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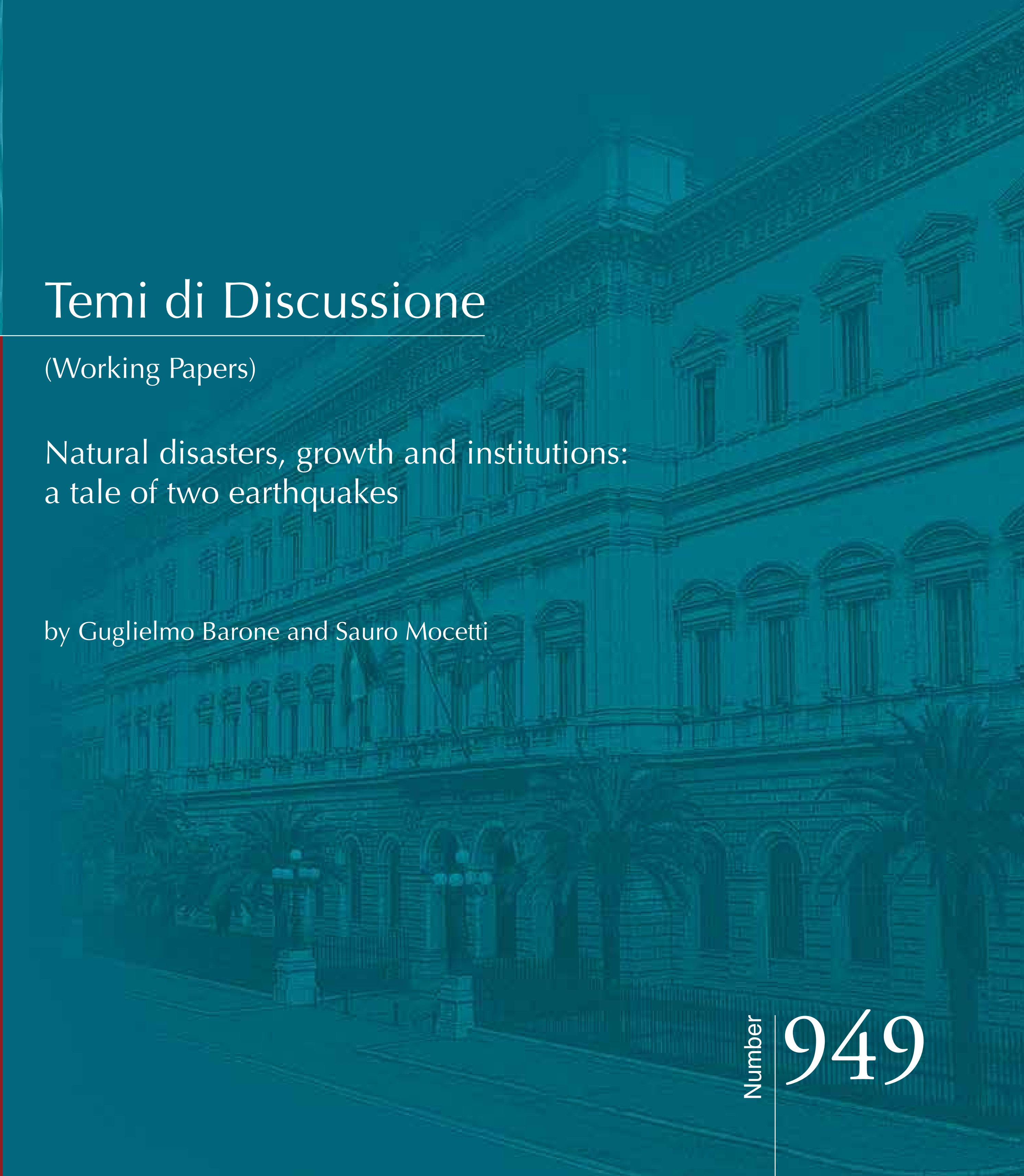

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NATURAL DISASTERS, GROWTH AND INSTITUTIONS: A TALE OF TWO EARTHQUAKES

by Guglielmo Barone* and Sauro Mocetti**

Abstract

We examine the impact of natural disasters on GDP per capita by applying the synthetic control approach. Our analysis encompasses two major earthquakes that occurred in two different Italian regions in 1976 and 1980. We show that the short-term effects were negligible in both regions, though they become negative when we simulate the GDP that would have been recorded in the absence of financial aid. In the long-term, our findings indicate a positive effect in one case and a negative effect in the other, largely reflecting divergent patterns of total factor productivity. Consistently with these findings, we offer further evidence suggesting that an earthquake and related financial aid can increase technical efficiency via a disruptive creation mechanism or else reduce it by stimulating corruption, distorting the markets and deteriorating social capital. Finally, we show that the bad outcome is more likely to occur in areas with lower pre-quake institutional quality. As a result, our evidence suggests that natural disasters are likely to exacerbate differences in economic and social development.

JEL Classification: R11, O40, H84, Q54.
Keywords: natural disasters, economic growth, aids, corruption, synthetic control method.

Contents

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1. Introduction[1]

Large-scale natural disasters regularly affect societies in all corners of the globe. The immediate consequences, thanks to massive media coverage, are clear to all: deaths, displacement of people, damage to physical capital and infrastructure. As time passes, attention diminishes and long-term consequences become less clear. However, understanding a disaster's impact on later economic growth and how local institutions and economic actors react is crucial to better assess the costs of a disaster and design financial aid programs.

The available literature regarding the economic impact of natural disasters is still scant and inconclusive. Some studies report negative effects on economic growth, while others indicate no, or even positive, effects.[2] Moreover, many existing studies have a number of limitations that make their conclusions less than convincing. First, the effects of natural disasters are typically geographically concentrated, and the adoption of a cross-country approach (common to most of the existing studies) may lead, by construction, to an attenuation bias. Moreover, cross-country evidence is based on natural disasters that differ substantially in terms of type (from climatic to geological) and magnitude and that occur across countries exhibiting very different levels of economic development. Data are often not equally comparable across countries, adding further bias to estimates. Finally, the GDP dynamics following a quake can be largely affected by the amount of post-quake financial aid, a variable that has been rarely taken into account in existing studies. There are also econometric concerns regarding the difficulty of constructing appropriate counterfactuals. Indeed, rather than simply relying on a before-after analysis, one should compare the path of the GDP with that which would have been observed in the absence of the natural disaster (Cavallo et al., 2013).

Even less is known about *why* we observe heterogeneous long-term effects of natural disasters. Indeed, in the aftermath of a quake, the local economy typically receives a second large shock – a storm of public transfers – that plays a crucial role in the recovery period because it positively affects the GDP in the short run. However, the long run effects are uncertain and depend on the quality of the outlay. For example, the construction of better infrastructures to replace those which are old and damaged might increase the potential output of the economy. On the other hand, if public resources are

[1] We thank Antonio Accetturo, Edward Miguel, conference participants at ERSA and SIEP, seminar participants at the Bank of Italy and two anonymous referees for useful suggestions. The views expressed here are those of the authors and do not necessarily reflect those of the Bank of Italy. The usual disclaimers apply.

[2] The first attempt to empirically assess the economic effects of natural disasters was by Albala-Bertrand (1993) who used a before-after statistical analysis and found positive effects on the GDP. Similar results have been found using a wider temporal perspective and a larger panel by Skidmore and Toya (2002). Loayza et al. (2009) and Noy (2009) argue that heterogeneous effects, either positive or negative, are observable depending on the type of disaster and the level of socio-economic development of the country. Finally, Cavallo et al. (2013) critically review previous empirical strategies and, by adopting the synthetic control approach, find that disasters do not significantly affect economic growth. See also Cavallo and Noy (2011) for a review of the literature.

misallocated and diverted due to rent-seeking behaviors, this may distort the markets and corrupt the economy and, ultimately, reduce the potential output.

The aim of this paper is to examine the economic impact of natural disasters by using, unlike the previous literature, a within-country perspective and a richer dataset. Namely, we investigate the consequences of two almost contemporaneous earthquakes that occurred in Italy ("Friuli" quake in 1976 and "Irpinia" quake in 1980). We compare the observed GDP per capita after the quake (which is an exogenous and largely unanticipated shock by definition) in each area with that which would have been observed in the absence of the natural disaster. We carry out this comparative analysis using a rigorous counterfactual approach, the synthetic control method, proposed by Abadie and Gardeazabal (2003) and Abadie et al. (2010).

According to our findings there are no significant effects of the quake in the short term. However, this result can be largely attributed to the role of financial aid in the aftermath of the disaster. Using different assumptions regarding the magnitude of the fiscal multiplier, we estimate that the yearly GDP per capita growth rate in the five years after the quake, in the absence of financial aid, would have been approximately 0.5-0.9 percentage points lower in Friuli and between 1.3-2.2 points lower in Irpinia. In the long term, we find two opposite results: the quakes yielded a positive effect in Friuli and a negative one in Irpinia. In the former, 20 years after the quake, the GDP per capita growth was 23 percent higher than in the synthetic control, while in the latter, the GDP per capita experienced a 12 percent drop. After showing that in both cases, the dynamics of the GDP per capita largely mirrors that of the TFP, we provide evidence that the institutional quality shapes these patterns. In the bad-outcome case (Irpinia), in the years after the quake fraudulent behaviors flourished, the fraction of politicians involved in scandals increased, and the civic capital deteriorated. Almost entirely opposite effects were observed in Friuli. Since in Irpinia the pre-quake institutional quality was 'low' (with respect to the national average) while in Friuli it was 'high', we argue that the pre-existing local economic and social *milieu* is likely to play a crucial role in the sign of the economic effect of a natural disaster. Consequently, our results also suggest that disasters may exacerbate differences in economic and social development.

This paper adds to existing literature in several ways. Our empirical strategy is similar to that of Cavallo et al. (2013), who studied the economic effects of natural disasters using the synthetic control approach with cross-country data. That study found that even large disasters do not significantly affect the economy unless they are followed by radical political revolutions (as Iran 1979 and Nicaragua 1979). However, we believe that both our data and the adoption of a within-country perspective have some advantages over the work of Cavallo et al. (2013).[3] First, we can correctly define

[3] Unsurprisingly, the two seminal papers regarding the synthetic control approach (Abadie et al, 2010, and Abadie and Gardeazabal, 2003) adopt a within-country perspective. Other papers using within-country data (but not the synthetic control approach) in a somewhat similar field are Strobl (2011) – that analyzes the impact of hurricanes using a panel of US counties – Miguel and Roland (2011) – that

the geographical area affected by the quake. For instance, the impact of the Friuli quake – which Cavallo et al. (2013) define as a severe disaster – is significant at the local level (resulting death toll and homelessness accounted for approximately 18 percent of the regional population) and negligible at the country level (0.4 percent of the national population). Second, the within-country perspective mitigates the role of unobserved confounders that might affect the outcome dynamics between the treated and control units and which cannot be credibly controlled in a cross-country approach. Moreover, the (Italian) regions are much more comparable to each other than different countries (which have different institutional regimes and may be in various stages of development) are. This increases the similarity among the treated regions and the set of donors and, therefore, the reliability of the construction of the synthetic control. Third, we use data that are much more susceptible to comparison – being drawn from the same national sources – and are much richer than those available in a cross-country context. Indeed, we have data on financial aid – that allows us to estimate the short-term impact on the GDP while applying different assumptions regarding the fiscal multiplier – and on (time-varying) indicators of institutional quality.

Besides data and empirical issues, a further element of novelty of this paper is that we shed light on *why* certain outcomes arise. As far as the short term is concerned, we analyze the expanding role of public spending. As to the long run outcome, we highlight the transmission mechanism from the quake to the GDP per capita by examining the mediating role of institutions: their quality might affect the ability to deal with the recovery process and we show that institutions themselves endogenously change in response to the shock.[4] In this respect, our results are consistent with those of Acemoglu et al. (2005), who discuss how institutions determine the incentives and the constraints on economic actors and shape economic outcomes. Our paper is also related to Rajkumar and Swaroop (2008), who show that the quality of public spending can be largely explained by the quality of governance, and Nannicini et al. (2013), who show how (pre-existing) social capital may improve the functioning of institutions.

The rest of this paper is organized as follows. In Section 2, we discuss how a quake may impact on economic growth. In Section 3, we describe our empirical strategy. In Section 4, we present the data and variables. In Section 5, we discuss our results and provide a rich set of robustness checks and refinements. Section 6 concludes the paper.

investigates the impact of U.S. bombing on later local economic development in Vietnam districts – and Hornbeck (2012) – that examines the impact of the 1930s American Dust Bowl.

[4] In this respect, our paper also shares an interest with Kahn (2005), Stromberg (2007) and Noy (2009) who argue that countries with better institutions suffer fewer deaths and are better able to withstand the disaster. However, these studies consider institutions as given.

2. Theoretical framework

What does economic theory predict about short and long run economic consequences of an earthquake? In the textbook neoclassical growth model, an earthquake causes an instantaneous destruction of capital stock. After the disaster, the economy converges towards its old long-run, steady-state equilibrium through faster capital accumulation. Therefore, in the short run there is a decrease in the GDP while in the long run there are no effects. However, this is clearly an oversimplification since it does not capture other channels through which the quake might impact on the production function, on the inputs and on their use. With no claim of being exhaustive, in what follows we illustrate a number of facts that makes the post-quake outcome unclear.

In the aftermath of the disaster, large aid flows usually occur. They are typically temporary and largely financed with external funds and not by local taxes: hence, these aids are very likely to have an expansive short-run effect on output that can limit or even neutralize the negative impact of the quake.

The long-run outcome is vaguer. On the positive side, post-quake equilibrium might benefit from a process of "creative destruction" (Skidmore and Toya, 2002; Cuaresma et al., 2008): firms may replace old production technologies with new, more productive ones. Local governments, in turn, may adapt public infrastructure to the new needs, such as reconstruction of schools with improved equipment and of roads better suited for the productive system. This process might positively affect the technical efficiency of the economy. At the same time, citizens' joint efforts and solidarity behaviors in the reconstruction process may spur an increase in generalized trust in the local community. A large involvement of the local community may also translate in higher social participation, more civic engagement and increase citizens' clamor for greater transparency and accountability in economic governance. All in all, this may lead to an improvement of social capital and other intangible inputs in the production process and, consequently, to better economic outcomes (Hall and Jones, 1999). On the negative side, the disaster may induce some workers to migrate so reducing potential output. At the same time, the windfall transfers may generate corruption and reduce the quality of serving politicians (Brollo et al., 2013), which, in turn, may deteriorate long-term productivity and efficiency in the allocation of inputs (e.g., the firm that pays a bribe to a bureaucrat to obtain access to public transfers also imposes externalities onto other firms and distorts the market). Local governments might also misallocate resources due to favoritism and/or rent-seeking rather than public welfare criteria (Tanzi and Davoodi, 1997; Mauro, 1998). Keeping apart the inflow of aids, the quake and the displacement of people may disrupt social ties and local networks. The deterioration of the social environment, in turn, might affect the individual propensity to adopt and retain pro-social behaviors (whether willingly, consciously or not). All in all, this may lead to a decrease of the quality of local institutions and a deterioration of civic capital (Guiso et al., 2010), thus undermining long-term economic development. This rapid overview shows that the theoretical predictions on the short- and, above all, the long-term impact of a quake on GDP are necessarily undetermined. Therefore, the issues of which scenario prevails and the underlying mechanisms have to be addressed on an empirical ground.

A second and related issue pertains to the forces that make a long-term positive or negative scenario more plausible. Following a consolidated literature, our claim is that the balance between these two opposing outcomes crucially depends on the quality of local institutions before the quake (Acemoglu et al., 2005). Stated differently, initial conditions matter and they may lead to different equilibria in response to the shock. On the one hand, stronger civic attitudes and social pressure are an important prerequisite for cooperative behaviors and the successful solutions of collective actions problems (Olson, 1965). Moreover, individuals may ostracize and reprimand behaviors they deem to be antisocial, spending time and effort to preserve and reinforce the cooperative equilibrium. Social ties can also serve as informal insurance, providing information, financial help and physical assistance (Aldrich, 2012). What is true for individuals is also true at the community level. Local social networks may collaborate with the government to speed up reconstruction by providing information and facilitating implementation of recovery plans. Moreover, the degree of social cohesion is essential for generating the confidence and the patience needed to implement the policies for the reconstruction effort (Easterly et al. 2006). Finally, the diffusion of newspaper readership and higher social participation may contribute to greater political accountability and responsiveness (Besley and Burgess, 2002). These same arguments can be reversed for areas with poorer institutions. Indeed, pre-existing rampant corruption and muddled bureaucracy may weaken the effectiveness of public spending (Rajkumar and Swaroop, 2008), favor the diversion of financial aids and lead to an unorganized reconstruction effort. Moreover, poorly informed people and lower social participation may increase the scope for fraudulent behaviors and lessen electoral punishment (Ferraz and Finan, 2008; Nannicini et al., 2013). Similarly, among voters a myopic view that rewards candidates for their ability to attract resources in the short term rather than their ability to plan a thoughtful reconstruction process may prevail. All in all, the quake might reinforce and exacerbate initial differences in institutional quality.

3. The empirical strategy

We compare the patterns over time in the GDP per capita of regions exposed to the earthquake with that of a control group of unaffected regions. To construct a credible control group, we adopt the synthetic control method for comparative case studies (Abadie and Gardeazabal, 2003; Abadie et al., 2010). Namely, we construct a synthetic counterfactual as a weighted average of potential control regions that replicates the initial conditions and the growth potential of the region of interest before the earthquake.

Following Abadie et al. (2010), there are $J + 1$ regions. Without loss of generality, let the first region be the one exposed to the earthquake. Let y_{it}^{1} be the potential GDP per capita in region i ($i = 1, \ldots, J + 1$) at time t ($t = 1, \ldots, T$) if the region is hit by the earthquake and y_{it}^{0} if the region is unexposed to the earthquake. Let T_0 be the number of periods before the earthquake ($1 \leq T_0 < T$). We assume that the earthquake has not any effect on the outcome variable before it occurs so that $y_{it}^{0} = y_{it}^{1}$ for any region i and any time $t < T_0$. This is equivalent to assuming that the earthquake is unpredictable so that there are no anticipation effects. Let $\alpha_t = y_{it}^{1} - y_{it}^{0}$ be the effect of the earthquake at time $t > T_0$. Let D_t be an indicator variable that takes value if $i = 1$ and $t > T_0$. Then the observed per capita GDP in the affected region can be written as $y_{it}^{1} = y_{it}^{0} + \alpha_t D_t$. It follows that for $t > T_0$, $\alpha_t = y_{it}^{1} - y_{it}^{0}$ but y_{it}^{0} is not observed and has to be estimated. This is the well-known fundamental problem of causal inference. Abadie et al. (2010) suggests estimating α_t with $\hat{\alpha}_t = y_{it} - \sum_{j=2}^{J} w_j y_{it}$ for $t > T_0$ where weights w_j are chosen to minimize a certain penalty function that is selected as follows.

Let X_1 be a ($k \times 1$) vector of GDP per capita predictors for the treated region and, analogously, X_0 be a ($k \times J$) matrix that contains the same variable for the donor regions. The ($J \times 1$) vector of optimal weights W*(V) minimizes the distance:

$$\left\| X_1 - X_0 W \right\|_V = \left[\left(X_1 - X_0 W \right)' V \left(X_1 - X_0 W \right) \right]^{\frac{1}{2}}$$

subject to $w_j \geq 0$ for $j = 2, \ldots J$ and $w_1 + w_2 + \ldots + w_J = 1$. V is a ($k \times k$) symmetric and positive definite matrix that contains weights to the variables in X_1 and X_0 according to their predictive power with respect to the outcome. The choice of V is data driven. The optimal matrix V* is a diagonal positive definite matrix that minimizes the Mean Squared Prediction Error (MSPE) of the outcome variable over some set of the pre-earthquake period. More formally, let Z_1 be a ($T_p \times 1$) vector containing the values of the outcome variable for the treated unit and Z_0 be a ($T_p \times J$) matrix that contains the same variable for the control regions where ($1 \leq T_p \leq T_0$). Then V* minimizes:

$$\left(Z_1 - Z_0 W^*(V) \right)' \left(Z_1 - Z_0 W^*(V) \right).$$

The outcome of interest is the GDP per capita at constant 1985 euro-equivalent prices. Following a rather consolidated approach (Abadie and Gardeazabal, 2003; Barro and Sala-i-Martin, 2004), we include among our main predictors the investment-to-GDP ratio, the share of graduates (as proxy for human capital), the population density, the sectoral shares of value added and a synthetic measure of institutional quality (Acemoglu et al., 2005; see Subsection 4.2). The GDP per capita predictors are averaged over a five-year period before the earthquake (1971-1975 as for the Friuli earthquake, 1975-1979 as for the Irpinia one). The MSPE is minimized over the 1951-1975 period ("Friuli") or the 1951-1979 period ("Irpinia").

4. Data and descriptive evidence

4.1 Data and variables

Most of the time-series data at the regional level are drawn from the research institute CRENOS.[5] Specifically, these data include the GDP, labor units, investment, population and sectoral shares of value added in agriculture, industry, construction, market services and non-market services. They cover the 1951-2004 period. Investment and sector breakdowns of the value added are available for 1960 onward. The time-series have been updated up to 2009 by using official figures provided by the National Institute of Statistics (Istat). Data on human capital are taken from population censuses conducted by Istat. Censuses are run every 10 years; inter-census data are obtained through interpolation.

Moreover, we use four region-level, time-varying variables aimed at capturing the quality of local institutions; these variables are relatively new and deserve further description. The first variable measures the intensity of corruption and fraudulent behavior in the local economy. More specifically, we consider crimes under articles of the criminal code 286 through 318 (i.e., embezzlement, bribery, corruption and other infringement of public duties), articles 110 through 118 (i.e., different types of frauds and fencing), and articles 374 through 376 (i.e., bankruptcies). This large set of crimes is arguably better suited to capture the different dimensions of corruption, which exists in both the public and private sectors and is interwoven with different types of fraudulent behavior. Crime data are drawn from the Annals of Judicial Statistics (AJS), a yearly publication by Istat available for the 1968-2004 period that contains statistics, at the local level, on the number of crimes detected by Italian law. The indicator is calculated as a 3-year moving average (to capture potential delays in the penal procedure) of the number of crimes, normalized with respect to labor units (a proxy for the number of economic transactions at the local level).

The second variable is the fraction of national members of parliament appointed in each region who were involved in scandals. The Fondazione Rodolfo de Benedetti (RdB) provided this information, which is available for all individuals who have been elected to the Camera dei Deputati of the Italian Parliament (the House) and it is aimed at capturing the quality of "local" politicians and the spread of corruption in the political sphere. Data are available from 1946 to 1994 and for subsequent years they have been imputed through extrapolation.

The third variable is referenda and European election turnout at the regional level and it is aimed at capturing, following Guiso et al. (2004), the political participation.[6]

[5] See http://crenos.unica.it/crenos/databases for details on the database. See Pinotti (2012) for a recent paper using the same data.

[6] We considered European elections for the following years: 1979, 1984, 1989, 1994, 1999 and 2004 (see http://elezionistorico.interno.it). The referendum included in our temporal window concerned the following issues: the choice between republic and monarchy in 1946; divorce legislation in 1974; public

There are some reasons that justify this choice. On the one hand, until 1993, it was a legal duty in Italy to participate in general elections but not in referenda. Thus, it is very likely that many Italians went to the polls in general elections, irrespective of their sense of civic duty; the same is not true in the case of referenda. On the other hand, voting in general or local elections can lead to personal patronage benefits, that is, an "exchange" rather than a measure of civic involvement; however, there are no immediate personal benefits in the case of European elections or referenda. Therefore, our measure of electoral participation is not driven by legal or economic incentives, but only by social and internal norms. As explained by Putnam (1993), the primary motivation is a concern for public issues.

The last variable is the diffusion of newspaper readership, drawn from the *Accertamenti Diffusione Stampa* (ADS) Association and available for the period 1980-2000. The underlying idea is that well-informed citizens have better knowledge of public affairs and are more likely to be involved in collective action and public life. Putnam (1993) used this variable as an indicator of citizens' civic engagement in Italy.

To get a summary indicator of a multidimensional concept like the quality of local institutions we also rely on a principal component analysis, which extracts information from the four variables discussed above. The first principal component, which we use as a synthetic measure, explains about 45 percent of the total variance of the underlying variables. Table 1 shows the descriptive statistics of all these variables.

4.2 The two earthquakes

Italy lies directly over the Eurasian and African fault lines, where two tectonic plates meet. The peninsula has suffered many major earthquakes over the centuries and is one of the most earthquake-prone countries in the world. The three largest earthquakes recorded in the last millennium were the Sicily earthquake in 1693 (60,000 deaths), the Calabria earthquake in 1783 (50,000 deaths) and the Messina earthquake in 1908 (120,000 deaths). Regarding more recent events, for which a richer set of data is available, the two most important earthquakes since World War II were the Friuli earthquake in 1976 and the Irpinia earthquake in 1980 (see Figure 1 for a finer localization of these two earthquakes).

The Friuli earthquake took place in the Friuli-Venezia Giulia region (in north-eastern Italy) on May 6, 1976. In the following months, there were aftershocks, the most significant of which occurred on September 15, 1976. The earthquake measured 6.4 on

security and public financing of parties in 1978; public security, anti-terrorism and abortion legislation in 1981; wage escalator clauses in 1985; nuclear power in 1987; hunting regulation and use of pesticides in agriculture in 1990; political preferences in 1991; drugs, public financing of parties and abolition of certain ministries in 1993; labor unions, television and commercial rules in 1995; abolition of certain ministries, hunting and professions regulation in 1997; electoral rules in 1999; electoral rules, labor unions and professions regulation in 2000. For missing years, political participation was obtained through interpolation. Since those elections were quite heterogeneous in terms of public interest, we normalize the regional figures with the national turnout.

the Richter scale. According to EMDAT data, the earthquake killed 922 people (0.07 percent of the regional population), while the total number of affected people was 218,200 (17.7 per cent of the regional population). It ranked 2nd on the list of most relevant Italian earthquakes since 1950 (84th in a worldwide comparison).

The second earthquake took place in the Irpinia region of Southern Italy on November 23, 1980. The quake measured 6.9 on the Richter scale and damage was spread over a large area, mostly corresponding to the provinces of Benevento, Avellino, Salerno (belonging to the Campania region) and Potenza (Basilicata region). Since the empirical analysis is based on regions as geographical units of observation because of data availability, in what follows Campania and Basilicata are jointly considered as the treated area. According to the EMDAT data, this earthquake killed 4,689 people (0.08 percent of the regional population), and affected 407,700 people (6.9 percent of the regional population). It was the most relevant Italian earthquake since 1950 (the 52nd most relevant in a worldwide comparison).

In summary, the two earthquakes occurred almost contemporaneously and had comparable magnitudes. It is also worth noting that they can be both unambiguously considered as large disasters in the affected regions, according to the definition given by Cavallo et al. (2013).[7]

The two areas affected by the quakes differ in a number of dimensions. In the first half of the 1970s, Friuli's GDP per capita was more than 40 percent higher than that of Irpinia. Friuli also held a slightly larger share of the industry sector (39 percent as opposed to Irpinia's 33 percent) and a smaller share of the nonmarket sector (19 and 22 percent, respectively). The Irpinia region was much more densely populated (244 and 156 people per sq. km, respectively) whereas the fraction of individuals with a university degree was roughly similar in the two areas (approximately 1.5 percent). The differences in institutional quality were quite large. The corruption and fraud rate in Irpinia was more than double that in Friuli and among the highest in Italy; corruptive practices were also widespread in the political sphere: in Irpinia the fraction of politicians involved in scandals was 9 points larger than in Friuli. Moreover, Irpinia displayed much lower civic attitudes: the electoral turnout was 12 points lower and the diffusion of newspapers readership was less than half that of Friuli. Figure 2 shows a map with regions divided in four groups, depending on the synthetic indicator of the quality of their local institutions. Campania and Basilicata were, in the first half of the 1970s, among the regions with the lowest institutional quality while Friuli-Venezia Giulia was in a middle-high position. More generally, the map reflects the conventional wisdom on the North-South divide in terms of social capital (Putnam, 1993).[8]

[7] They consider the world distribution of the number of people killed (as a share of population) and define large disasters to be those above the 99th percentile – with more than 0.02 percent of the population killed.

[8] A further important (time-invariant) institutional difference between the two areas is the tradition of political autonomy. The database ISL-University of Parma provides a discrete measure of this variable based on historical observations. Friuli-Venezia Giulia is coded as a region with a long tradition of economic and political autonomy. Moreover, the Italian Constitution recognized a broad amount of

After the earthquakes, a huge amount of public transfers occurred. The financial aid represented, on average, 5.7 percent of the regional GDP per year in the first decade after the Irpinia quake. The corresponding figure for the Friuli quake was 3.8 percent. In both cases, a larger amount of resources were concentrated in the aftermath of the quake (Figure 3).

5. Results

Our main findings are reported in subsection 5.1. Robustness checks are carried out in subsection 5.2. We discuss the short-term role of financial aid in subsection 5.3. Finally, a long-term analysis of economic growth, TFP and institutional change is presented in subsection 5.4.

5.1 Main findings

First, we consider the Friuli quake. The synthetic control method delivers positive weights (see Table 2) for Piedmont (0.002), Liguria (0.043), Tuscany (0.413), Umbria (0.404), Latium (0.034), Campania (0.078) and Basilicata (0.026). In Table 3, Panel A, we report the pre-treatment growth determinants of the treated region (Friuli-Venezia Giulia), the synthetic control and the population-weighted average of the entire set of regions in the donor pool. As clearly shown, the synthetic control closely mimics the treated region in all variables considered. In Figure 4, Panel A, we compare the evolution of the GDP per capita in Friuli-Venezia Giulia and in the synthetic control over a period of approximately 50 years. The evolution of GDP in most regions mostly overlaps until 1975, underscoring the credibility of the synthetic control as a counterfactual estimator. In the aftermath of the earthquake, no detectable effect is observed; nevertheless, in the second half of the 1980s, the trend in the treated region (positively) starts to diverge from the control unit. Indeed, 20 years after the quake, the GDP per capita growth in Friuli-Venezia was 23 percent higher than in the synthetic control.

Concerning the Irpinia quake, the synthetic control method delivers positive weights for Liguria (0.101), Molise (0.332) and Calabria (0.566). In Table 3, Panel B, we report the balancing properties of the relevant pre-earthquake variables. Overall, the synthetic control resembles Campania and Basilicata (the two treated regions) more closely than the entire set of donors do, especially with respect to the GDP per capita and the institutional quality. As shown in Figure 4, Panel B, in the pre-treatment period the evolution of the GDP per capita in the treated region and in the synthetic control is largely comparable. In the first year after the quake, there is a negative (though almost

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autonomy through a special statute. Campania and Basilicata have instead completely different historical legacies because, for centuries, they were part of a broader economic and political system (i.e., foreign dominant and overpowering authorities).

indistinguishable) effect on the GDP per capita. As time passed, GDP per capita in the treated area displays weaker dynamics; 10 years after the quake, GDP per capita growth in Irpinia was 6 percent lower than that of the synthetic control, and 20 years later was 12 percent lower.

Are these estimates statistically significant? In the comparative case study setting the standard statistical tests based on the normality assumption are not available. An alternative method to measure significance is running a number of placebo studies. The underlying idea is that if relevant effects are detected in the placebo exercises, as well, one may doubt the credibility of the empirical strategy. Therefore, for each quake we apply the synthetic control method to all other regions that were not exposed to a quake in the same year. We then compute the estimated effect associated with each placebo run. Afterward, we have a distribution of estimated effects for the regions where no treatment took place. Figure 5 shows the results of this test. The black line represents the estimated gap between the treated unit and the synthetic control for Friuli-Venezia Giulia (top graph) and Campania and Basilicata (bottom graph). The grey lines denote the same gap for the placebo runs. In the Friuli case, the estimated effect is, on average, larger with respect to the distribution of the gaps in the potential controls. In contrast, in the case of the Irpinia earthquake, the estimated gap is negative and larger (in absolute values) relative to most of the placebo gaps. Overall, these exercises confirm our baseline findings. In the Friuli case, at the end of the sample period the estimated gap for the treated region ranked 3rd out of 20 tests. This indicates that the probability of estimating a larger effect under a random permutation of the treatment is 2/20 = 10%. In a confidence interval setting, we would conclude that the estimate effect for Friuli-Venezia Giulia is positive and significant at a 10 percent confidence level. In the Irpinia case, the pseudo p-value is below 1 percent, confirming the significance of the estimated effect.

5.2 Robustness checks

In this subsection, we conduct several robustness checks. First, we exclude from the donor pool those regions that experienced a large-scale quake within a 10-year window that could bias the estimated effect. In the Friuli case, we exclude Sicily (because of the quake that occurred in 1968 in the "Valle del Belice", a large area in the western part of the region), Campania and Basilicata (both affected by the Irpinia quake in 1980). In the Irpinia quake case, we exclude the Friuli-Venezia Giulia region. Regional weights in the construction of the synthetic control are reported in Table 4 while empirical results are shown in Figure 6, Panel A. In both cases the results are largely confirmed.

In the second robustness check, we resort to a cross-validation approach. Namely, we minimize the MSPE up to 5 years before the earthquake: if the synthetic control is a credible counterfactual then we would expect that after the MSPE-minimization-end year and before the treatment, treated and control regions would show similar evolution patterns. Our baseline findings prove to be robust under this check, as well (see Figure 6, Panel B).

In the third robustness check we exclude from the set of donors the region with the highest weight in our baseline specification (i.e. Tuscany for the Friuli quake and Calabria for the Irpinia quake). Indeed, the synthetic control method usually delivers positive weights for just a few units and one may wonder whether the estimates are sensitive to the particular performance of a single region. Again, the results (reported in Figure 6, Panel C) are qualitatively similar.

According to our results, the estimated effects are somewhat delayed. This is consistent with the notion that adjustment to a new steady state requires time. However, from an empirical point of view, it may be difficult to discriminate between the delayed effect of the quake and the immediate effect of a totally different exogenous shock. Therefore, our fourth robustness check aims to rule out other potentially competing factors. As far as the Friuli case is concerned, we have not been able to find in the local economic history any significant event that might explain the divergent trend in the GDP (compared to the synthetic control) since the second half of the 1980s. However, one might argue that the Friuli-Venezia Giulia is a small and export-oriented region and, consequently, may have benefited from the competitive devaluation that occurred in Italy at the beginning of the 1990s (see Marcellino and Mizon, 2001). Therefore, we check the robustness of our result by restricting the sample of donors to regions with a relatively similar degree of trade openness. In the pre-quake years, Friuli-Venezia Giulia ranked 5th among all the Italian regions. In the restricted pool of donors, we include the regions from the first to the ninth position in the ranking (excluding Friuli-Venezia Giulia), which are +4 or –4 positions from the treated region: Piedmont, Lombardy, Trentino-Alto Adige, Veneto, Liguria, Emilia-Romagna, Tuscany and Marche. The results are reported in Figure 6, Panel D, and are substantially similar to our baseline findings. With regard to the Irpinia quake, Pinotti (2012) noted that starting in the 1970s, there was a sudden increase in organized crime activities in Basilicata (and in Apulia), which have been shown to negatively impact the GDP. To analyze the robustness of our results against this potential confounding factor, we have repeated the synthetic control approach using only Campania as the treated unit. The results are reported in Figure 6, Panel D and again confirm our main findings. This is likely because Basilicata accounts for a very small fraction of the treated region, which includes both Campania and Basilicata.[9]

The role of further potentially relevant confounding factors can also be addressed properly selecting the set of donors on the basis of the macro-area to which the treated

[9] A further potential confounding factor concerning Basilicata is the intensive oil production that started in the mid-1990s. Again, this does not represent a concern for us. First, Basilicata represents a small part of the entire treated region (about 10 percent both in terms of GDP and population). Second, and more importantly, the effect of oil extraction on the GDP per capita is positive. This result (available from the authors upon request) has been obtained applying the synthetic control approach to analyze the effect of oil extraction on GDP per capita in Basilicata. Therefore, our estimates for Irpinia (which document a negative effect of the quake) can be thought of as an upper bound.

regions belong. Indeed, one might argue that the regions in the synthetic control are very similar by construction with respect to the set of observable characteristics but are potentially very different with respect other variables that can influence growth after the treatment. Therefore in our fifth robustness check we restrict the set of donors to regions in the Centre-North for Friuli and to southern regions for Irpinia, according to the well known Italian regional divide. The assumption is that the two macro-areas have been subjected, in the years after the quake, to different shocks and this restriction on the set of donors may help to control for them. The results, reported in Figure 6, Panel E, are substantially unchanged.

A further concern with our empirical analysis is the fulfillment of the non-interference assumption that is violated if the quake affects the GDP of other regions beyond the treated one. The most obvious examples are bordering regions which may be affected by the quake either positively (e.g. they benefits from the reconstruction effort) or negatively (e.g. geographically close firms that were either suppliers or clients of the firms damaged by the quake). To rule out these effects we repeat the analysis excluding from the set of donors the regions which share their borders with the treated ones. Results are reported in Figure 6, Panel F. Even though the pre-quake fit of the synthetic control is slightly poorer in the case of Irpinia, our main findings are qualitatively confirmed in both cases.

The last robustness check regards the geographical units of analysis. While in the Friuli case the quake was spread to almost the entire Friuli-Venezia Giulia region, in the Irpinia quake the area that we consider as treated (Campania and Basilicata regions) is larger than the more severely hit zone (Benevento, Avellino, Salerno e Potenza provinces). This might lead to an attenuation bias. Despite the scarcity of provincial data for the years of interest, we test whether our results are robust in this respect. Available data include only GDP, schooling and sectoral composition at a ten-year frequency (1951, 1961, 1971, 1981, 1991, 2001, 2009). The synthetic control was not able to satisfyingly reproduce the treated area in the pre-treatment period so we resorted to a standard diff-in-diff analysis. Namely, we regress the GDP per capita on a dummy that equals 1 for treated area, a dummy that equals 1 for years 1991, 2001 and 2009, their interaction, and a full set of province and time fixed effects. The results (available upon request) indicate that the disaster had a large, negative and statistically significant impact on the dependent variable.

5.3 The short-term impact: the role of financial aid

One apparently striking result of our empirical analysis is the absence of any significant negative shock in the short term. Although this finding is not completely new in the literature[10], we believe that accounting for reconstruction fiscal stimulus may provide a better understanding of the macroeconomic impact.

Fortunately, we have data regarding the yearly flow of financial aid from the central government that, as we have observed before, represents a sizeable fraction of the regional GDP. Therefore, we can plot the GDP per capita dynamics net of financial aids. To do this, it is necessary to make some assumptions regarding the fiscal multiplier. We rely on estimates provided by Acconcia et al. (2013) because they use a setting that is very similar to ours. First, they estimate the fiscal multiplier at the local level in Italy. Second, the within-country perspective allows them to control for national monetary and fiscal policy and to hold the tax burden of local residents constant. Third, they refer to a sharp change in fiscal policy. Acconcia et al. (2013) yielded a preferred estimation of the local fiscal multiplier of 1.2, slightly lower than what has been found in the United States (Nakamura and Steinsson, 2013). However, we consider two bounds to these estimates, allowing the true (and unobserved) fiscal multiplier to fluctuate within this interval. As a lower bound, we consider a value of 1, which Acconcia et al. (2013) cannot statistically reject in their preferred estimation. As an upper bound, we consider a value of 1.8, which accounts also for the effects of delayed spending.[11]

Figure 7 provides a clear illustration of this exercise. Without financial aid, in the five years after the Friuli quake, the GDP per capita would have been between 2 and 4 percent lower; the yearly GDP per capita growth rate would have been between 0.5 and 0.9 percent lower than the synthetic control. The corresponding figures for Irpinia were between 6 and 11 percent, in terms of levels, and between 1.3 and 2.2 percent, in terms of growth rates.

5.4 The long-term impact: growth, TFP and institutions

So far, we have documented that the two earthquakes, after taking into account the aid inflows, had negative short-term consequences in the affected areas. In the long-term, however, we detect opposite large-scale effects on the GDP per capita. These findings are consistent with the theoretical predictions described in Section 2 according to which the quake is expected to have a restrictive short-run effect while the long-run one is undetermined. In the latter case, a virtuous reconstruction might improve private capital stock, public infrastructure, and less tangible production factors thus raising the production frontier; however, the earthquake might also destroy social ties and the aids may spur corruption and deteriorate the local quality of institutions. In this Section, we

[10] Albala-Bertrand (1993), in one of the first attempts to empirically describe the macroeconomic dynamics of natural disasters, found a positive (though modest) impact on GDP growth. See Cavallo and Noy (2011) for a thoughtful review of the literature.

[11] In detail, Acconcia et al. (2013) obtain the value of 1.8 by adding up the coefficients on the contemporaneous and one-year delayed spending variable, after having corrected for the impact of the first delay in the value added.

focus on the long-run outcome and offer a deeper insight on the transmission channels of the effects from the quake to the GDP per capita.

We start with a traditional growth accounting exercise. The production function is described by a Cobb-Douglas technology $Y = AK^{\alpha}L^{1\text{-}\beta}$ where Y is the GDP, A is the total factor productivity or Solow residual, K denotes the capital input, L is the labor input and α and β are the capital and labor's shares, respectively. We then decompose the GDP growth as:

$$\frac{\Delta Y}{Y} = \frac{\Delta A}{A} + \hat{\alpha}\frac{\Delta K}{K} + \hat{\beta}\frac{\Delta L}{L}$$

where $\hat{\alpha}$ and $\hat{\beta}$ are the estimated parameters the TFP growth is computed residually. According to a standard Cobb-Douglas regression, whose results are reported in Table 5, we cannot reject the constant-return-to-scale hypothesis; and the labor share is slightly below 0.7 while the capital share equals 0.3.

Table 6 reports the growth accounting distinguishing between factor accumulation and productivity and comparing the results of the treated area with those of the synthetic control. The exercise encompasses the 20 years after the quake.[12] With regard to Friuli-Venezia Giulia, the difference in the GDP per capita growth translates to a gap in the GDP growth. The evidence on labor input dynamics is consistent with the outflows migration conjecture[13] while the accumulation of capital stock was substantially similar with respect to the control group. However, the most interesting finding regards the TFP whose comparatively higher growth (39 percent, nearly 20 percentage points above the synthetic control) largely explains the positive gap in the GDP growth. In our empirical setting, the Solow residual captures the quality of private and public physical capital, social capital and other intangible infrastructures for which we do not have data. Thus, it emerges that after the quake there was an improvement in these factors pushing up growth.

Turning to the Irpinia, the difference in the GDP growth was smaller than that in the GDP per capita. Moreover, we find that in the treated area the labor input dynamics is weaker and the capital accumulation is more intense. As far as the TFP growth is concerned, we detect a specular case with respect to the Friuli: the negative gap in GDP growth is mostly due to the lower TFP growth (18 percent, about 5 points less than in the synthetic control) that, in turn, signals deterioration in the underlying variables.

Summing up, the long-term differences in GDP between treated regions and synthetic controls broadly mirrors differences in TFP growth after the quake. These differences, in turn, are likely to reflect the different evolutions of the quality of institutions (as well as the unobserved quality of private and public capital). The prevailing empirical literature supports this argument. With no claim of being

[12] CRENOS reports consistent time-series of regional capital stock (reconstructed through the perpetual inventory method) for the period 1970-1994. We extended this series forward using data regarding the investments and assuming a (data-driven) depreciation rate of 6.5 percent.

[13] We focus on labor units instead of population because migration usually regards working-age people.

exhaustive, Mauro (1995) documents the (negative) impact of corruption on economic growth; Knack and Keefer (1997) show the role of civic norms in shaping economic performance; Hall and Jones (1999) argue that cross-country variation in productivity is largely due to differences in "social infrastructures"; finally, Jones and Olken (2005) suggest that politicians' quality plays an important role in enacting the right policies and affecting economic performance. Our data are consistent with these findings. First, we averaged the TFP over the '70s, the '80s and the '90s to smooth the year-to-year fluctuations. Then, we regressed the growth rate of the TFP on the analogous growth rate of our proxy for the overall institutional quality, controlling for time fixed effects and the initial TFP level (following e.g. Griffith et al., 2004). The parameter of the institutional quality turned out to be positive and significant at 1 percent level (results are available upon request).

Against this background, in what follows we offer further evidence supporting the idea that divergent post-quake trends in the two treated areas are related to changes in the institutional quality and that the pre-quake quality of institutions may affect the prevalence of a positive scenario over a negative one. Figure 8 reports a simple graphical analysis which mirrors a difference-in-difference type evidence: each histogram represents the difference in the variable of interest between the treated region and the control group, before and after the quake.[14] Moreover, we rely on two control groups: all the Italian regions (which are useful to compare the treated region with respect to the national mean and trend) and the baseline synthetic control (which is chosen, by construction, to be similar to the treated region before the quake). Indeed, the difference between the treated region and the synthetic control is smaller than that between the treated region and the national mean for most of the institutional variables. From the graphical inspections two key facts arise. First, the quality of institutions before the quake in Irpinia was lower with respect to the mean of all the other Italian regions while the picture is completely reversed in Friuli. Second, the deterioration of the quality of institutions after the quake in Irpinia was stronger with respect to both the national trend and the synthetic control trend. Indeed, the corruption and fraud rate (Figure 8a) and the fraction of politicians involved in scandals (Figure 8b) increased markedly and the civic engagement (proxied by electoral turnout and newspaper readership; Figures 8c and 8d) declined, relatively to the control units. Almost completely different results were observed in Friuli where civic attitudes and social participation increased (relatively to both the national figure and the synthetic control) whereas the corruption and fraud rate decreased; a partially conflicting result concerns the fraction of politicians involved in scandals that has moderately increased.[15]

[14] The institutional variables (corruption and fraud rate, politicians involved in scandals, electoral turnout and newspaper readership) are normalized to guarantee more comparability across them. Moreover, we consider for each variable the mean value in the 5-years before the quake and the mean value in the 20-years after the quake. This choice is dictated by the fact that institutional variables tend to move smoothly across time and year-to-year fluctuations are less informative.

[15] These pieces of evidence are also in line with anecdotal evidence on the reconstructions after the two quakes. See http://www.corriere.it/europeo/cronache/2010/14/europeo-14-sergio-rizzo-professionisti-

6. Concluding remarks

Natural disasters affect thousands of people each year in every corner of the world. Though the images of destruction attract much attention from the media and the public, we still lack solid empirical evidence regarding the economic consequences of these disasters, mainly due to data limitations. In this paper, we start by illustrating the basic forces that drive the economy after a quake and the different scenarios that may arise. Then, we use a synthetic control empirical strategy and find that similarly disruptive quakes generated large and opposite long-term effects on the GDP per capita. These outcomes largely reflect differences in the TFP.

We argue that the institutional setting significantly affects these patterns. Better pre-quake institutions might be more capable of withstanding the shock and managing the recovery period. Moreover, when institutions are weaker, the huge inflow of financial aid is more likely to be misallocated and diverted to less productive activities, negatively affecting the technical efficiency of the economy and further deteriorating institutional quality. Our empirical evidence supports this analysis. Overall, in the long-term, the earthquake might exacerbate regional disparities in both economic and social development.

From a policy perspective, we have shown that financial aid plays an important role in the recovery period, favoring immediate reconstruction and attenuating the GDP drop. However, the design of the aid is crucial. Especially when a natural disaster hits an area with weak institutions – i.e. a higher intensity of corruption, lower civic engagement and, plausibly, less familiarity and experience in the management of public funds – aid supervisors must set proper rules to avoid the irregular use of resources. Indeed, an improper use of financial aid may not only be less productive but also may have detrimental effects in the long run.

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Tables

Table 1. Descriptive statistics

	All sample				Friuli-Venezia Giulia		Campania and Basilicata	
Variables:	mean	s.d.	min	max	mean	s.d.	mean	s.d.
GDP per capita (euro 1985)	7,210	2,371	3,139	13,069	7,783	1,854	4,791	752
Investments/GDP	0.268	0.078	0.144	0.659	0.258	0.041	0.320	0.057
Share agriculture	0.058	0.028	0.013	0.161	0.039	0.004	0.066	0.017
Share industry	0.330	0.078	0.174	0.546	0.357	0.030	0.288	0.032
Share market services	0.418	0.057	0.216	0.565	0.430	0.038	0.407	0.042
Share non market services	0.195	0.050	0.102	0.298	0.174	0.010	0.239	0.018
Population density	1.747	1.032	0.331	4.307	1.545	0.024	2.611	0.106
Share university degree	0.030	0.014	0.010	0.072	0.033	0.016	0.029	0.014
Corruption and fraud rate (1)	4.16	3.376	0.97	27.49	2.97	1.937	7.69	7.261
Share of politicians involved in scandals	0.209	0.141	0.000	1.000	0.257	0.152	0.289	0.106
Electoral turnout (Italy = 100)	98.3	9.820	74.0	128.3	104.4	3.144	86.1	3.055
Diffusion of newspaper readership (2)	71.0	45.27	9.3	322.8	112.7	52.33	32.8	5.863
Overall institutional quality (3)	0.000	1.337	-5.332	2.711	0.681	0.756	-1.843	1.422

All variables are drawn from Crenos with the exception of share of university degree (Census), corruption and fraud rate (AJS), electoral turnout (Ministry of Interior), diffusion of newspapers readership (ADS) and share of politicians involved in scandals (RdB). (1) Crimes per thousand of labor units; (2) newspapers per thousand of inhabitants; (3) first principal component of the variables: corruption and fraud rate, electoral turnout, diffusion of newspaper readership and share of politicians involved in scandals.

Table 2. Donors

Earthquake	Region in the synthetic control (weights)	MSPE
Friuli (Friuli-Venezia Giulia)	Piedmont (0.002) Liguria (0.043) Tuscany (0.413) Umbria (0.404) Latium (0.034) Campania (0.078) Basilicata (0.026)	204.9
Irpinia (Campania and Basilicata)	Liguria (0.101) Molise (0.332) Calabria (0.566)	54.6

The weights of the synthetic controls are chosen to minimize the distance with Friuli-Venezia Giulia (top panel) and Campania and Basilicata (bottom panel) in terms of GDP per capita and predictors of its subsequent growth. See Section 3 for a methodological discussion.

Table 3. Balancing properties

	Panel A: Friuli		
	Treated area	Synthetic control	All donors
GDP per capita	5,432	5,434	5,459
Investment/GDP	0.310	0.311	0.292
Share of graduates	0.016	0.017	0.015
Population density	1.561	1.563	2.238
Share VA agriculture	0.038	0.053	0.068
Share VA industry	0.393	0.392	0.373
Share VA market services	0.383	0.376	0.383
Share VA non market services	0.186	0.178	0.177
Overall institutional quality	0.682	0.683	0.276
	Panel B: Irpinia		
	Treated area	Synthetic control	All donors
GDP per capita	4,127	4,169	5,938
Investment/GDP	0.337	0.373	0.269
Share of graduates	0.019	0.019	0.019
Population density	2.527	1.354	2.378
Share VA agriculture	0.081	0.090	0.061
Share VA industry	0.311	0.275	0.363
Share VA market services	0.382	0.403	0.394
Share VA non market services	0.226	0.230	0.182
Overall institutional quality	-0.641	-0.855	0.286

The table reports the characteristics of the treated regions (Friuli-Venezia Giulia in panel A and Campania and Basilicata in panel B), their synthetic controls and all the regions in the set of donors during the 5 years before each quake. The weights used to build the synthetic controls are presented in Table 2.

Table 4. Other donors in the robustness checks

	Friuli						Irpinia					
Figures:	6a	6b	6c	6d	6e	6f	6a	6b	6c	6d	6e	6f
Piedmont	0.0	2.5	9.2	0.0	0.0	2.5	0.0	0.0	0.0	0.0	0.0	0.0
Valle d'Aosta	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lombardy	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0
Trentino-Alto Adige	0.0	0.0	0.0	0.0	3.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Veneto	0.0	0.0	0.0	0.0	21.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Friuli-Venezia Giulia	-	-	-	-	-	-	0.0	0.0	0.0	0.0	0.0	0.0
Liguria	0.0	9.6	0.0	0.0	7.0	9.6	10.1	7.1	8.2	10.6	0.0	0.0
Emilia-Romagna	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tuscany	19.9	41.5	0.0	0.0	7.6	41.8	0.0	0.0	0.0	0.0	0.0	0.0
Umbria	45.7	32.1	45.2	0.0	39.1	32.1	0.0	0.0	0.0	0.0	0.0	0.0
Marche	25.7	0.3	33.0	100.0	18.9	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Latium	7.5	0.0	12.5	0.0	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Abruzzi	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.2	0.0
Molise	1.1	0.0	0.0	0.0	0.0	0.0	33.2	50.0	47.4	33.9	16.3	0.0
Campania	0.0	5.2	0.0	0.0	0.0	5.2	-	-	-	-	-	-
Apulia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.4	44.4	0.0	0.0	0.0
Basilicata	0.0	8.7	0.0	0.0	0.0	8.8	-	-	-	-	-	-
Calabria	0.0	0.0	0.0	0.0	0.0	0.0	56.6	29.4	0.0	55.5	61.4	0.0
Sicily	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	94.6
Sardinia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.2	5.4

The table reports the weights of the synthetic controls, chosen to minimize the distance with Friuli-Venezia Giulia (left panel) and Campania and Basilicata (right panel) in terms of GDP per capita and predictors of its subsequent growth. Each column refers to a different specification (see section 5.2 and Figure 6a-6f for details).

Table 5. Estimated factor shares in the Cobb-Douglas regression

Dependent variable:	$\ln GDP_t - \ln GDP_{t-1}$
$\ln K_t - \ln K_{t-1}$	0.306***
	(0.071)
$\ln L_t - \ln L_{t-1}$	0.687***
	(0.054)
Constant	0.011***
	(0.002)
Obs.	600
R^2	0.308
Test: $\alpha + \beta = 1$	0.01
	(0.924)

The table reports the results of production function estimates across Italian regions during the period 1970-2000. Robust standard errors are in parenthesis; *, **, and *** denote coefficients significantly different from zero at the 90%, 95% and 99% confidence level, respectively. The last row of the table reports the Wald tests for the factor shares to sum up to unity (p-value in parenthesis).

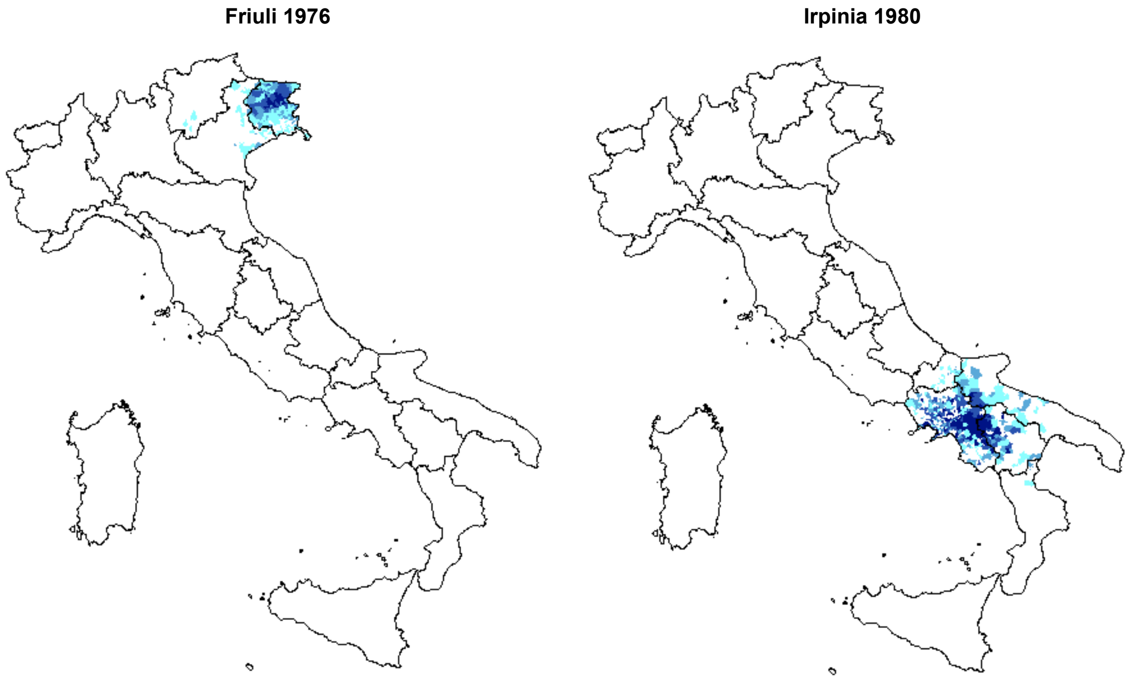
Table 6. Growth accounting

	Panel A: Friuli		
	Treated area	Synthetic control	Difference
GDP per capita growth	69.6	46.4	23.2
GDP growth	63.5	48.5	15.1
Contribution:			
Labour units	1.9	5.5	-3.6
Capital stock	22.7	23.7	-1.0
TFP	38.9	19.2	19.7
	Panel B: Irpinia		
	Treated area	Synthetic control	Difference
GDP per capita growth	29.7	41.6	-11.9
GDP growth	36.9	39.6	-2.7
Contribution:			
Labour units	-2.7	-1.3	-1.4
Capital stock	21.5	17.9	3.6
TFP	18.1	23.0	-4.9

Figures refer to the growth rates in the 20 years after the quake. Contributions of labour and capital have been computed using coefficients estimated in Table 4; contribution of the TFP is determined residually.

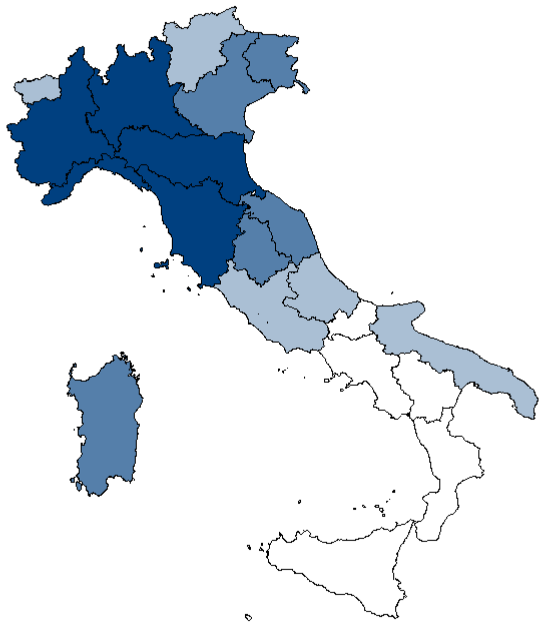
Figures

Figure 1. The areas hit by the two earthquakes



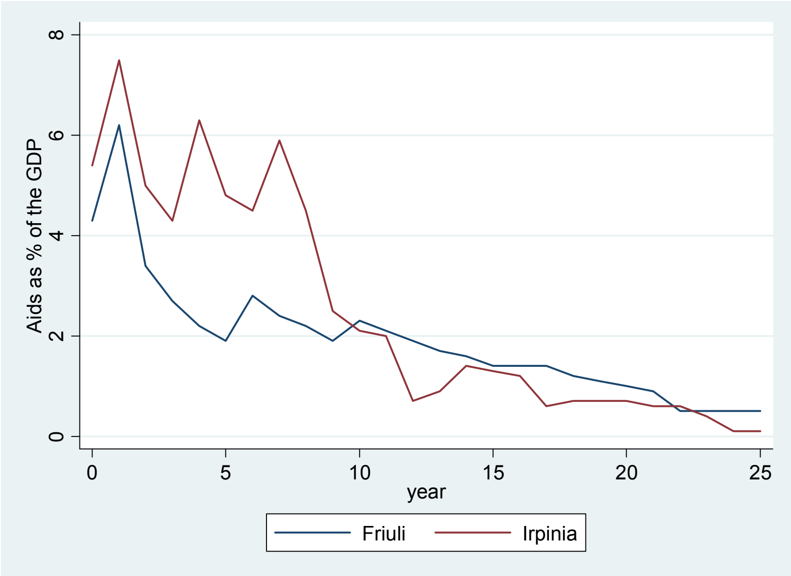
Source: INGV and Istat. Each map shows the quartiles of the earthquake intensity on the Mercalli scale for all municipalities where the intensity was at least 6. Darker colors indicate more severe intensity.

Figure 2. Quality of institutions in the first half of the 70s



Source: authors elaborations on data from AJS, Ministry of Interior, ADS and RdB. The map shows the quartiles of the overall institutional quality index. Darker colors indicate better quality of local institutions.

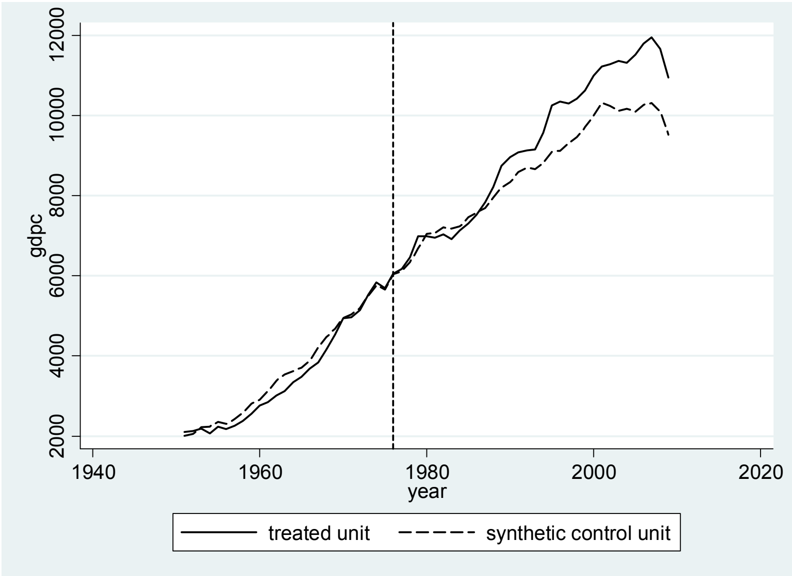
Figure 3. Public transfer over GDP



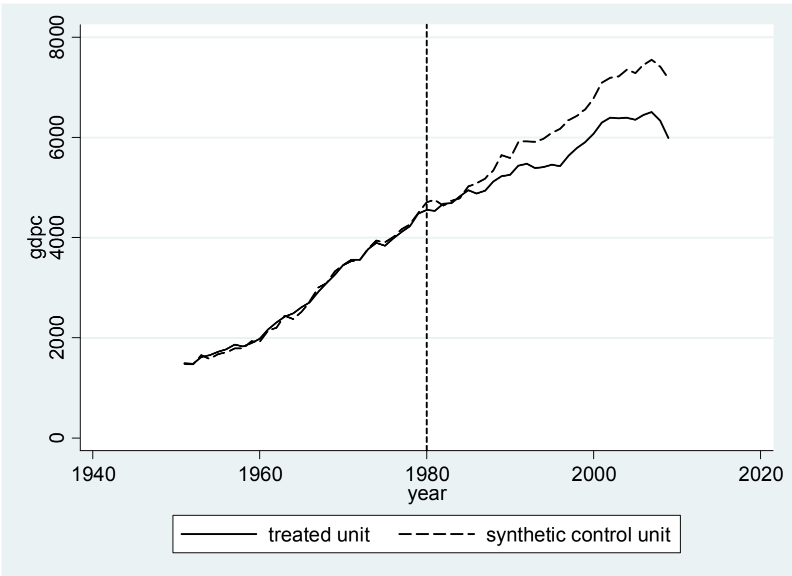
The figure represents the amount of transfer as % of the local GDP; the x-axis represents the number of year after the quake. Source: Italian parliament (see http://documenti.camera.it/leg16/dossier/testi/Am0065.htm) and Crenos.

Figure 4. Baseline results: GDP per capita 1951-2009

Panel A: Friuli



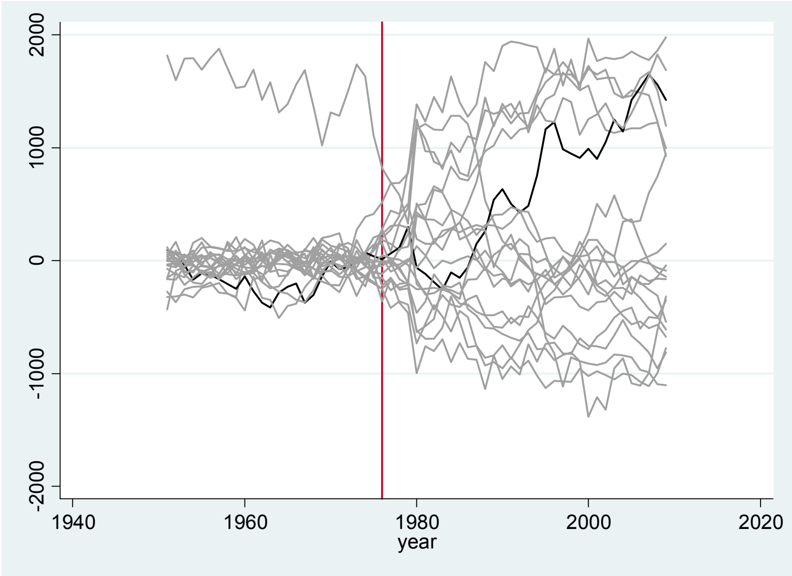
Panel B: Irpinia



The graphs report the GDP per capita of the treated regions (Friuli-Venezia Giulia in panel A and Campania and Basilicata in panel B) and of the respective synthetic control. The weights used to build the synthetic controls are presented in Table 2.

Figure 5. Placebo test

Panel A: Friuli



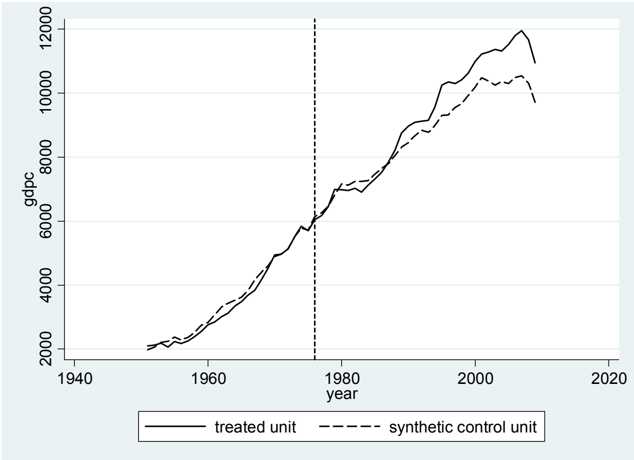
Panel B: Irpinia

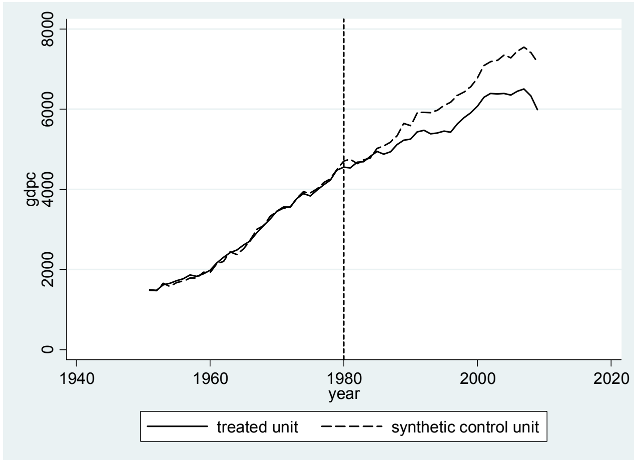
The graphs report the difference, in terms of GDP per capita, between the treated regions (Friuli-Venezia Giulia in panel A and Campania and Basilicata in panel B) and their synthetic controls (black lines) as well the same differences for all other Italian regions (placebo in grey lines).

Figure 6. Robustness checks

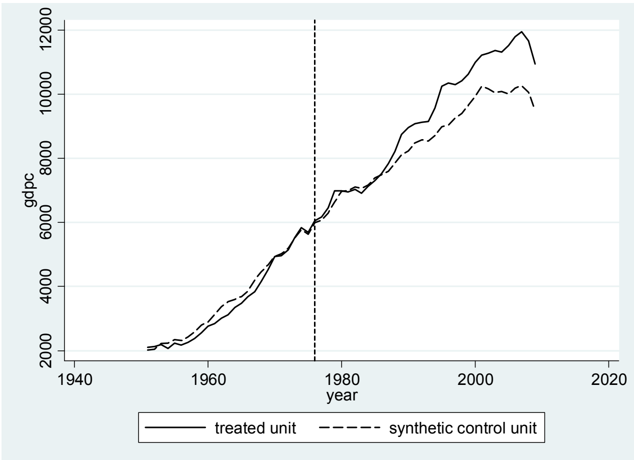
Friuli | Irpinia

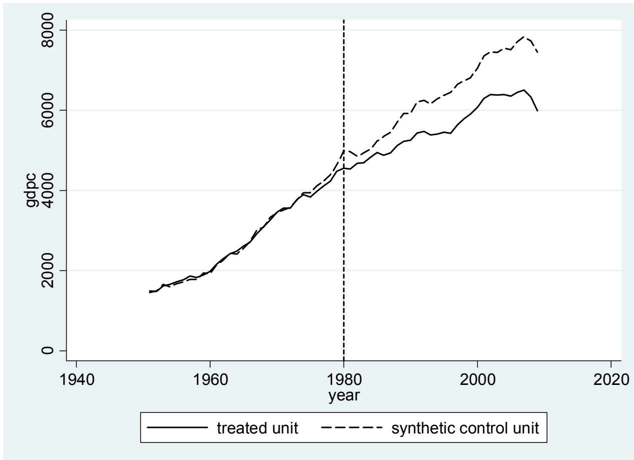
Panel A: Excluding other treated regions in a 10-year window



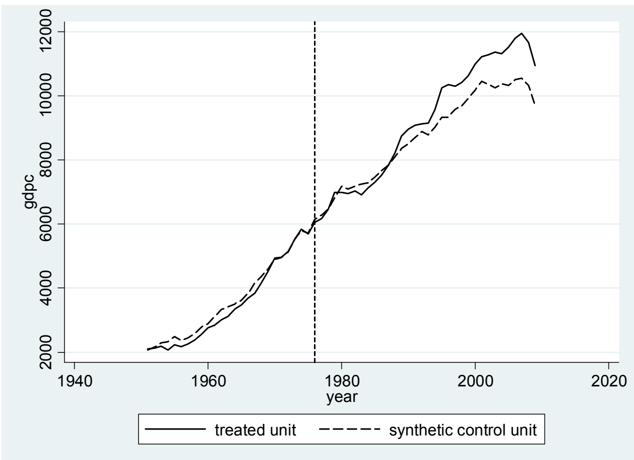


Panel B: Cross validation





Panel C: Excluding main donor



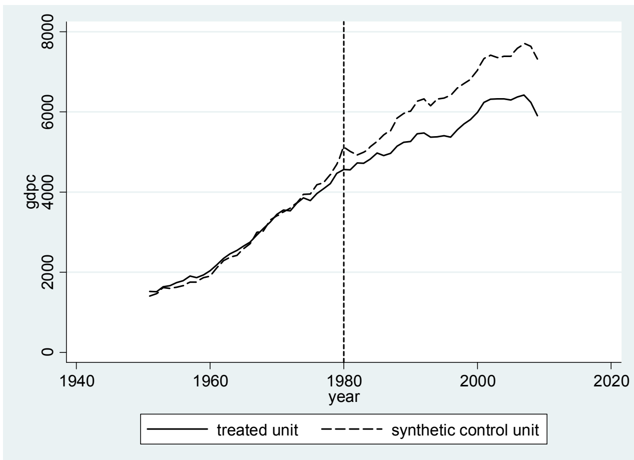
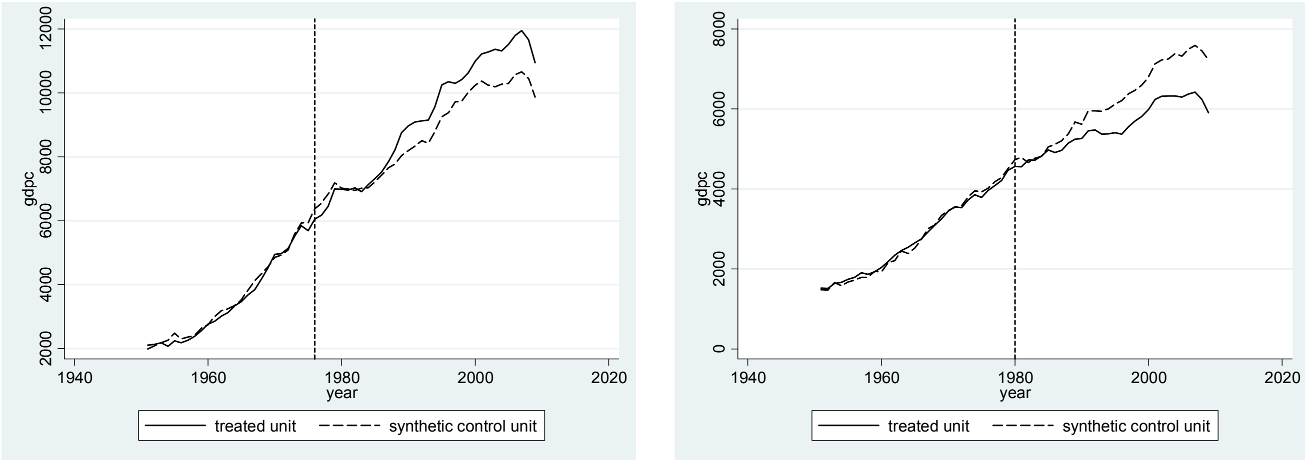


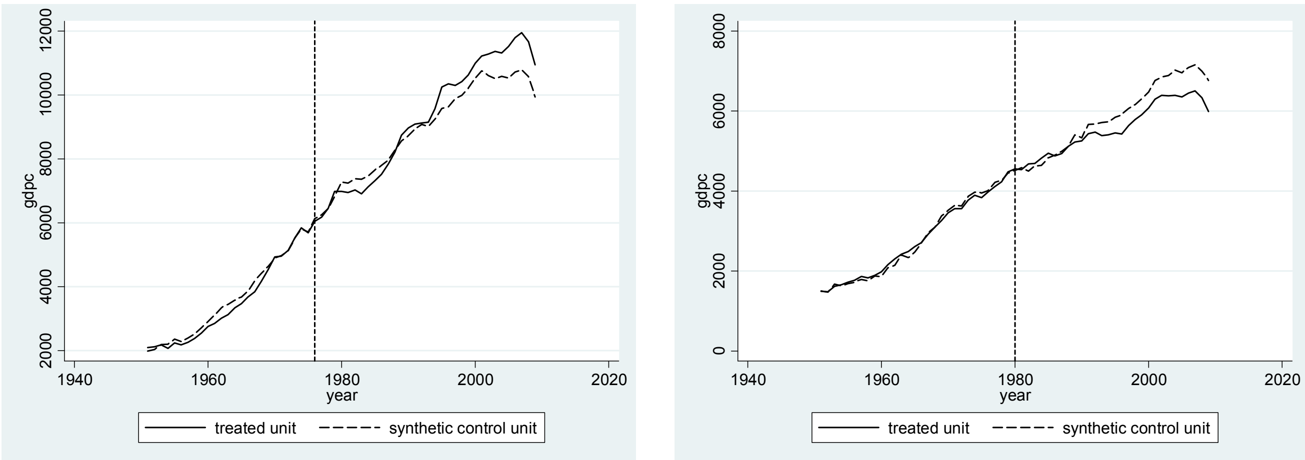
Figure 6. Robustness checks (continued)

Friuli | Irpinia

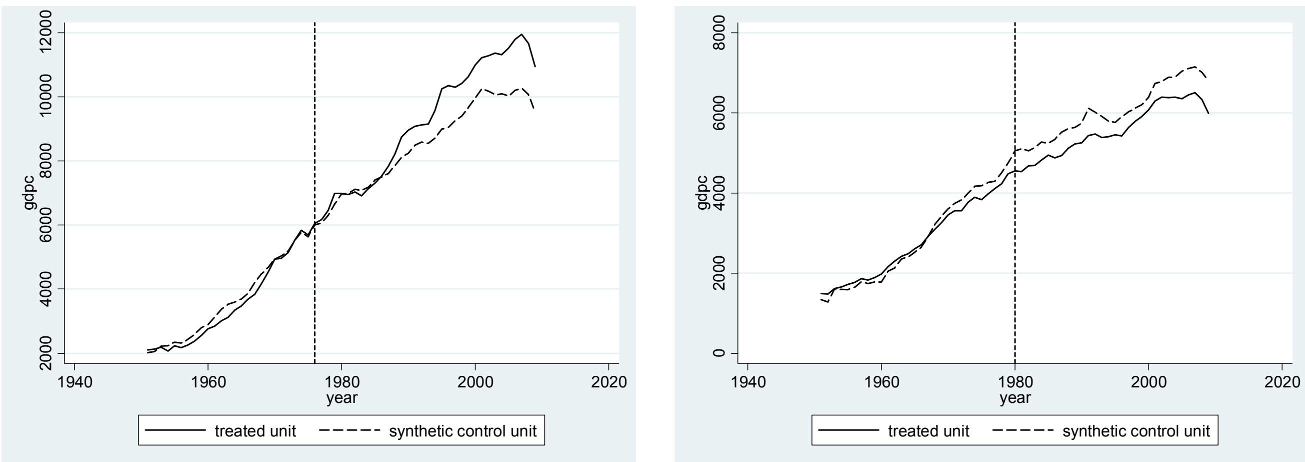
Panel D: Confounding factors



Panel E: Donors among regions of the same area



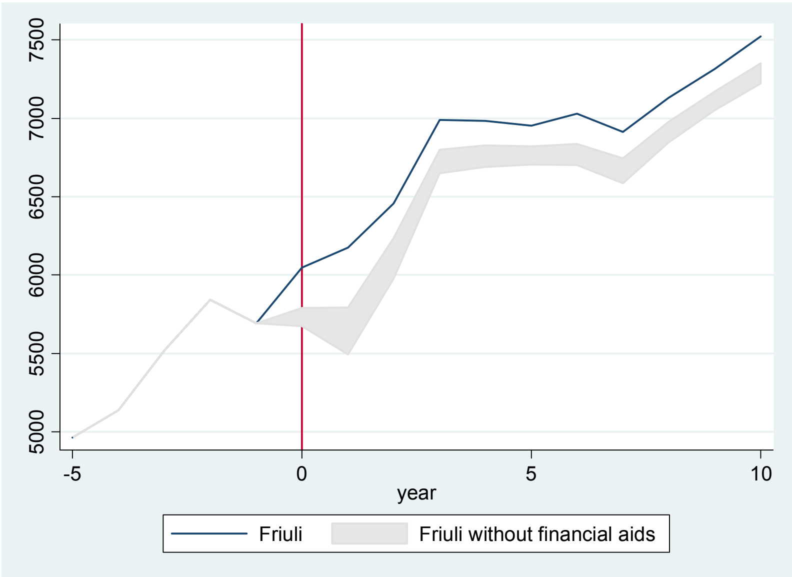
Panel F: Excluding bordering regions



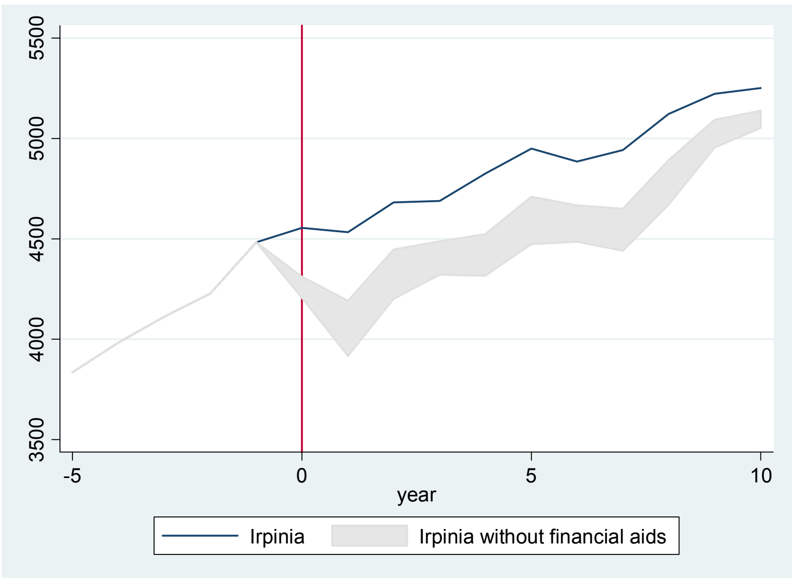
See subsection 5.2 for a discussion of each robustness check.

Figure 7. The role of financial aids in the short-term

Friuli



Irpinia

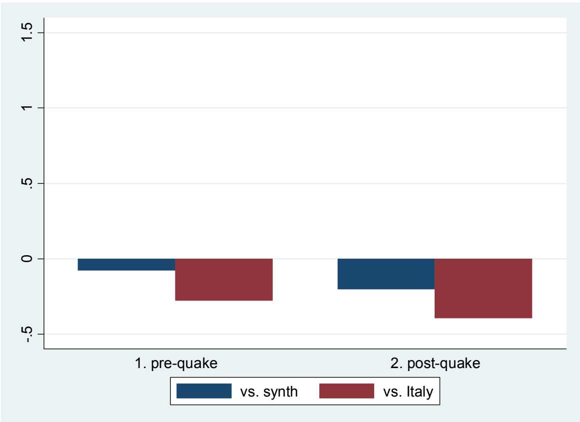


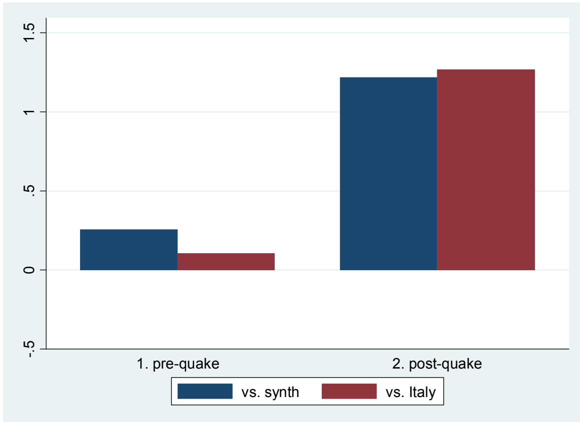
The shaded area indicate the GDP of the treated region without financial aids: the fiscal multiplier is assumed to be equal to 1 as lower bound and to 1.8 (including the effects of lagged spending) as upper bound.

Figure 8. Comparison of institutional quality before- and after-quake

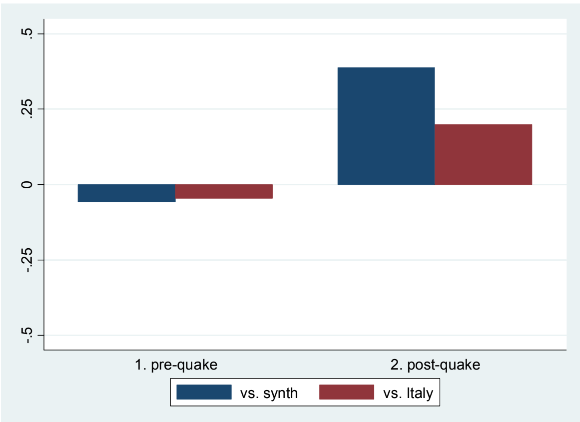
Friuli	Irpinia

Panel A: Corruption and fraud rate





Panel B: Politicians involved in scandals



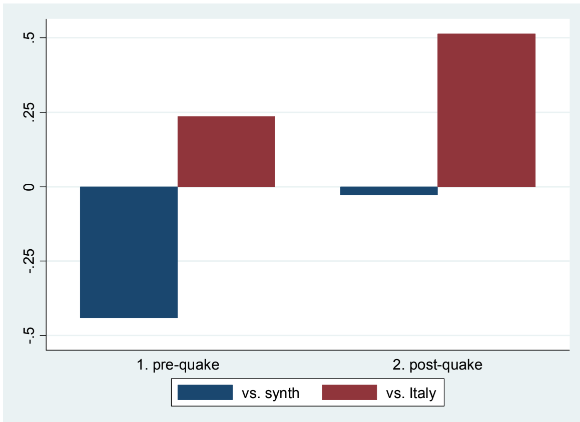
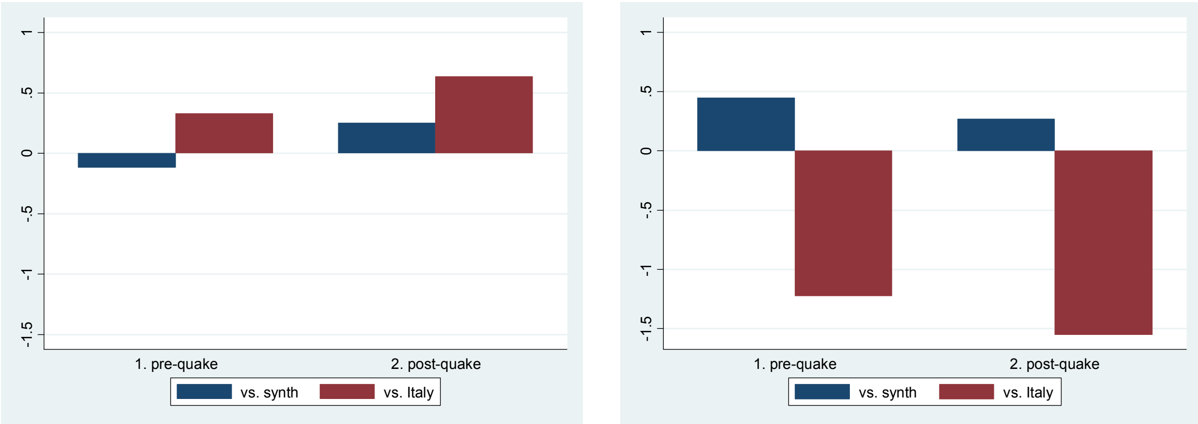


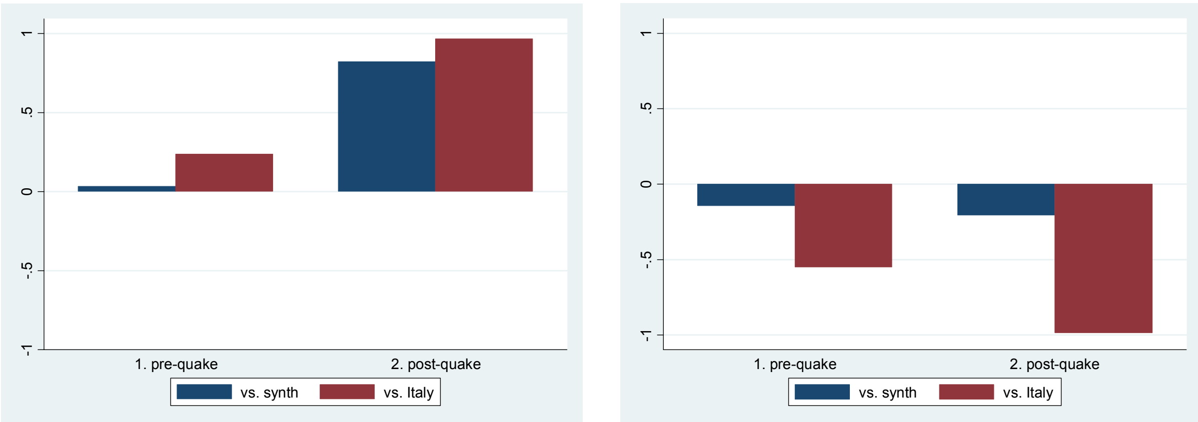
Figure 8. Comparison of institutional quality before- and after-quake (continued)

Friuli | Irpinia

Panel C: Electoral turnout



Panel D: Diffusion of newspaper readership



Each histogram represents the difference between the treated region (either Friuli or Irpinia) and the control unit (either synthetic control or the national figure).

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