maximum intensity, coordinates of the epicenter). The second database is the macro-seismic database DBMI15 (Locati et al., 2016), which reports local earthquake intensity measures. The selection criteria for the inclusion of an earthquake in the databases are either a maximum intensity equal to or greater than 5 on the Mercalli scale, or a moment magnitude equal to or greater than 4.¹³ Although data on earthquakes for 2015 are not available, their impact is likely negligible

⁸A small number of municipalities merged over this period. Therefore, to construct a homogeneous panel over the entire period, we aggregate the data of merged municipalities in the years before the merger. We replicate the 2016 municipality structure because some data are available only for that level of aggregation.

⁹Actually, we have data for the period 1990-2015 but differences in the statistics before 1998 and the lack of data on household income in 1998 and 1999 advise not to use those data before 2000.

¹⁰The competence account registers expenditures and revenues related to cash flows, while the residual account registers transactions for which the cash flow has not occurred yet.

¹¹For the years 2000 and 2001 currency values expressed in Italian Lira were converted to Euro using the fixed exchange rate of 1,936.27.

¹²<https://emidius.mi.ingv.it/CPTI15-DBMI15/>.

¹³The intensity is measured on the Mercalli scale and quantifies the observed effects of an earthquake on a scale from 1 to 12. The moment magnitude is a logarithmic scale that measures the energy released by an earthquake. A unit increase in the scale corresponds to $10^{1.5}$ times higher released energy. While the magnitude is measurable with instruments, the intensity is an evaluation performed by experts based on the observable effects on humans, infrastructures and objects.

since INGV stated that fewer earthquakes occurred than in 2014 and only 18 shocks had a magnitude equal to or above 4, no one bigger than 5.

The third data set includes socioeconomic, sociodemographic, and environmental characteristics of Italian municipalities between 2000 and 2015. In particular, the data set contains data on income levels, sourced from the Department of Finance of the Ministry of Economics and Finance, data on population size, age structure and environmental characteristics sourced from the Italian Institute for Statistics (ISTAT), and political characteristics sourced from the Italian Ministry of Interior. Moreover, we use data on minimum and maximum housing prices (per square meter) provided by the Real Estate Market Observatory of the Italian Revenue Agency. These data are collected twice a year and are complete since the second semester of 2003.

The total number of observations (municipality \times year) is 127,952. Balance sheet data and political variables are not complete for 8,076 observations. Therefore, our final data set is an unbalanced panel composed of 119,876 observations.

3.2 Measurement of earthquake occurrence

Two measures of earthquake occurrence can be used to identify municipalities affected by earthquakes (treated municipalities): the *magnitude* and the *intensity*. The *magnitude* is an objective measure of the strength of an earthquake and its ability to serve as a proxy for damages to human and physical capital may be questioned. Since the *magnitude* is a space-invariant measure, some assumptions on the propagation of the effect in terms of distance and direction are required to assign earthquake events to municipalities. Generally, the propagation of earthquake waves depends on the depth of the epicenter and on the characteristics of the soil. Instead, *intensity* is the result of the evaluation of the observable impact performed by experts, who usually inspect disaster areas immediately after the shock. One cannot exclude that this evaluation is to some extent affected by subjective judgment driven by emotional involvement (e.g., attachment to the disaster area or to people who live there) or even corruption (e.g., the overestimation of the impact of an earthquake could allow to attract more financial resources from upper-level government). However, *intensity* is assessed for each municipality affected by an earthquake and allows easily to identify towns affected by damages due to the shock. In our analysis, we prefer the *intensity*-based measure of earthquake occurrence because this is a qualitative measure of the local impact of an earthquake and varies among municipalities. The use

of fixed effects in our econometric models should address any claim of systematic bias in the measurement of earthquake occurrence due to subjective judgment correlated with the geographical/institutional setting. More than that, we perform robustness checks of our results based on the described *magnitude*-based measure of earthquake occurrence under different assumptions of propagation. We provide a more detailed description of this approach later on in Section 5.1.1.

We assign treatment if a municipality is struck by at least one earthquake with *intensity* ≥ 5 in a given year. We choose this threshold because 5 is the lowest *intensity* level at which damages usually occur, and because it is the minimum *intensity* level for which we have complete data. Then, we define a set of treatment dummies $EQ_{i,t-j} = 1$, where i denotes the municipality and t the year, if the local maximum intensity of earthquakes occurred in the year $t - j$ (with $j \geq 0$) is ≥ 5 . This set of variables allows to capture the impact of an earthquake at different points in time before the current year t . Our treatment variables show that 2658 municipalities are struck by an earthquake at least once over the period 1985-2015, and 1129 out of these municipalities are affected at least once over the period 2000-2015.

3.3 Descriptive evidence

As preliminary suggestive evidence we compare the per capita local government expenditure of municipalities struck by at least one earthquake over the period 1985-2015 with the expenditure of municipalities that did not face any earthquake during the same period. Figure 2 shows that, on average, municipalities affected by earthquakes spend more than other municipalities, with a mean difference for the period 2000-2015 of 106 Euro per individual at 2010 prices. In 2015, local governments increased expenditure by 10% on average because the central government loosed the constraints on capital expenditures, which were limited as a consequence of the economic crises in order to attempt to reduce public debt. Clearly, we cannot exclude that this difference is due to factors other than earthquake occurrence, such as institutional differences or historical spending behavior. Indeed, local government expenditure varies both across and within Italian regions, which may be due to factors such as geographical and institutional characteristics and economic development (see Figure A.1 in the Appendix).

To identify the impact of earthquakes on local government expenditure, it would be desirable to observe the same municipality under the two scenarios of treatment (earthquake

occurrence) and no treatment. Clearly, this is not possible but may not represent a problem if earthquakes are randomly assigned to municipalities. The assumption of random assignment is challenged by earthquake occurrence over time since some areas are more exposed than others. However, a matching procedure that enhances the comparability of municipalities may grant sufficient strength to the analysis. Therefore, we sharpen the evidence of Figure 2 and reduce the unobserved variability, by comparing municipalities that are similar in the period before the occurrence of an earthquake. To do this we construct a counterfactual group of municipalities that allow us to analyze post-treatment variations of spending levels and to claim a causal relationship with earthquakes. Figure 3 illustrates the average spending trend of 517 treated municipalities, before and after the occurrence of a shock, with 517 matched municipalities. We identify matched municipalities with coarsened exact matching on average financial, sociodemographic and socioeconomic pre-treatment characteristics (see the Appendix Section A.1 for further information on the matching procedure and Table A.1 for the balancing properties). Note that, before treatment occurs, average per capita local government expenditure is almost identical in the two groups. Starting from the first year after the treatment period (period 0), expenditure sharply diverges. Treated municipalities seem to spend much more than the counterfactual group. Spending trends start to converge again from the 7th year after the disaster, though not completely.

Table 1 provides some descriptive statistics on the characteristics of 1129 municipalities struck by an earthquake over the period 2000-2015 and 5339 unaffected municipalities. We observe that in the year before the occurrence of an earthquake, municipalities do not significantly differ in terms of per capita expenditure and revenues, while the revenue composition tends to differ in treated municipalities. Treated municipalities collect less local taxes than the control group, which could be due to the lower household income and the higher share of low-income population.¹⁴ The lower amount of local tax revenues is partially offset by increased transfers of financial resources from the central and regional governments. The aggregate revenues from local taxation and transfers account for about 60% of total revenues.

After an earthquake, both local government expenditure and revenues significantly

¹⁴We define the share of low-income population as the share of individuals earning a yearly income less than or equal to 10,000 Euro. Note that our income data is structured in 8 income classes and for each class we have information on the total amount of income and the number of individuals. According to our definition, the low-income individuals are those of the two lowest income classes representing about 39% of the total number of individuals.

increase by 198 and 185 Euro per capita, respectively. The immediate increase of revenues allows to limit losses. Additional revenues are composed for more than 60% of transfers from the central and regional governments. Revenues from local taxation, instead, do not vary significantly on average. As for the population size and age structure, treated municipalities are almost twice as populated as other municipalities and, before the shock, they have a slightly higher fraction of the youngest and oldest age cohorts. Population size does not significantly vary after the shock, but the age structure changes since the percentage of young people tend to shrink, while the elderly share increases. This could suggest that elderly people are less mobile because of physical limitations, or stronger emotional attachment to their town.

This preliminary evidence suggests that the comparison of expenditure levels between municipalities affected and not affected by earthquakes should carefully address differences in terms of characteristics that could confound expenditure variations. The following empirical strategy controls for those observable characteristics as well as other unobservable time-invariant characteristics.

4 Empirical strategy

4.1 Earthquakes and spending levels

To assess the impact of earthquakes on local government expenditure, we regress per capita expenditure against earthquake measures and control for characteristics of municipalities and local institutions that may affect spending levels as well as for time-invariant heterogeneity.¹⁵ We specify the following model:

$$y_{it} = T'_{it}\alpha + x'_{it}\beta + \theta_t + \gamma_i + \varepsilon_{it} \quad (1)$$

where y_{it} is the natural logarithm of per capita expenditure of municipality i in year t . T'_{it} is a vector of treatment variables, i.e., earthquake indicators, and x'_{it} is a vector of time-varying controls, including the intercept term. Controls (x'_{it}) include income, population age structure, geographic and political characteristics, and funding sources from the central and regional governments. α and β are the vectors of parameters to be estimated. θ_t are time fixed effects, γ_i is a municipality-specific time-invariant element,

¹⁵The literature has suggested several features of local governments that are likely to affect the expenditure. See for instance Gennari and Messina (2014) and Lundqvist (2015).

and ε_{it} is the idiosyncratic error term.

In our baseline specification $T'_{it}\alpha$ is defined as:

$$T'_{it}\alpha = \sum_{j=0}^1 \alpha_j EQ_{i,t-j} + EQ_{i,t-d} \times (\alpha_{d1} Dist_{it} + \alpha_{d2} Dist_{it}^2 + \alpha_{d3} Dist_{it}^3) \quad (2)$$

where $EQ_{i,t-j}$ and $EQ_{i,t-d}$ are the dummy treatment variables described in Section 3.2. More precisely, the two terms in the summation, EQ_{it} and $EQ_{i,t-1}$, capture the effect of an earthquake occurred in the current year and one year before, respectively. The shocks occurred earlier (more than one year before) are captured by $EQ_{i,t-d}$, where d is the temporal distance from the most recent earthquake before $t - 1$ ($1 < d \leq 15$). We define $Dist_{it} = d$ if $EQ_{i,t-d}$ is equal to 1, and 0 otherwise. Therefore, the distance polynomial of third degree (within brackets) is a non-linear time-trend capturing medium-run marginal effects of earthquakes on expenditure. We consider a non-linear time-trend to capture a possible inverse U -shaped effect and a tail of earthquakes on expenditure.¹⁶ Indeed, our descriptive statistics suggest that expenditure initially grows and then tends to converge to pre-treatment levels. We impose $Dist_{it} \leq 15$ since beyond this period we generally observe a convergence of expenditure to pre-treatment levels, as suggested by the descriptive statistics in Section 3.3.¹⁷

The covariates that compose the vector x'_{it} are a set of time-varying financial, political, socioeconomic, and sociodemographic variables, and a set of time-invariant environmental characteristics. Financial variables include the natural logarithm of per capita transfers from the central and regional governments, and the natural logarithm of per capita revenues from local taxation. Political variables include the vote-share concentration of the local government Council, the number of years before municipal elections, a dummy variable equal to one if the incumbent government is center-right oriented, and a dummy variable equal to one if the incumbent mayor reached his term limit. Socioeconomic variables include the natural logarithm of average yearly per capita income and the share of low-income population, and sociodemographic variables include the share of the youngest (0-14 years) and oldest (≥ 65 years) age cohorts. Environmental characteristics are cap-

¹⁶We use a third-order polynomial time-trend because, according to preliminary findings, it is the most suitable specification to capture the effect of an earthquake on local government expenditure. Indeed, in what follows we use also a model specification including yearly lags of earthquake occurrence measures (see Section 5.2).

¹⁷Preliminary findings suggest that spending levels tend to converge to pre-disaster levels between the 10th and the 15th year after an earthquake. Moreover, the impact of an earthquake is fully observed for a maximum of 15 periods in our panel.

tured by dummy variables equal to 1 indicating whether a municipality is a partially mountainous jurisdiction, a mountainous jurisdiction, or a coastal jurisdiction.

To estimate the parameters of our model we use three methods: pooled OLS, random effects, and fixed effects regressions. Pooled OLS provides consistent parameters but treats observations as mutually independent and does not account for serial dependence of observations. Hence, the main limitation of the pooled OLS model is that possible unobserved heterogeneity among municipalities is neglected ($\gamma_i = 0$). However, both OLS and random effects regressions include a region-specific time-invariant effect.¹⁸ The random effects model treats unobserved heterogeneity of municipalities as a random shock and requires the assumption that γ_i is *iid*. The fixed effects model relaxes this assumption by allowing γ_i to be correlated with the other exogenous variables, but it does not allow to include environmental time-invariant characteristics and region fixed effects.¹⁹ The random effects model is more efficient, but if the assumption on the independence of the time-invariant error is violated, the estimates are biased. In that case, the fixed effects model should be preferred because it estimates consistent parameters. Since several unobserved factors could lead to differences in spending levels (e.g., geographic characteristic, touristic attractiveness, economic development), we expect the fixed effects model to be more appropriate. We formally test this assumption using the Hausman test.

In addition, we specify a first-order autoregressive model and include the lag of the dependent variable as a regressor in Equation 1. This specification allows to capture the persistence of local government expenditure that may be driven by historic and institutional factors. We estimate this model with municipality fixed effects. Since serial correlation and heteroskedasticity may affect the estimation of the standard errors, we use robust standard errors clustered by municipality in all specifications.

An issue that needs to be discussed is the possible endogeneity of upper-level government transfers. In Equation 1, we assume that transfers are exogenous, and hence transfers lead to a variation of local government expenditure because more resources are available, as literature in this field suggests (e.g. Gennari and Messina, 2014; Revelli, 2006). However, variations of transfers from upper-level governments may not be completely ex-

¹⁸Note that region-specific time-invariant effects account for heterogeneity between ordinary and autonomous regions with special statute (i.e. the regions Valle D'Aosta, Friuli Venezia Giulia, Sicily and Sardinia, and the provinces of Bolzano and Trento), such as differences in the funding mechanism of public expenditure. Moreover, conditional on region-specific time-invariant effects, our regression results are not sensitive to the inclusion/exclusion of autonomous regions with special statute.

¹⁹Two municipalities of the region Marche became part of Emilia-Romagna in 2010. However, this change is not significant.

ogenous to expenditure variations if they are influenced by higher spending requirements (Lundqvist, 2015) or by the ability of politicians to attract financial resources from upper-level governments (Galletta, 2017). In this case, OLS and GLS estimates could be biased because the assumption on the independence of the error term ($E[\varepsilon_{it}|X] = 0$) is violated. The within-estimator of the fixed effects model partially accommodates this problem since it accounts for time-invariant factors that lead to the endogeneity of transfers. We further address this issue by a two-stage instrumental variable (IV) approach discussed in Section 5.1.

We test the robustness of our identification strategy by defining other criteria for the assignment of treatment. We use different earthquake-intensity thresholds and magnitude-based measures to define treated municipalities. Note, however, that raising the intensity threshold implies a reduction in the number of treated municipalities. Over the period 2000-2015, municipalities struck by an earthquake with intensity ≥ 6 are 213, and only 46 with intensity ≥ 7 . Such a low number of treated municipalities could have some drawbacks in the econometric estimation. If we raise the intensity cut-off and sharpen our sample of affected municipalities we expect to observe a larger impact of earthquakes on expenditure. Finally, to confirm our evidence, we repeat the analysis using the sharper sample of matched municipalities defined in Section 3.3, which is likely less exposed to unobserved heterogeneity but also more prone to dim the effect due to proximity between treated and matched municipalities.

4.2 Asymmetric and heterogeneous responses to grants

Descriptive evidence in Section 3.3 suggests that central and regional governments largely contribute to local disaster relief through the transfer of financial resources to municipalities. To better understand how earthquakes, local government expenditure and transfers are related to each other, we run a preliminary analysis using two models, where the dependent variable is either local government expenditure (as in the previous Equation 1) or transfers. To see the impact of earthquakes in different years, we use a linear vector of all earthquake occurrence dummies in the last 12 years, $T'\alpha = \sum_{j=0}^{11} \alpha_j EQ_{t-j}$, instead of the polynomial specification of Equation 2. Therefore, we estimate the yearly ATT of an earthquake on both expenditure and transfers. We limit the analysis to the 11th year after the disaster since previous results suggest that after that period the effect of one

single earthquake is negligible.²⁰

One interesting aspect on the effect of grants is the comparison between earthquake-related grants (mostly matching grants) and other types of grants (mostly unconditional grants). The literature on flypaper effects generally suggests that matching grants have greater influence on expenditure than unconditional grants, since the former combine an income and a substitution effect (Gramlich, 1977).²¹ To provide empirical evidence on the flypaper effect in Italy, Gennari and Messina (2014) focus on unconditional grants and, therefore, try to exclude outlier observations due to shocks to avoid any confounding factor related to matching grants. We can contrast this approach by exploiting the large and unique dataset of earthquake occurrences to separate (earthquake-specific) matching grants from unconditional grants. This allows us to disentangle heterogeneous flypaper effects and asymmetric responses to different types of grants. Since data on earthquake-specific grants are limited and incomplete, we use the control group of not treated municipalities identified by the matching procedure above to predict the average growth rate of (unconditional) transfers if earthquakes would not have occurred.^{22,23}

We can now use predicted grants of different types to expand the linear flypaper effect model (Gennari and Messina, 2014) as follows:

$$Y_{it} = \alpha_1 MG_{it} + \alpha_2 MA_{it} + \alpha_3 UG_{it} + \alpha_4 UA_{it} + X'_{it}\beta + \theta_t + \gamma_i + \varepsilon_{it} \quad (3)$$

where Y_{it} is the level of per capita expenditure of municipality i in year t , MG_{it} is the level of (earthquake-specific) matching grants and UG_{it} is the level of unconditional grants. X'_{it} is the vector of control variables as in Section 4. θ_t and γ_i are time and municipality fixed effects, and ε_{it} is an *iid* error term.

The variables MA_{it} and UA_{it} measure the decrease of matching and unconditional grants relative to the previous year ($t - 1$), respectively, and are specified as $MA_{it} = MD_{it}(MG_{it} - MG_{i,t-1})$ and $UA_{it} = UD_{it}(UG_{it} - UG_{i,t-1})$, with MD_{it} and UD_{it} being dummy variables equal to one if the respective grants are decreasing, and 0 otherwise.

²⁰We also perform the analysis with $j = 15$, but coefficients for $j > 11$ are not significant.

²¹This is because public goods relative prices tend to fall, which shifts resources away from private goods.

²²Balance sheet data does not allow to identify transfers received for disaster relief. The Department of the Civil Protection provides reports on the allocation of earthquake relief funds, but these documents cover only the period 2012-2015 and detailed information on the resources received by each local government is not always available.

²³Barone and Mocetti (2014) compare the effects of two large earthquakes in Italy by means of a synthetic control approach based on regional data.

Therefore, MA_{it} and UA_{it} capture the asymmetric response of expenditure to variations in the two types of grants. In accordance with Gennari and Messina (2014), not significant estimates of the parameters α_2 and α_4 imply that local governments react similarly to increases and decreases in transfers. Conversely, significant estimates of α_2 and α_4 imply that $\alpha_1 + \alpha_2$ measures the expenditure response to decreasing matching grants, and $\alpha_3 + \alpha_4$ is the response to decreasing unconditional grants. Negative and significant parameters α_2 and α_4 suggest that local government expenditure is more sensitive to increases than to decreases in transfers, while positive and significant estimates suggest the opposite. In the literature on flypaper effect, the former type of response is known as the "fiscal replacement" effect (Gramlich, 1987), while the latter type of response is the so-called "fiscal restraint" effect (Gamkhar and Oates, 1996).

The final part of our empirical strategy hypothesizes that the response of local governments to earthquake shocks differs across the country, between Northern and Southern municipalities. To this aim, we modify the above Equation 3 to include the interaction terms between grants (both unconditional and earthquake-specific grants) and a dummy variable equal to one if a municipality is located in Southern regions, namely Abruzzo, Molise, Campania, Puglia, Basilicata, Calabria and Sicily.²⁴ The two asymmetry variables are now dropped.²⁵ For simplicity, we will use *North* and *Northern* to refer to all other regions. A further distinction between North and Center has been considered but did not provide significant differences.

5 Results

5.1 The impact on spending levels

The effect of earthquake shocks on local government spending from the estimation of Equation 1 using pooled OLS, random effects, fixed effects, and autoregressive fixed-effects regressions is summarized in Table 2.²⁶ Since the dependent variable, i.e., the per capita local government expenditure, is log-transformed, coefficients multiplied by 100 can be interpreted as percentage changes of expenditure after the occurrence of an

²⁴This classification is provided by ISTAT, except for Sicily which is classified as *Island* together with Sardinia. However, Sicily is commonly identified as a Southern region because of its geographical location and cultural and environmental aspects.

²⁵Note that the two asymmetry variables are not significantly different between municipalities in the North and in the South (results not reported here).

²⁶Note that the lag of the dependent variable in the autoregressive model is grouped with the financial time-variant controls.

earthquake. The coefficients of earthquake occurrence in the current and the previous year (EQ_t and EQ_{t-1}) can be interpreted as average treatment effects on treated municipalities (ATT). The coefficients of all treatment variables are highly significant, slightly less for the immediate effect EQ_t . The OLS results are basically in line with panel data models although repeated observations over time and possible correlation between the treatment variables and unobserved characteristics of municipalities are not taken into account. Only the coefficient of the immediate effect, EQ_t , is likely overestimated.

The estimates from the random and fixed effects models are very similar. However, we can easily reject the null hypothesis of the Hausman test, which suggests that the fixed effects model should be preferred.²⁷ The fixed effects specification controls for time-invariant municipality-specific characteristics such as geographical seismic zones.²⁸ All the coefficients are slightly lower in the autoregressive specification (column 4), which suggests that earthquake measures partially capture the effect of persistent spending.

In the fixed effects specifications, the immediate impact of an earthquake on local government expenditure is between 1.90% and 1.94%, which roughly corresponds to 27-28 Euro per capita. After one year, the effect of the shock is three times larger with a shift of local government expenditure between 6.03% and 6.60% (98-108 Euro per capita). This is an expected result for a developed country according to Noy and Nualsri (2011). Since local governments may not respond immediately to the shock and the budget needs some time to be adjusted, we observe that the impact is higher one year after the event. The local government may rather decide to respond immediately by changing the spending composition and reallocate the resources destined to services that cannot be offered anymore due to unavailable infrastructures or loss of human capital. Other spending categories (e.g. local services, social protection) may now require more resources to tackle the consequences of the seismic event. After one year the expenditure tends to increase because of investments in disaster relief, e.g. cleaning, reconstruction and reimbursement of damages to citizens. Moreover, the delay in the increase of expenditure may be due to the timing of external aid from upper-level governments and from charity.

Differences in spending levels between treated and unaffected municipalities are not limited to the short-run. The first-, second- and third-order interaction terms between

²⁷The Hausman test returns the statistic $\chi^2(29) = 10,709.28$, and the critical value in a 99.9% confidence interval is $\chi^2_{0.001}(29) = 58.30$.

²⁸Note, however, that the inclusion of seismic zones into OLS and random effects models does not affect the results.

earthquake occurrence and time passed since the latest shock suggest that the effect on spending levels tends to increase in the years after the event, but then expenditure slowly converges to pre-disaster levels (negative coefficient of second-order interaction and positive coefficient of the third-order interaction). The estimates show that expenditure continues to grow until 4-5 years after the disaster and then regresses to pre-disaster levels after 11-12 years.²⁹

To correct the estimates for possible endogeneity of transfers from central and regional governments, we use an IV approach and estimate the model in column 3 using 2SLS and the second lag of transfers received by neighboring jurisdictions as an exogenous instrument.³⁰ The estimates for the parameters are reported in column 5. Diagnostic tests confirm that transfers are endogenous and that the IV specification provides consistent estimates compared to the fixed effects specification. The coefficients of all earthquake-occurrence variables are lower in absolute values and EQ_t loses significance. This is most likely determined by the fact that transfers from central and regional governments increase when an earthquake occurs and, given that the first-stage regression of the IV approach accounts also for earthquake variables, exogenous transfers in the second stage regression capture part of the effect of an earthquake on expenditure. Nevertheless, the coefficients still show that the effect of an earthquake on expenditure lasts for 11-12 years.

5.1.1 Robustness checks

The robustness of our main results is ensured by an alternative approach to identify the effect of earthquakes on local government expenditure based on the matching sample described in Section 3.3 (see also the Appendix Section A.1 for information on the matching procedure). Moreover, we consider several different criteria for the assignment of treatment. When we run regressions using the sample of matched municipalities (see Table A.2 in the Appendix) we obtain similar results, but the coefficients of the treatment variables are slightly larger. This is because the prevalence of municipalities struck by stronger earthquakes is greater in the matching sample than in the full population of

²⁹We compute the growing period by looking at the maximum of the estimated function defined by the two interaction terms ($d = (-2\hat{\alpha}_{d2} - \sqrt{4\hat{\alpha}_{d2}^2 - 12\hat{\alpha}_{d1}\hat{\alpha}_{d3}})/6\hat{\alpha}_{d3}$, with $\hat{\alpha}_{d1}$, $\hat{\alpha}_{d2}$ and $\hat{\alpha}_{d3}$ being the estimates of the parameters α_{d1} , α_{d2} and α_{d3} in Equation 2, respectively) and calculate the convergence period by computing the zeros of the same function ($d = (-\hat{\alpha}_{d2} - \sqrt{\hat{\alpha}_{d2}^2 - 4\hat{\alpha}_{d1}\hat{\alpha}_{d3}})/2\hat{\alpha}_{d3}$).

³⁰Differences are negligible indeed if we repeat the estimation using the first or the second temporal lag of transfers instead of the spatial-temporal lag.

Italian municipalities.³¹ Exception is the pooled OLS model (column 1) which provides a significant estimate only for the coefficient of EQ_{t-1} , but the limitations of this model have been described in Section 4.1.

We run a second robustness check using higher minimum intensity levels (6 and 7 instead of 5) to assign treatment (see Table A.3, columns 1 and 2, in the Appendix). The results are in line with our baseline results, although the effects are much larger due to the focus on stronger earthquakes. Also, spending levels reach pre-treatment levels 15 years after the shock, three years later than previous estimates suggest.

Finally, we define earthquake occurrence measures based on the magnitude of the earthquake. We select earthquakes with moment magnitude ≥ 4 because this is the minimum magnitude for which the INGV includes earthquakes in the database. The magnitude is generally more objective than the intensity, but we need to assume that the energy released by an earthquake propagates homogeneously from the epicenter in all directions since it is measured at the epicenter only.³² Therefore, we considered municipalities within some distance from the closest epicenter. In particular, we use 10 km, 20 km, and 30 km distance thresholds between the epicenter and the centroid of each municipality. As shown in Table A.3, columns 3-5, in the Appendix, our baseline results are confirmed. The estimates show that the greater the distance from the epicenter, the lower is the impact on local government expenditure (moving from column 3 to column 5). In particular, the model using the 20-km range for the assignment of treatment (column 4) provides similar estimates to those obtained in Table 2. This implies that municipalities struck with intensity ≥ 5 are located, on average, within 20 km from an epicenter with magnitude ≥ 4 .

5.2 The role of grants

The role played by grants from upper-level governments in raising expenditure following an earthquake is summarized by the results reported in Table 3. Column 1 shows fixed effects estimates on the natural logarithm of per capita local government expenditure, and column 2 on the natural logarithm of per capita transfers. The coefficients of treatment variables are significant until the 10th year after the disaster for local government expenditure, similarly to the results obtained in Table 2, and until the 9th year for

³¹In the total population of municipalities, 19% of the treated municipalities are struck by an earthquake with intensity equal to 6, and 4% with intensity ≥ 7 . In the matching sample, these percentages increase to 20% and 5%, respectively.

³²In 2017, an earthquake struck the isle of Ischia in the Campania region with a relatively low magnitude of 4, but caused relevant damages.

transfers. Moreover, transfers of financial resources grow initially faster than local government expenditure after an earthquake, and absolute per capita variations (in Euro) show that transfers increase more than expenditure between the 2nd and the 7th year after an event (see columns 3 and 4 of Table 3).³³ This evidence is illustrated in Figure 4 with 95% confidence intervals. While the increase in per capita expenditure is roughly stable between the 2nd and the 6th year after an earthquake, transfers from central and regional governments follow a different trend. Central and regional governments tend to respond immediately to the higher spending requirements of treated municipalities. Then, from the 8th year after the event, additional transfers fall below the increase in expenditure. Overall, the increase in transfers overcomes the increase in expenditure.

Over the overall period (11 years), treated municipalities spend 952 Euro per individual more than not affected municipalities, while per capita transfers are 1201 Euro higher. Hence, transfers of financial resources from central and regional governments seem to exceed expenditure by 249 Euro per individual. If we consider that the average population of a treated municipality between 2000 and 2015 is about 10,000 individuals and 1129 municipalities are struck by an earthquake, the difference between transfers and expenditure amounts to almost 2.8 billion Euro. Generally, policy makers at central and regional levels allocate grants to municipalities affected by earthquakes mainly in the form of matching transfers. Although local governments are supposed to make use of these resources over time, some amount remains on hold and does not translate into higher expenditure for several years. Actually, an effective monitoring system on how resources are spent is still not in place, and transfers may also partially compensate lower revenues from local taxation, since the central government can allow to postpone the payment of taxes for people residing in disaster areas.

5.3 Flypaper effect and asymmetric response

The effects of earthquake-related grants (matching grants) and unconditional grants on local government spending are compared in Table 4. This table reports the results from fixed effects regressions using Equation 3. In column 1 the two asymmetry variables are initially excluded from the estimation. Note that both earthquake-specific and unconditional grants stimulate expenditure more than income. The expenditure response

³³We transform the estimates of the treatment variables in columns 1 and 2 into real per capita variations using $A\hat{T}_{t-j} = (1 - e^{-\hat{\alpha}_j})\hat{y}_{t-j}$, with y identifying either per capita expenditure or per capita transfers at 2010 prices, $\hat{y}_{t-j} = E[y_{it}|EQ_{i,t-j} = 1]$, and $\hat{\alpha}_j$ being the estimated coefficients of EQ_{t-j} .

to one additional Euro of unmatching grants is almost 13 times larger than the response to income.³⁴ Our estimated coefficient is slightly different from the coefficient estimated by Gennari and Messina (2014). This is because we use a fixed effects specification and data for a different period, and aggregate central and regional government transfers and current and capital transfers. However, our results are similar to the results obtained by Gamkhar and Oates (1996). Although the impact of matching grants is more than 5 times the effect of income, the multiplier is smaller than the multiplier of unconditional grants (about half). This is apparently surprising since the theory suggests that specific transfers should have at least the same effect on expenditure as unconditional transfers (Bailey and Connolly, 1998). However, as we will see later in Section 5.4, this is an average effect that does not account for heterogeneity in the response across the country, likely due to remarkable variation of efficiency in the use of earthquake-specific transfers.

In column 2, we extend the model to include the two asymmetry variables that capture different effects between increasing and decreasing transfers. The negative and significant coefficient of the asymmetry variable relative to unconditional grants suggests that there is a replacement effect when transfers decrease, i.e., expenditure is sticky to decreasing unconditional grants, a result in line with the findings of Gennari and Messina (2014). Similarly, expenditure is less responsive to decreasing than to increasing earthquake-specific grants, although this asymmetric response is more pronounced than the response to unconditional transfers. The sum of the estimated parameters of earthquake-specific grants ($\hat{\alpha}_1$) and their asymmetry variable ($\hat{\alpha}_2$) is close to zero and suggests that a reduction in the transfers for earthquake recovery has negligible effects on spending levels.

In column 3, we report the results from the estimation of a 2SLS fixed effects regression instrumenting general transfers and the relative asymmetry variable with the second lag of general transfers and the second lag of general transfers of neighboring municipalities (2-years spatial lag).³⁵ Diagnostic tests confirm that general transfers are endogenous and that the instrumental variable approach yields consistent estimates. We can see that the effect of general grants on spending levels is more remarkable than in column 1 and 2, and the coefficient of the asymmetric response to decreasing grants loses significance. These coefficients are very close to the estimates of Gennari and Messina (2014). Conversely, the

³⁴The coefficient of unmatching grants does not change if we estimate Equation 3 using only the subsample of municipalities not affected by earthquakes.

³⁵To enhance the comparability of our results with those obtained by Gennari and Messina (2014), we repeat the estimation using the first and the second temporal lag of transfers, but differences are insignificant.

estimated parameters of earthquake-specific grants and their asymmetry variable are very close to the coefficients reported in column 2. Overall, these results allow to conclude that there is evidence of flypaper effect for both types of grants. However, we find inconclusive evidence of an asymmetric response to increasing vs. decreasing unconditional transfers (fiscal replacement), similarly to most previous studies but differently, for instance, from Levaggi and Zanola (2003), who testify a fiscal restraint type of asymmetry on regional health care expenditure in Italy. Conversely, the fiscal replacement effect is remarkable for earthquake-specific matching grants, suggesting that public officials may exploit the occurrence of earthquakes to maintain higher spending levels. Moreover, local governments are apparently unable to fully exploit upper-level government transfers to increase expenditure when struck by an earthquake. This suggests a delay in the response to increasing grants, leading to an inefficient use of resources for disaster relief. We further address this aspect in the next Section 5.4.

5.4 The North-South divide

5.4.1 Timing of the response

Local governments may differ in the response to earthquake recovery measures. Several aspects, such as culture, history and institutional quality, may affect this response. Barone and Mocetti (2014) argue that these differences influence economic outcomes after an earthquake. They compare two big earthquakes in Italy and show that the lower institutional quality in the South worsened after the shock and led to a lower economic growth (for a discussion on the regional divide in Italy, see for instance Felice (2018) and González (2011)). Following this evidence and inspired by the above findings on asymmetric and heterogeneous flypaper effects, we analyze how the response of local governments to earthquake shocks differs between Northern and Southern municipalities. The results from the estimation of the extended Equation 3 to include the interaction terms between grants and location are reported in Table 5.

As for unconditional grants, we do not observe a significantly different effect between Northern and Southern municipalities (in column 1, the coefficient of the interaction term between the South dummy and unconditional grants is not significant). Conversely, earthquake-specific grants show a significantly different effect between Northern and Southern municipalities. In the North, one additional Euro of transfers for earthquake recovery raises expenditure by 1.43 Euro, while in the South the effect is significantly lower

(0.22 Euro, i.e., the sum of the coefficient of earthquake-specific grants and the interaction term). Therefore, municipalities in the North seem to overreact to transfers for earthquake recovery, while expenditure in the South is much more sticky. Note that Northern municipalities are generally less dependent on transfers and their spending levels are lower, which may suggest a lower inertia to changes in transfers. Also, the slower use of earthquake-related resources by municipalities in the South may be the consequence of higher levels of corruption (Mauro, 1995).

The possible delay in the utilization of earthquake-related funds is worth of further analysis. The model in columns 2 and 3 includes the first and second lag of earthquake-specific grants and runs separate regressions for Northern and Southern municipalities. In the North, the inclusion of past matching grants in the regression reduces the estimated coefficient of current-period grants below 1, while the coefficient of the first lag is significant and equal to 1.1, and the coefficient of the second lag is not significant. This suggests that Northern local governments have at most one-year delay in the reaction to additional resources from upper-level governments. Instead, in the South, the immediate response to matching grants is lower (0.128 vs. 0.686), and both the first and the second lag of grants are significant. Moreover, both lag coefficients are below 1 and lower than the estimated coefficients for the North, suggesting that a larger amount of financial resources received by local governments is not spent in the short-run. This may indicate that municipalities in the South are affected by poorer institutional quality, which in turn may cause only partial or delayed recovery from earthquake damages and hinder local economic growth in the future.

5.4.2 Spending composition and growth

To further explore possible inefficiencies in local government response to earthquake shocks, we analyze how disaster relief resources are allocated to different spending categories. In Table 6, we compare variations in the spending composition between municipalities in the North and in the South in the 5 years before and after the occurrence of an earthquake.^{36,37} Before the shock, municipalities in the South spend on average 25.9% of the total budget on *local services*, which exceeds by 6.6% the budget allocated

³⁶The spending category *Other* includes local police, justice, culture, sports and economic development which aggregated account on average for less than 10% of the total budget.

³⁷Table 6 in the Appendix reports variations before and after the shock and between municipalities in the North and in the South and significance levels of *t*-tests on mean differences.

by municipalities in the North. Not surprisingly, after the shock, the expenditure share of *local services* grows in both macro regions since it includes expenditure on public infrastructures, water supply and waste disposal. More precisely, municipalities in the North allocate 2.32% and 0.96% significantly more resources to *local services* and *administration*, respectively, while the budget share for the other spending categories significantly decreases, except for *transport services*. Instead, the share allocated to *local services* by Southern municipalities increases by 5.1%, which goes to the detriment of the budget share allocated to the other spending categories (a significant decrease for *transport services* and *other services*). Therefore, the main difference in the spending composition between Northern and Southern municipalities lies in the remarkable increase of funds for local services in the South, and a relatively more equal allocation of resources across spending categories in the North. While the response of local governments to earthquake shocks in Northern municipalities encompasses all areas of government action, Southern municipalities put their effort mainly in the enhancement of *local services*.

The heterogeneous response to earthquake shocks observed between the North and the South in terms of timing in the use of resources and their allocation points at the most efficient recovery from earthquake shocks. Therefore, we relate the availability and allocation of earthquake-specific resources to economic growth and compare treated and matched unaffected municipalities in the North and in the South.³⁸ We use personal income and mean housing prices as proxies for local economic growth since data on gross domestic product (GDP) are not available at municipality level.³⁹ The trends of these variables are illustrated in Figure 5. Note that, in the North, personal income grows faster in struck municipalities than in unaffected municipalities in the first decade after an earthquake (Figure 5a). Conversely, in the South, the two groups of municipalities have identical income trends (Figure 5b). Similarly, housing prices (per square meter) in the South do not change significantly between struck and unaffected municipalities (Figure 5d). Instead, in the North, housing prices start to grow faster after 4 years in struck municipalities as compared to unaffected municipalities (Figure 5c). This evidence is even more pronounced if we limit the focus to earthquakes with intensity equal or greater than 6. It appears that the result is related to different responses to earthquake shocks between

³⁸In this part of the analysis we exclude municipalities from the region Abruzzo because the 2009 earthquake that affected this region is an outlying shock with strong damages and large financial windfall for reconstruction from upper-tier governments.

³⁹See, for instance, Cheung et al. (2018) and Naoi et al. (2009) for an examination of the effects of earthquakes in terms of house and land values.

municipalities in the two macro-regions. Transfers from central and regional governments in the North (Figure 6a) grow after the occurrence of an earthquake, but converge to pre-earthquake levels after 6 years. Conversely, in the South, struck municipalities remain persistently more dependent on upper-tier government transfers for at least 10 years (see Figure 6b) and allocate a large share of additional resources to *local services* (Figure 6c and 6d).

This evidence obtained from the large dataset of all Italian municipalities and earthquake events between 2000 and 2015, seems to confirm the heterogeneous effects between North and South found by Barone and Mocetti (2014) in their deep investigation of two Italian earthquakes. Even if a larger amount of resources for recovery is allocated to disaster areas in the South, these jurisdictions seem unable to exploit the financial windfall to recover from damages and improve economic growth. Conversely, local governments in the North appear more efficient in exploiting transfers from upper-level governments to expand expenditure and recover from damages. This translates into new infrastructure and the replacement of obsolete technologies destroyed or damaged by the earthquake, which allows to foster local economic development and to accelerate growth. Likely, the allocation of resources among spending categories in the North speeds up recovery and fosters local economic growth. The higher increase in the expenditure share for *local services* in the South could suggest that resources are not used efficiently or favor corruption. Indeed, although *local services* represents the spending category mostly affected by earthquakes (urban road maintenance and the maintenance/construction of public buildings), the construction industry is also well exposed to corruption scandals.

6 Concluding remarks

Local governments differ in the response to economic and social damages caused by natural disasters (earthquakes), in terms of spending behavior and the use of grants from upper tiers. Earthquake-related grants (matching grants) may also differ from other types of grants (mostly unconditional) in terms of stimulatory power, and expenditure may differ in the response to increasing and decreasing grants, leading to asymmetric and heterogeneous reactions (different *flypaper effects*). We explore these differences using municipality data and all earthquake shocks from a country largely exposed to seismic events - Italy - between 2000 and 2015.

We find evidence of increasing expenditure for about 11-12 years after a shock, before regressing to pre-earthquake levels. Over the whole period, affected municipalities spend 950 Euro per individual more than not affected municipalities, and transfers from central and regional governments exceed expenditure by about 250 Euro per individual. The average impact of both earthquake-specific and unconditional grants on expenditure is much larger than the response to income, suggesting the presence of a flypaper effect. However, we find evidence of an asymmetric response to decreasing grants (i.e., a fiscal replacement effect) only for earthquake-specific grants, suggesting that public officials tend to maintain higher spending levels after the occurrence of an earthquake.

The impact of matching grants is remarkably heterogeneous across the country. In the North, municipalities seem to overreact to transfers (one additional Euro raises expenditure by 1.43 Euro), while Southern municipalities react to the drop of grants showing inertia in expenditure levels (0.22 Euro response). This evidence is coupled with a more efficient recovery in Northern municipalities which allows both personal income and housing prices to grow faster than if no earthquake would have occurred, as suggested by (Barone and Mocetti, 2014). Moreover, while the response of Northern municipalities encompasses all areas of government action, Southern municipalities put their effort mainly in the enhancement of local services. Therefore, evidence from Northern municipalities points at a possible explanation in accordance with the recent finding by Allers and Vermeulen (2016), showing that additional grants are capitalized into house values rather than in rent taking by bureaucrats or politicians. Conversely, the extraction of rent from uninformed voters by self-interested politicians (Brollo et al., 2013; Persson and Tabellini, 2000) could represent a more valid explanation for Southern regions. Here, the spending category mostly affected by earthquake damages (local services) attracts the largest part of additional grants, fostering exposure to corruption scandals within the construction industry (Galletta, 2017).

To conclude, the role of upper-level governments is crucial in disaster relief but the quality of the response of local governments affects economic outcomes. There is scope for an improved monitoring system on how local governments employ disaster relief resources in order to recover quickly and efficiently. Future research should investigate more in detail factors affecting efficient recovery to identifying best-practices and provide guidance for policy makers.

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Table 1: Descriptive statistics: Municipality characteristics.

	(1)	(2)	(3)
	<i>Control group</i>	<i>Treated group</i>	
		Before	After
Expenditure p/c	1509.7 (1647.6)	1332.1** (861.9)	1664.1*** (1517.1)
Revenues p/c	1624.7 (1686.7)	1674.4 (1041.0)	1833.3** (1583.5)
Transfers p/c	550.9 (881.1)	623.5* (706.5)	706.2* (903.3)
Tax revenues p/c	420.4 (305.3)	340.9*** (196.7)	344.1 (184.9)
Average income	16504.4 (3799.4)	14966.0*** (3728.9)	15296.9 (3609.5)
% low-income population	38.79 (13.26)	47.68*** (14.51)	45.44*** (13.65)
Population	6260.8 (26275.1)	11714.2*** (88876.1)	10479.5 (79286.5)
% young (0-14 years)	13.19 (2.865)	13.40* (3.169)	12.94*** (3.007)
% old (≥ 65 years)	21.99 (6.150)	22.65** (6.755)	23.41** (6.412)
Partial mountain jurisdiction	10.11%	9.83%	
Mountain jurisdiction	53.59%	54.03%	
Coastal jurisdiction	10.68%	6.55%	
Observations	84521	920	1165
Municipalities	5339	1129	

Notes - The table presents mean characteristics of municipalities struck by earthquakes (treated group) with intensity ≥ 5 over the period 1985-2015 and mean characteristics of unaffected municipalities (control group). Column 1 presents means for the period 2000-2015, Columns 2 and 3 present means for the year before and the year after an earthquake occurs, respectively. If a municipality is affected by multiple earthquakes within three consecutive years, we aggregate the events and define the before-period as the year before the first shock and the after-period as the year after the last shock. This excludes the overlapping of observations on expenditure for the year after the first event and the year before the following event for the same municipality. Stars in column 2 indicate significance levels of t -tests on mean differences between column 1 and 2. Stars in column 3 indicate significance levels of t -tests on mean differences between column 2 and 3. For the last three variables, we show sample frequencies because they are time-invariant. Significance levels: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$. Standard deviations are in parentheses. Currency values are discounted at 2010 prices.

Table 2: Impact of earthquakes on local government expenditure.

	(1)	(2)	(3)	(4)	(5)
	OLS	RE	FE	FE (AR1)	IV_FE
EQ_t	0.0278** (0.0107)	0.0179* (0.00827)	0.0194* (0.00860)	0.0190** (0.00736)	0.0139 (0.00934)
EQ_{t-1}	0.0651*** (0.0110)	0.0632*** (0.00945)	0.0660*** (0.00976)	0.0603*** (0.00808)	0.0554*** (0.00949)
$EQ_{t-d} \times \text{Dist}$	0.0242*** (0.00402)	0.0285*** (0.00375)	0.0305*** (0.00398)	0.0166*** (0.00254)	0.0186*** (0.00387)
$EQ_{t-d} \times \text{Dist}^2$	-0.00284*** (0.000636)	-0.00409*** (0.000593)	-0.00456*** (0.000617)	-0.00261*** (0.000405)	-0.00253*** (0.000610)
$EQ_{t-d} \times \text{Dist}^3$	0.0000797** (0.0000264)	0.000142*** (0.0000245)	0.000163*** (0.0000252)	0.0000966*** (0.0000170)	0.0000783** (0.0000253)
Observations	119816	119816	119816	119102	112153
Overall R-squared	0.711	0.675	0.433	0.778	0.457
Within R-squared		0.678	0.682	0.733	0.522
Between R-squared		0.687	0.280	0.826	0.423
Region fixed effects	Yes	Yes	No	No	No
Year fixed effects	Yes	Yes	Yes	Yes	Yes
Financial time-variant controls	Yes	Yes	Yes	Yes	Yes
Political controls	Yes	Yes	Yes	Yes	Yes
Socioeconomic controls	Yes	Yes	Yes	Yes	Yes
Sociodemographic controls	Yes	Yes	Yes	Yes	Yes
Environmental controls	Yes	Yes	No	No	No
Hausman test					801.2***
Endogeneity test					40.62***

Notes - The table presents regression results for the log of per capita local government expenditure. Model 1 is a pooled OLS regression, model 2 a random effects regression, models 3 and 4 are fixed effects regressions, and model 5 is a two-stage fixed effects regression where log transfers are instrumented with the second lag of log average transfers received by neighboring municipalities. EQ_{t-d} is a dummy variable equal to 1 measuring the occurrence of the latest earthquake within the last 15 years, and 0 otherwise. $1 < d \leq 15$ measures the temporal distance from the latest earthquake. All models control for financial time-variant (logs of per capita transfers from the central and regional governments and revenues from local taxation), political (center-right government, vote concentration, term limit, years before elections), socioeconomic (average income and % of low-income population) and sociodemographic factors (population density, % of young and % of old population), and year fixed effects. Models 1 and 2 further control for environmental characteristics (mountain, partial mountain and coastal jurisdiction) and region fixed effects, which are time-invariant, and model 4 for the lag of the dependent variable. Significance levels: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$. Standard errors (in parentheses) are robust and clustered by municipality.

Table 3: Impact of earthquakes on local government expenditure and transfers by year

	(1)	(2)	(3)	(4)
	<i>Log</i>		<i>Euro per capita</i>	
	Exp.	Transf.	Exp.	Transf.
EQ_t	0.0280*** (0.00835)	0.0900*** (0.0226)	38.84	62.66
EQ_{t-1}	0.0746*** (0.00941)	0.162*** (0.0232)	117.2	110.1
EQ_{t-2}	0.0664*** (0.00899)	0.206*** (0.0238)	114.0	157.7
EQ_{t-3}	0.0616*** (0.00831)	0.221*** (0.0227)	95.84	174.3
EQ_{t-4}	0.0616*** (0.00814)	0.248*** (0.0231)	102.7	235.2
EQ_{t-5}	0.0771*** (0.00854)	0.196*** (0.0190)	135.6	137.5
EQ_{t-6}	0.0688*** (0.00843)	0.210*** (0.0193)	129.7	146.9
EQ_{t-7}	0.0416*** (0.00727)	0.134*** (0.0176)	73.49	88.13
EQ_{t-8}	0.0313*** (0.00686)	0.0651*** (0.0185)	53.43	41.90
EQ_{t-9}	0.0333*** (0.00644)	0.0771*** (0.0173)	54.28	46.17
EQ_{t-10}	0.0251*** (0.00576)	0.0192 (0.0162)	36.67	11.41
EQ_{t-11}	0.00791 (0.00529)	-0.0189 (0.0145)	11.62	-11.03
Observations	119816	119837		
Overall R-squared	0.434	0.121		
Within R-squared	0.682	0.370		
Between R-squared	0.282	0.0319		
Municipality fixed effects	Yes	Yes		
Year fixed effects	Yes	Yes		
Financial time-variant controls	Yes	No		
Political controls	Yes	Yes		
Socioeconomic controls	Yes	Yes		
Sociodemographic controls	Yes	Yes		

Notes - The table presents fixed effects regression results for the log of per capita local government expenditure (column 1) and the log of per capita transfers from central and regional governments (column 2). Columns 3 and 4 transform regression results in real per capita values. EQ_{t-j} , with $0 \leq j \leq 11$, is a dummy variable equal to 1 if the latest earthquake occurred j years before the current year, and 0 otherwise. Model 1 controls for financial time-variant factors (logs of per capita transfers from the central and regional governments and revenues from local taxation), and both models control for political (center-right government, vote concentration, term limit, years before elections), socioeconomic (average income and % of low-income population) and sociodemographic factors (population density, % of young and % of old population), and year fixed effects. Significance levels: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$. Standard errors (in parentheses) are robust and clustered by municipality.

Table 4: Flypaper effect and asymmetric response to variations in transfers.

	(1)	(2)	(3)
	FE	FE	IV
Earthquake-specific grants	0.275*** (0.0798)	0.290*** (0.0802)	0.245** (0.0846)
Asymmetry (Eq.-specific grants)		-0.242*** (0.0443)	-0.215*** (0.0482)
General grants	0.658*** (0.0500)	0.747*** (0.0445)	1.640** (0.588)
Asymmetry (General grants)		-0.337*** (0.0285)	-0.0336 (0.670)
Income	0.0521*** (0.00769)	0.0427*** (0.00689)	0.0422*** (0.00991)
Observations	119816	111825	103681
Overall R-squared	0.262	0.300	0.524
Within R-squared	0.248	0.241	0.0259
Between R-squared	0.268	0.321	0.649
Municipality fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Financial time-variant controls	Yes	Yes	Yes
Political controls	Yes	Yes	Yes
Sociodemographic controls	Yes	Yes	Yes
Hausman test			-11636.1
Endogeneity test			21.61***

Notes - The table presents regression results for per capita local government expenditure. Models 1 and 2 are OLS regressions and model 3 is a two-stage least square regression where general grants and the relative asymmetry variable are instrumented with the second lag of general grants and the second lag of general grants of neighboring municipalities (2-years spatial lag). *Matching grants* are earthquake-specific per capita transfers from central and regional governments allocated for recovery after the occurrence of an earthquake. *Unconditional grants* are general grants obtained as the difference between total grants and earthquake-specific grants. The two asymmetry variables measure decreases of each type of transfers between period $t - 1$ and t . All models control for financial-time variant characteristics (per capita revenues from local taxation), political (center-right government, vote concentration, term limit, years before elections), socioeconomic (average income and % of low-income population) and sociodemographic factors (population density, % of young and % of old population), municipality and year fixed effects. All values are expressed at 2010 prices. Significance levels: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$. Standard errors (in parentheses) are robust and clustered by municipality.

Table 5: Impact of transfers on local government expenditure by macro regions.

	(1)	(2)	(3)
	Full sample	North and Center	South
Earthquake-specific grants	1.455** (0.501)	0.686*** (0.134)	0.128** (0.0408)
South \times Earthquake-specific grants	-1.234* (0.505)		
Earthquake-specific grants ($t - 1$)		1.129* (0.511)	0.154*** (0.0379)
Earthquake-specific grants ($t - 2$)		1.414 (0.778)	0.308*** (0.0436)
General grants	0.645*** (0.0572)	0.756*** (0.0505)	0.786*** (0.0391)
South \times General grants	0.0761 (0.0613)		
Income	0.0521*** (0.00761)	0.0451*** (0.00973)	0.0731*** (0.0208)
Observations	119816	74587	29253
Overall R-squared	0.271	0.394	0.483
Within R-squared	0.258	0.220	0.409
Between R-squared	0.276	0.457	0.525
Municipality fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Financial time-variant controls	Yes	Yes	Yes
Political controls	Yes	Yes	Yes
Sociodemographic controls	Yes	Yes	Yes

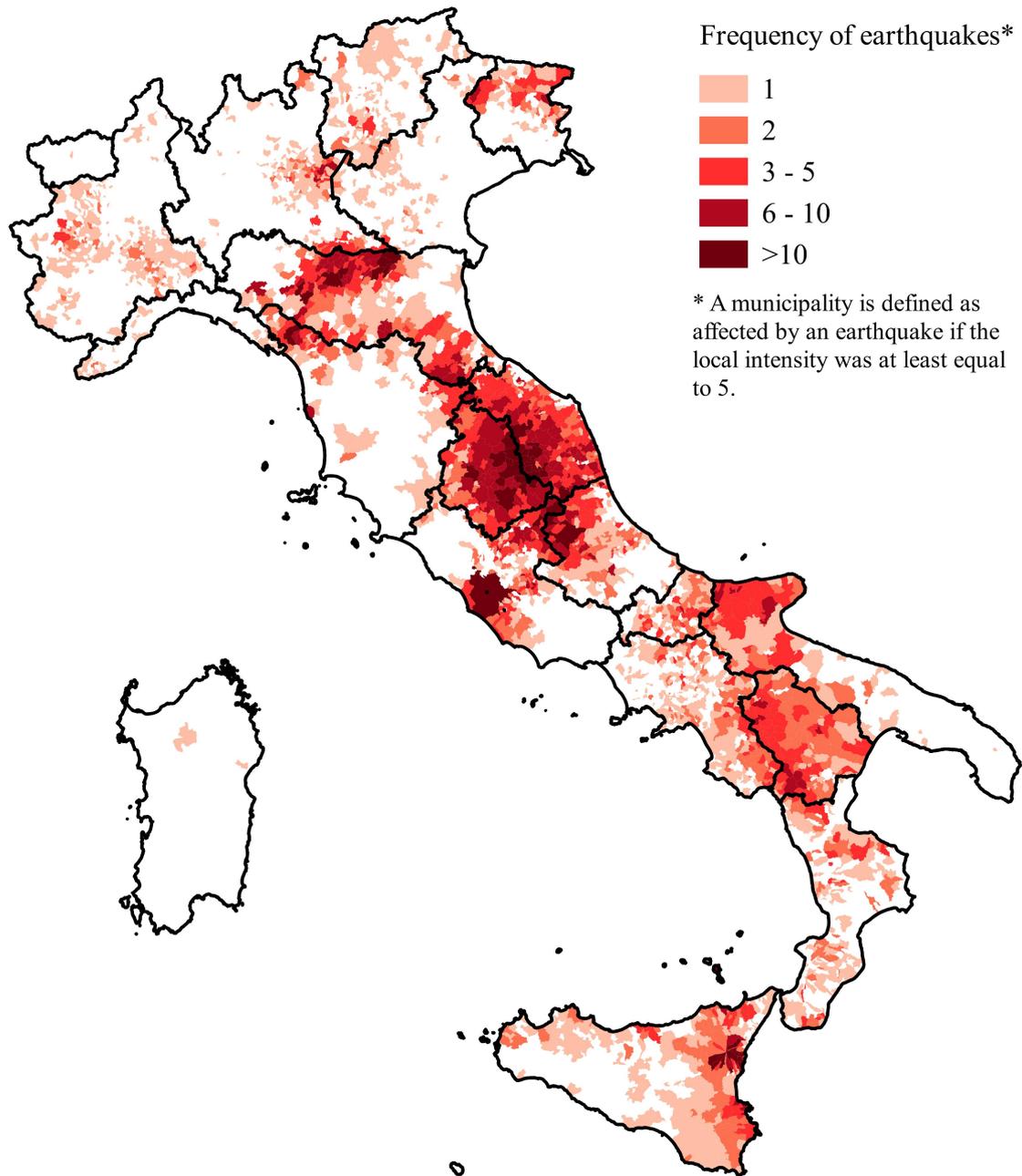
Notes - The table presents fixed effects regression results for per capita local government expenditure. Model 1 uses the full sample of observations, model 2 uses the sub-sample of municipalities located in the regions in the Northern and Central regions, and model 3 uses the sub-sample of municipalities located in the Southern regions (Abruzzo, Campania, Puglia, Basilicata, Calabria and Sicily). *Matching grants* are earthquake-specific per capita transfers from central and regional governments, allocated for recovery after the occurrence of an earthquake. *Unconditional grants* are general transfers calculated as the difference between total grants and earthquake-specific grants. The two asymmetry variables measure decreases of each type of transfers between period $t - 1$ and t . *South* is a dummy variable equal to 1 for municipality located in the Southern regions of Italy. All models control for financial-time variant characteristics (per capita revenues from local taxation), political (center-right government, vote concentration, term limit, years before elections), socioeconomic (average income and % of low-income population) and sociodemographic factors (population density, % of young and % of old population), and year fixed effects. Significance levels: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$. Standard errors (in parentheses) are robust and clustered by municipality.

Table 6: Variation (in %) of spending composition after an earthquake.

	(1)	(2)	(3)	(4)	(5)
	Before		After		
	North	South	Δ North	Δ South	Δ North - Δ South
Local services	19.34	25.94	2.32***	5.10***	-2.78***
General administration	30.93	32.36	0.96*	-0.80	1.76**
Education	11.02	7.90	-0.84***	-0.32	-0.52
Social protection	11.82	6.72	-1.65***	-0.22	-1.42***
Transport services	13.44	12.25	0.38	-0.65*	1.03**
Other services	13.05	14.75	-0.94**	-3.04***	2.10***
Observations	911	951	3587	2572	

The table reports budget shares (columns 1 and 2) allocated to the main local government spending categories in the five years before a shock (with intensity ≥ 5) and average variations (in %) within five years after the occurrence of the shock (columns 3 and 4). Southern municipalities include the regions of Abruzzo, Campania, Puglia, Basilicata, Calabria and Sicily. Stars in columns 3 and 4 indicate significance levels of t -tests on differences in means before and after the shock. Column 5 reports mean differences between variations in the North and the South, and stars indicate significance levels of t -tests on mean differences. Significance levels: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

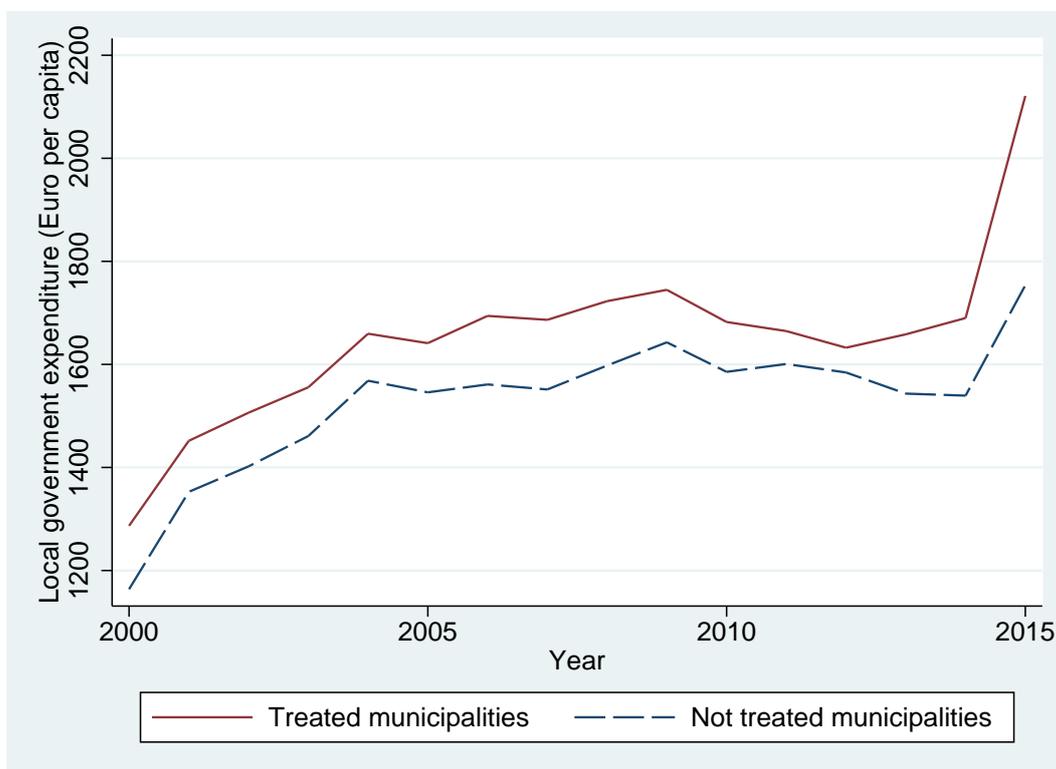
Figure 1: Frequency of earthquakes by municipality (1985-2015).



Notes - The map represents the frequency of earthquakes with intensity ≥ 5 by municipality for a 31-year period (1985-2015). The darker the color, the higher the frequency. White areas represent municipalities that did not face any earthquake with intensity ≥ 5 over the period.

Source: Our elaboration on data from the DBMI15 database of INGV (Locati et al., 2016). The shape map of the 2016 administrative borders is provided by ISTAT.

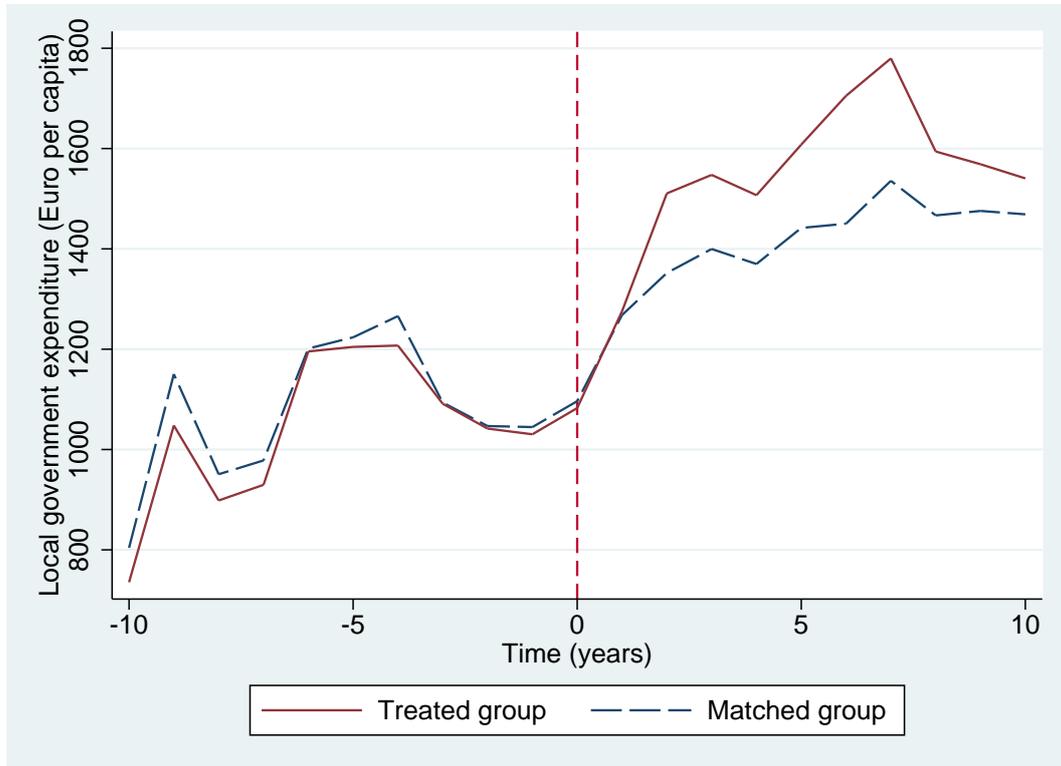
Figure 2: Per capita local government expenditure over time (2000-2015).



Notes - The graph compares the average per capita local government expenditure for the period 2000-2015 of 2658 municipalities struck by at least one earthquake with intensity ≥ 5 over the period 1985-2015 (red solid line) with 5339 municipalities not struck by an earthquake over the same period (blue dashed line).

Source: Our elaboration on balance sheet data of Italian local governments for the period 2000-2015 provided by the Italian Ministry of Interior and data from the DBMI15 database of INGV (Locati et al., 2016).

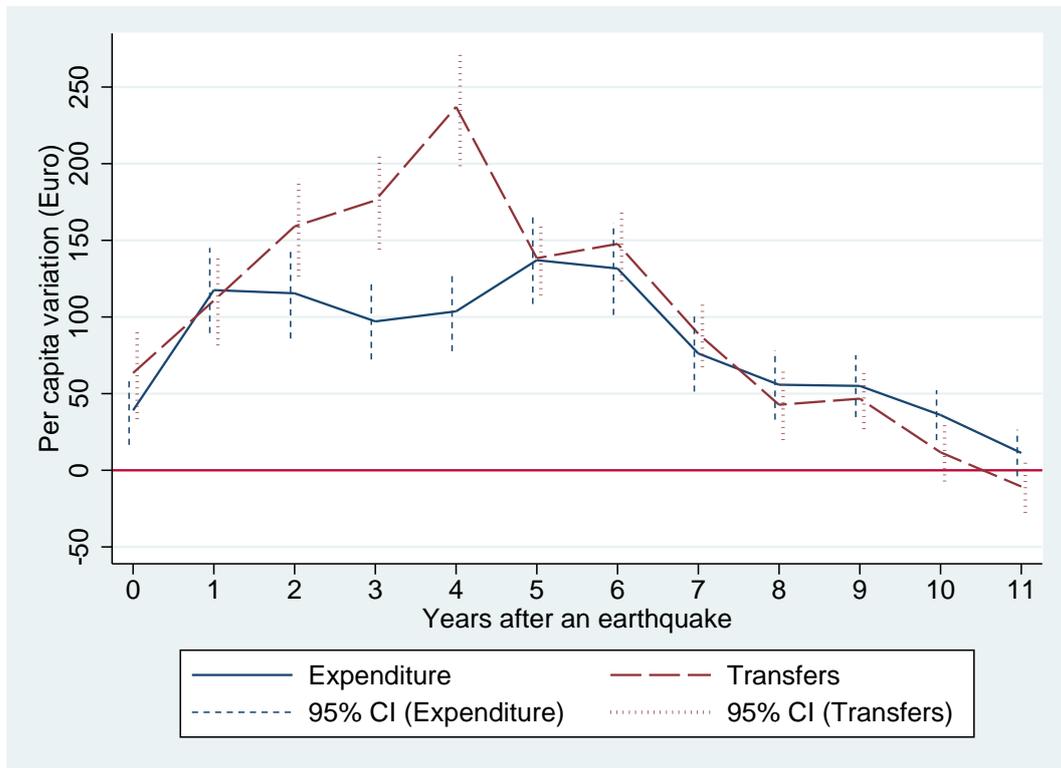
Figure 3: Expenditure variation after the occurrence of an earthquake.



Notes - The graph compares the average per capita local government expenditure before and after the occurrence of an earthquake, which occurs at time 0, with expenditure of matched municipalities (without an earthquake) in the same year. Treatment is assigned if an earthquake with intensity ≥ 5 occurred over the period 2000-2015. The red solid line represents 517 treated municipalities, while the blue dashed line represents 517 matched municipalities identified with coarsened exact matching performed on average pre-treatment characteristics of municipalities (institutional, sociodemographic, and environmental). Both groups include only municipalities with complete expenditure data for the period 2000-2015. Positive (negative) values on the x -axis indicate years after (before) the treatment.

Source: Our elaboration on balance sheet data of Italian local governments for the period 2000-2015 provided by the Italian Ministry of Interior and data from the DBMI15 database of INGV (Locati et al., 2016).

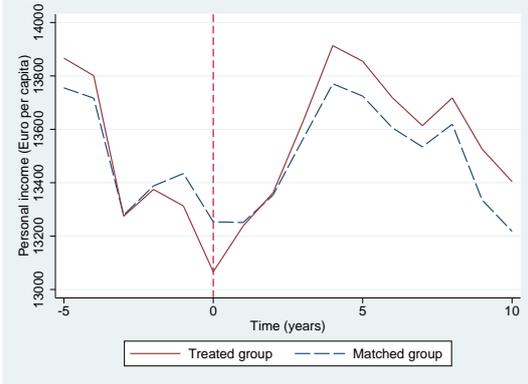
Figure 4: Variation of local government expenditure and transfers after an earthquake.



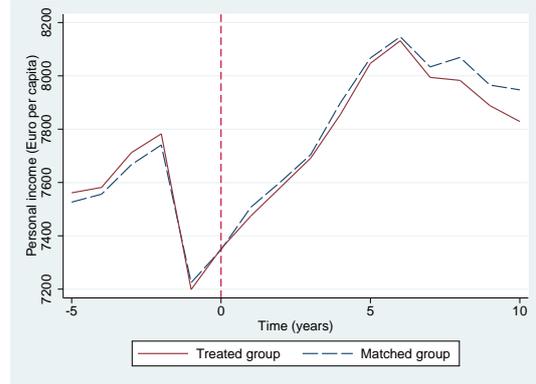
Notes - The graph represents the estimates of the impact of an earthquake with intensity ≥ 5 on per capita local government expenditure (blue solid line) and per capita transfers of financial resources from central and regional governments (red dashed line) for a 12-year period after the occurrence of an earthquake. Vertical blue dashed and red dotted segments are 95% confidence intervals for the estimates of expenditure and transfers respectively. Local government expenditure is adjusted for time-variant financial, political, socioeconomic and sociodemographic factors, and municipality and time fixed effects. Transfers are adjusted for time-variant socioeconomic and sociodemographic factors, and municipality and time fixed effects.

Source: Our elaboration on socioeconomic and sociodemographic data of ISTAT, local government balance sheet data provided by the Italian Home Office, and data on earthquakes of the DBMI15 database of INGV (Locati et al., 2016).

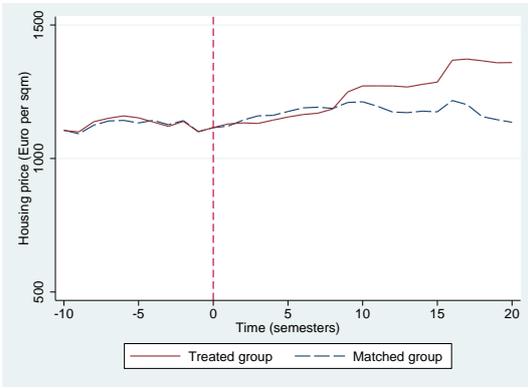
Figure 5: Economic outcomes after the occurrence of an earthquake.



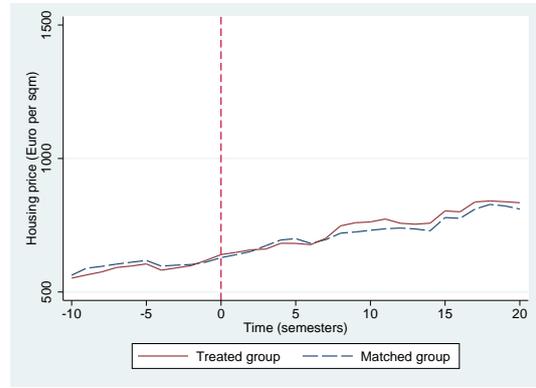
(a) Personal income (North)



(b) Personal income (South)



(c) Housing prices (North)

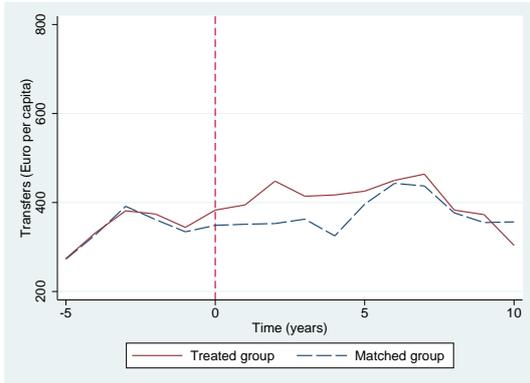


(d) Housing prices (South)

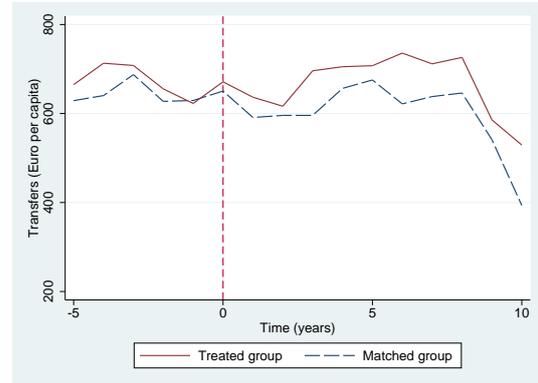
Notes - The graphs illustrate personal income (Figure (a) for Northern municipalities and Figure (b) for Southern municipalities) and mean housing prices per square meter (Figure (c) for Northern municipalities and Figure (d) for Southern municipalities) before and after the occurrence of an earthquake with intensity ≥ 5 , which occurs at time 0. The top figures compare municipalities struck by an earthquake over the period 2000-2015 (treated group - red solid line) with matched unaffected municipalities (blue dashed line) identified with coarsened exact matching performed on average pre-treatment characteristics of municipalities (institutional, socioeconomic, financial, sociodemographic). The bottom figures compare municipalities struck by an earthquake over the period 2003-2015 with matched unaffected municipalities identified with coarsened exact matching performed on average pre-treatment housing prices. Both groups include only municipalities with complete data for the respective period. Positive (negative) values on the x -axis indicate years (or semesters for housing prices) after (before) the treatment.

Source: Our elaboration on income data provided by the Italian Ministry of Economics and Finance, data on housing prices provided by the Real Estate Market Observatory of the Italian Revenue Agency, and data on earthquakes of the DBMI15 database of INGV (Locati et al., 2016).

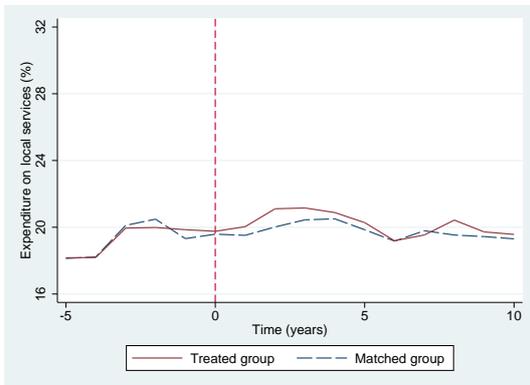
Figure 6: Variation of municipal financial characteristics after an earthquake.



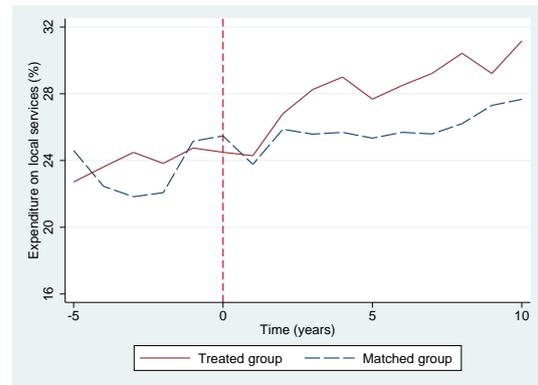
(a) Transfers (North)



(b) Transfers (South)



(c) Budget share for local services (North)



(d) Budget share for local services (South)

Notes - The graphs illustrate per capita transfers from central and regional governments (Figure (a) for Northern municipalities and Figure (b) for Southern municipalities) and the budget share allocated to local services (Figure (c) for Northern municipalities and Figure (d) for Southern municipalities) before and after the occurrence of an earthquake with intensity ≥ 5 , which occurs at time 0. Each graph compares municipalities struck by an earthquake over the period 2000-2015 (treated group - red solid line) with matched unaffected municipalities (blue dashed line) identified with coarsened exact matching performed on average pre-treatment characteristics of municipalities (institutional, socioeconomic, financial, sociodemographic). Both groups include only municipalities with complete data for the period 2000-2015. Positive (negative) values on the x -axis indicate years after (before) the treatment. *Source*: Our elaboration on local government balance sheet data provided by the Italian Home Office, and data on earthquakes of the DBMI15 database of INGV (Locati et al., 2016).

Appendix

A.1 Matching approach

To construct a counterfactual group of municipalities, we apply a matching procedure starting from the full sample of 1129 municipalities struck at least once by an earthquake over the period 2000-2015. We exclude 252 municipalities affected by an earthquake in year 2000 because we lack data on pre-treatment characteristics before that year. Moreover, we keep only municipalities with complete data for the period 2000-2015. The resulting sub-sample of treated municipalities is composed of 743 units.

To build an equal-sized control group of municipalities not struck by earthquakes, we use the remaining 5339 municipalities with complete data for the period 2000-2015. Since geographical proximity may be not sufficient to build a control group with similar institutional characteristics in the pre-treatment period, especially if contiguous municipalities are located in other regions, we build a control based on institutional proximity, intended as similarity in institutional factors.⁴⁰ To this aim, we force the matching with municipalities in the same region. This procedure guarantees that matched municipalities are subject to the same institutional setting and have little geographical discontinuity. Other municipality characteristics that we match are pre-treatment averages of transfers of financial resources from the central government and from the regions, personal income population size (less or greater than 15,000 people) and the budget share allocated to local services.

To perform the matching we use the coarsened exact matching (CEM) applied with the *cem* command in Stata 13 developed by Blackwell et al. (2009). The advantage of CEM compared to other matching procedures is that the matching imbalance is lower, model dependence and bias in postmatching estimation are reduced, and efficiency is improved. Since the treatment occurs at different points in time for different municipalities, we repeat the matching procedure for each period between 2001 and 2015 by allowing replacement of matched untreated municipalities. We do not impose any custom restrictions on the cutpoints that define the coarsening and use the standards. Since we want exact matching to occur on the region, we repeat the CEM algorithm for each regional sub-sample.

CEM was able to match 517 municipalities out of the 743 treated municipalities. In-

⁴⁰Cipollone and Rosolia (2007) construct a control group of municipalities using geographical proximity as a proxy for the similarity of treated and controlled municipalities to analyze social interactions in high school after an earthquake. While the schooling system is mostly centralized, local institutional aspects related to spending levels and funding sources may be quite heterogeneous, especially across regions.

deed, t -tests on mean differences show that matching characteristics and per capita local government expenditure are not significantly different between the two groups before the occurrence of an earthquake (see columns 1 and 2 of Table A.1 below). Conversely, average characteristics of the universe of municipalities (column 3) differ significantly from the characteristics of the treated group, except for population size and budget share allocated to local services.

Table A.1: Balancing properties resulting from the matching approach.

	(1)	(2)	(3)
	Treated	Matched	All unaffected
Expenditure p/c	1167.6	1196.9	1508.6***
Transfers p/c	447.2	447.0	548.8***
Income	11081.1	11055.2	11808.6***
Population	6463.5	7067.9	6264.4
Local services	21.38	21.43	21.74
Observations	3458	3458	84967

Notes - The table reports mean characteristics of 611 municipalities struck by an earthquake with intensity ≥ 5 (column 1) and their matched unaffected municipalities (column 2) before the occurrence of an earthquake, and of the universe of unaffected municipalities for the period 2000-2015 (column 3). Except for expenditure, the reported characteristics are those used to build the group of matched municipalities (institutional proximity is omitted because of exact matching on that characteristic - see Section A.1). Stars in column 3 indicate significance levels of t -tests on mean differences between column 1 and 3. t -tests on mean differences between column 1 and 2 reveal not significant differences for all characteristics. Significance level: *** $p < 0.001$. Currency values are discounted at 2010 prices.

Table A.2: Impact of earthquakes on local government expenditure using the matching sample.

	(1)	(2)	(3)	(4)
	OLS	RE	FE	FE (AR1)
EQ_t	0.0253 (0.0146)	0.0252* (0.0115)	0.0241* (0.0119)	0.0339*** (0.0102)
EQ_{t-1}	0.0595*** (0.0154)	0.0664*** (0.0135)	0.0670*** (0.0141)	0.0675*** (0.0112)
$EQ_{t-d} \times \text{Dist}$	0.0132 (0.00688)	0.0217*** (0.00614)	0.0228*** (0.00640)	0.0134*** (0.00396)
$EQ_{t-d} \times \text{Dist}^2$	-0.000681 (0.00110)	-0.00228* (0.00100)	-0.00246* (0.00102)	-0.00150* (0.000655)
$EQ_{t-d} \times \text{Dist}^3$	-0.0000209 (0.0000490)	0.0000507 (0.0000447)	0.0000570 (0.0000451)	0.0000375 (0.0000298)
Observations	15789	15789	15789	15789
Overall R-squared	0.661	0.639	0.387	0.746
Within R-squared		0.689	0.691	0.753
Between R-squared		0.597	0.157	0.739
Region fixed effects	Yes	Yes	No	No
Year fixed effects	Yes	Yes	Yes	Yes
Financial time-variant controls	Yes	Yes	Yes	Yes
Political controls	Yes	Yes	Yes	Yes
Socioeconomic controls	Yes	Yes	Yes	Yes
Sociodemographic controls	Yes	Yes	Yes	Yes
Environmental controls	Yes	Yes	No	No

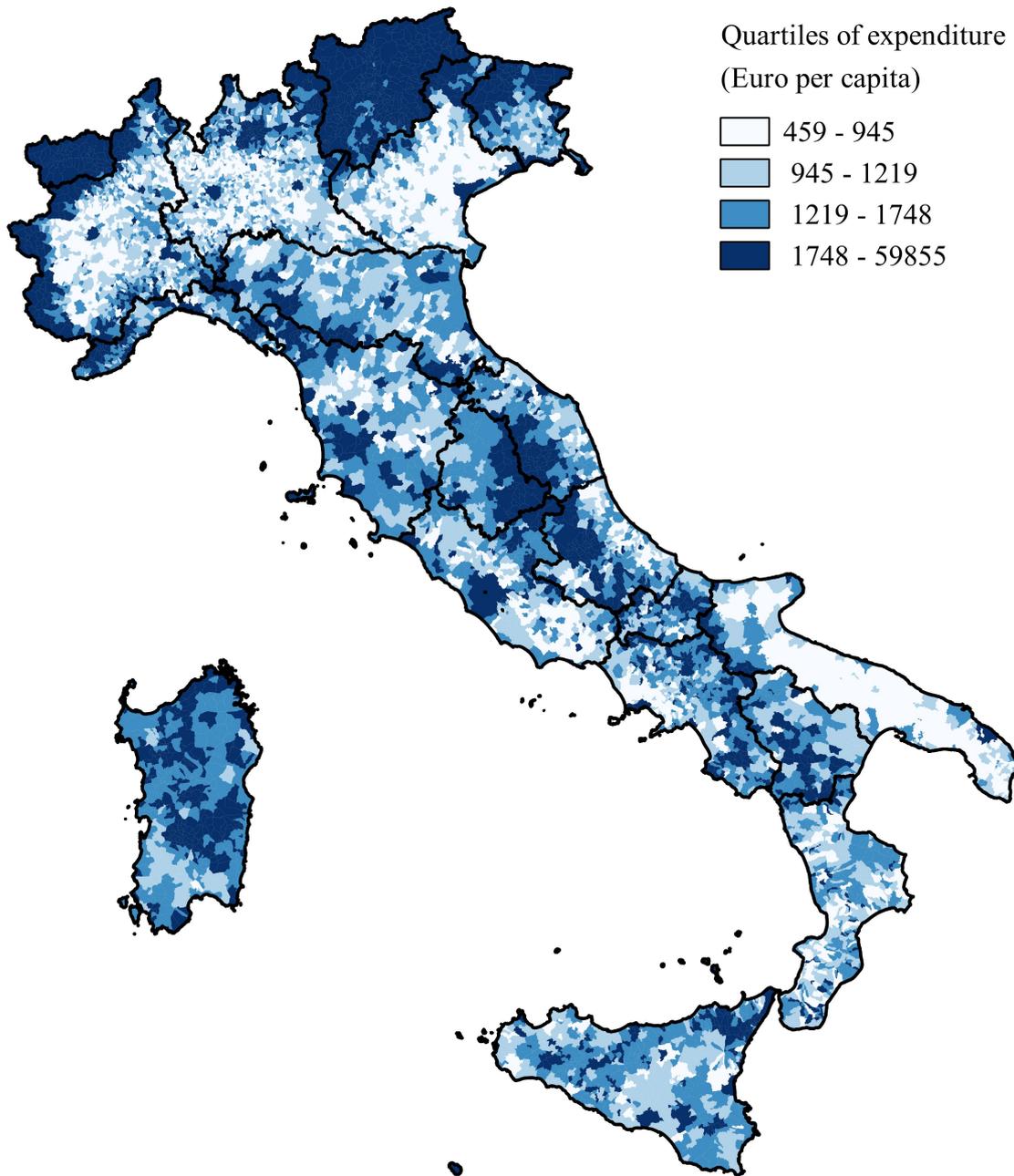
Notes - The table presents regression results for the log of per capita local government expenditure using a sample composed by 517 treated and 517 matched municipalities identified with coarsened exact matching (*cem* command in Stata 13) on average pre-treatment institutional, sociodemographic, and environmental characteristics. Model 1 is an OLS regression, model 2 a random effects regressions, and models 3 and 4 are fixed effects regressions. EQ_{t-d} is a dummy variable equal to 1 measuring the occurrence of the latest earthquake within the last 15 years, and 0 otherwise. $1 < d \leq 15$ measures the temporal distance from the latest earthquake. All models control for financial time-variant (logs of per capita transfers from the central and regional governments and revenues from local taxation), political (center-right government, vote concentration, term limit, years before elections), socioeconomic (average income and % of low-income population) and sociodemographic factors (population density, % of young and % of old population), and year fixed effects. Models 1 and 2 further control for environmental characteristics (mountain, partial mountain and coastal jurisdiction) and region fixed effects, which are time-invariant, and model 4 for the lag of the dependent variable. Significance levels: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$. Standard errors (in parentheses) are robust and clustered by municipality.

Table A.3: Impact of earthquakes on local government expenditure using different intensity-based earthquake occurrence measures.

	(1)		(2)		(3)		(4)		(5)	
	Intensity-based measures		Magnitude-based measures		D >= 6 km	D <= 10 km	D <= 20 km	D <= 30 km		
EQ_t	0.0555** (0.0203)	0.156** (0.0562)	0.0182* (0.00914)	0.0133** (0.00485)	0.0182* (0.00914)	0.0133** (0.00485)	0.0133** (0.00485)	0.0101** (0.00389)		
EQ_{t-1}	0.250*** (0.0262)	0.550*** (0.0717)	0.0602*** (0.0107)	0.0426*** (0.00549)	0.0602*** (0.0107)	0.0426*** (0.00549)	0.0426*** (0.00549)	0.0328*** (0.00422)		
$EQ_{t-d} \times \text{Dist}$	0.120*** (0.0102)	0.262*** (0.0294)	0.0231*** (0.00694)	0.0168*** (0.00384)	0.0231*** (0.00694)	0.0168*** (0.00384)	0.0168*** (0.00384)	0.00736* (0.00307)		
$EQ_{t-d} \times \text{Dist}^2$	-0.0165*** (0.00159)	-0.0343*** (0.00425)	-0.00393** (0.00129)	-0.00301*** (0.000739)	-0.00393** (0.00129)	-0.00301*** (0.000739)	-0.00301*** (0.000739)	-0.000951 (0.000611)		
$EQ_{t-d} \times \text{Dist}^3$	0.000565*** (0.0000636)	0.00112*** (0.000165)	0.000160* (0.0000655)	0.000134*** (0.0000390)	0.000160* (0.0000655)	0.000134*** (0.0000390)	0.000134*** (0.0000390)	0.0000269 (0.0000333)		
Observations	119816	119816	119816	119816	119816	119816	119816	119816		
Overall R-squared	0.438	0.445	0.441	0.441	0.441	0.441	0.441	0.441		
Within R-squared	0.685	0.685	0.681	0.681	0.681	0.681	0.681	0.681		
Between R-squared	0.286	0.295	0.291	0.291	0.291	0.291	0.291	0.291		
Municipality fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes		
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes		
Financial time-variant controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes		
Political controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes		
Socioeconomic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes		
Sociodemographic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes		

Notes - The table presents fixed effects regression results for the log of per capita local government expenditure using earthquakes with intensity ≥ 6 (column 1) and ≥ 7 (column 2), and magnitude ≥ 4 (columns 3-5) for the identification of treated municipalities. In columns 3, 4 and 5, treatment is assigned if the centroid of a municipality is located within 10 km, 20 km and 30 km, respectively. EQ_{t-d} is a dummy variable equal to 1 measuring the occurrence of the latest earthquake within the last 15 years, and 0 otherwise. $1 < d \leq 15$ measures the temporal distance from the latest earthquake. All models control for financial time-variant (logs of per capita transfers from the central and regional governments and revenues from local taxation), political (center-right government, vote concentration, term limit, years before elections), socioeconomic (average income and % of low-income population) and sociodemographic factors (population density, % of young and % of old population), and year fixed effects. Models 2 and 4 further control for the lag of the dependent variable. Significance levels: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$. Standard errors (in parentheses) are robust and clustered by municipality.

Figure A.1: Local government expenditure (2000-2015).



Notes - The map shows the average per capita local government expenditure in Euro by municipality for a 16-year period (2000-2015). The darker the color, the higher the expenditure per individual.

Source: Our elaboration on balance sheet data of Italian local governments for the period 2000-2015 provided by the Ministry of Interior. The shapemap of the 2016 administrative borders is provided by ISTAT.

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