Shake me the money![☆]

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Abstract

During a natural disaster, the negative supply shock due to the destruction of productive capacity is counteracted by a positive demand shock due to public grants for assistance and reconstruction, positing an identification issue in empirical work. Focusing on the 2009 'Aquilano' earthquake in Italy as a case study, we take advantage of quantified measure of damages for 75,424 buildings to estimate the negative supply shock and of a law issued to allocate reconstruction grants, which resulted in a sharp, exogenous discontinuity in transfers and output behavior across neighboring municipalities to estimate the positive demand shock. Diff-in-diff analysis suggests that local output multipliers of reconstruction grants (net of marginal tax rebates) are below unity. Yet the size of the grants act as a public insurance scheme, preventing a fall in output.

Keywords: Natural disasters, Fiscal multipliers, Mercalli scale.

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1 Introduction

Concerns over containing or reducing the potential negative effects on economic activity generated by earthquakes have been an important driver of policy and academic debates in recent years. However, despite earthquakes create disarray in large sectors of the local economy, there is still little or no consensus on their impact on economic activity: previuos papers have reached opposing conclusions on how disasters affect local output and employment. Furthermore, because of the nature of such natural events (earthquakes are rare and counterfactuals are often absent) there remains uncertainty over the multiplicative effects on output of public grants for assistance and reconstruction. While recent work on local fiscal multipliers (reviewed below) suggests that the elasticity of output to public grants is positive and above unity, an open question is whether the effectiveness of public intervention applies also to situations of profound stress, such as those characterizing the aftermath of a natural disaster.

Focusing on the *'Aquilano'* earthquake that hit the Italian region of 'Abruzzo' in 2009, in this paper we estimate the output effect generated by the event, as a result of two combined shocks, the negative supply shock due to the quake, and the positive demand shock driven by reconstruction grants to the region. Our empirical strategy relies on the following two factors: (i) a quantified measure of damages reported by the 75,424 buildings classified after the quake, and (ii) the specific characteristics of the institutional arrangement of public grants providing insurance to the municipalities affected by the event. With regard to the first factor, in the aftermath of the earthquake specialists from the Civil Protection Department (CPD)[1] and the National Institute of Geophysics and Vulcanology ($INGV$) visited the epicentral area with the goal of surveying the affected buildings. Relying on the reported damages, we construct a synthetic index that captures the negative supply shock generated by the event at the micro-municipal level. With regard to the second factor, 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 ranking was based on the so-called Mercalli scale that classifies the destructive effects of an earthquake on twelve

[1] 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.

notches, ranging from 'instrumental' (I) to 'catastrophic' (XII).[2] 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 to marginal damages to civil structures) and resulted in a sharp discontinuity in grants across *ex ante* identical neighbor municipalities. The assigned grants were then used by the qualified municipalities for two purposes: to finance the increase of local spending directed towards reconstruction activities and to compensate for the loss in local tax revenues due to the tax base shock and the suspension of tax payments in the most affected regions.

Studying the 305 municipalities in the Abruzzo region over the period 2002 to 2011 (3,050 observations in total) we estimate three things. First, we estimate the output loss generated by the negative supply shock due to the destruction of physical capital relying on our index of damages. Second, we estimate the 'grants multiplier' - the elasticity of local output to exogenous reconstruction grants allocated from the central government to the qualified municipalities. Third, noticing that the discontinuity in local spending is identified at Mercalli VI as for grants while the discontinuity in local tax revenues is at Mercalli VII (due to an exogenous reduction in the local marginal tax rate which applied only to municipalities with severe damages), we estimate the 'local spending multiplier' net of marginal tax rebates around the Mercalli VI cutoff and the the 'local tax multiplier' net of variations of the tax base around the Mercalli VII cutoff.

In our econometric analysis we rely on two identification strategies based on a linear fixed-effects panel data model. In the first identification strategy in order to address the grants endogeneity issue we rely on a difference-in-differences approach regressing output over the index of damages and the interaction between a dummy which identifies the treatment and control groups (around the Mercalli VI cutoff) and the *per capita* grants. The second identification strategy addresses the possible endogeneity of damages using an instrumental variable approach. As a strictly exogenous instrument we employ the distance of each municipality from the epicenter which confirms the prior to be highly correlated with the recorded damages and fully satisfies the exclusion restriction criteria.

[2]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. See for C details.

In our findings, the direct effect of the earthquake on output is unambiguously negative. Our instrumental variables analysis shows that, on impact, the output loss from the quake averages 3.7 percentage points. Against the output effects of the negative supply shock, we document positive multiplicative effects of reconstruction grants. The estimated 'grants multiplier' is bounded between 0.14 and 0.36 according to the model. Multiplying these elasticities by the magnitude of the fiscal shock, our results suggest that public grants compensate the output fall (which is instead suffered by the control group) generated by the quake. Therefore, although grants multipliers remain well below unity in all models, our results suggest that following seismic events reconstruction grants provide public insurance. Output in uninsured regions contracts while it expands, although marginally, in qualified municipalities. Also, the 'local spending multiplier' net of marginal tax rebates is virtually identical to the 'grants multiplier' signaling, as expected, that most of the exogenous variations in grants financed reconstruction activities and translated into a sharp increase of local spending. On the other hand, the 'local tax multiplier' is well above unity with point estimate of 2.56 even if this last estimate should be interpreted with caution given the restricted number of observations in the corresponding treatment group (above Mercalli VII).

Our findings contribute to two strands of the literature, one assessing the macroeconomic implications of natural disasters, and the other one on local fiscal multipliers. Regarding the first one, some authors argue that earthquakes are setbacks for economic growth (Noy [2009]), while others, like Loayza et al. [2012] find that they might activate a creative destruction process even in the short-run.[3] Regarding the second one, 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. [2011]), census revisions (Serrato and Wingender [2011]), variations in *ARRA* stimulus outlays (Chodorow-Reich et al. [2012]), or military buildups across US states (Nakamura and Steinsson [2011]). Close in spirit to our paper is a recent contribution by Corbi et al. who rely on a discontinuity in federal transfers to municipal governments in Brazil to identify the causal effect of fiscal policy on economic growth. Our estimates are lower than those reported in the aforementioned contributions. While output elasticity to fiscal shocks is predicted to be higher in downturns (Woodford [2011]), the grants (and spending) multipliers contained in this paper remain well below unity in all models. Although the marginal utility of public spending in the aftermath of a seismic event is high

[3] For a review of this literature see Cavallo and Noy [2009].

because the level of spending is below optimality, we think that the main explanation of such low multipliers might be related to the inefficient use of public funds due to cases of corruption well documented by the dozens of public officials and business men arrested or persecuted following the reconstruction activities.[4] Furthermore, to our knowledge the estimate of the 'local tax multipliers' is the first one in the literature so far opening the ground for future research.

The rest of the paper is organized as follows. Section 2 describes the 2009 *'Aquilano'* earthquake, the natural event at the heart of this study. Section 3 explains and discusses the empirical models. Section 4 describes the main features of our dataset. Section 5 discusses our main results. Section 6 is devoted to the discussion of our set of robustness checks. Section 7 concludes. Additional tables, charts, and complementary results are reported in Appendix A to F.

2 The 2009 'Aquilano' 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.[5] Three hundred and nine people were killed and more than 1,500 were injured. The seismic event generated damages in 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 (April 6^{th}, 2009), a team of specialists from the Civil Protection Department (CPD) and the National Institute of Geophysics and Vulcanology ($INGV$) 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' (Baggio et al. [2007]). 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').[6] Table 1 shows the distribution of

[4] The exact number of people either arrested of formally persecuted is unknown at the moment because investigations are still underway.

[5] 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 11.

[6] The six categories are defined as follows: A: 'usable building'; B: 'usable building after short-term measures'; C: 'partially

Table 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, Ministry of Interior.

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.[7] 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').[8] The definitions of the Mercalli levels are reported in C, while figure 2 plots the map of the earthquake, highlighting each municipality according to the Mercalli rank.[9]

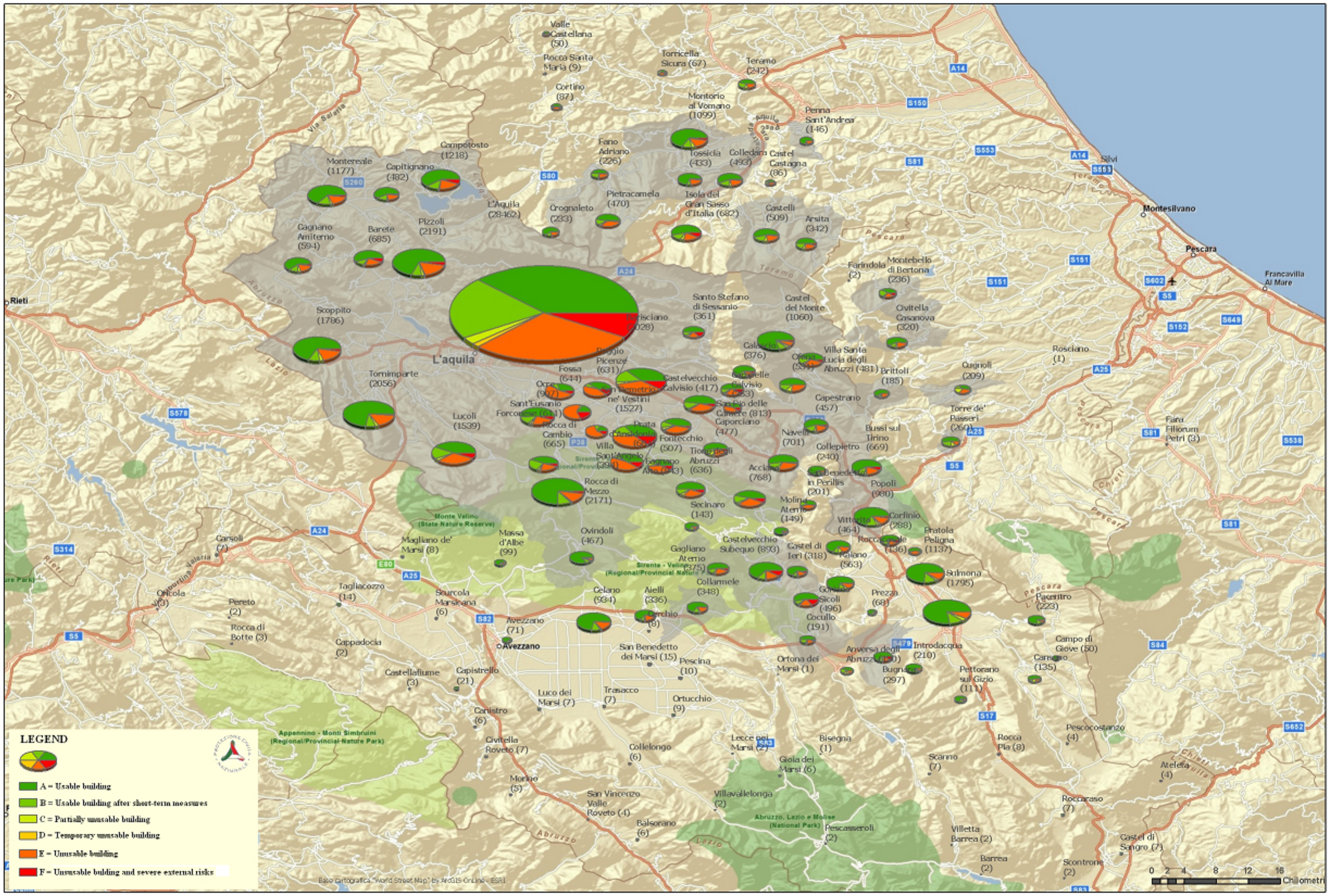
unusable building'; D: 'temporary unusable building'; E: 'unusable building'; F: 'unusable building and severe external risks'. For details see Baggio et al. [2007].

[7]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).

[8]As an example we report the definition of level 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.

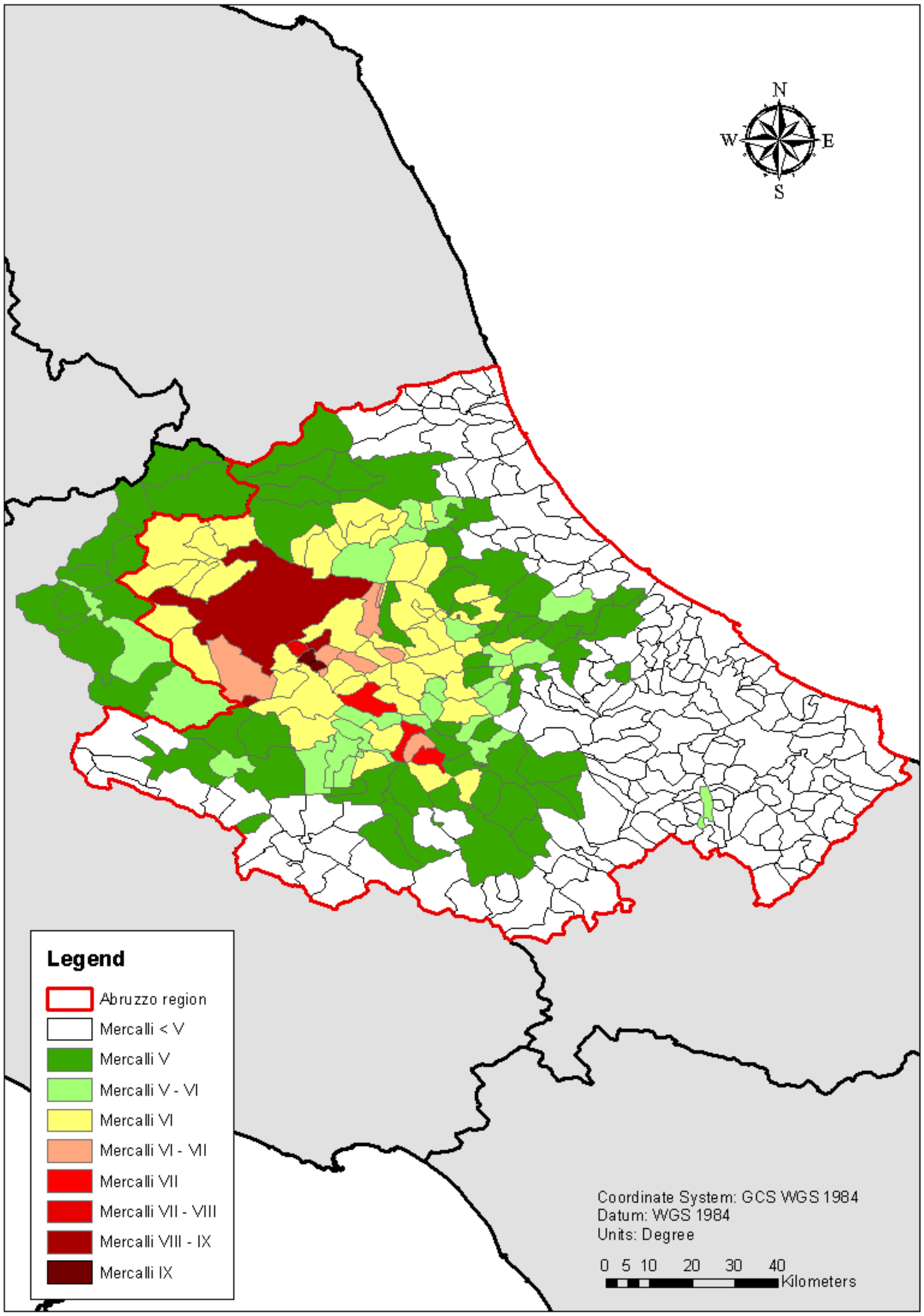
[9]Out of 305 municipalities in Abruzzo, 177 were ranked below V, 79 at level V (including V-VI), 41 at level VI (including VI-VII) and 8 at level VII or above. Table 12 shows the distribution across provinces.

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



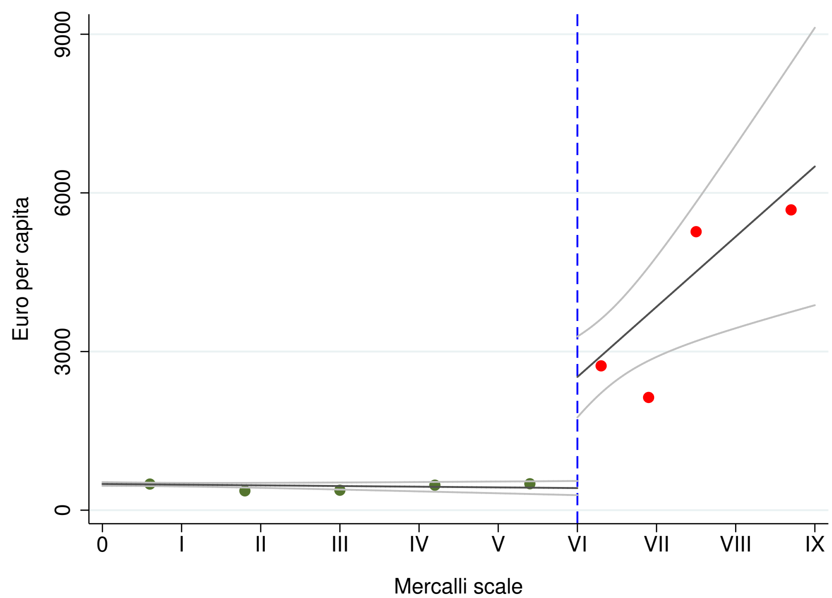
Note: The size of the pies reflects the absolute number of buildings (in brackets) classified in each municipality.

Figure 2: Map of *'L'Aquila'* earthquake.



On April 28th 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.[10] 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 C for details). The decision of the government - crucial for 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). Figure 3 shows the discontinuity by plotting total grants against the Mercalli scale. The average *per capita* grant to the left of the cut-off is 488.4 Euros

Figure 3: Discontinuity in grants.



Note: each dot is a bin (bandwidth of 0.2).
Number of bins determined using an F-test.
Grants are current plus capital from central governement.

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

[10]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".

identifies the *severity* of the damages).[11]

The exogenous reconstruction grants were used by the qualified municipalities for two different purposes. On the one hand they financed post-disaster activities directed towards the reconstruction of public and private buildings. On the other hand, they compensated municipal budges for losses in revenues due to the suspension of local taxes. Figures 9 and 10 show the discontinuity in total expenditure (current and capital) and total tax revenues across municipalities according to Mercalli ranks. There exhists a sharp discontinuity in local government expenditures at Mercalli VI which closely mimics the discontinuity in grants. However, the discontinuity in tax revenues is observed at Mercalli VII rather then VI with 49 municipalities on the immediate left of the cut-off (Mercalli VI and VI-VII) and 8 to the right (at or above Mercalli VII).[12] The fact that the discontinuities in grants, local spending and local tax revenues are identified at different Mercalli levels allows a neat identification of respectively the 'grants multiplier', the 'local spending multiplier' net of marginal tax rebates and the 'local tax multiplier' net of variations in the tax base.

3 The empirical model

In our study we aim to estimate the short-run multiplicative effects of reconstruction grants on local economic activity at the municipal level following the 2009 *'Aquilano'* 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 the real *per capita* value added 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,[13] 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 [2011] or Acconcia et al. [2011]) we estimate the grants multiplier relating the growth of *per capita* value added in municipality i ($Y_{i,t}$), to the correspondent change in *per capita* grants in the same municipality in the same year ($G_{i,t}$).

[11] See figure 7 for the correlation between Mercalli ranks and the index of damages.

[12] The discontinuity in tax revenues is generated by two shocks: a negative shock to the tax base (mainly buildings for the property tax) and a shock to the marginal tax rate due to the suspension of tax payments in 2009 for municipalities reporting severe damages.

[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.

Our empirical strategy is based on a linear fixed-effect panel data model with a difference-in-differences approach relying on the identical *ex-ante* behavior across control and treatment groups identified around the Mercalli VI cut-off. The empirical model is

$$Y_{i,t} \quad = \quad \alpha_i + \lambda_t + \beta Interaction_{i,t} + \gamma Damages_{i,t} + \delta_{\mathbf{1}} G_{i,t} + \delta_{\mathbf{2}} D_{i,t} + \boldsymbol{\theta}^{\prime} \mathbf{X}_{i,t} + \eta_{i,t} \tag{1}$$

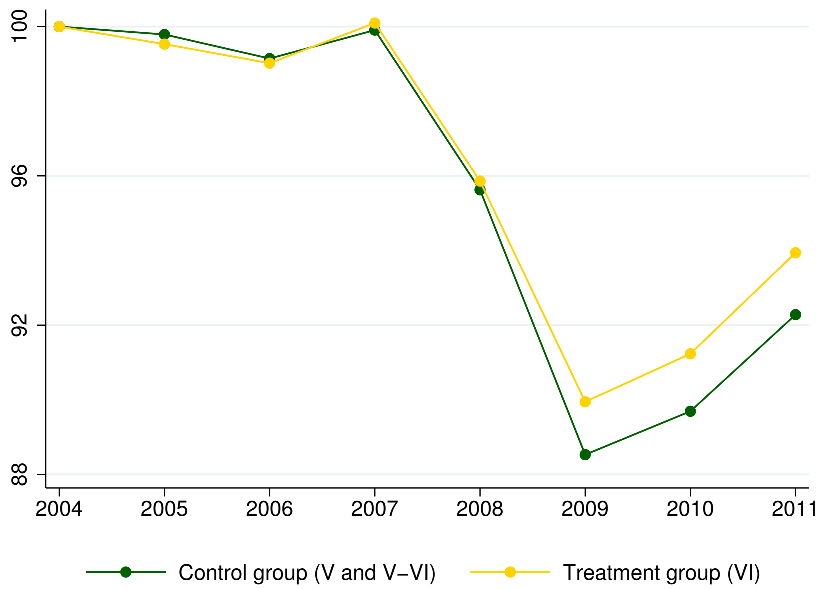
where α_i is a municipal fixed-effect, λ_t is a time trend, $D_{i,t}$ is a dummy variable that takes the value of 1 for the municipalities belonging to the treatment group and 0 for the municipalities in the control group, $\boldsymbol{\theta}^{\prime}$ is a vector of coefficients, $\mathbf{X}_{i,t}$ is a set of control variables, and $\eta_{i,t}$ is a disturbance term. As standard in the literature, the variable $Interaction_{i,t}$ interacts $G_{i,t}$ with $D_{i,t}$, and the coefficient β measures the contemporaneous one-year grants multiplier, meaning the elasticity of local output to exogenous shocks in grants. The selection criteria of the bandwidth around the discontinuity (figure 3) should satisfy the crucial assumption of *ex-ante* similarity between the control and the treatment group. Following Imbens and Kalyanaraman [2010] we estimate the optimal bandwith around the discontinuity in grants which suggests to compare Mercalli V and V-VI ranked municipalities (control group) to Mercalli VI (treatment group). Figure 4 plots the variable of interest (local output) across the two groups (in order to ensure consistency in our estimates we also check the similarity of other observable characteristics, see table 14 in Appendix D). Before the event there exhists a clear common trend but when the earthquake strikes output contracts less for treated municipalities than for the rest. Also, the *ex-ante* behavior of grants is tested to be identical across control and treatment group before the event.[14]

The variable $Damages_{i,t}$ captures the negative supply shock generated by the earthquake and the coefficient γ identifies the contemporaneous one-year output growth loss due to the destruction of physical capital. Our measure of capital stock loss is a weighted average of the number of buildings categorized in each AeDES level expressed as a share of the population. Formally

$$Damages_{i,t} = \frac{\sum_{k=A}^{F} \omega_k \cdot Buildings_{k,i,t}}{Population_{i,t}}, \tag{2}$$

[14] We tested the *ex-ante* similarity of each variable of interest by regressing the variable on a set of yearly dummies and the interaction between the year dummies and $D_{i,t}$. The F-statistics on the interactions never reject the null hypothesis of similar behavior across treatment and control groups. Specifically, the p-values of the F-test are the following: output (0.4941), grants (0.9083), and local spending (0.3431).

Figure 4: Per capita GDP (2004 = 100).



where $\omega_A = 0$, $\omega_B = 0$, $\omega_C = 0.5$, $\omega_D = 0.5$, $\omega_E = 1$, $\omega_F = 1$.[15] The variable $Damages_{i,t}$ captures both, the *severity* and the *extension* of the damages. A higher score in the index can be determined either by a higher number of buildings reporting damages or (conditional on a given number of buildings) by a higher number of buildings reporting severe damages (categorized on a higher AeDES level).

Through the inclusion of fixed effects we capture unobserved time invariant municipal characteristics. In order to avoid collinearity issues between the variable $Damages_{i,t}$ and yearly dummies we include a time trend[16] (λ_t) that controls for aggregate monetary and fiscal policies affecting growth across all municipalities. Our choice to include a common time trend across municipalities is consistent with the evidence presented in figure 4.[17] Furthermore, our difference in differences approach addresses potential endogeneity problems raised by the possibility that municipal-specific characteristics may be correlated with grants allocation criteria. For instance, it may be possible that the central government systematically allocates more resources

[15]Robustness checks (not reported in this version of the paper but available on request) show that our results are insensitive to this choice.

[16]We specify a quadratic trend. This choice - instead of a linear trend - is driven by the observed U-shaped growth path during the considered period. Specifying a linear trend instead of quadratic makes little (or no difference) on the estimated parameters.

[17]The inclusion of individual-specific time trends makes no difference on the estimates. For this reason we prefer a more conservative model with a common trend across municipalities.

in municipalities with output growth below the median in an attempt to boost it. Under this allocation rule the coefficient δ_1 would be downwardly biased while β would correctly capture the exogenous component of grants.

Another possible source of endogeneity is represented by the variable $Damages_{i,t}$. The negative supply shock captured with our index of damages might be either downwardly biased if municipalities with higher per capita income report less damages because of an *ex-ante* lower vulnerability of the buildings, or upwardly biased if municipalities with *ex-ante* higher output growth reported a higher *ex-post* index of damages due to the higher *per capita* capital stock. We address this potential issue in two ways. First, we consider the rate of growth of output as dependent variable instead of its level. Second, we instrument the variable $Damages_{i,t}$ relying on the strict exogeneity and randomness[18] of the earthquake. As an instrument we use the inverse of the distance of each municipality from the epicenter (variable $Distance_{i,t}$).[19] Given this instrument, our estimates are unbiased under three conditions. First, the distance should be a good predictor of the damages. Figure 8 provides robust evidence in support of this hypothesis. Second, the distance and the stochastic component of output growth should be uncorrelated, formally $E(\varepsilon_{i.t}|Distance_{i,t}) = 0$. Finally, the distance should be uncorrelated with output growth ($Y_{i,t}$) in order to satisfy the necessary exclusion restrictions criteria, formally $E(Y_{i.t}|Distance_{i,t}) = 0$. Preliminary regressions show that the distance is indeed highly correlated with the damages while it is not with output growth.

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 31th of each year, (ii) share of population younger than 14 years old, and (iii) share of population older than 65 years old (see Appendix D for details).

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 (see map in figure 11). Our choice

[18]Abruzzo is the second most seismic region in Italy after Calabria. Virtually the entire territory is classified as 'highly seismic' by the INGV. Therefore, the *ex-ante* probability of an earthquake (meaning the *ex-ante* probability of a municipality to be relatively close to the epicenter) is uniformly distributed across points in the region.

[19]The coordinates of the epicenter were determined by the *INGV* and they are as follows: latitude 42.295, longitude 13.628. The distance is calculated using the municipal coordinates released by the national institute of statistics (typically the chosen point is the center of the inhabited part of the municipal surface).

eliminates 14 municipalities ranked at Mercalli V or V-VI in the neighborhood region of Lazio.[20] However, the earthquake did not generate Mercalli ranks higher than V-VI outside Abruzzo and no municipalities qualified for reconstruction grants in Lazio. Also, our main dependent variable (GDP) is not available for municipalities in Lazio because it is estimated only for southern regions. For this reason, we prefer to restrict the attention to Abruzzo only and maximize the *ex-ante* similarity between control and treatment group.

As a measure of municipal economic activity we rely on four different variables. Our main dependent variable is the municipal value added (GDP) estimated by the European Union Commission to monitor the development of the so-called European 'zones 3'. These estimates are based on the official figures of provincial[21] value added released by the Italian National Institute of Statistics ($ISTAT$) decomposed according to the sectoral composition of output at the municipal level. Given the possibility of measurement errors in the dependent variable we consider three alternatives. As a first alternative we employ high-resolution data on night lights density measured by satellites at night. These data come from the National Geophysical Data Center ($NGDC$) of the National Oceanic and Atmospheric Administration (U.S. Department of Commerce)[22] and it has been shown (Henderson et al. [2012]) to proxy well for local economic activity. 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. The luminosity of each municipality is calculated by taking the average luminosity of all pixels corresponding to the surface of the municipality. Figure 12 shows the average luminosity over night in 2007 for the municipalities in our sample while figure 6 plots the remarkably high correlation between the GDP growth rates and night luminosity growth rates across all municipalities in the sample. As a final check, we collected data on other two alternative dependent variables: total declared personal income (tax base of national personal income tax) and business income provided by the Italian Ministry of Economics and Finance. The first one 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. The second one refers to the sum of all incomes generated by small and medium firms and self-employed workers, therefore offering an excellent proxy of economic activity.

[20]The municipalities are: 'Accumoli', 'Amatrice', 'Antrodoco', 'Borbona', 'Borgo Velino', 'Borgorose', 'Castel Sant'Angelo', 'Cittaducale', 'Cittareale', 'Fiamignano', 'Micigliano', 'Pescoracchiano', 'Petrella Salto' and 'Posta', all located in the province of Rieti.

[21]The Italian provinces are well defined political and geographical entities similar to the US counties. In Abruzzo there are four provinces ('Chieti', 'L'Aquila', 'Pescara', and 'Teramo') composed by an average of 76 municipalities each.

[22]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. 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 the Italian National Institute of Statistics ($ISTAT$). 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 turnover and voting patterns at regional elections, and political alignment of the local government with the central government.[23] 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 Vulcanology ('2011 Italian Macroseismic Database ($DBMI$11))'; table 13 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 Civil Protection Department.

[23]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 which 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.

5 Results

In this section, we discuss the results from our regression model. Table 2 reports the baseline results using value added as dependent variable. There are 73 municipalities in the control group (52 with Mercalli rank V and 21 with V-VI) and 43 in the treatment group (Mercalli VI). We run our baseline considering the period 2008-2011 for a total of 464 observations (116 municipalities, 4 years). The choice of the time span for the baseline is determined by the necessity of maximing the similarity of the institutional framework given the 2008 reform of grants allocation which followed the reform in the municipal property tax. In robustness checks we extend both, the regession sample and the time dimension and show that our results are fully robust to the sample structure. The first two columns of table 2 refer to the difference in differences model ('Model 1') while the remaining four columns ('Model 2') show the results instrumenting the $Damages_{i,t}$ with the $Distance_{i,t}$ (the last two columns of table 2 shows the first stage of the 2SLS estimation). Each model contains two separate columns which differ for the inclusions of demographic controls.

As reported in table 2, the one-year multiplier is statistically different from zero at 1 percent level in both models with point estimates respectively of 0.15 and 0.36. Considering model 2 as a reference, this result suggests that an exogenous increase in reconstruction grants by 1 percent of local value added determines a contemporaneous increase in local output of 0.36 percent. The variable $Damages_{i,t}$ enters in model 1 with the expected negative coefficient. Once the damages are instrumented (model 2), the coefficient is significant at 1 percent level and the magnitude is higher than model 1 signaling endogeneity (the point estimates of $\hat{\gamma}$ average around -0.32). The upward bias in model 1 is determined by the fact that the municipalities with *ex-ante* higher output growth reported a higher *ex-post* index of damages due to the higher capital stock. Given that the mean of the index of damages is 0.11 in the regression sample, the result from model 2 implies a negative impact of the quake of around 3.5 percentage points[24] on output growth. Overall, given an average grants shock of 7.0 percent of local output in the regression sample, the negative supply shock generated by the quake is entirely compensated by the countercyclical reconstruction policies.

[24] The figure is calculated by multiplying 0.11 times 0.32.

Table 2: Baseline results.

	Model 1 (DiD)		Model 2 (DiD + IV)		Model 2 (first stage)	
Interaction	**0.145****	**0.146****	**0.367*****	**0.363*****	**0.500*****	**0.494*****
	[0.061]	[0.061]	[0.096]	[0.094]	[0.178]	[0.178]
Damages	**-0.017**	**-0.023**	**-0.314*****	**-0.315*****	-	-
	[0.046]	[0.046]	[0.086]	[0.084]		
Distance	-	-	-	-	**1.544*****	**1.547*****
					[0.429]	[0.431]
Controls		YES		YES		YES
Constant	YES	YES	YES	YES	YES	YES
Fixed effects	YES	YES	YES	YES	YES	YES
$G_{i,t}$ and $D_{i,t}$	YES	YES	YES	YES	YES	YES
Observations	464	464	464	464	464	464
R^2	0.35	0.37	-	-	0.66	0.66
Underidentification test (Kleibergen-Paap)			-	-	14.7	15.1
Weak identification test (Cragg-Donald)			-	-	71.9	72.3

Note: robust standard errors in brackets.
*** indicates significance at 1% level, ** at 5% * at 10%.

This result is in line with the official GDP estimates released by the Italian national institute of statistics ($ISTAT$) at the provincial level according to which output growth in 2009 in the province of L'Aquila[25] was

[25] According to $ISTAT$ output 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 by 5.2 percent in the province of L'Aquila despite the seismic event.

slightly higher than the national one despite the seismic event.

Table 3: Spending multiplier results.

	Model 1 (DiD)		Model 2 (DiD + IV)		Model 2 (first stage)	
Interaction	**0.108***	**0.113***	**0.332*****	**0.331*****	**0.511*****	**0.509*****
	[0.063]	[0.064]	[0.098]	[0.096]	[0.179]	[0.178]
Damages	**-0.013**	**-0.019**	**-0.307*****	**-0.308*****	-	-
	[0.049]	[0.050]	[0.085]	[0.082]		
Distance	-	-	-	-	**1.559*****	**1.555*****
					[0.470]	[0.461]
Controls		YES		YES		YES
Constant	YES	YES	YES	YES	YES	YES
Fixed effects	YES	YES	YES	YES	YES	YES
$G_{i,t}$ and $D_{i,t}$	YES	YES	YES	YES	YES	YES
Observations	464	464	464	464	464	464
R^2	0.35	0.37	-	-	0.65	0.65
Underidentification test (Kleibergen-Paap)			-	-	15.3	15.9
Weak identification test (Cragg-Donald)			-	-	71.4	71.3

Note: robust standard errors in brackets.
*** indicates significance at 1% level, ** at 5% * at 10%.

The first stage reported in the last two columns of table 2 confirms two important priors. First, there exhists a very high correlation between $Distance_{i,t}$ and $Damages_{i,t}$ (see figure 8 for a graphical evidence).

The coefficient of $Distance_{i,t}$ is significant at 1 percent level with point estimates around 1.55. Second, there exhists a very high correlation between reconstruction grants and the index of damages. The coefficient of $Interaction_{i,t}$ is significant at 1 percent level with point estimates at 0.50. The goodness of fit is satisfactory in both models: the R^2 is as high as 0.37 for model 2 while it increases to 0.66 in the first stage. Also, the underidentification test (Kleibergen-Paap LM statistic) and the weak identification test (Cragg-Donald Wald F statistic) confirm that our instrument is indeed a valid one. Finally, we provide evidence that the 'grants multiplier' can be interpreted as a 'local spending multiplier' around the Mercalli VI cutoff. In table 3 we report the output elasticity estimated following the baseline and substituting the grants with local spending (current plus capital municipal expenditure). Because around the cutoff there is no discontinuity in local tax revenues as shown in figure 10, the coefficient of the variable $Interaction_{i,t}$ in table 3 is virtually identical to the baseline (0.33 versus 0.36) and therefore it can be interpreted as a 'local spending multiplier' net of marginal tax rebates.

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. For brevity, we present the checks only of the baseline while the tables showing the corresponding checks for spending are virtually identical and available upon request.

Different bandwidth. As a first additional result we allow for a different bandwidth with respect to the baseline. The results of this check are shown in table 5.[26] We consider three alternative bandwidths. In the first one (first two columns of the table) we consider a more restrictive bandwidth with respect to the baseline and include only Mercalli V-VI and Mercalli VI for a total of 64 municipalities (21 in the control group and 43 in the treatment group). The multiplicative effects of exogenous grants is significative at 1 percent level with point estimates as high as 0.27 in the difference in differences model *cum* instrumental variables. Also the variable $Damages_{i,t}$ enters significantly at 1 percent level with the expected sign and a magnitude similar to the one in the baseline. Similar results, presented in the two central columns of table 5, emerge when

[26] In the last two models the number of observations is 486 rather 488 and 1212 rather then 1220 because 4 municipalities are missing the 2010 and 2011 fiscal entries. The municipalities (all located in the province of L'Aquila) are: 'Capistrello', 'Carapelle Calvision', 'Civitella Alfedena', and 'Scontrone'.

considering as a bandwidth all municipalities ranked between Mercalli V and Mercalli VI-VII (this choice enlarges the number of municipalities used in the regressions to 122 for a total of 486 observations). The only significant difference compared to the baseline emerges in the last three columns of table 5 where we allow in the regressions for all municipalities equal or above Mercalli V for a total of 130 municipalities.[27] Given the observed discontinuity in local taxes (figure 10), in this case we introduce three extra variables in the model: an additional treatment dummy that takes the value of 1 for municipalities ranked at or above Mercalli VII, the *per capita* total tax revenues in each municipality and the interaction between the two. The coefficient of the interaction variable captures the output elasticity to an exogenous variation in the marginal tax rate (driven by the property tax rate) net of variations of the tax base (captured by the variable $Damages_{i,t}$). Therefore, the coefficient of the new interaction variable can be interpreted as a ' local tax multiplier'. The estimates reported in table 5 remain in line with the baseline for the 'grants multiplier' and for the index of damages. On the other hand, the estimated 'tax multiplier' is well above unity with point estimate at 2.5. Although we rely on a robust identification strategy, this last result should be interpreted with caution given that only eight municipalities are included in the additional treatment group (above Mercalli VII). However, this estimate of the 'local tax multiplier' is virtually the only empirical estimate at the local level in Italy.

Extending the time period. As a second exercise we check whether the time choice made in our baseline is the driver of our results. In this check we progressively extend the time dimension of our panel in order to maximize the number of observations included in the regressions. The results of this check are reported in table 6.[28] The first three columns consider the period from 2006 to 2011 and we report the results of model 1 (first column), model 2 (second column), and the first stage of model 2 (third column). The same logic is applied to the remaining columns of the table that show the results when considering all years included in our dataset (from 2002 to 2011). This last regression runs over 1,160 observations (116 municipalities over 10 years). Overall, the evidence emerging from table 6 largely confirms our baseline. All coefficients in model 2 (including the first stage) remain significant at 1 percent level, the magnitude of the estimates is in line with the baseline as well as the goodness of fit the models and the instrumental variables tests.

[27]The total number of observations in these regressions is 518 rather then 520 because the municipality of 'Carapelle Calvisio' did not report the budget data for 2010 and 2011.

[28]In the last three columns the number of observations is 1,158 rather than 1,160 because the 2003 and 2004 fiscal data for municipality of 'Secinaro' are missing.

Alternative dependent variable. As a final check we employ a set of different dependent variables as a measure of economic activity. The first alternative dependent variable that we consider is the average night lights intensity over the year as recorded by satellite images. Because this variable is an indirect measure of economic activity, 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 7. The variables of interest enter with the expected sign and they are significant at 1 percent level in model 2. 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 estimating the average fiscal shock $\bar{G}_t$ (0.47), the average change in night light intensity $\bar{Y}_t$ (0.05), and the elasticity between night lights change and output change (0.03). In our sample such multiplier is estimated at 0.35, remarkably close to the baseline result. Furthermore, the goodness of fit of the models is significantly high as well as the instrumental variables tests are all well above the critical values. The other two alternative dependent variables that we employ are total income and business income. We report the results of these regressions respectively in table 8 and 9. Despite the fact that the source of these data is not the same as for the previous regressions, we obtain very similar results compared to the baseline. The multiplier estimated using total income is 0.21 and the variable damages is significant at 1 percent level. On the other hand, employing business income as dependent variable confirms the baseline in two dimensions (despite the lower number of observations):[29] the level of significance of grants and the sign of the damages, although the magnitude of the latter is higher than in the baseline.

Placebo. As third check we run a placebo experiment. Because Mercalli ranks between I and V were not assigned, we compare Mercalli 0 ranked municipalities with Mercalli V assuming the former as control group and the latter as treatment group. In this case the regression sample is composed by 227 municipalities out of which 175 in the control group and 52 in the treatment and the variable $D_{i,t}$ is a dummy that takes the value of 1 for Mercalli V and 0 for Mercalli 0. We report the results of these regressions in table 10.[30] The evidence confirms our baseline since none of the coefficient of interests ($\hat{\beta}$ and $\hat{\gamma}$) are significant. Also, in model 1 the variable $Damages_{i,t}$ enters with the wrong coefficient as well as the distance in the first stage of

[29] The lower number of observations is due to missing values in the data from the Ministry of Interior due to 'privacy issues'.

[30] The total number of observations in table 10 is 902 rather than 908 (= 227 times 4) since three municipalities have not reported the budgets for 2010 and 2011. The three municipalities (all located in the province of L'Aquila and all reporting a Mercalli 0 in 2009) are: 'Capistrello', 'Civitella Alfedena', and 'Scontrone'.

model 2.

Errors robust to clusters. As a fourth check we allow for errors robust to geographical clusters. As is well known, inference in panel estimation can be highly misleading if there is spatial correlation within groups of observations (Bertrand et al. [2004]). Following a common approach in the literature, in this check our inference is based on standard errors robust to clusters, allowing for individual clusters (therefore maximizing the possible number of clusters). Our results are reported in table 11 and they confirm the baseline since all coefficients remain significant at 1 percent level.

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 quake, and the positive demand shock driven by reconstruction grants. Using a difference-in-differences *cum* instrumental variables analysis we have shown non negligible output effects of negative supply shocks. In our estimates, the output loss from the quake averages 3.7 percentage points. Also, we estimated the 'grants multipliers' as high as 0.36. Spending multipliers net of marginal tax rebates are estimated virtually identical to grants multipliers while tax multipliers net of variations in the tax base are estimated well above unity.

The policy relevance of quantifying local fiscal multipliers is apparent. On one hand, we shed light to the extent to which fiscal tools can alleviate the output loss generated by large idyosinchratic shocks like earthquakes. 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 event preventing output from falling below trend. However, the marginal cost of this insurance scheme is estimated to be particularly high (also stressed by the stark evidence on small 'local spending multiplier' and high 'local tax multiplier') raising the need of future research on the efficiency of public funds management. Regarding the second factor, our study pointed out that the grants allocation rule used after the 2009 *'Aquilano'* quake 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 based on a combination between a discontinuous variables such as the Mercalli scale and a continuos variable such as the distance from the epicenter could provide a more equitable and efficient distribution of grants.

References

Antonio Acconcia, Giancarlo Corsetti, and Saverio Simonelli. Mafia and public spending: Evidence on the fiscal multiplier from a quasi-experiment. CEPR Discussion Papers 8305, C.E.P.R. Discussion Papers, April 2011. URL http://ideas.repec.org/p/cpr/ceprdp/8305.html.

Carlo Baggio, Alberto Bernardini, Riccardo Colozza, Livio Corazza, Mariana Della Bella, Giacomo Di Pasquale, Mauro Dolce, Agostino Goretti, Antonio Martinelli, Giampiero Orsini, Filomena Papa, and Giulio Zuccaro. Field manual for post-earthquake damage and safety assessment and short term countermeasures (aedes). Technical report, European Commission Joint Research Centre Institute for the Protection and Security of the Citizen, 2007.

Robert J. Barro and Charles J. Redlick. Macroeconomic effects from government purchases and taxes. *The Quarterly Journal of Economics*, 126(1):51–102, 2011. URL http://ideas.repec.org/a/oup/qjecon/v126y2011i1p51-102.html.

Marianne Bertrand, Esther Duflo, and Sendhil Mullainathan. How Much Should We Trust Differences-in-Differences Estimates? *The Quarterly Journal of Economics*, 119(1):249–275, February 2004. URL http://ideas.repec.org/a/tpr/qjecon/v119y2004i1p249-275.html.

Eduardo Cavallo and Ilan Noy. The economics of natural disasters: A survey. Research Department Publications 4649, Inter-American Development Bank, Research Department, December 2009. URL http://ideas.repec.org/p/idb/wpaper/4649.html.

Gabriel Chodorow-Reich, Laura Feiveson, Zachary Liscow, and William Gui Woolston. Does state fiscal relief during recessions increase employment? evidence from the american recovery and reinvestment act. *American Economic Journal: Economic Policy*, 4(3):118–45, September 2012. doi: 10.1257/pol.4.3.118. URL http://www.aeaweb.org/articles.php?doi=10.1257/pol.4.3.118.

Raphael Corbi, Elias Papaioannou, and Paolo Surico. The effects of government spending. London Business School.

J. Vernon Henderson, Adam Storeygard, and David N. Weil. Measuring economic growth from outer space. *American Economic Review*, 102(2):994–1028, April 2012. URL http://ideas.repec.org/a/aea/aecrev/v102y2012i2p994-1028.html.

Guido Imbens and Karthik Kalyanaraman. Optimal bandwidth choice for the regression discontinuity estimator. CeMMAP working papers CWP05/10, Centre for Microdata Methods and Practice, Institute for Fiscal Studies, March 2010. URL http://ideas.repec.org/p/ifs/cemmap/05-10.html.

Norman V. Loayza, Eduardo Olaberria, Jamele Rigolini, and Luc Christiaensen. Natural disasters and growth: Going beyond the averages. *World Development*, 40(7):1317–1336, 2012. URL http://ideas.repec.org/a/eee/wdevel/v40y2012i7p1317-1336.html.

Emi Nakamura and Jon Steinsson. Fiscal stimulus in a monetary union: Evidence from u.s. regions. NBER Working Papers 17391, National Bureau of Economic Research, Inc, September 2011. URL http://ideas.repec.org/p/nbr/nberwo/17391.html.

Ilan Noy. The macroeconomic consequences of disasters. *Journal of Development Economics*, 88(2):221–231, March 2009. URL http://ideas.repec.org/a/eee/deveco/v88y2009i2p221-231.html.

Francesco Porcelli and Riccardo Trezzi. The impact of earthquakes on economic activity: Evidence from italy. University of Exeter and University of Cambridge.

Juan Carlos Suarez Serrato and Philippe Wingender. Estimating the incidence of government spending. *Mimeo*, 2011.

Michael Woodford. Simple analytics of the government expenditure multiplier. *American Economic Journal: Macroeconomics*, 3(1):1–35, January 2011. URL http://ideas.repec.org/a/aea/aejmac/v3y2011i1p1-35.html.

Appendix

A Are the Mercalli ranks artificially manipulated?

Given our identification strategy, a natural concern about the Mercalli ranks is whether they effectively reflect the damaged suffered by each municipality or whether they are 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 area of the central government. In this way reconstruction grants would be endogenous to political or economic cycles.

We test this hypothesis using a probit model estimated by 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[31] or was influenced by other factors (although the qualifying threshold was *ex ante* unknown to the delegates). The empirical model is

$$DM_i = \alpha + \phi Damages_i + \boldsymbol{\gamma}^{'}\mathbf{Z}_i + \boldsymbol{\delta}^{'}\mathbf{X}_i + \eta_i. \tag{3}$$

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 output, municipal unemployment rate, and political alignment with the central government since reconstruction grants come almost exclusively from the central government), $\mathbf{X}_i$ is a matrix that contains all other controls,[32] $\boldsymbol{\gamma}$ and $\boldsymbol{\delta}$ are vectors of coefficients, and η_i is a disturbance term. We are interested in testing whether ϕ or any of the coefficients in $\boldsymbol{\gamma}$ are significantly different from zero. As a proxy of political 'allignment' of each municipality with the central government, we take the results of the previous regional election.[33]

Our results are shown in table 4. We consider four models with an increasing number of regressors and controls.

[31] 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.

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

[33] 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.

Table 4: Probit analysis results.

	Model A	Model B	Model C	Model D
Damages	**5.327*** **	**24.350*** **	**5.263*** **	**23.770** **
	[0.000]	[0.000]	[0.000]	[0.000]
GDP			0.000	0.000
			[0.944]	[0.549]
Unemployment			-0.028	-0.054
			[0.492]	[0.546]
Alignment			0.016	0.011
			[0.161]	[0.603]
Controls		YES		YES
Constant	YES	YES	YES	YES
Number of observations	116	116	116	116
Log likelihood	-55.39	-25.94	-54.07	-25.33

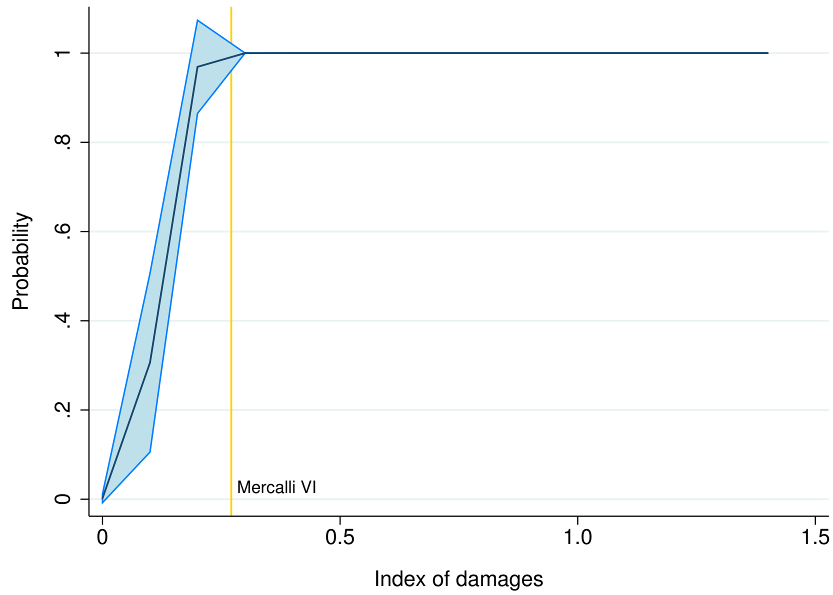
P-values in brackets. *** significant at 1%, ** at 5% and * at 10%.

The only variable with some explanatory power is the index of damages.[34] All other regressors, including municipal output, municipal unemployment rate and political alignment are not statistically different from zero. 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). Finally, because the coefficients in a probit model do not provide direct measure of the partial effect, we estimate the marginal effect of the variable $Damages_i$ keeping all other variables at their mean levels. The marginal effect is reported in figure 5. Visibly, the index of damages alone is able to increase the probability of receiving reconstruction grants to 1 for values slightly below 0.3. A yellow vertical line reports the average value of damages (0.25) 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

[34]Very similar results are obtained when allowing for the distance as a regressor instead of the damages.

a municipality qualifies or not for reconstruction grants.

Figure 5: Marginal probability - *Damages* variable.



B Results and robustness checks

Table 5: Different bandwidth results.

	V-VI to VI			V to VI-VII			Equal or higher than V		
	DiD	DiD + IV	First stage	DiD	DiD + IV	First stage	DiD	DiD + IV	First stage
Interaction grants	**0.139****	**0.268*****	**0.484*****	**0.156****	**0.441*****	**0.695*****	**0.108****	**0.325*****	**0.721*****
	[0.066]	[0.076]	[0.190]	[0.062]	[0.116]	[0.179]	[0.045]	[0.084]	[0.127]
Interaction taxes	-	-	-	-	-	-	**-0.673**	**-2.559****	**0.061**
							[0.738]	[1.006]	[0.042]
Damages	**-0.018**	**-0.192*****	-	**-0.010**	**-0.315*****	-	**-0.004**	**-0.246*****	-
	[0.051]	[0.065]		[0.030]	[0.086]		[0.030]	[0.077]	
Distance	-	-	**1.577*****	-	-	**1.175*****	-	-	**1.125*****
			[0.548]			[0.362]			[0.346]
Controls	YES	YES	YES	YES	YES	YES	YES	YES	YES
Constant	YES	YES	YES	YES	YES	YES	YES	YES	YES
Fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES
$G_{i,t}$ and $D_{i,t}$	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	256	256	256	486	486	486	518	518	518
R^2	0.42	-	0.67	0.38	-	0.71	0.40	-	0.77
Underidentification test		-	15.4		-	17.5		-	20.0
Weak identification test		-	33.3		-	49.5		-	49.1

Note: robust standard errors in brackets.
*** indicates significance at 1% level, ** at 5% * at 10%.

Table 6: Different time selection results.

	2006 to 2011			2002 to 2011		
	DiD	DiD + IV	First stage	DiD	DiD + IV	First stage
Interaction	**0.101***	**0.330*****	**0.504*****	**0.097***	**0.432*****	**0.538*****
	[0.055]	[0.096]	[0.187]	[0.053]	[0.131]	[0.187]
Damages	**-0.038**	**-0.337*****	-	**-0.046**	**-0.466*****	-
	[0.049]	[0.086]		[0.051]	[0.118]	
Distance	-	-	**1.523*****	-	-	**1.492*****
			[0.419]			[0.415]
Controls	YES	YES	YES	YES	YES	YES
Constant	YES	YES	YES	YES	YES	YES
Fixed effects	YES	YES	YES	YES	YES	YES
$G_{i,t}$ and $D_{i,t}$	YES	YES	YES	YES	YES	YES
Observations	696	696	696	1158	1158	1158
R^2	0.25	-	0.66	0.19	-	0.66
Underidentification test		-	14.7	-	-	13.9
Weak identification test		-	124.7	-	-	223.7

Note: robust standard errors in brackets.
*** indicates significance at 1% level, ** at 5% * at 10%.

Table 7: Night lights intensity as dependent variable.

	Model 1 (DiD)		Model 2 (DiD + IV)		Model 2 (first stage)	
Interaction	**0.073***** [0.016]	**0.069***** [0.016]	**0.074***** [0.028]	**0.072**** [0.029]	**-0.003** [0.011]	**-0.003** [0.011]
Damages	**-0.045** [0.071]	**-0.060** [0.072]	**-1.850***** [0.489]	**-1.886***** [0.486]	-	-
Distance	-	-	-	-	**2.024***** [0.501]	**2.021***** [0.495]
Controls		YES		YES		YES
Constant	YES	YES	YES	YES	YES	YES
Fixed effects	YES	YES	YES	YES	YES	YES
$G_{i,t}$ and $D_{i,t}$	YES	YES	YES	YES	YES	YES
Observations	464	464	464	464	464	464
R^2	0.53	0.54	-	-	0.60	0.61
Underidentification test (Kleibergen-Paap)			-	-	16.2	16.7
Weak identification test (Cragg-Donald)			-	-	115.7	115.4

Note: robust standard errors in brackets.
*** indicates significance at 1% level, ** at 5% * at 10%.

Table 8: Income as dependent variable results.

	Model 1 (DiD)		Model 2 (DiD + IV)		Model 2 (first stage)	
Interaction	**0.130**	**0.129**	**0.225***	**0.215**	**0.757*****	**0.749*****
	[0.099]	[0.098]	[0.134]	[0.133]	[0.198]	[0.200]
Damages	**-0.117*****	**-0.117*****	**-0.208*****	**-0.199*****	-	-
	[0.039]	[0.040]	[0.077]	[0.077]		
Distance	-	-	-	-	**1.503*****	**1.508*****
					[0.412]	[0.422]
Controls		YES		YES		YES
Constant	YES	YES	YES	YES	YES	YES
Fixed effects	YES	YES	YES	YES	YES	YES
$G_{i,t}$ and $D_{i,t}$	YES	YES	YES	YES	YES	YES
Observations	464	464	464	464	464	464
R^2	0.31	0.32	-	-	0.67	0.67
Underidentification test (Kleibergen-Paap)			-	-	16.1	16.6
Weak identification test (Cragg-Donald)			-	-	73.4	73.8

Note: robust standard errors in brackets.
*** indicates significance at 1% level, ** at 5% * at 10%.

Table 9: Business income as dependent variable results.

	Model 1 (DiD)		Model 2 (DiD + IV)		Model 2 (first stage)	
Interaction	**0.012****	**0.012****	**0.038***	**0.042***	**0.005*****	**0.005*****
	[0.005]	[0.005]	[0.022]	[0.022]	[0.000]	[0.000]
Damages	**-2.798****	**-2.721****	**-7.580***	**-8.157****	-	-
	[1.074]	[1.072]	[4.155]	[4.149]		
Distance	-	-	-	-	**0.274*****	**0.272*****
					[0.082]	[0.087]
Controls		YES		YES		YES
Constant	YES	YES	YES	YES	YES	YES
Fixed effects	YES	YES	YES	YES	YES	YES
$G_{i,t}$ and $D_{i,t}$	YES	YES	YES	YES	YES	YES
Observations	215	215	215	215	215	215
R^2	0.32	0.32	-	-	0.97	0.97
Underidentification test (Kleibergen-Paap)			-	-	9.2	8.9
Weak identification test (Cragg-Donald)			-	-	15.1	14.4

Note: robust standard errors in brackets.
*** indicates significance at 1% level, ** at 5% * at 10%.

Table 10: Placebo test results.

	Model 1 (DiD)		Model 2 (DiD + IV)		Model 2 (first stage)	
Interaction	**-0.105**	**-0.089**	**1.124**	**1.112**	**0.276**	**0.275**
	[0.216]	[0.214]	[1.134]	[1.104]	[0.197]	[0.198]
Damages	**0.126***	**0.116***	**-2.434**	**-2.393**	-	-
	[0.066]	[0.064]	[2.157]	[2.098]		
Distance	-	-	-	-	**-0.002**	**-0.001**
					[0.026]	[0.025]
Controls		YES		YES		YES
Constant	YES	YES	YES	YES	YES	YES
Fixed effects	YES	YES	YES	YES	YES	YES
$G_{i,t}$ and $D_{i,t}$	YES	YES	YES	YES	YES	YES
Observations	902	902	902	902	902	902
R^2	0.46	0.48	-	-	0.31	0.15
Underidentification test (Kleibergen-Paap)			-	-	0.0	0.0
Weak identification test (Cragg-Donald)			-	-	0.0	0.0

Note: robust standard errors in brackets.
*** indicates significance at 1% level, ** at 5% * at 10%.

Table 11: Clusters results.

	Model 1 (DiD)		Model 2 (DiD + IV)		Model 2 (first stage)	
Interaction	**0.145****	**0.146****	**0.367*****	**0.363*****	**0.500*****	**0.494*****
	[0.061]	[0.061]	[0.096]	[0.095]	[0.195]	[0.194]
Damages	**-0.017**	**-0.023**	**-0.314*****	**-0.315*****	-	-
	[0.046]	[0.046]	[0.091]	[0.088]		
Distance	-	-	-	-	**1.544*****	**1.547*****
					[0.486]	[0.488]
Controls		YES		YES		YES
Constant	YES	YES	YES	YES	YES	YES
Fixed effects	YES	YES	YES	YES	YES	YES
$G_{i,t}$ and $D_{i,t}$	YES	YES	YES	YES	YES	YES
Observations	464	464	464	464	464	464
R^2	0.35	0.37	-	-	0.65	0.66
Underidentification test (Kleibergen-Paap)			-	-	11.4	11.8
Weak identification test (Cragg-Donald)			-	-	71.9	72.3

Note: robust standard errors in brackets.
*** indicates significance at 1% level, ** at 5% * at 10%.

C 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 vulcanologist 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. Landsliding 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:* Landsliding 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.

D Description of variables in the dataset

D.1 Population controls

Population: total number of residents at December the 31^{th} of each year. *Source: ISTAT*. **Migration:** total net migration effect (immigrants minus emigrants). *Source: ISTAT*. **Balance:** natural balance (births minus deaths). *Source: ISTAT*. **Population14:** share of population younger than 14 years old. *Source:*

ISTAT. **Population65:** share of population older than 65 years old. *Source: ISTAT*

D.2 Political controls

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

D.3 Time invariant controls

Unemployment: number of unemployed people as a share of working labor force. *Source: ISTAT*. **Population band.** Number of residents (1 = small town, 8= large city). *Source: ISTAT*. **Graduates:** number of graduates as a share of total residents. *Source: ISTAT*. **Unliterary:** rate of unliterary per thousand habitants. *Source: ISTAT*. **Altimetry:** average altimetry expressed on a discrete scale from 1 (high) to 5 (low). *Source: ISTAT*. **Altimetrymax:** maximum altimetry in meters. *Source: ISTAT*. **Altimetrymin:** minimum altimetry in meters. *Source: ISTAT*. **Urbanization:** degree of urbanization rate, measured on a discrete scale from 1 (low) to 3 (high). *Source: ISTAT*. **Surface:** geographical surface expressed in kilometers squared. *Source: ISTAT*. **Coast:** dummy variable taking the value of 1 if the municipality is on the coast. *Source: ISTAT*. **Family:** average number of people per family. *Source: ISTAT*. **Foreigners:** number of non-italian residents as a share of total population. *Source: ISTAT*. **Commuters:** number of working commuters as a share of total population. *Source: ISTAT*. **Head:** dummy variable taking the value of 1 if the municipality is the political head of a province. *Source: ISTAT*. **Buildings19:** share of buildings built before 1919. *Source: ISTAT*. **Buildings45:** share of buildings built before 1945. *Source: ISTAT*. **Buildings61:** share of buildings built before 1961. *Source: ISTAT*. **Buildings71:** share of buildings built before 1971. *Source: ISTAT*. **Buildings81:** share of buildings built before 1981. *Source: ISTAT*. **Buildings91:** share of buildings built before 1991. *Source: ISTAT*. **Buildingspost91:** share of buildings built after 1919. *Source: ISTAT*.

E List of municipalities in control and treatment group

Prov. of Chieti - control: Chieti (V), Fara Filiorum Petri (V), Filetto (V), San Giovanni Teatino (V), Villa Santa Maria (V). **Prov. of L'Aquila - control:** Campo di Giove (V), Sulmona, 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 - treatment:** 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 - control:** 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 - treatment:** Brittoli (VI), Bussi sul Tirino (VI), Civitella Casanova (VI), Cugnoli (VI), Montebello di Bertona (VI), Popoli (VI), Torre de' Passeri (VI). **Prov. of Teramo - control:** 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 - treatment:** Arsita (VI), Castelli (VI), Colledara (VI), Fano Adriano (VI), Montorio al Vomano (VI), Penna Sant'Andrea (VI), Pietracamela (VI), Tossicia (VI).

F Descriptive statistics and complementary figures

Table 12: 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**

Figure 6: Output change - Lights intensity change.

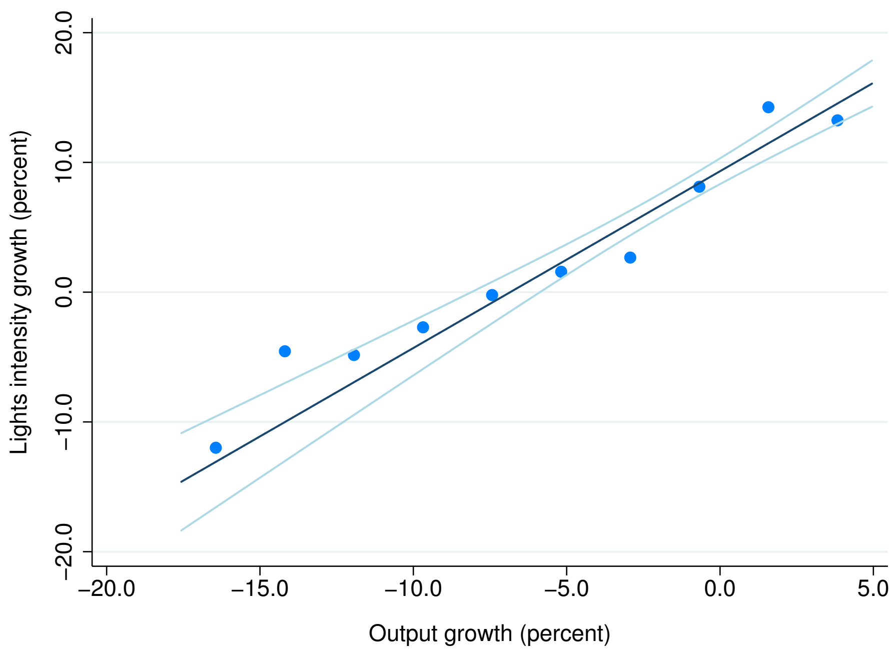


Table 14: Summary Statistics (regression sample)

	All				**Control (V and V-VI)**				**Treatment (VI and VI-VII)**			
Variable	*Mean*	*St. Dev.*	*Min*	*Max*	*Mean*	*St. Dev.*	*Min*	*Max*	*Mean*	*St. Dev.*	*Min*	*Max*
GDP	13,274	6,472	4,915	77,014	13,342	5,263	6357	47,128	12,962	4,277	6,414	27,227
Total income	13,106	2,237	7,582	21,454	13,119	2,354	7970	19,934	13,201	2,503	7,582	20,468
Business income	334	734	0	8,252	352	609	6	32,06	105	86	0	450
Night lights intensity	16.1	12.4	1.9	62.3	15.0	10.8	1.9	60.0	9.7	5.0	3.2	29.4
Grants	534	1,019	0	21,300	439	727	0	14,054	990	1341	33	9,313
Local expenditure	1,748	1,873	77	25,954	1,594	1,876	77	25,754	2,476	2,006	559	15,674
Local tax revenues	1,955	643	868	7,149	1,927	759	1003	4,096	2,236	775	890	5,160
Population	4,301	10,589	77	123,077	4,778	10,085	120	56,127	1,460	1,522	141	8,283
Pop under 14	12.3	3.0	1.3	26.5	12.5	2.8	1.3	21.3	10.9	3.2	2.1	18.7
Pop over 65	26.6	9.4	7.3	86.4	26.3	8.5	11.9	63.0	30.6	10.2	12.8	67.3
Unemployment	10.1	3.8	0	28.8	10.5	3.8	4.5	23.2	10.2	3.5	0	23.0
Left	50.4	13.1	5.6	91.4	50.0	12.7	15.6	91.4	51.5	12.5	21.8	79.0
Distance*	45.9	21.8	2.5	95.2	33.2	10.9	6.7	70.9	21.7	10.4	2.7	40.5
Index of damages*	0.07	0.20	0	1.40	0.02	0.09	0	0.64	0.27	0.27	0.01	1.06
No. of observations	**3,050**				**730**				**430**			

*refers to 2009 only.

Other statistics availble upon request.

Table 13: 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).

Figure 7: Index of damages - Mercalli ranks.

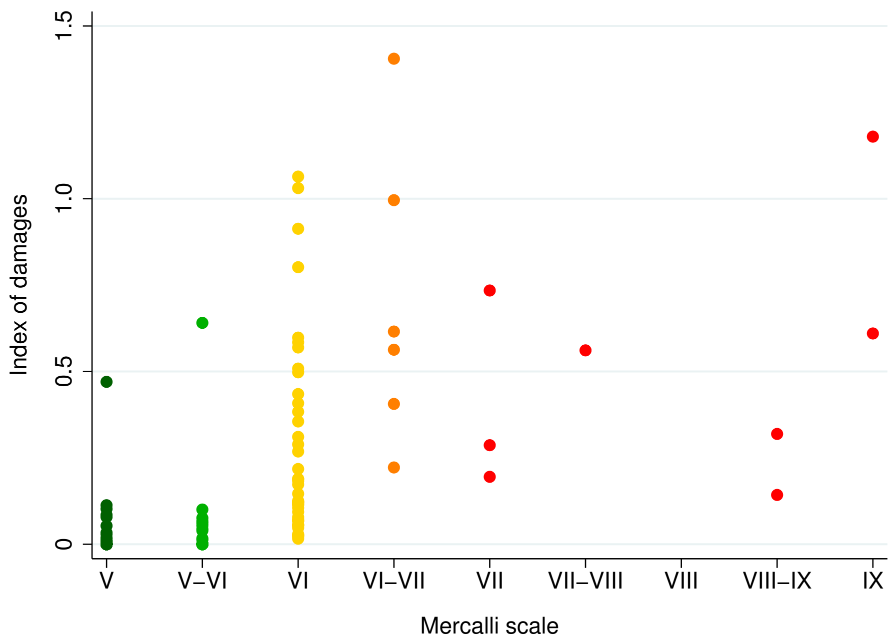


Figure 8: Index of damages - distance.

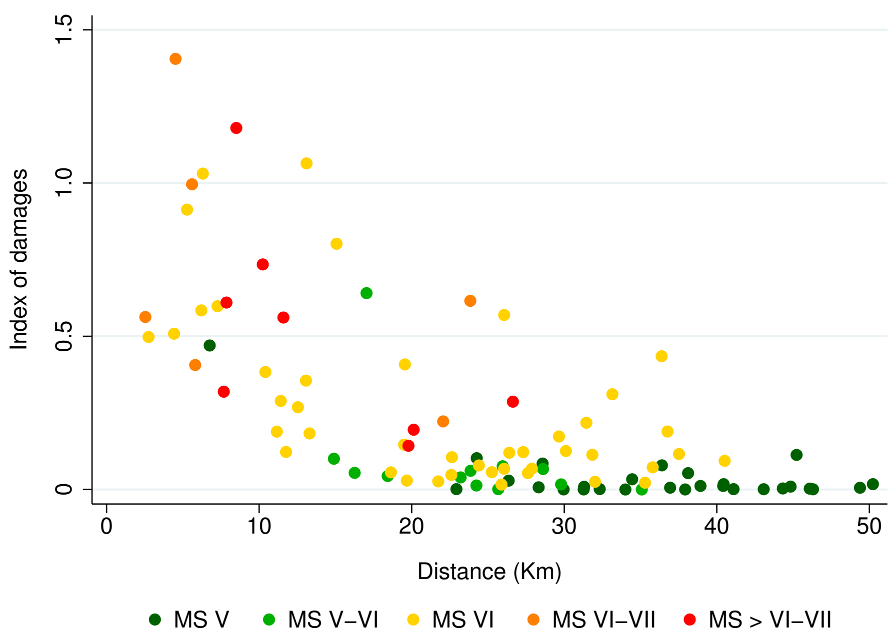


Figure 9: Discontinuity in expenditures (bandwidth 0.2).

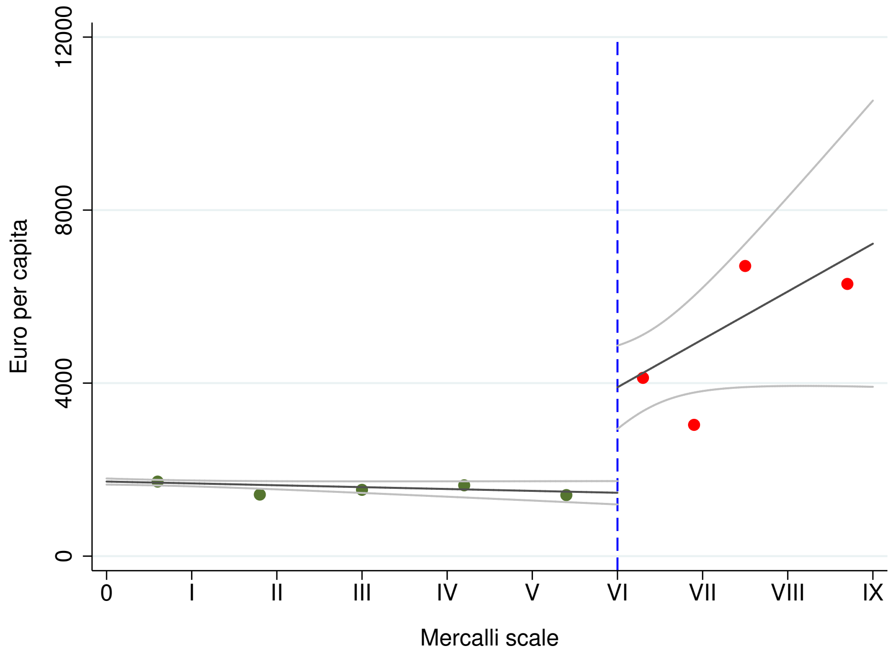


Figure 10: Discontinuity in tax revenues (bandwidth 0.2).

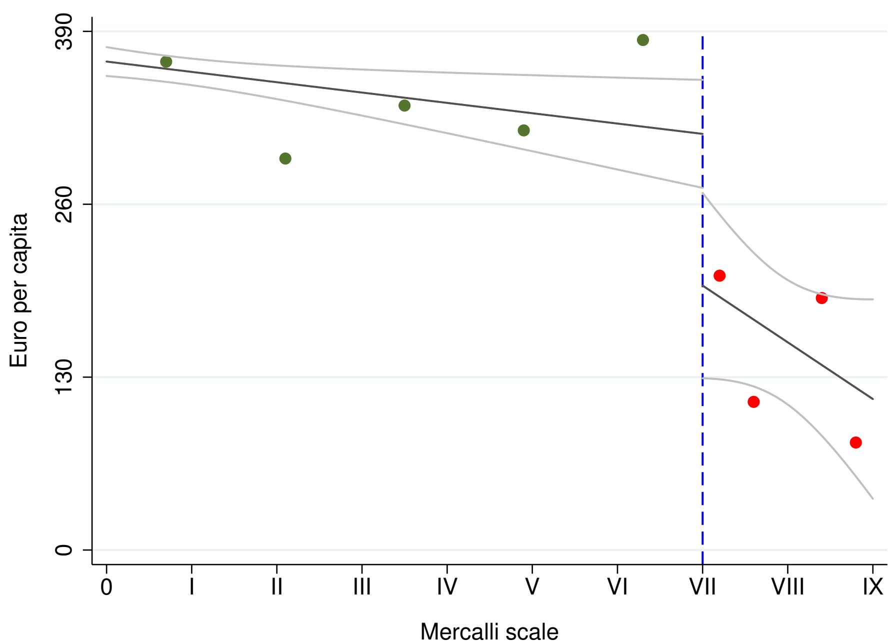


Figure 11: Map of Italian regions.

Figure 12: Map of night lights intensity (average of 2007).