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Reconstruction multipliers

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Abstract

Following the 2009 L'Aquila earthquake, financing of reconstruction by the Italian central government resulted in a sharp and unanticipated discontinuity in grants across municipalities that were ex-ante very similar. Using the financing law as an instrument, we identify the effect of government spending on local activity, controlling for the negative supply shock. The "reconstruction multiplier" is around unity, and we show that the grants provided public insurance. Economic activity contracted in municipalities that did not receive the grants, while it did not contract in the others. Our results suggest several implications with respect to the allocation mechanism of such grants.

Keywords: Natural disasters, Fiscal multipliers, Mercalli scale.

JEL: classification C36, E62, H70.

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1. Introduction

The effectiveness of fiscal policy - typically summarized by a numeric "multiplier" - has been an important driver of policy and academic debates in recent years. Although several contributions have estimated "the multiplier" using different identification strategies, the literature is far from reaching a consensus. While virtually all earlier contributions have focused on aggregate effects, recent papers have shifted the attention to the local dimension. As Acconcia et al. [1] point out, this shift is motivated not only by specific policy questions - such as countering area-specific recessionary shocks - but also by the opportunity to address econometric issues in identification. For example, fiscal policy is highly endogenous to the business cycle, and its effects are often anticipated by rational agents.[1]

This paper contributes to the debate on the effects of government interventions relying on a natural experiment, the 2009 "L'Aquila" earthquake that hit the Italian region of Abruzzo. Specifically, we distinguish two resulting output effects -one from the negative supply shock due to the earthquake and one from the positive demand shock driven by reconstruction grants. Our empirical strategy relies on a rich dataset covering the geophysical information of the event as well as the damages recorded in each of the 75,424 buildings classified after the earthquake. Furthermore, we rely on the specific characteristics of the institutional allocation of public grants providing insurance to the affected municipalities. With regard to the dataset, in the aftermath of the earthquake specialists from the Civil Protection Department (CPD) and the National Institute

[1] On this point see Blanchard and Perotti [6] and Ramey [23].

of Geophysics and Volcanology ($INGV$) visited the epicentral area to survey the affected buildings.[2] In our econometric model, we control for the negative supply shock generated by the event by using either a strictly exogenous regressor (such as the distance of each municipality from the epicenter of the event), or an index of damages for each municipality. With regard to the grants allocation, as a complementary task the delegates assigned a synthetic number to the municipalities in the epicentral area reflecting the overall severity of the damages. Following a well-established practice, the rankings were based on the so-called "Mercalli scale" that classifies the destructive effects of an earthquake on twelve notches, ranging from "instrumental" (I) to "catastrophic" (XII).[3] Once the list of affected municipalities was delivered to the national authorities, the central government enacted a law by decree establishing a qualifying Mercalli threshold for reconstruction grants. This threshold, ex-ante unknown to the delegates, was fixed at level VI of the scale (the lowest level associated with marginal damages to civil structures) and resulted in a sharp discontinuity in reconstruction grants across ex-ante identical neighbor municipalities.

Studying the 305 municipalities in the Abruzzo region over the period 2002 to 2011, our econometric analysis relies on an instrumental variable approach. In our model, we regress a measure of local economic activity on the grants received by each municipality, on a variable capturing the destructive effects of the earthquake, municipal and time fixed effects, and on a set of controls. Because of the well-known endogeneity

[2]The Department of Civil Protection is a structure of the Prime Minister's Office which coordinates and directs the national service of civil protection. When a national emergency is declared, it coordinates the relief on the entire national territory. It coordinates activities in response to natural disasters, catastrophes or other events which, due to their intensity and extent, must be tackled using special means and powers. In this case, the council of ministers declares the "state of emergency" by issuing a law by decree and identifies the actions to be undertaken to manage the event.

[3]Contrary to the well-known Richter scale (which quantifies the moment magnitude of an earthquake meaning the energy released by the event), the Mercalli scale classifies the destructive effects of an earthquake. While every quake has only one magnitude recorded at the epicenter, the destructive effects (therefore the Mercalli ranks) vary greatly across municipalities according to a large set of factors, including the distance from the epicenter or the ex-ante vulnerability of buildings.

of grants, we employ the grants allocation law as an instrument, which identifies the exogenous reconstruction grants allocated to the municipalities above the Mercalli VI threshold. As a measure of local economic activity -given the absence of official estimates of output at the municipal level- we compare two different variables: the first one is declared personal income, and the second one is high-resolution data on night lights density measured by satellites at night that has been shown (Henderson et al. [17]) to proxy well for local economic activity. As for the variable capturing the negative supply shock generated by the destruction of physical capital, we compare two approaches. In the first approach, we employ the distance of each municipality from the epicenter. This approach offers the advantage of relying on a strictly exogenous regressor given the fact that the ex-ante probability of a seismic event was uniformly distributed across all municipalities. In the second approach, we rely on the reported damages covering classified 75,424 buildings to construct a synthetic index of damages. This approach has the advantage of a more accurate description of the ex-post damages, therefore eliminating or at least reducing the need for additional controls.

In our findings, the direct effect of the earthquake on economic activity is unambiguously negative. Our instrumental variables analysis shows that, on impact, the loss from the earthquake averages 6.1 percentage points. Against the output effects of the negative supply shock, we document positive multiplicative effects of reconstruction grants. The estimated "grants multiplier" remains around unity in all models (the point estimates are bounded between 0.71 and 0.96 according to the model and we cannot reject the null of unity in any estimate). Multiplying these elasticities by the magnitude of the fiscal shock, our results suggest that public grants compensated the economic fall generated by the earthquake that is instead suffered by the municipalities just below the grants allocation threshold. In other words, reconstruction grants provided public insurance. Economic activity contracted in "uninsured" regions and expanded, or at least did not fall, in qualified municipalities.[4]

Our findings contribute to the literature assessing the effectiveness of government interventions. A small but dynamic literature has produced estimates on local output elasticities to exogenous fiscal shocks using different instruments: dismissal of elected officials (Acconcia et al. [1]), census revisions (Serrato and Wingender [25]), variations in stimulus outlays mandated by the American Recovery and Reinvestment Act (*ARRA*) of 2009 (Chodorow-Reich et al. [10]), or military buildups across US states (Nakamura and Steinsson [21]). Also, Shoag et al. [26] exploits the idiosyncratic components in the returns on defined-benefit pension plans managed by the U.S. states, and Fishback and Kachanovskaya [15] exploit a swing voting measure, which varies primarily across U.S. states, to instrument government grants during the New Deal. Close in spirit to our paper is a recent contribution by Corbi et al. [14] who rely on a discontinuity in federal transfers to municipal governments in Brazil to identify the causal effect of fiscal policy on economic growth. We depart from the existing literature by estimating the "reconstruction grants multiplier", which is the elasticity of local economic activity to exogenous reconstruction grants, controlling for the output loss generated by the earthquake at a micro municipal level.[5] Our estimates of the "multiplier" remain below unity -although not statistically so- in all regressions.[6] While output elasticity to fiscal shocks is predicted to be higher in

[4] Although Italy is one of the most seismic countries in the world, households and firms cannot insure against seismic risks since no there is no private insurance market.

[5] See Cavallo et al. [9] for an excellent review on the papers investigating the effects of natural disasters on economic activity.

[6] In this dimension, our estimated multipliers are in line with those estimated by Clemens and Miran [11], or Cohen et al. [12] who instrument public spending with changes in congressional committee chairmanship, noticing that spending variations appear to significantly dampen corporate sector investment and employment activity. Possible explanations about low multipliers are

downturns (Woodford [27]), some empirical contributions (Ramey and Zubairy [24]) have argued that there is no evidence that fiscal multipliers differ by the amount of slack in the economy or the degree of monetary accommodation. The grants multipliers contained in this paper remain around unity in all models. In the discussion of our results we provide a description of the channels that might have compensated for the stimulative effects of public grants. Yet the size of the reconstruction grants acted as a public insurance preventing a fall in output. Economic activity declined in uninsured regions but did not in insured ones. Our results underline the importance of countercyclical fiscal interventions and suggest policy implications for the allocation mechanism of such grants.

The rest of the paper is organized as follows. Section 2 describes the 2009 L'Aquila earthquake, the natural event at the heart of this study. Section 3 explains and discusses the empirical model. Section 4 describes the main features of our dataset. Section 5 discusses our main results. Section 6 is devoted to the discussion of complementary results and robustness checks. Section 7 concludes.

2. The 2009 L'Aquila earthquake

At 03:32 am on April 6^{th} 2009 a 6.3 magnitude earthquake hit the southern part of Italy. The epicenter was located 19.79 Kilometers to the west of L'Aquila, the capital city of Abruzzo region.[7] Three hundred and nine people were killed and more than 1,500 were injured. The seismic event generated damages in

discussed in Section 5.

[7] Abruzzo is a southern region of Italy composed by 305 municipalities grouped in 4 provinces (L'Aquila, Chieti, Teramo, and Pescara) for a total 1.3 million inhabitants. See figure A.1 in Appendix A.

97 municipalities, 72 of which located in the province of L'Aquila. Following the declaration of the state of emergency by the Council of Ministers, a team of specialists from the CPD and the $INGV$ visited the affected regions to assess the severity and extension of the damages. The procedure lasted ten days and on April 16^{th} the list of affected municipalities and the estimate of total damages was made publicly available and sent to the central government.

During their mission the delegates had two separate tasks. First, they visited each building reporting damages (or suspected so) and ranked them following the "AeDES international classification system".[8] This system categorizes civil structures after a seismic event on six levels ranging from "A" ("usable building") to "F" ("unusable building and severe external risks").[9] Table A.1 in Appendix A shows the distribution of buildings across levels of damages and figure 1 plots the map of damages across municipalities in the epicentral region. Out of 75,424 buildings visited by the CPD and $INGV$ specialists 55.2 percent were ranked at level "A", 16.5 percent "B", 3.4 percent "C", 1.9 percent "D", 20.4 percent "E" and the remaining 2.6 percent "F" with no significant differences across types of buildings.

As a second task, the delegates assigned a number to the municipalities in the epicentral region according to the severity of the damages.[10] This number reflects a level of the so-called "Mercalli scale" which quantifies the effects of an earthquake on the Earth's surface, humans, objects of nature, and man-made structures on twelve notches ranging from I ('instrumental') to XII ('catastrophic'). The definitions of the Mercalli levels

[8] See Baggio et al. [2] for details about the "AeDES" international classification system.

[9] The six categories are defined as follows: A: "usable building"; B: "usable building after short-term measures"; C: "partially unusable building"; D: "temporary unusable building"; E: "unusable building"; F: "unusable building and severe external risks". For details see Baggio et al. [2].

[10] Because of the extension and severity of the damages in the epicentral region, the delegates did not distinguish between Mercalli levels below V and assigned a 0 instead (not shown in the map).

are reported in Appendix B, while figure 2 plots the map of the earthquake, highlighting each municipality according to the Mercalli rank.[11]

On April 28^{th} 2009 the central government enacted a law by decree ("Decreto Legge 28 Aprile 2009, n.39") establishing a qualifying Mercalli threshold to receive reconstruction grants.[12] The threshold, ex-ante unknown to the delegates, was fixed at level VI, the lowest level associated to (marginal) structural damages to civil structures (see Appendix B for details). The decision of the government - at the core of our identification strategy - resulted in a sharp discontinuity around the cut-off, with 49 municipalities at the immediate right (level VI and VI-VII) and 73 to the left (level V and V-VI). The discontinuity is apparent in Figure 3, which plots total grants against the Mercalli scale. The average per capita grant to the left of the cut-off is 488.4 Euros while it increases to 2949.6 Euros per capita to the right. The cross-sectional standard deviation of grants is higher to the right-hand-side because the overall amount is proportional to the *extension* of the damages - meaning the number of buildings damaged - which is not captured by the Mercalli scale (which instead identifies the *severity* of the damages).

3. The empirical model

In our study we aim to estimate the short-run multiplicative effects of reconstruction grants on local

[11] Out of 305 municipalities in Abruzzo, 177 were ranked below V, 73 at level V (including V-VI), 41 at level VI (including VI-VII) and 8 at level VII or above. Table A.2 in Appendix A shows the distribution across provinces.

[12] For completeness we report the original text (in Italian) from the law by decree ("Decreto Legge" 28 Aprile 2009, n.39): "I predetti provvedimenti hanno effetto esclusivamente nei confronti dei comuni interessati dagli eventi sismici che hanno colpito la regione Abruzzo a partire dal 6 aprile 2009 che, sulla base dei dati risultanti dai rilievi macrosismici effettuati dal Dipartimento della protezione civile, hanno risentito un'intensita' MSC uguale o superiore al sesto grado".

economic activity at the municipal level following the 2009 L'Aquila seismic event. We present the empirical model and our instrument in this section while we discuss our baseline results in section 5.

For each municipality i let $y_{i,t}$ denote a per capita measure of local economic activity in year t, and $Y_{i,t}$ its rate of growth defined as $Y_{i,t} = \frac{y_{i,t}-y_{i,t-1}}{y_{i,t-1}}$. Also, let $g_{i,t}$ denote the real per capita value of grants received by municipality i in year t from the central government, and $G_{i,t}$ its growth rate as a ratio of lagged output, defined as $G_{i,t} = \frac{g_{i,t}-g_{i,t-1}}{y_{i,t-1}}$. Following the recent literature (see for instance Barro and Redlick [4] or Acconcia et al. [1]) we estimate the grants multiplier relating $Y_{i,t}$, to the correspondent change in per capita grants in the same municipality in the same year ($G_{i,t}$).[13]

Our empirical strategy is based on a linear fixed-effect panel data model. Formally:

$$Y_{i,t} \quad = \quad \alpha_i + \lambda_t + \beta\, G_{i,t} + \gamma\, E_{i,t} + \boldsymbol{\theta}^{'} \mathbf{X}_{i,t} + \eta_{i,t}, \tag{1}$$

where α_i is a municipal fixed-effect, λ_t is a time fixed-effect, $E_{i,t}$ is a variable capturing the negative supply shock generated by the quake in 2009 (and zero otherwise), $\boldsymbol{\theta}^{'}$ is a vector of coefficients, $\mathbf{X}_{i,t}$ is a set of control variables, and $\eta_{i,t}$ is a disturbance term. The coefficients of interest (β and γ), provide a measure of the elasticities and their interpretation is straightforward: β is a measure of the grants multiplier, γ measures the negative supply shock of a seismic event on output net of reconstruction grants. As standard in the literature, the inclusion of fixed effects captures unobserved time invariant municipal characteristics.

[13] As a measure of grants we consider the sum of both, current and capital grants from central government given that regional government did not provide any financial support for the reconstruction. Since the total amount of reconstruction grants was announced in 2009, we treat the part eventually disbursed in following years as fully anticipated.

OLS estimates of equation 1 would create several identification issues. First, estimates of β would be biased since grants are notoriously endogenous to local business cycles. Second, although the variable $E_{i,t}$ is exogenous with respect to the dependent variable, its correlation with the level of grants would bias also the estimates of γ. The instrumental variable estimator offers a way to overcome this endogeneity problem, relying on a dummy for the qualified municipalities (those with a Mercalli rank at or above VI) as an instrument and on a classical two-stage estimation procedure.[14] Equation 2 reports the linear model that constitutes the first stage:

$$G_{i,t} = \alpha_i + \lambda_t + \delta_1 Dummy_{i,t} + \delta_2 E_{i,t} + \boldsymbol{\phi}'\mathbf{X}_{i,t} + \xi_{i,t}, \tag{2}$$

where $Dummy_{i,t}$ is a dummy that takes the value of 1 in 2009 for those municipalities ranked at or above Mercalli VI, and $\xi_{i,t}$ is an error term. As standard, the predicted values $\widehat{G}_{i,t} = E(G_{i,t})$, are plugged in equation 3 to get the second stage:

$$Y_{i,t} = \alpha_i + \lambda_t + \beta\widehat{G}_{i,t} + \gamma E_{i,t} + \boldsymbol{\theta}'\mathbf{X}_{i,t} + \varepsilon_{i,t}. \tag{3}$$

In order to avoid inference problems, coefficients in equation 3 have been estimated using *Two-Stage Least Squares (2SLS)*. Our estimates of β and γ in equation 3 are unbiased under two main conditions. First, the

[14] A diff-in-diff approach in this case would not eliminate the endogeneity issue. This because the variable $G_{i,t}$ would still be endogenous in a model regressing $Y_{i,t}$, on $G_{i,t}$, a "treatment" dummy (taking the value of 1 for municipalities at or above Mercalli VI in 2009 and 0 otherwise), the interaction between $G_{i,t}$ and the "treatment" dummy, and some fixed effects. For this reason, we prefer the instrumental variable approach. However, in the same spirit of a diff-in-diff our baseline scenario is also run restricting the attention around the cutoff (see section 5 for details) in order to maximize the ex-ante similarity between municipalities in the "treatment" group with respect to those in the "control" group.

variable $Dummy_{i,t}$ should be a good predictor of reconstruction grants. Figure 3 provides robust evidence in support of this hypothesis.[15] Second, the variable $Dummy_{i,t}$ and the stochastic component of the output growth should be uncorrelated, formally $E(\varepsilon_{i.t}|Dummy_{i,t}) = 0$. Although we cannot provide a formal over-identification test to verify this hypothesis, we believe that, as long as the Mercalli ranks reflect the severity of the damages and are immune from manipulations (as shown in details in Appendix C), the only common shock between $Y_{i.t}$ and $Dummy_{i,t}$ is correctly captured by the variable $E_{i,t}$. For the same reasons Mercalli ranks can be considered uncorrelated with municipal output ($Y_{i,t}$) satisfying the necessary exclusion restrictions criteria. This, and the obvious randomness of earthquakes, leads us to conclude that the variable $Dummy_{i,t}$ is -indeed- a valuable instrument.[16]

As for the variable $E_{i,t}$ we compare two alternatives. The first one employes the distance of each municipality from the epicenter. The prior is that municipalities closer to the epicenter suffered the highest damages and that the damages declined geometrically getting more distant. For this reason we also allow the square of the distance to enter in equation 1. This approach offers the advantage of relying on a strictly exogenous regressor given the fact that the ex-ante probability of a seismic event was uniformly distributed across all municipalities. In the second alternative we rely on the reported damages covering 75,424 buildings to construct a synthetic index of damages. This approach offers a more accurate description of the ex-post damages, therefore eliminating or at least reducing the need for additional controls. Our measure of capital

[15] Preliminary regressions, available on request, show that the Mercalli scale is a good predictor for grants. One standard deviation of Mercalli scale generates a statistically significant (above 1%) increase in grants equal to 0.67 standard deviations.

[16] A similar identification strategy has been used by Bracco et al. [7] in order to estimate the flypaper effect, i.e. the relationship between local public expenditure and intergovernmental grants. Bracco et al. [7] use a dataset of Italian municipalities and as an instrument for grants a dummy for municipalities which are politicaly aligned with the central government.

stock loss is a weighted average of the number of buildings categorized in each AeDES level expressed as a share of the total number of buildings in each municipality. Formally:

$$Damages_{i,t} = \frac{\sum_{k=A}^{F} \omega_k \cdot Buildings_{k,i,t}}{Buildings_{i,t}}, \tag{4}$$

where $\omega_A = 0$, $\omega_B = 0$, $\omega_C = 0.5$, $\omega_D = 0.5$, $\omega_E = 1$, $\omega_F = 1$.[17] The variable $Damages_{i,t}$ captures both, the *severity* (that is the AeDES level) and the *extension* (that is the number of buildings categorized at or above AeDES level "C") of the damages.

As regards the matrix of controls $\mathbf{X}_{i,t}$ we include three variables capturing the evolution of the population: (i) total number of residents at December the 31st of each year, (ii) share of population younger than 14 years old, and (iii) share of population older than 65 years old. On top of these, we also include the number of victims in each municipality in 2009 in order to capture the human capital loss. The inclusion of municipal fixed effects prevents the inclusion of all time-invariant controls. All details are reported in Appendix D.

4. Data

Our dataset is a balanced panel of 305 municipalities over the period 2002 - 2011 for a total of 3,050 observations. All municipalities are located in the region of Abruzzo. Our choice eliminates 14 municipalities ranked at Mercalli V or V-VI in the neighborhood region of Lazio.[18] The earthquake did not generate

[17] Robustness checks (not reported in this version of the paper but available on request) show that our results are insensitive to this weights choice. The total number of buildings is estimated using census data (source: ISTAT) and assuming a constant growth rate in each municipality equal to the growth rate of the respective provinces.

[18] The municipalities are: Accumoli, Amatrice, Antrodoco, Borbona, Borgo Velino, Borgorose, Castel Sant'Angelo, Cittaducale,

Mercalli ranks higher than V-VI outside Abruzzo and no municipalities qualified for reconstruction grants in Lazio. For this reason, we prefer to restrict the attention to Abruzzo only.

As a measure of municipal economic activity we rely on two different variables: declared personal income and high-resolution data on night lights density measured by satellites at night. Regarding the first one (personal income), the variable refers to the tax base of the national personal income tax and the data are taken from the Italian Ministry of Economy and Finance. Personal income refers to the sum of all declared personal incomes in each municipality in each year and it offers the advantage of reducing the possibility of measurement errors due to fiscal evasion which, for each municipality, we assume to be time-invariant. Regarding the second variable (high-resolution data on night lights density measured by satellites at night), data come from the National Geophysical Data Center of the National Oceanic and Atmospheric Administration (U.S. Department of Commerce) and they have been shown (Henderson et al. [17]) to proxy well for local economic activity.[19] For our purposes we use the "Average Visible, Stable Lights, and Cloud Free" images taken from two satellites: F16 for the years from 2004 to 2009 and F18 for 2010 and 2011. In order to reduce the possibility of measurement errors when switching across satellites, we do not consider data prior to 2004, although our results do not seem to be driven by any specific time selection as confirmed by robustness checks. The luminosity of each municipality is calculated by taking the average luminosity of all pixels corresponding to the surface of the municipality. Figure A.2 in Appendix A shows the average luminosity over night in 2007 for the municipalities in our sample.

Cittareale, Fiamignano, Micigliano, Pescoracchiano, Petrella Salto and Posta, all located in the province of Rieti.

[19]The data are publicly available at: http://ngdc.noaa.gov/eog/dmsp/downloadV4composites.html

Fiscal data come from the municipal budget accounts ("certificati di conto consuntivi") released by the Italian Ministry of Interior.[20] These data include disaggregated information on expenditures, revenues and grants recorded on accrual bases. All monetary variables are deflated using the regional consumer price index from $ISTAT$.[21] Demographic variables and time invariant characteristics are taken from $ISTAT$. We also include a set of political variables collected from the Ministry of the Interior such as municipal turnout and voting patterns at regional elections, and political alignment of the local government with the central government.[22] A detailed description of all variables, sources and summary statistics is reported in Appendix D. All earthquakes-related geophysical data (including Mercalli ranks) come from the Italian National Institute of Geophysics and Volcanology ("2011 Italian Macroseismic Database ($DBMI11$))";[23] table A.3 in Appendix A reports the distribution of Mercalli ranks across all years for all recorded events showing that the only major quake in the considered period is the one of interest in this paper. Finally, data on AeDES classified buildings come from the CPD.

5. Results

In this section, we discuss the baseline results of our empirical model while in the next section we present complementary results and robustness checks. Table 1 reports the baseline results in which we use the distance

[20] Available at: http://finanzalocale.interno.it.

[21] All ISTAT data are available at: http://dati.istat.it/?lang=en.

[22] For the measure of the political orientation of each municipality, we take the results of regional election rather than the results of municipal elections because the presence of local political parties do not allow to unambiguously identify the political orientation of the council. Instead, at regional elections voters choose among the same parties as in the general elections.

[23] Available at: http://emidius.mi.ingv.it/DBMI11/.

of each municipality from the epicenter (variable $Distance_{i,t}$) and its square to proxy for $E_{i,t}$. In the next section we show the results when using the synthetic index of damages (variable $Damages_{i,t}$) instead. The first two columns of Table 1 present the OLS results (with and without controls), the second two columns present the results of the first stage of the instrumental variable regressions, and the last two columns present the second stage. All models report standard errors clustered at municipal level which are robust for serial correlation and heteroscedasticity. In the OLS regression the coefficient of $G_{i,t}$ enters significantly at 1 percent level and remains as such even after adding controls. In the second column of the OLS regression, the coefficient of $G_{i,t}$ implies an elasticity of 0.14, meaning that a 1 percent increase in grants (as a share of past level of personal income) increases personal income by around 0.14 percent. At the same time, neither the variable $Distance_{i,t}$ nor its square are significant and both have a coefficient close to zero. Also, the coefficient of $Distance_{i,t}$ is negative, meaning the opposite of what one could in principle expect. In other words, the endogeneity of $G_{i,t}$ and the correlation between $G_{i,t}$ and the variable $Distance_{i,t}$ (and its square) bias the estimates of both, β and γ.

The remaining columns of Table 1 presents the results of the instrumental variable regressions which remove the endogeneity bias. There is a high correlation, as expected, between $Dummy_{i,t}$ and $G_{i,t}$, this result provides a direct evidence that our identification strategy is free of any weak instrument problem. The coefficient of $Dummy_{i,t}$ suggests that on average the municipalities ranked at or above Mercalli VI received 7 percent (as a share of total personal income) grants more than the remaining municipalities. Also, the variable $Distance_{i,t}$ and its square enter significantly in the regressions at 1 percent level. When adding controls, the coefficient of the variable $Distance_{i,t}$ is 0.05, meaning that reconstruction grants increased by around 5 percent (expressed as a share of total personal income) every 10 kilometers getting closer to the epicenter. Also, the relation appears quadratic since the square of $Distance_{i,t}$ also enters significantly with a coefficient around 1 percent. Finally, the last two columns of Table 1 show the results of the second stage where coefficients' point estimates have been obtained through 2SLS estimator. Once the endogeneity of $G_{i,t}$ is removed, the estimated $\hat{\beta}$ increases to 0.71 and remains significant at 1 percent level also when adding controls. Given the estimated standard errors (0.20), we fail to reject the null of $\hat{\beta} = 1$, although the point estimate below unity suggests a private spending contraction following the event. Furthermore, the estimates of the variable $Distance_{i,t}$ are significant at 5 percent level when adding controls, including for the square. The estimates of $\hat{\gamma}$ suggests that on average 10 more kilometers of distance from the epicenter implied a 4 percent higher growth rate of personal income, meaning that municipalities closer to the epicenter suffered a larger contraction. A similar reasoning applies to the coefficient of the square of $Distance_{i,t}$. Finally, the underidentification test (Kleibergen-Paap Lagrange multiplier statistic) and the weak identification test (Cragg-Donald Wald F statistic) confirm that our instrument is -indeed- a valid one.

Table 2 presents the results of the baseline regressions, restricting the sample to municipalities with Mercalli ratings in the neighborhood of the cutoff (Mercalli VI). There are five reasons why we restrict the attention around the cutoff. First, by looking at municipalities that suffered only marginal damages we reduce the possibility of possible measurement errors, especially in the dependent variable(s). Second, we maximize the likelihood of fitting a linear model in a local setting around the cutoff. Third, we maximize the ex-ante similarity across "treatment" and "control" groups. Fourth, because the damages at Mercalli VI are only marginal and because the reconstruction activities were assigned to local firms, we reduce the eventual bias coming from possible fiscal spillovers. Finally, because of the specificity of the natural event we rely on, by looking at municipalities that only suffered marginal damages we can interpret our results more generally, providing ground for external validity. Our results are reported in Table 2 in which we explore all possible combinations of Mercalli ranks around the cutoff. In the first three columns we restrict the attention to all municipalities ranked between Mercalli V and Mercalli VI. In the second set of three columns we replicate the regressions for the municipalities between Mercalli V and VI-VII. In the third set of columns we show the results for the municipalities between Mercalli V-VI and VI. Finally, in the last set of columns we restrict the attention between Mercalli V-VI and Mercalli VI-VII. Overall, the evidence emerging from Table 2 closely mimics the baseline reported in Table 1. OLS estimates remain downwardly biased as expected. Also, the estimated reconstruction grants multiplier is very close to the baseline and it is bounded between 0.69 and 0.74 according to the column. Furthermore, the variable $Dummy_{i,t}$ continues to enter significantly (at 1 percent level) in all regressions, while the variable $Distance_{i,t}$ and its square enter significantly in the first stage of the IV regressions but not in the second stage since the municipalities included in this set of regressions tend to have a similar distance from the epicenter. Finally, the underidentification test (Kleibergen-Paap Lagrange multiplier statistic) and the weak identification test (Cragg-Donald Wald F statistic) confirm that our instrument is a valid one.

There are several possible explanations why the point estimates in our regressions are below unity, although not significantly so. The literature (see Batini et al. [5] for a review) has identified two types of determinants of the fiscal multipliers: (i) structural characteristics that influence the economy's response to fiscal shocks in "normal times", and (ii) conjunctural/cyclical factors. Regarding the structural characteristics, regions with a lower propensity to import tend to have higher fiscal multipliers because the demand leakage through imports is less pronounced (Barrell et al. [3], Ilzetzki et al. [18]). Also, regions with more rigid labor markets have larger fiscal multipliers if such rigidity implies reduced wage flexibility, since rigid wages tend to amplify the response of output to demand shocks (Cole and Ohanian [13], Gorodnichenko et al. [16]). Furthermore, regions with high-debt generally have lower multipliers, as a fiscal stimulus is likely to have negative credibility and confidence effects on private demand and the interest rate risk premium (Ilzetzki et al. [18], Kirchner et al. [19]). Finally, fiscal spillovers -meaning the extent to which one region's expenditure increases economic activity in a neighbor region- might reduce the size of the multiplier. Regarding the conjunctural/cyclical factors, fiscal multipliers are expected to be larger in downturns than in expansions (Woodford [27]), especially when aggregate monetary policy is unresponsive to local economic conditions such as in the case of this paper. Also, if a fiscal expansion is associated with higher uncertainty about future policies (Mahfouz et al. [20]), households and firms precautionary behavior can lower the size of the multiplier. In particular, households may accumulate precautionary savings and firms may delay irreversible investments (Caballero and Pindyck [8]). While the exact contribution of each of the aforementioned channels remain uncertain, because we cannot reject the null of $\hat{\beta} = 1$ we conclude that these effects have compensated each other, although the point estimate below unity is presumably driven by a decline in private spending due to one or more of the above channels.

However, despite the point estimate below unity, the government intervention provided public insurance against the negative supply shock. A back-of-the-envelop calculation suggests that the average economic loss (calculated by multiplying the estimated $\hat{\gamma}$ by the average distance from the epicenter) implies a 6.1 percent reduction in the growth rate of personal income for the affected municipalities in 2009. However, multiplying the estimated grants elasticities by the (average) size of the intervention, we estimate that the reconstruction grants prevented economic activity from falling below trend by compensating (or more than compensating around the cutoff) the negative supply shock. These results are in line with official statistics released by the Italian National Institute of Statistics ($ISTAT$). According to $ISTAT$, GDP contracted by 5.5 percent in Italy in 2009. Not surprisingly, the contraction was bigger for Abruzzo region (6.6 percent) given that traditionally the output performance of southern regions is lower than the corresponding national one. However, output contracted only 5.2 percent in the province of L'Aquila despite the seismic event, reinforcing the evidence of a positive effect of reconstruction grants.

6. Robustness checks and further results

We compare our baseline results against a large set of robustness checks. In this section we explain the set of checks and presents the results of these complementary regressions. In each case, as for the baseline, we show the results of the regressions run on the entire sample as well as around the Mercalli cutoff.

Night lights density data. As a first robustness check we employ a different dependent variable.

While declared personal income data offers the advantage of being available at the municipal level, it raises questions about the correlation with the underlying economic activity.[24] As a proxy for local output, in this check we rely on high-resolution night lights density data measured by satellites at night. These data, which come from the National Geophysical Data Center of the National Oceanic and Atmospheric Administration (U.S. Department of Commerce), have been shown (Henderson et al. [17]) to proxy well for local economic activity. Because this variable is not calculated in monetary terms, we do not express the growth rate of real per capita grants as a ratio of the lagged dependent variable. Rather, we express it as a ratio of its own lag $\left(G_{it,} = \frac{g_{i,t}-g_{i,t-1}}{g_{i,t-1}}\right)$. The results of these regressions are shown in Table A.5 for the entire sample and in Table A.6 around the Mercalli cutoff. The coefficient of interest $\left(\hat{\beta}\right)$ enters with the expected sign and it remains significant in all regressions. This is true for both, the regressions run on the entire sample and those reported in Table A.6. The magnitude of $\hat{\beta}$ in this case cannot be interpreted as a traditional multiplier given the definition of $G_{i,t}$. However, it is possible to recover the multiplier by estimating the average fiscal shock $\bar{G_t}$, the average change in night light density $\bar{Y_t}$, the elasticity between night lights change and personal income change, and the estimated $\hat{\beta}$.[25] In our sample such multiplier is estimated at 0.94, remarkably close to the baseline result.[26] Furthermore, the goodness of fit of the models is high and the instrumental variables tests are all well above the critical values. Finally, the variable $Distance_{i,t}$ and its square enter significantly at 1 percent level in the first stage of the instrumental variable regressions while in the second stage it is

[24] While output data are not available at the municipal level, at the aggregate national level (as well as at the regional level), output data appear to be highly correlated, and significantly so, with personal disposable income.

[25] The elasticity between night lights change and personal income change has been computed by regressing personal income change on night lights change, a set of yearly dummies and municipal fixed effects.

[26] The 0.94 figure is calculated as (0.06*0.19)*(0.03/0.01).

significant at 10 percent level.[27] Overall, this robustness check largely confirms the baseline results.[28]

Different time selection. In this second check, we run our baseline regressions restricting the time sample from 2008 onwards. The choice is determined by the 2008 reform of grants allocation which followed the change in the municipal property tax. Therefore, running our regressions on the 2008-2011 period ensures a stable sample in terms of grants allocation rules. For completeness, we also run our regressions on the 2005-2011 time period as a way to check our results against the same time span of the night lights data. For brevity, we show and comment only the results for the 2008-2011 period, although they are in line with the 2005-2011 ones. Our results are reported in Table A.7 for the entire sample and in Table A.8 for the regressions restricting around the Mercalli cutoff. The evidence emerging from these regressions largely confirms the baseline results. The only significant difference is that the estimated grants multiplier is higher than in the baseline, and it is bounded between 0.76 and 0.89. All other relevant dimensions (significance of the coefficients of variable $Distance_{i,t}$, its square, $Dummy_{i,t}$, goodness of fit, and IV tests) are extremely close to the baseline, signaling that our results are not driven by a specific time selection.

Index of damages. In this third check, we employ our index of damages (variable $Damages_{i,t}$) rather than the distance from the epicenter. The relative advantages of this approach as well as the definition of the variable $Damages_{i,t}$ have already been discussed in Section 3. Here we discuss our results which are reported in Table A.9 for the entire sample and in Table A.10 for the regressions restricting the attention around the

[27]For comparability issues we kept the very same specification of the baseline model. However, with this dependent variable the inverse of the variable $Distance_{i,t}$ (formally $(Distance_{i,t})^{-1}$) enters significantly in all regressions either at 5 or at 6 percent level while the estimated $\hat{\beta}$ remains virtually identical to the one shown in Tables A.5 and A.6.

[28]For brevity, we do not report all the other checks using night lights density data as a dependent variable but they are available upon request. Overall, they largely confirm these findings.

cutoff. The main evidence that emerges from these tables is that our baseline results are largely confirmed, despite the fact that the variable used to proxy for the negative supply shock induced by the earthquake is radically different. Looking at Table A.9, the grants multiplier (0.68) is very close to the baseline and the estimated $\hat{\beta}$ is significant at 1 percent level as in the baseline. Also, the goodness of fit and the instrumental variables test remain in line with those in the baseline. The variable $Damages_{i,t}$ enters significantly at 5 percent level in both, the first stage and the second stage. The estimated $\hat{\gamma}$ in the first stage implies that increasing the index of damages by 1 percent is associated to an increase of grants of around 7 percent. The variable $Damages_{i,t}$ remains highly significant also in the second stage and the estimated coefficient implies that an increase of 1 percent in the index of damages triggered a decline of around 8 percent of growth in declared personal income. Multiplying these elasticities by the average reconstruction grants and the average measure of damages, we conclude as for the baseline that the public intervention prevented income to fall below trend compensating (or more than compensating around the cutoff) for the negative effects induced by the earthquake.

Placebo. As a final check, we run placebo regressions. In order to do so, we simulate that the Mercalli grants allocation cutoff was not set at level VI, construct our instrument accordingly, and consider only municipalities ranked below Mercalli VI. Specifically, we simulate three different scenarios and report the results in Table A.11. In the first one (reported in the first two columns of Table A.11) we consider only the municipalities ranked between Mercalli 0 and Mercalli V-VI. Therefore, in this case, we compare output behavior between Mercalli 0 and and those above 0, pretending that the qualifying threshold was set at level

V. In the second case (reported in the mid columns of Table A.11), we consider only the municipalities at or below Mercalli V and our instrument is a dummy that takes the value of 1 for the municipalities at Mercalli V and 0 otherwise. Finally, in the third case (reported in the last two columns of Table A.11) we consider only the municipalities between Mercalli V and Mercalli V-VI and assign a value of 1 in the instrumental dummy to the second ones. Our results, reported in Table A.11 confirm our empirical model since in this placebo check none of the coefficients is statistically significant and in most cases appear to have to wrong sign.

7. Conclusion

In this paper, we have contributed evidence of local fiscal multipliers. By relying on a natural event in Italy, we estimated the output effect generated by the event, as a result of two combined shocks, the negative supply shock due to the earthquake, and the positive demand shock driven by reconstruction grants. Using an instrumental variables analysis we have shown non negligible output effects of negative supply shocks. In our estimates, the output loss from the earthquake averages 6.1 percentage points. Also, we estimated the "grants multipliers", that is the output response to reconstruction activities, to be around unity.

The policy relevance of quantifying local fiscal multipliers is apparent. On the one hand, we shed light on the extent to which fiscal tools can alleviate the output loss generated by large idiosyncratic shocks like earthquakes, although our estimates around the Mercalli cutoff can be generalized to other policy relevant situations. On the other hand, this paper analyzes the optimality of the institutional rule used to allocate grants after the event. Regarding the first factor we showed that reconstruction grants effectively provided public insurance following the earthquake preventing output from falling below trend. Regarding the second factor, our study pointed out that the grants allocation rule used after the 2009 L'Aquila earthquake based on a discontinuous scale might not be optimal since it translated into significant geographical variations in economic activity across neighbor municipalities with similar damages. In this dimension, a grants allocation rule based on a combination between a discontinuous variables such as the Mercalli scale and a continuous variable such as the distance from the epicenter could provide a more equitable and efficient distribution of grants.

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Tables

Table 1: Baseline results.

	OLS		IV - First stage		IV - Second stage	
Grants	**0.15*** **	**0.14*** **			**0.71*** **	**0.71*** **
	[0.05]	[0.05]			[0.19]	[0.20]
Distance	**-0.00**	**-0.00**	**-0.06*** **	**-0.05*** **	**0.05** **	**0.04** **
	[0.01]	[0.01]	[0.02]	[0.01]	[0.02]	[0.02]
Distance^2	**-0.00**	**-0.00**	**0.01*** **	**0.01*** **	**-0.01*** **	**-0.01** **
	[0.01]	[0.01]	[0.00]	[0.00]	[0.00]	[0.00]
Dummy			**0.08*** **	**0.07*** **		
			[0.02]	[0.02]		
Controls		YES		YES		YES
Observations	3,050	3,050	3,050	3,050	3,050	3,050
R^2	0.23	0.23	0.17	0.19	-	-
Underidentification test (Kleibergen-Paap)					14.6	14.4
Weak identification test (Cragg-Donald)					54.4	47.7

Note: robust standard errors in brackets, clustered by municipality. The dependent variable in the OLS regressions is the percentage change in per capita personal declared income; the same is true for the second stage of the IV regressions while the dependent variable in the first stage of the IV regressions is "Grants". Each regression includes a constant term, time (year) fixed-effects and municipal fixed-effects. "Grants" refers to the sum of (per capita) current and (per capita) capital grants received by a municipality in year 't'. The variable "Grants" is expressed as a change between year 't' and year 't-1', divided by declared per capita personal income in year 't-1'. "Distance" refers to the distance of each municipality from the epicenter of the 2009 L'Aquila earthquake, expressed in (x10) kilometers. "Distance^2" refers to the square of the variable "Distance". "Dummy" is a dummy variable that takes the value of 1 in 2009 for those municipalities ranked at or above Mercalli VI. *** indicates significance at 1% level, ** at 5%, and * at 10%.

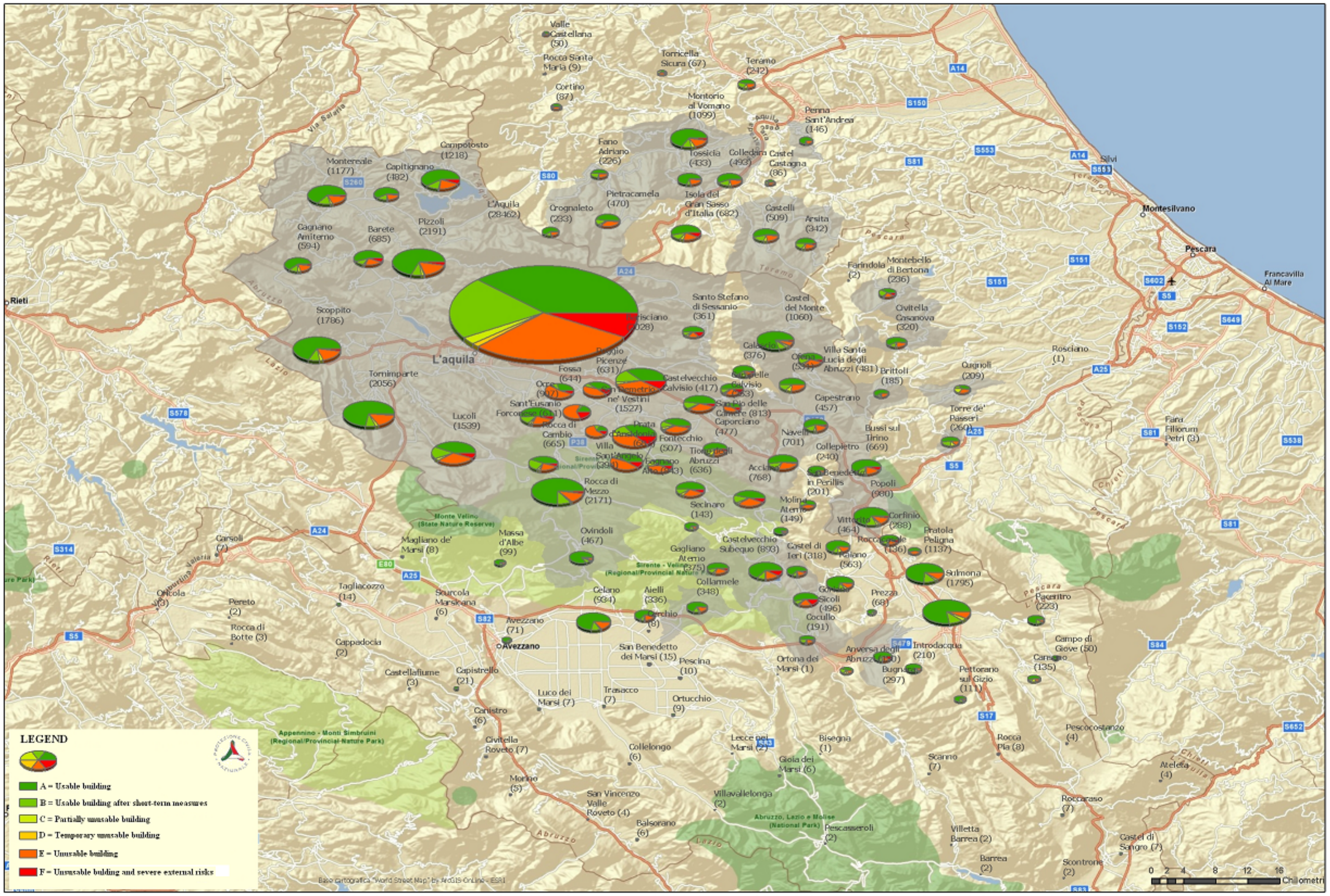
Table 2: Baseline results - around cutoff.

	Mercalli V - Mercalli VI			Mercalli V - Mercalli VI-VII			Mercalli V-VI - Mercalli VI			Mercalli V-VI - Mercalli VI-VII		
	OLS	IV 1^{st}	IV 2^{nd}	OLS	IV 1^{st}	IV 2^{nd}	OLS	IV 1^{st}	IV 2^{nd}	OLS	IV 1^{st}	IV 2^{nd}
Grants	**0.16****		**0.69*****	**0.18*****		**0.69*****	**0.16****		**0.74*****	**0.18*****		**0.73*****
	[0.07]		[0.20]	[0.07]		[0.20]	[0.07]		[0.24]	[0.07]		[0.25]
Distance	**0.02**	**-0.05***	**0.06***	**-0.01**	**-0.09****	**0.05**	**-0.01**	**-0.07***	**0.04**	**-0.04**	**-0.10****	**0.03**
	[0.02]	[0.03]	[0.03]	[0.02]	[0.04]	[0.03]	[0.03]	[0.04]	[0.05]	[0.03]	[0.04]	[0.05]
Distance^2	**-0.00**	**0.00**	**-0.01****	**-0.00**	**0.01****	**-0.01***	**0.00**	**0.00**	**-0.00**	**0.00**	**0.01****	**-0.00**
	[0.01]	[0.01]	[0.00]	[0.01]	[0.00]	[0.00]	[0.01]	[0.01]	[0.01]	[0.01]	[0.00]	[0.00]
Dummy		**0.08*****			**0.08*****			**0.08*****			**0.08*****	
		[0.02]			[0.02]			[0.02]			[0.02]	
Observations	1,160	1,160	1,160	1,220	1,220	1,220	640	640	640	700	700	700
R^2	0.20	0.14	-	0.21	0.21	-	0.19	0.17	-	0.22	0.26	-
Underidentification test			12.6			10.6			10.0			7.7
Weak identification test			32.0			27.7			10.8			9.4

Note: robust standard errors in brackets, clustered by municipality. IV 1^{st} refers to the first stage of the IV regression, IV 2^{nd} refers to the second stage. The dependent variable in the OLS regressions is the percentage change in per capita personal declared income; the same is true for the second stage of the IV regressions while the dependent variable in the first stage of the IV regressions is “Grants”. Each regression includes a constant term, time (year) fixed-effects, municipal fixed-effects, and control variables. “Grants” refers to the sum of (per capita) current and (per capita) capital grants received by a municipality in year ’t’. The variable “Grants” is expressed as a change between year ’t’ and year ’t-1’, divided by declared per capita personal income in year ’t-1’. “Distance” refers to the distance of each municipality from the epicenter of the 2009 L’Aquila earthquake, expressed in (x10) kilometers. “Distance^2” refers to the square of the variable “Distance”. “Dummy” is a dummy variable that takes the value of 1 in 2009 for those municipalities ranked at or above Mercalli VI. *** indicates significance at 1% level, ** at 5%, and * at 10%.

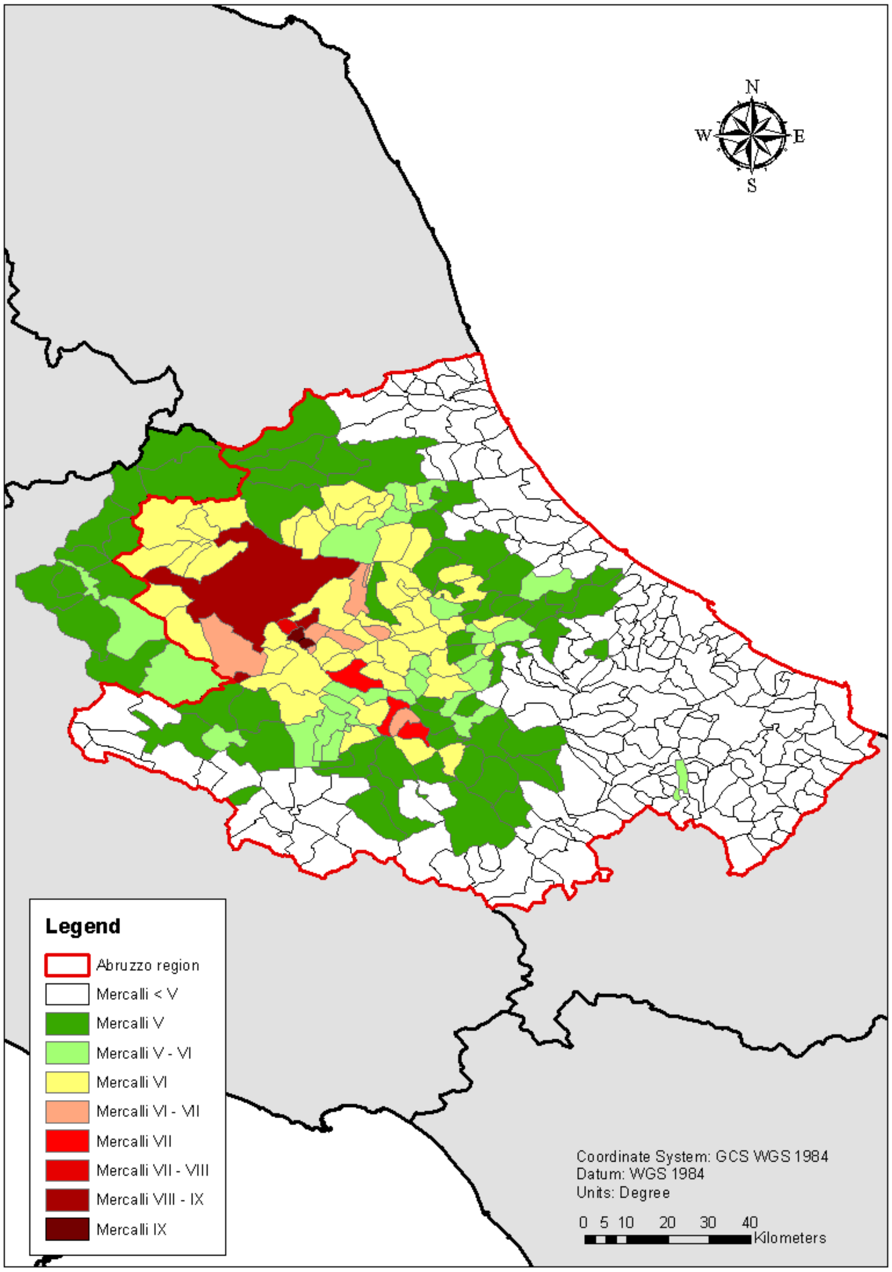
Figures

Figure 1: Map of classified damages according to AeDES classification system.



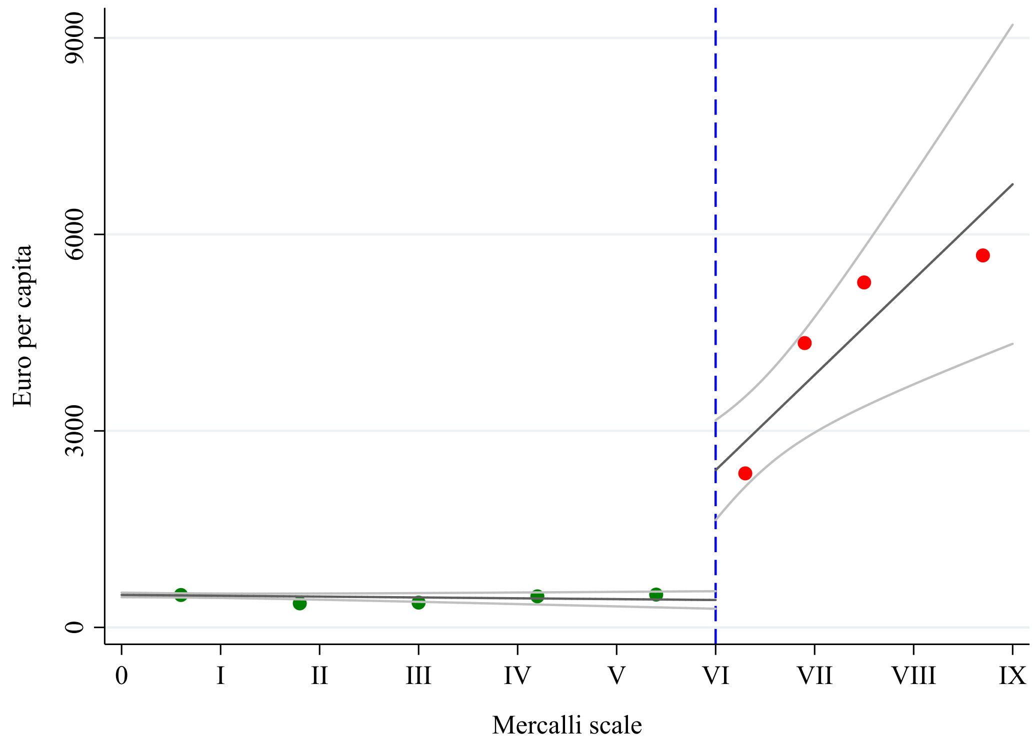
Note: The size of the pies reflects the absolute number of buildings (in brackets) classified in each municipality. Source: CPD database.

Figure 2: Map of the 2009 L'Aquila earthquake.



Source: authors' calculation on *INGV* data (available at http://emidius.mi.ingv.it/DBMI11/).

Figure 3: Discontinuity in grants.



Note: each dot is a bin (bandwidth of 1). Number of bins determined using an F-test. Grants are current plus capital from central government. The chart refers to all years in the dataset. Mercalli VII have been attributed to the Mercalli VI-VII bin to avoid a low number of observations in that bin. Source: authors' calculation on Italian Ministry of Interior data (available at: http://finanzalocale.interno.it/apps/floc.php/in/cod/4).

Appendix

Appendix A. Additional Tables and Figures

Table A.1: Percentage of buildings in each AeDES category.

	Type of building						
AeDES category	Private	Public	Hospitals	Barracks	Schools	Factories	**Overall**
A	55.0	57.5	51.5	71.0	52.9	56.6	**55.2**
B	15.6	19.1	18.2	25.0	26.7	19.4	**16.5**
C	3.3	4.5	15.2	3.0	2.4	4.5	**3.4**
D	1.9	3.4	3.0	-	3.7	0.8	**1.9**
E	21.5	14.3	12.1	1.0	12.5	15.7	**20.4**
F	2.7	1.2	-	-	1.8	3.0	**2.6**
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Source: Civil Protection Department, Italian Ministry of Interior (http://www.protezionecivile.gov.it).

Table A.2: Distribution of Mercalli ranks across provinces in 2009.

Mercalli rank	Chieti	L'Aquila	Pescara	Teramo	**Total**
0	99	31	18	27	**175**
V	4	25	15	8	**52**
V-VI	1	10	6	4	**21**
VI	0	28	7	8	**43**
VI-VII	0	6	0	0	**6**
VII	0	3	0	0	**3**
VII-VIII	0	1	0	0	**1**
VIII	0	0	0	0	**0**
VIII-IX	0	2	0	0	**2**
IX	0	2	0	0	**2**
Total	**104**	**108**	**46**	**47**	**305**

Source: INGV database (available at: http://emidius.mi.ingv.it/DBMI11/)

Table A.3: Distribution of Mercalli ranks across years.

Mercalli	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	**Total**
0	136	160	172	246	247	305	305	175	305	305	**2,356**
I	3	96	82	58	48	0	0	0	0	0	**287**
II	3	10	8	1	1	0	0	0	0	0	**23**
II-III	4	6	3	0	0	0	0	0	0	0	**13**
III	10	10	4	0	5	0	0	0	0	0	**29**
III-IV	29	16	12	0	3	0	0	0	0	0	**60**
IV	44	2	9	0	1	0	0	0	0	0	**56**
IV-V	54	4	10	0	0	0	0	0	0	0	**68**
V	22	1	4	0	0	0	0	52	0	0	**79**
V-VI	0	0	1	0	0	0	0	21	0	0	**22**
VI	0	0	0	0	0	0	0	43	0	0	**43**
VI-VII	0	0	0	0	0	0	0	6	0	0	**6**
VII	0	0	0	0	0	0	0	3	0	0	**3**
VII-VIII	0	0	0	0	0	0	0	1	0	0	**1**
VIII	0	0	0	0	0	0	0	0	0	0	**0**
VIII-IX	0	0	0	0	0	0	0	2	0	0	**2**
IX	0	0	0	0	0	0	0	2	0	0	**2**
Total	**305**	**305**	**305**	**305**	**305**	**305**	**305**	**305**	**305**	**305**	**3,050**

Note: Mercalli ranks before 2009 refer to the following events: “Subappennino Dauno” (November 1^{st} 2002, magnitude 5.72, epicenter in Molise region), “Zona Ascoli Piceno” (May 25^{th} 2003, magnitude 4.30, epicenter in Marche region), “Molise” (June 1^{st} 2003, magnitude 4.66, epicenter in Molise region), “Monti dei Frentani” (December 30^{th} 2003, magnitude 4.63, epicenter in Molise region), “Monti Tiburtini” (October 5^{th} 2004, magnitude 4.05, epicenter in Lazio region), “Zona Teramo” (December 9^{th} 2004, magnitude 4.54, epicenter in Abruzzo region), “Monti dei Frentani” (March 1^{st} 2005, magnitude 4.24, epicenter Marche region), “Maceratese” (April 12^{th} 2005, magnitude 4.24, epicenter in Marche region), “Valle del Topino” (December 15^{th} 2005, magnitude 4.69, epicenter in Marche region), “Maceratese” (April 10^{th} 2006, magnitude 4.55, epicenter Marche region), and “Promontorio del Gargano” (May 29^{th} 2006, magnitude 4.92, epicenter in Puglia region).

Table A.4: Summary Statistics

		Full sample				Mercalli VI and above			
Variable	**Unit of measure**	*Mean*	*St. Dev.*	*Min*	*Max*	*Mean*	*St. Dev.*	*Min*	*Max*
Personal income	Euro per capita	16,654	1,944	10,065	28,939	17,311	2,065	10,065	25,616
Night lights density	Index (0 to 62)	16.1	12.4	1.9	62	9.9	5.1	2.5	29.4
Grants	Euro per capita	530	1,016	0	21,300	1,180	1,891	0	21,300
△ Personal income	Percent	-0.0	5.6	-39.7	49.8	-0.0	7.2	-39.7	49.8
△ Night lights density	Percent	6.1	21.7	-47.2	105.7	6.8	22.2	-42.4	89.2
△ Grants	Percent	0.2	5.2	-80.4	87.8	1.2	9.2	-37.8	77.6
Population	Unit	4,301	10,589	77	123,077	2,502	9,310	85	72,988
Pop under 14	Unit	12.3	3.0	1.3	26.5	11.1	3.3	2.1	26.6
Pop over 65	Unit	26.6	9.4	7.3	86.4	30.3	9.8	12.5	67.3
Unemployment	Percent	10.1	3.8	0	28.8	10.6	3.7	0	23.0
Left	Percent	50.4	13.1	5.6	91.4	51.1	12.3	11.3	79.0
Distance*	Kilometers	45.9	21.8	2.5	95.2	19.5	10.6	2.5	40.5
Index of damages*	Index (0 to 100)	6.29	16.7	0	100	29.7	27.8	0.5	100
Casualties*	Unit	0.02	0.23	0	3.98	0.11	0.54	0	3.98
No. of observations		**3,050**				**570**			

Note: Number of observations for variable "Night lights density" is 2,440. A "△" symbol refers to the change between year 't' and year 't-1'. "Pop under 14" refers to the share of the population under 14 years old. "Pop over 65" refers to the share of the population above 65 years old. "Left" refers to the share of votes to the left-wing coalition in the most recent regional elections. "Casualties" refers to the number of victims expressed as a share of total population in 2009. Number of observations for variable "△ Night lights density' is 2,135. Variable with an*refers to 2009 only.

Table A.5: Night lights density results.

	OLS		IV - First stage		IV - Second stage	
Grants	**0.01*** **	**0.01*** **			**0.02*** **	**0.03*** **
	[0.00]	[0.00]			[0.01]	[0.01]
Distance	**-0.01**	**0.02**	**-1.46*** **	**-1.37*** **	**0.03**	**0.06* **
	[0.02]	[0.02]	[0.39]	[0.41]	[0.03]	[0.03]
Distance^2	**0.00**	**-0.00**	**0.01*** **	**0.01*** **	**-0.00**	**-0.00**
	[0.01]	[0.01]	[0.00]	[0.00]	[0.01]	[0.01]
Dummy			**4.05*** **	**3.85*** **		
			[0.69]	[0.69]		
Controls		YES		YES		YES
Observations	2,135	2,135	2,135	2,135	2,135	2,135
R^2	0.68	0.69	0.39	0.41	-	-
Underidentification test (Kleibergen-Paap)					22.6	20.6
Weak identification test (Cragg-Donald)					226.7	208.5

Note: robust standard errors in brackets, clustered by municipality. The dependent variable in the OLS regressions is the percentage change in night lights density data; the same is true for the second stage of the IV regressions while the dependent variable in the first stage of the IV regressions is "Grants". Each regression includes a constant term, time (year) fixed-effects and municipal fixed-effects. "Grants" refers to the sum of (per capita) current and (per capita) capital grants received by a municipality in year 't'. The variable "Grants" is expressed as a percentage change between year 't' and year 't-1'. "Distance" refers to the distance of each municipality from the epicenter of the 2009 L'Aquila earthquake, expressed in (x10) kilometers. "Distance^2" refers to the square of the variable "Distance". "Dummy" is a dummy variable that takes the value of 1 in 2009 for those municipalities ranked at or above Mercalli VI. *** indicates significance at 1% level, ** at 5%, and * at 10%.

Table A.6: Night lights density - around cutoff.

	Mercalli V - Mercalli VI			Mercalli V - Mercalli VI-VII			Mercalli V-VI - Mercalli VI			Mercalli V-VI - Mercalli VI-VII		
	OLS	IV 1^{st}	IV 2^{nd}	OLS	IV 1^{st}	IV 2^{nd}	OLS	IV 1^{st}	IV 2^{nd}	OLS	IV 1^{st}	IV 2^{nd}
Grants	**0.01****		**0.02***	**0.01****		**0.02****	**0.01****		**0.02***	**0.01***		**0.02***
	[0.01]		[0.01]	[0.01]		[0.01]	[0.01]		[0.01]	[0.01]		[0.01]
Distance	**-0.01**	**-2.17****	**0.00**	**0.00**	**-2.68*****	**0.02**	**-0.07**	**-4.53*****	**-0.04**	**-0.04**	**-4.97*****	**0.01**
	[0.05]	[1.08]	[0.06]	[0.05]	[0.94]	[0.06]	[0.06]	[1.54]	[0.08]	[0.06]	[1.27]	[0.09]
Distance^2	**0.00**	**0.01***	**0.00**	**0.00**	**0.01*****	**0.00**	**0.00**	**0.00**	**0.01*****	**0.00**	**0.01*****	**0.00**
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.01]	[0.01]	[0.01]	[0.00]	[0.01]	[0.00]	[0.01]
Dummy		**3.79*****			**3.76*****			**3.61*****			**3.62*****	
		[0.72]			[0.73]			[0.78]			[0.83]	
Observations	812	812	812	854	854	854	448	448	448	490	490	490
R^2	0.71	0.42	-	0.71	0.48	-	0.74	0.48	-	0.73	0.53	-
Underidentification test			16.7			15.9			39.1			10.9
Weak identification test			124.8			126.3			41.4			45.6

Note: robust standard errors in brackets, clustered by municipality. IV 1^{st} refers to the first stage of the IV regression, IV 2^{nd} refers to the second stage. The dependent variable in the OLS regressions is the percentage change in per capita personal declared income; the same is true for the second stage of the IV regressions while the dependent variable in the first stage of the IV regressions is "Grants". Each regression includes a constant term, time (year) fixed-effects and municipal fixed-effects. "Grants" refers to the sum of (per capita) current and (per capita) capital grants received by a municipality in year 't'. The variable "Grants" is expressed as a percentage change between year 't' and year 't-1'. "Distance" refers to the distance of each municipality from the epicenter of the 2009 L'Aquila earthquake, expressed in (x10) kilometers. "Distance^2" refers to the square of the variable "Distance". "Dummy" is a dummy variable that takes the value of 1 in 2009 for those municipalities ranked at or above Mercalli VI. *** indicates significance at 1% level, ** at 5%, and * at 10%.

Table A.7: Different time selection results.

	OLS		IV - First stage		IV - Second stage	
Grants	**0.27***** [0.07]	**0.27***** [0.07]			**0.86***** [0.30]	**0.84***** [0.32]
Distance	**0.00** [0.01]	**0.01** [0.01]	**-0.07***** [0.02]	**-0.06***** [0.02]	**0.06**** [0.03]	**0.05*** [0.03]
Distance^2	**-0.00** [0.01]	**-0.00** [0.01]	**0.01***** [0.00]	**0.01***** [0.00]	**-0.01**** [0.00]	**-0.01**** [0.00]
Dummy			**0.07***** [0.02]	**0.07***** [0.02]		
Controls		YES		YES		YES
Observations	1,220	1,220	1,220	1,220	1,220	1,220
R^2	0.24	0.25	0.25	0.27	-	-
Underidentification test (Kleibergen-Paap)					8.4	7.2
Weak identification test (Cragg-Donald)					22.7	20.0

Note: robust standard errors in brackets, clustered by municipality. The dependent variable in the OLS regressions is the percentage change in per capita personal declared income; the same is true for the second stage of the IV regressions while the dependent variable in the first stage of the IV regressions is “Grants”. Each regression includes a constant term, time (year) fixed-effects and municipal fixed-effects. “Grants” refers to the sum of (per capita) current and (per capita) capital grants received by a municipality in year ’t’. The variable “Grants” is expressed as a change between year ’t’ and year ’t-1’, divided by declared per capita personal income in year ’t-1’. “Distance” refers to the distance of each municipality from the epicenter of the 2009 L’Aquila earthquake, expressed in (x10) kilometers. “Distance^2” refers to the square of the variable “Distance”. “Dummy” is a dummy variable that takes the value of 1 in 2009 for those municipalities ranked at or above Mercalli VI. *** indicates significance at 1% level, ** at 5%, and * at 10%.

Table A.8: Different time selection - around cutoff.

	Mercalli V - Mercalli VI			Mercalli V - Mercalli VI-VII			Mercalli V-VI - Mercalli VI			Mercalli V-VI - Mercalli VI-VII		
	OLS	IV 1^{st}	IV 2^{nd}	OLS	IV 1^{st}	IV 2^{nd}	OLS	IV 1^{st}	IV 2^{nd}	OLS	IV 1^{st}	IV 2^{nd}
Grants	**0.28*** **		**0.77*** **	**0.31*** **		**0.76*** **	**0.26*** **		**0.89** **	**0.29*** **		**0.85** **
	[0.10]		[0.28]	[0.09]		[0.28]	[0.10]		[0.43]	[0.09]		[0.42]
Distance	**0.02**	**-0.04**	**0.06**	**0.01**	**-0.09** **	**0.06**	**-0.02**	**-0.06**	**0.03**	**-0.04**	**-0.10** **	**0.02**
	[0.02]	[0.03]	[0.04]	[0.02]	[0.04]	[0.04]	[0.03]	[0.05]	[0.05]	[0.03]	[0.05]	[0.07]
Distance^2	**-0.00**	**0.00**	**-0.01**	**0.00**	**0.01** **	**-0.00**	**0.00**	**0.00**	**-0.00**	**0.00**	**0.01***	**-0.00**
	[0.01]	[0.01]	[0.00]	[0.01]	[0.00]	[0.01]	[0.01]	[0.01]	[0.01]	[0.01]	[0.00]	[0.00]
Dummy		**0.07*** **			**0.07*** **			**0.06** **			**0.06** **	
		[0.02]			[0.02]			[0.03]			[0.03]	
Observations	464	464	464	488	488	488	256	256	256	280	280	280
R^2	0.20	0.23	-	0.25	0.32	-	0.23	0.27	-	0.29	0.37	-
Underidentification test			7.5			6.8			4.2			3.9
Weak identification test			14.5			12.4			3.4			3.1

Note: robust standard errors in brackets, clustered by municipality. IV 1^{st} refers to the first stage of the IV regression, IV 2^{nd} refers to the second stage. The dependent variable in the OLS regressions is the percentage change in per capita personal declared income; the same is true for the second stage of the IV regressions while the dependent variable in the first stage of the IV regressions is "Grants". Each regression includes a constant term, time (year) fixed-effects, municipal fixed-effects, and control variables. "Grants" refers to the sum of (per capita) current and (per capita) capital grants received by a municipality in year 't'. The variable "Grants" is expressed as a change between year 't' and year 't-1', divided by declared per capita personal income in year 't-1'. "Distance" refers to the distance of each municipality from the epicenter of the 2009 L'Aquila earthquake, expressed in (x10) kilometers. "Distance^2" refers to the square of the variable "Distance". "Dummy" is a dummy variable that takes the value of 1 in 2009 for those municipalities ranked at or above Mercalli VI. *** indicates significance at 1% level, ** at 5%, and * at 10%.

Table A.9: Damages results.

	OLS		IV - First stage		IV - Second stage	
Grants	**0.16***** [0.06]	**0.15***** [0.06]			**0.58***** [0.14]	**0.68***** [0.17]
Damages	**0.02** [0.03]	**0.01** [0.02]	**0.07**** [0.03]	**0.07**** [0.03]	**-0.07*** [0.04]	**-0.08**** [0.04]
Dummy			**0.12***** [0.02]	**0.10***** [0.02]		
Controls		YES		YES		YES
Observations	3,050	3,050	3,050	3,050	3,050	3,050
R^2	0.22	0.23	0.15	0.17	-	-
Underidentification test (Kleibergen-Paap)					15.1	18.7
Weak identification test (Cragg-Donald)					156.4	93.1

Note: robust standard errors in brackets, clustered by municipality. The dependent variable in the OLS regressions is the percentage change in per capita personal declared income; the same is true for the second stage of the IV regressions while the dependent variable in the first stage of the IV regressions is “Grants”. Each regression includes a constant term, time (year) fixed-effects and municipal fixed-effects. “Grants” refers to the sum of (per capita) current and (per capita) capital grants received by a municipality in year ’t’. The variable “Grants” is expressed as a change between year ’t’ and year ’t-1’, divided by declared per capita personal income in year ’t-1’. “Damages” refers to the index of damages. “Dummy” is a dummy variable that takes the value of 1 in 2009 for those municipalities ranked at or above Mercalli VI. *** indicates significance at 1% level, ** at 5%, and * at 10%.

Table A.10: Damages - around cutoff.

	Mercalli V - Mercalli VI			Mercalli V - Mercalli VI-VII			Mercalli V-VI - Mercalli VI			Mercalli V-VI - Mercalli VI-VII		
	OLS	IV 1^{st}	IV 2^{nd}	OLS	IV 1^{st}	IV 2^{nd}	OLS	IV 1^{st}	IV 2^{nd}	OLS	IV 1^{st}	IV 2^{nd}
Grants	**0.16****		**0.83*****	**0.19*****		**0.73*****	**0.17****		**0.96*****	**0.19*****		**0.92*****
	[0.08]		[0.27]	[0.07]		[0.20]	[0.08]		[0.33]	[0.07]		[0.28]
Damages	**0.00**	**0.13*****	**-0.12****	**0.01**	**0.09*****	**-0.08***	**-0.01**	**0.12*****	**-0.13****	**-0.01**	**0.09*****	**-0.10****
	[0.01]	[0.02]	[0.05]	[0.03]	[0.02]	[0.04]	[0.03]	[0.02]	[0.06]	[0.03]	[0.02]	[0.05]
Dummy		**0.07*****			**0.09*****			**0.07*****			**0.08*****	
		[0.02]			[0.02]			[0.02]			[0.02]	
Observations	1,160	1,160	1,160	1,220	1,220	1,220	640	640	640	700	700	700
R^2	0.20	0.16	-	0.21	0.20	-	0.19	0.18	-	0.21	0.22	-
Underidentification test			12.5			15.3			9.5			9.1
Weak identification test			22.5			33.1			7.7			9.2

Note: robust standard errors in brackets, clustered by municipality. IV 1^{st} refers to the first stage of the IV regression, IV 2^{nd} refers to the second stage. The dependent variable in the OLS regressions is the percentage change in per capita personal declared income; the same is true for the second stage of the IV regressions while the dependent variable in the first stage of the IV regressions is "Grants". Each regression includes a constant term, time (year) fixed-effects, municipal fixed-effects, and control variables. "Grants" refers to the sum of (per capita) current and (per capita) capital grants received by a municipality in year 't'. The variable "Grants" is expressed as a change between year 't' and year 't-1', divided by declared per capita personal income in year 't-1'. "Damages" refers to the index of damages. "Dummy" is a dummy variable that takes the value of 1 in 2009 for those municipalities ranked at or above Mercalli VI. *** indicates significance at 1% level, ** at 5%, and * at 10%.

Table A.11: Placebo results.

	Mercalli 0 to Mercalli V-VI		Mercalli 0 to Mercalli V		Mercalli V to Mercalli V-VI	
Grants	**-0.10**	**-0.31**	**0.02**	**-0.04**	**-1.49**	**-20.39**
	[1.49]	[1.54]	[1.16]	[1.19]	[3.80]	[353.83]
Distance	**0.02**	**0.02**	**0.02***	**0.02**	**0.02**	**0.02**
	[0.02]	[0.02]	[0.01]	[0.01]	[0.06]	[0.82]
Distance^2	**-0.00**	**-0.00**	**-0.01****	**-0.01***	**-0.00**	**-0.00**
	[0.01]	[0.01]	[0.00]	[0.01]	[0.01]	[0.01]
Controls		YES		YES		YES
Observations	2,480	2,480	2,270	2,270	730	730

Note: robust standard errors in brackets, clustered by municipality. The dependent variable is the percentage change in declared personal income; Each regression includes a constant term, time (year) fixed-effects and municipal fixed-effects. “Grants” refers to the sum of (per capita) current and (per capita) capital grants received by a municipality in year ’t’. The variable “Grants” is expressed as a percentage change between year ’t’ and year ’t-1’ as a share of total personal income of the previous year. “Distance” refers to the distance of each municipality from the epicenter of the 2009 L’Aquila earthquake, expressed in (x10) kilometers. “Distance^2” refers to the square of the variable “Distance”. *** indicates significance at 1% level, ** at 5%, and * at 10%.

Appendix B. Mercalli scale

The Richter scale (or simply “magnitude”) was invented by Charles Francis Richter at the California Institute of Technology. It quantifies the energy released during an earthquake on a base-10 logarithmic scale. For instance, an earthquake that measures 5.0 on the Richter scale has a shaking amplitude 10 times larger than one that measures 4.0, and corresponds to a 31.6 times larger release of energy. Technically, the magnitude is defined as the logarithm of the ratio of the amplitude of waves measured by a seismograph to an arbitrary small amplitude. However, before seismologists were able to measure the moment-magnitude of earthquakes, other scales were invented to categorize seismic episodes. In 1783 an Italian architect (Pompeo Schiantarelli) invented a rudimentary scale to classify the affected regions according to the severity of the damages. The scale underwent several revisions and it is now known as 'Mercalli scale', from the Italian volcanologist Giuseppe Mercalli who modified it in 1908. The scale is a narrative description of the damages defined on twelve levels ranging from 'instrumental' (I) to 'catastrophic' (XII). Here below we report the definitions of each level.

- **I Instrumental** *People:* Not felt except by a very few people under exceptionally favorable circumstances.
- **II Weak** *People:* Felt by persons at rest, on upper floors or favorably placed.
- **III Slight** *People:* Felt indoors, hanging objects may swing, vibration similar to passing of light trucks,duration may be estimated, may not be recognized as an earthquake.
- **IV Moderate** *People:* Generally noticed indoors but not outside. Light sleepers may be awakened. Vibration may be likened to the passing of heavy traffic, or to the jolt of a heavy object falling or striking the building. *Fittings:* Doors and windows rattle. Glassware and crockery rattle. Liquids in open vessels may be slightly disturbed. Standing motorcars may rock. *Structures:* Walls and frames of buildings, and partitions and suspended ceilings in commercial buildings, may be heard to creak.
- **V Rather Strong** *People:* Generally felt outside, and by almost everyone indoors. Most sleepers awakened. A few people alarmed. *Fittings:* Small unstable objects are displaced or upset. Some

glassware and crockery may be broken. Hanging pictures knock against the wall. Open doors may swing. Cupboard doors secured by magnetic catches may open. Pendulum clocks stop, start, or change rate. *Structures:* Some windows Type I cracked. A few earthenware toilet fixtures cracked.

- **VI Strong** *People:* Felt by all. People and animals alarmed. Many run outside. Difficulty experienced in walking steadily. *Fittings:* Objects fall from shelves. Pictures fall from walls. Some furniture moved on smooth floors, some unsecured free-standing fireplaces moved. Glassware and crockery broken. Very unstable furniture overturned. Small church and school bells ring. Appliances move on bench or table tops. Filing cabinets or "easy glide" drawers may open (or shut). *Structures:* Slight damage to Buildings Type I. Some stucco or cement plaster falls. Windows Type I broken. Damage to a few weak domestic chimneys, some may fall. *Environment:* Trees and bushes shake, or are heard to rustle. Loose material may be dislodged from sloping ground, e.g. existing slides, talus slopes, shingle slides.

- **VII Very Strong** *People:* General alarm. Difficulty experienced in standing. Noticed by motorcar drivers who may stop. *Fittings:* Large bells ring. Furniture moves on smooth floors, may move on carpeted floors. Substantial damage to fragile contents of buildings. *Structures:* Unreinforced stone and brick walls cracked. Buildings Type I cracked with some minor masonry falls. A few instances of damage to Buildings Type II. Unbraced parapets, unbraced brick gables, and architectural ornaments fall. Roofing tiles, especially ridge tiles may be dislodged. Many unreinforced domestic chimneys damaged, often falling from roof-line. Water tanks Type I burst. A few instances of damage to brick veneers and plaster or cement-based linings. Unrestrained water cylinders (water tanks Type II) may move and leak. Some windows Type II cracked. Suspended ceilings damaged. *Environment:* Water made turbid by stirred up mud. Small slides such as falls of sand and gravel banks, and small rock-falls from steep slopes and cuttings. Instances of settlement of unconsolidated or wet, or weak soils. Some fine cracks appear in sloping ground. A few instances of liquefaction (i.e. small water and sand ejections).

- **VIII Destructive** *People:* Alarm may approach panic. Steering of motorcars greatly affected. *Structures:* Buildings Type I heavily damaged, some collapse. Buildings Type II damaged, some with partial collapse. Buildings Type III damaged in some cases. A few instances of damage to Structures Type IV.

Monuments and pre-1976 elevated tanks and factory stacks twisted or brought down. Some pre-1965 infill masonry panels damaged. A few post-1980 brick veneers damaged. Decayed timber piles of houses damaged. Houses not secured to foundations may move. Most unreinforced domestic chimneys damaged, some below roof-line, many brought down. *Environment:* Cracks appear on steep slopes and in wet ground. Small to moderate slides in roadside cuttings and unsupported excavations. Small water and sand ejections and localized lateral spreading adjacent to streams, canals, lakes, etc.

- **IX Violent** *Structures:* Many Buildings Type I destroyed. Buildings Type II heavily damaged, some collapse. Buildings Type III damaged, some with partial collapse. Structures Type IV damaged in some cases, some with flexible frames seriously damaged. Damage or permanent distortion to some Structures Type V. Houses not secured to foundations shifted off. Brick veneers fall and expose frames. *Environment:* Cracking of ground conspicuous. Land sliding general on steep slopes. Liquefaction effects intensified and more widespread, with large lateral spreading and flow sliding adjacent to streams, canals, lakes, etc.

- **X Intense** *Structures:* Most Buildings Type I destroyed. Many Buildings Type II destroyed. Buildings Type III heavily damaged, some collapse. Structures Type IV damaged, some with partial collapse. Structures Type V moderately damaged, but few partial collapses. A few instances of damage to Structures Type VI. Some well-built timber buildings moderately damaged (excluding damage from falling chimneys). *Environment:* Land sliding very widespread in susceptible terrain, with very large rock masses displaced on steep slopes. Landslide dams may be formed. Liquefaction effects widespread and severe.

- **XI Extreme** *Structures:* Most Buildings Type II destroyed. Many Buildings Type III destroyed. Structures Type IV heavily damaged, some collapse. Structures Type V damaged, some with partial collapse. Structures Type VI suffer minor damage, a few moderately damaged.

- **XII Catastrophic** *Structures:* Most Buildings Type III destroyed. Structures Type IV heavily damaged, some collapse. Structures Type V damaged, some with partial collapse. Structures Type VI suffer minor damage, a few moderately damaged.

Construction types. *Buildings Type I:* Buildings with low standard of workmanship, poor mortar, or constructed of weak materials like mud brick or rammed earth. Soft storey structures (e.g. shops) made of masonry, weak reinforced concrete or composite materials (e.g. some walls timber, some brick) not well tied together. Masonry buildings otherwise conforming to buildings Types I to III, but also having heavy unreinforced masonry towers. (Buildings constructed entirely of timber must be of extremely low quality to be Type I.). *Buildings Type II:* Buildings of ordinary workmanship, with mortar of average quality. No extreme weakness, such as inadequate bonding of the corners, but neither designed nor reinforced to resist lateral forces. Such buildings not having heavy unreinforced masonry towers. *Buildings Type III:* Reinforced masonry or concrete buildings of good workmanship and with sound mortar, but not formally designed to resist earthquake forces. *Structures Type IV:* Buildings and bridges designed and built to resist earthquakes to normal use standards, i.e. no special collapse or damage limiting measures taken (mid-1930s to c. 1970 for concrete and to c. 1980 for other materials). *Structures Type V:* Buildings and bridges, designed and built to normal use standards, i.e. no special damage limiting measures taken, other than code requirements, dating from since c. 1970 for concrete and c. 1980 for other materials. *Structures Type VI:* Structures, dating from c. 1980, with well-defined foundation behavior, which have been specially designed for minimal damage, e.g. seismically isolated emergency facilities, some structures with dangerous or high contents, or new generation low damage structures. **Windows.** *Type I:* Large display windows, especially shop windows. *Type II:* Ordinary sash or casement windows. **Water tanks.** *Type I:* External, stand mounted, corrugated iron tanks. *Type II:* Domestic hot-water cylinders unrestrained except by supply and delivery pipes.

Appendix C. Are the Mercalli ranks artificially manipulated?

A possible concern about the Mercalli ranks is whether they reflect the damages suffered by each municipality or whether they might be artificially manipulated. This would happen if, for instance, the delegates assigned higher ranks to poorer municipalities or to municipalities in which the mayor belongs to the same political party of the central government. While this would not necessarily bias our estimates, in this section we investigate the key dimensions that determined whether a municipality was ranked at or above Mercalli VI.

We test these effects using a probit model estimated via maximum-likelihood. Our goal is to test whether the decision of classifying a municipality as Mercalli VI instead of V was based on the recorded damages only or was influenced by other factors (although the qualifying threshold was ex-ante unknown to the delegates).[29] The empirical model (that we run using 2009 data only) is

$$DM_i = \alpha + \phi Damages_i + \boldsymbol{\gamma}'\mathbf{Z}_i + \boldsymbol{\delta}'\mathbf{X}_i + \eta_i. \tag{C.1}$$

where DM_i is a dummy variable that takes the value of 1 for Mercalli VI and zero for V or V-VI, $\mathbf{Z}_i$ is a matrix containing the other variables of interest (municipal personal income, municipal unemployment rate, and political alignment with the central government), $\mathbf{X}_i$ is a matrix that contains all other controls, $\boldsymbol{\gamma}$ and $\boldsymbol{\delta}$ are vectors of coefficients, and η_i is a disturbance term.[30] We are interested in testing whether ϕ or

[29] We assume that each building was correctly categorized following the AeDES system. This assumption is reinforced by the fact that the owner of the building is typically allowed to ask for a double check if the AeDES level is somehow controversial.

[30] The list of controls used in this regression is as follows (see Appendix D for definitions and sources): unemployment, alignment, population band, graduates, unliterary, altimetry, altimetry max, altimetry min, urbanization, surface, coast, family, foreigners, commuters, head, left, buildings19, buildings45, buildings61, buildings71, buildings81, buildings91, buildingspost91.

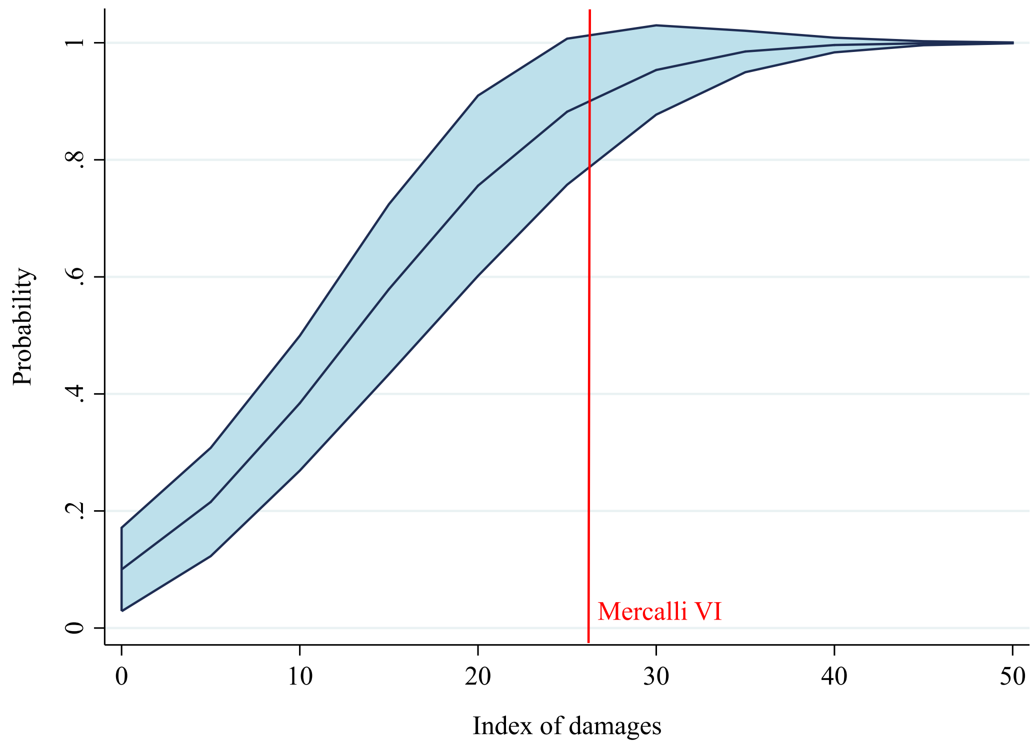
any of the coefficients in $\boldsymbol{\gamma}$ are significantly different from zero. As a proxy of political "alignment" of each municipality with the central government, we take the results of the previous regional election.[31] We estimate equation C.1 using two different approaches. In the first one, we rely on a classical probit analysis. In the second one, we run an instrumental variable probit regression instrumenting $Damages_i$ using the distance of each municipality from the epicenter (variable $Distance_i$) and its square in order to eliminate any possible endogeneity.

Our results are shown in table C.12. The first two columns show the results of the probit regressions. The mid two columns show the first stage of the instrumental variables probit regressions and the last two columns show the second stage of the instrumental variables regressions. In both, the first two columns and the last two columns the variable $Damages_i$ enters significantly at 1 percent level. At the same time, none of the other variables of interest (personal income, unemployment rate, and political alignment) enter significantly. Even more importantly, the coefficient of $Damages_i$ is virtually identical when instrumented with an exogenous instrument like the distance (which is instead highly correlated with the damages in the first stage) meaning that the damages themselves are exogenous (the Wald test reported at the bottom of the table confirms the exogeneity of damages). We take this result as an evidence that the Mercalli ranks reflect only the damages generated by the earthquake (additional evidence on the exogeneity of Mercalli ranks is provided by Porcelli and Trezzi [22]). Finally, because the coefficients in a probit model do not provide direct measure of partial effects, we estimate the marginal effect of the variable $Damages_i$ keeping all other

[31] We take the results of the previous regional election rather than the results of municipal elections because the huge heterogeneity of local political parties who run for mayoral elections do not allow us to identify the political orientation of the council. Instead, at regional elections voters choose among the very same parties as in the general elections.

variables at their mean levels. The marginal effect is reported in figure A.3. The index of damages alone is able to increase the probability of receiving reconstruction grants to 1 for values around 30 (percent). A red vertical line reports the average value of damages (26.3) at Mercalli VI which is associated with a marginal probability non statistically different from 1 indicating that the damages alone - and no other variables - can explain whether a municipality qualifies or not for reconstruction grants.

Figure A.3: Marginal probability - *Damages* variable.



Note: the Figure shows the marginal probability of receiving a reconstruction grant as a function of the reported damages. The marginal probability has been estimated running a Probit model in which the dependent variable is a dummy that takes the value of "1" if a municipality was ranked at Mercalli VI and zero otherwise. The Probit model was run on Mercalli V and Mercalli VI municipalities (including the Mercalli V-VI). The shaded area represents the confidence interval. The index of damages is defined from 0 to 100. The vertical red line indicates the average damages reported for Mercalli VI municipalities (26.3).

Table C.12: Probit results.

	Probit		IV - First stage		IV - Second stage	
Damages	**9.87*** **	**26.03*** **			**10.49*** **	**26.46*** **
	[1.71]	[8.04]			[1.57]	[7.59]
Income	**-0.00**	**0.00**	**0.00**	**-0.00**	**-0.00**	**0.00**
	[0.01]	[0.01]	[0.01]	[0.01]	[0.01]	[0.01]
Unemployment	**-0.06**	**-0.15**	**-0.00**	**-0.01***	**-0.05**	**-0.13**
	[0.05]	[0.11]	[0.01]	[0.00]	[0.04]	[0.11]
Alignment	**0.02**	**0.03**	**0.00**	**-0.00**	**0.01**	**0.02**
	[0.01]	[0.03]	[0.01]	[0.01]	[0.01]	[0.02]
Distance			**-0.60*** **	**-0.77*** **		
			[0.13]	[0.18]		
Distance^2			**0.01*** **	**0.01*** **		
			[0.00]	[0.00]		
Controls		YES		YES		YES
Observations	116	116	116	116	116	116
Wald test of exogeneity					3.67	0.82

Note: the above regressions refer to 2009 only. We include all municipalities around the Mercalli cutoff, that is in between Mercalli V and Mercalli VI. Including Mercalli V-VI produces virtually identical results. The null of the Wald test of exogeneity is "no endogeneity". We fail to reject the Wald test at 5 percent level. The dependent variable in the Probit regressions is a dummy that takes the value of 1 for the municipalities ranked at Mercalli VI and 0 for those below. The variable "Damages" refer to the index of damages in each municipality. "Unemployment" refers to the number of unemployed people as a share of labor force in each municipality. "Alignment" is a dummy that takes the value of 1 if a municipality is politically aligned with the central government (meaning that the major belongs to the same party of the governing coalition at the national level). The variable "Distance" refers to the distance of each municipality to the epicenter of the 2009 L'Aquila seismic event. "Distance^2" refers to the square of the variable "Distance". *** indicates significance at 1% level, ** at 5%, and * at 10%.

Appendix D. Description of variables in the dataset

Appendix D.1. Population controls (source: ISTAT if not otherwise indicated)

Population: total number of residents at December the 31^{th} of each year. **Migration:** total net migration effect (immigrants minus emigrants). **Balance:** natural balance (births minus deaths). **Population14:** share of population younger than 14 years old. **Population65:** share of population older than 65 years old. **Casualties:** number of victims generated by the earthquake in 2009. *Source: Ministry of Interior.*

Appendix D.2. Political controls (source: Ministry of Interior)

Alignment: number of votes in favor of the center-left coalition at the regional elections as a share of total votes.

Appendix D.3. Time invariant controls (source: ISTAT)

Unemployment: number of unemployed people as a share of working labor force. **Population band.** Number of residents (1 = small town, 8= large city). **Graduates:** number of graduates as a share of total residents. **Unliteracy:** rate of unliterary per thousand habitants. **Altimetry:** average altimetry expressed on a discrete scale from 1 (high) to 5 (low). **Altimetrymax:** maximum altimetry in meters. **Altimetry min:** minimum altimetry in meters. **Urbanization:** degree of urbanization, measured on a discrete scale from 1 (low) to 3 (high). **Surface:** geographical surface expressed in kilometers squared. **Coast:** dummy variable taking the value of 1 if the municipality is on the coast. **Family:** average number of people per family. **Foreigners:** number of non-italian residents as a share of total population. **Commuters:** number of working commuters as a share of total population. **Head:** dummy variable taking the value of 1 if the municipality is the political head of a province. **Buildings19:** share of buildings built before 1919. **Buildings45:** share of buildings built before 1945. **Buildings61:** share of buildings built before 1961. **Buildings71:** share of buildings built before 1971. **Buildings81:** share of buildings built before 1981. **Buildings91:** share of buildings built before 1991.

Appendix E. Municipalities around the Mercalli cutoff (ranks in brackets)

Prov. of Chieti: Chieti (V), Fara Filiorum Petri (V), Filetto (V), San Giovanni Teatino (V), Villa Santa Maria (V). **Prov. of L'Aquila:** Campo di Giove (V), Sulmona (V), Canistro (V), Cansano (V), Anversa degli Abruzzi (V), Prezza (V), Pacentro (V), Tagliacozzo (V), Magliano de' Marsi (V), Vittorito (V), Ortona dei Marsi (V), Scanno (V), Roccacasale (V), Rocca Pia (V), San Benedetto dei Marsi (V), Avezzano (V), Gioia dei Marsi (V), Lecce nei Marsi (V), Pettorano sul Gizio (V), Massa d'Albe (V), Opi (V), Introdacqua (V), Raiano (V), Pescina (V), Calascio (V), Collepietro (V-VI), Aielli (V-VI), Secinaro (V-VI), Molina Aterno (V-VI), Pratola Peligna (V-VI), Celano (V-VI), Scurcola Marsicana (V-VI), Cerchio (V-VI), San Benedetto in Perillis (V-VI), Corfinio (V-VI). **Prov. of L'Aquila:** Acciano (VI), Barete (VI), Barisciano (VI), Bugnara (VI), Cagnano Amiterno (VI), Campotosto (VI), Capestrano (VI), Capitignano (VI), Caporciano (VI), Castel del Monte (VI), Castelvecchio Calvisio (VI), Cocullo (VI), Collarmele (VI), Fagnano Alto (VI), Fontecchio (VI), Gagliano Aterno (VI), Montereale (VI), Navelli (VI), Ocre (VI), Ofena (VI), Ovindoli (VI), Pizzoli (VI), Rocca di Cambio (VI), Rocca di Mezzo (VI), San Pio delle Camere (VI), Scoppito (VI), Tornimparte (VI), Villa Santa Lucia degli Abruzzi (VI), Carapelle Calvisio (VI-VII), Castel di Ieri (VI-VII), Lucoli (VI-VII), Prata d'Ansidonia (VI-VII), San Demetrio ne' Vestini (VI-VII), Santo Stefano di Sessanio (VI-VII), Castelvecchio Subequo (VII), Goriano Sicoli (VII), Tione degli Abruzzi (VII), Fossa (VII-VIII), L'Aquila (VIII-IX), Poggio Picenze (VIII-IX), Sant'Eusanio Forconese (IX), Villa Sant'Angelo (IX). **Prov. of Pescara:** Bolognano (V), Catignano (V), Cepagatti (V), Civitaquana (V), Corvara (V), Farindola (V), Loreto Aprutino (V), Manoppello (V), Nocciano (V), Penne (V), Pescosansonesco (V), Rosciano (V), Scafa (V), Vicoli (V), Villa Celiera (V), Alanno (V-VI), Carpineto della Nora (V-VI), Castiglione a Casauria (V-VI), Pianella (V-VI), Pietranico (V-VI), Tocco da Casauria (V-VI). **Prov. of Pescara:** Brittoli (VI), Bussi sul Tirino (VI), Civitella Casanova (VI), Cugnoli (VI), Montebello di Bertona (VI), Popoli (VI), Torre de' Passeri (VI). **Prov. of Teramo:** Bisenti (V), Cellino Attanasio (V), Cortino (V), Crognaleto (V), Rocca Santa Maria (V), Teramo (V), Torricella Sicura (V), Valle Castellana (V), Basciano (V-VI), Castel Castagna (V-VI), Cermignano (V-VI), Isola del Gran Sasso d'Italia (V-VI). **Prov. of Teramo:** Arsita (VI), Castelli (VI), Colledara (VI), Fano Adriano (VI), Montorio al Vomano (VI), Penna Sant'Andrea (VI), Pietracamela (VI), Tossicia (VI).

Figure A.1: Map of Italian regions.

Figure A.2: Map of night lights density (average of 2007).