

Beyond Richter: A study on institutional quality and economic recovery from earthquakes in Italy

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Abstract: This research paper aims to investigate the relationship between a society's institutional quality and its resilience to economic shocks. To explore this topic, we utilize the natural occurrence of earthquakes to simulate localized shock events. Specifically, we focus on the Abruzzo earthquake of 2009 and the Emilia-Romagna earthquake of 2012, both of which were of similar magnitude on the Richter scale. Abruzzo, located in southern Italy, exhibits low institutional quality, while Emilia-Romagna, situated in the north of Italy, boasts high institutional quality. Furthermore, Abruzzo stands out as one of the economically strongest regions of Southern Italy, which partly mitigates economic disparities between the studied regions and further highlights differences in institutional quality when pursuing our comparisons. By applying the synthetic control method developed by Abadie and Gardeazabal (2003), we construct comparable peers by using the regions that avoided any disaster event. Consequently, the paper analyzes the difference in economic outcomes post-treatment between the regions of interest and their non treated peers. The outcomes revealed unexpected results for the Abruzzo region, as its performance post-treatment was comparatively better than its synthetic control in the short-term. However, the results failed to hold under robustness tests, implying non-significant effects of the earthquakes. Further studies could pursue more extensive models with more data points, as well as studies on municipal-level outcomes.

Keywords: Institutional quality, Economic growth, Natural disasters, Synthetic control method, Abruzzo, Emilia-Romagna, Italy, Earthquake

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1 Introduction

Situated at the fault line of the African and Eurasian plates, Italy has historically endured significant seismic activity, resulting in frequent and devastating earthquakes throughout its existence¹. These earthquakes pose substantial challenges to regional economies, causing widespread destruction, disruption, and displacement across the country.

As described by Musolini (2018), Italy has long been characterized by a pronounced cultural and economic divide between its northern and southern regions. The northern part of the country is notably more industrialized and benefits from higher institutional quality, whereas the South of Italy has long been plagued by corruption, organized crime, and a lack of governmental support. This disparity makes Italy an ideal case study for examining the relationship between institutional quality and post-disaster recovery, as demonstrated by Barone and Mocetti (2014). Their research highlights the stark contrast in recovery outcomes between the Friuli and Irpinia earthquakes of the 1970s and 1980s, emphasizing the detrimental effects of lower institutional quality on long-term economic development, particularly evident in the southern region of Irpinia.

Building upon the work of Barone and Moretti (2014), this article aims to examine the post-disaster recovery of two more recent earthquakes: one in the southern region of Abruzzo and another in the northern region of Emilia-Romagna. These case studies provide a contemporary perspective on the relationship between institutional quality and recovery outcomes. Furthermore, our paper adds an emphasized perspective on the differences in institutional quality, noting that the economic disparities between the examined regions are less pronounced than those discussed in other studies on similar topics in Italy.

Previous research efforts have showcased a strong relationship between weak institutional quality and society's ability to recover from economic shocks, papers on this matter are explored in-depth within the literature review section of this paper. By analyzing GDP per capita as an outcome variable and employing the synthetic control method to account for counterfactual GDP trajectories, our study seeks to evaluate the direct economic consequences of earthquakes while controlling for broader societal factors. This approach allows us to assess the differential effects of earthquakes on regions with varying levels of institutional quality.

However, the results of our analysis of Emilia-Romagna and Abruzzo yield inconclusive findings.

¹According to TIME (2016)

While initial models suggested positive effects, further robustness testing revealed inconsistencies and failed to provide reliable inference. Additionally, the exclusion of certain regions significantly impacted the model’s reliability, underscoring the influential role of specific donor regions on long-term recovery effects. In the case of Abruzzo, short-term positive trends following the earthquake were observed, but long-term effects appeared to be negative. Overall, our analysis remains inconclusive regarding the economic impacts of earthquakes in both regions.

Several limitations of our models must be acknowledged. Amongst these are the gaps in pre-treatment fit, particularly for Abruzzo. There were also challenges associated with disparities in our control variables in Emilia-Romagna, which hindered the construction of a synthetic control region with comparable characteristics. Furthermore, the absence of commonly used variables in synthetic control analysis such as investment rates and the share of graduates posed additional challenges. It is also plausible that the effect size of the earthquakes were too small for a regional-level study. This suggests that a municipal-level study might have provided more nuanced insights than a regional-level analysis.

The remainder of this paper is structured as follows: section two provides background information on natural disasters and their economic consequences, as well as the north-south divide in Italy. Section three outlines the research objectives and rationale for choosing Italy as the study context. Section four offers a comprehensive review of relevant literature. Section five explains our methodological approach, the construction of synthetic control units and the data used. Section six presents the results of our analysis, followed by a discussion of their implications and limitations in section seven. Finally, section eight offers concluding remarks drawn from our analysis.

2 Background

2.1 Natural disasters and economic fallout

Natural disasters can have serious impacts on local economies. Damage to critical infrastructure, loss of capital, and human casualties all contribute to the economic repercussions. Short-term outcomes are typically easy to quantify as the immediate destruction of machinery and infrastructure entails a straightforward assessment of economic losses. Additionally, any decrease in the local workforce directly affects wages and production capacity. However, the long-term effects on the economy are more nuanced, influenced by factors such as communities’

ability to mitigate and recover from the disaster. The capacity to rebuild and adapt post-disaster plays a significant role in shaping the lasting economic impact. Various measures can be taken to mitigate capital and human losses caused by natural disasters. Examples include reinforcing buildings, implementing special designs for local infrastructure, and constructing flood barriers around ports. However, for these measures to be effectively implemented, local communities need a certain degree of prior economic prosperity and institutional quality. Economic capacity is crucial for communities to afford the capital investments required for necessary preparations, while institutional quality is pivotal for making coordinated decisions both before, during, and after disaster events. External factors, such as international aid and partnerships, can play a crucial role in economic recovery. In the short-term, aid can provide essential support for saving and rebuilding damaged capital, while also facilitating the implementation of vital infrastructure necessary for economic activity to resurface.

According to the Solow (1956) a natural disaster like an earthquake can be seen as a temporary loss of both capital and labor resources. While this setback initially moves the economy away from its steady state, it theoretically leads to an accelerated growth period post-disaster. In simple terms, the reduced capital stock tends to boost the growth rate of capital, thus driving overall production growth. Other factors such as technological advancement and institutional quality also affects the pace and magnitude of growth.

2.2 Earthquake event in Abruzzo and Emilia-Romagna

Earthquakes occur more frequently in certain geographic areas and can result in varying degrees of damage. Movements of the Earth's tectonic plates are the primary cause of earthquake events. Regions located at the intersection or overlap of these plates are particularly vulnerable to earthquakes. The Italian peninsula, located at the convergence of the Eurasian and African plates, experiences numerous earthquake events annually. Over the past two millennia, more than 400 earthquakes with magnitudes exceeding 5.5 on the Richter scale have been documented in the region. Some of these events have resulted in the loss of up to 70,000 lives².

One of the most devastating recent occurrences was the 2009 earthquake that struck the Abruzzo region, particularly affecting the city of L'Aquila, situated near the region's center. This event resulted in over 300 fatalities and extensive damage to critical infrastructure. With a magnitude

²Data from Quantectum Earthquake Forecasting Center

of 6.3, it constituted a significant seismic event³. The region itself is home to over 1.3 million inhabitants, with 69 thousand residing in L'Aquila.

A couple of years later, in 2012, a similarly sized earthquake struck the northern region of Emilia-Romagna. The epicenter of the event was located between three cities, each with populations ranging from 6 to 15 thousand people. Two aftershocks followed within an hour of the main event. The earthquake struck with a magnitude of 6.1 on the Richter scale and claimed 7 lives⁴.

2.3 Italy and the north-south divide

Italy has since unification been marked by a notable north-south divide across cultural, social, and economic realms. The northern regions have historically held sway in terms of income, productivity, and various economic metrics, with a majority of the country's manufacturing industries concentrated there. According to Musolini (2018), proximity to other European markets has further bolstered the north's economic dominance, reflected in its higher GDP per capita and substantial share of the Italian export industry. Conversely, the south lags behind with lower GDP levels, limited industrial development, and diminished productivity, resulting in a persistent GDP gap of approximately 55%.

A primary factor often cited to explain this north-south disparity is the differing levels of industrialization. Despite national initiatives to foster industrial growth, the south has consistently been behind in this regard. Moreover, there is also lower levels of globalization and exports in the south, which in part can be attributed to its initial industrial underdevelopment. However, it's noteworthy that southern firms also allocate less expenditure to research and development (R&D) compared to their northern counterparts, potentially hampering their long-term competitiveness. Geographical isolation from major European export markets further exacerbates the south's economic challenges, compounded by inadequate air, road, and rail transport infrastructure. Even existing infrastructure in the south is shown to be less efficient than that of the north. This inferior infrastructure extends to essential services like information and communications technology (ICT), with the south experiencing lower internet coverage and PC usage rates.

These economic disparities can be seen in light of divergences in services and institutional

³According to World Data Info

⁴According to World Data Info

frameworks, which deepen the north-south divide. For instance, regional disparities in the judicial system are stark, with trials in southern regions often enduring over four years, while the north typically boasts shorter trial durations. Bureaucratic processes are similarly less efficient, as indicated by the Doing Business Survey. The prevalence of organized crime in the south also historically posed challenges, impeding entrepreneurship and firm growth through extortion and hindrances in securing public contracts. This criminal presence also erodes social capital and creates distrust in public institutions within affected communities. Studies also highlight the lower level of the institutional quality in Southern Italy, as shown by the institutional quality index.

However, attributing institutions as causal factors poses challenges due to endogeneity. The correlation between institutional quality and economic development can confound their individual effects. Nonetheless, evidence addressing endogeneity through instrumental variables, regional variation, and historical data demonstrates that institutional disparities do significantly account for regional economic divergence in Italy.

In the context of natural disasters, lower institutional quality in the south may hinder effective implementation of recovery programs and allocation of relief funds, while also amplifying the risk of rent-seeking behavior. Consequently, within-country natural disasters offer a natural experiment to examine the impact of institutions on economic development and recovery processes.

3 Research purpose

In this section, we delineate both the goals we aim to achieve by pursuing this research topic and the expectations we have for our results.

3.1 Goal of research

This paper aims to examine the influence of institutional quality on the economic outcome and the associated recovery capacity subsequent to an economic shock. Specifically, natural disaster events in the form of earthquakes are used as the shock-treatment. To pursue this study, we investigate the earthquakes that hit Abruzzo (region of southern Italy) in 2009 and Emilia-Romagna (region of northern Italy) in 2012. The size and breath of destruction following these events were comparably similar.

By using within-country data, we mitigate potential confounding variables stemming from cross-country disparities. While institutional quality varies within Italy, the national institutional frameworks remain consistent, minimizing the impact of unobservable factors. The disparity in institutional quality between the regions is quite large, with Abruzzo boasting far weaker institutions according to the IQI. However, both regions are heavily industrialized. Abruzzo is considered one of the economically strongest regions of southern Italy, thus, the minimized economic disparity coupled with the large difference in institutions, allows for a clear insight into our research question when comparing the outcomes post-treatment.

Leveraging the sudden disasters events and the following destruction of capital stock, we aim to identify variation in economic growth amongst the treated regions.

3.2 Hypothesis

Our hypothesis aims to observe divergent outcomes for the northern and southern regions.

Due to its relatively stronger institutional quality, we anticipate that Emilia-Romagna should possess the necessary organization of people and resources to swiftly recover from and withstand any significant economic repercussions of the earthquake. Consequently, we would expect to observe a minimal difference between Emilia-Romagna and its synthetic control post-treatment. As seen in Barone and Mocetti (2014), the northern region could display a positive deviation from its synthetic counterpart, potentially attributed to additional aid to the region combined with its pre-existing economic strength.

Conversely, for Abruzzo, we anticipate observing a substantial negative deviation in relation to its synthetic counterpart. This reasoning stems from the concept of institutional strength and resilience; given that the region harbors relatively weak institutions according to IQI data, it is likely to lack the governmental capacity to orchestrate a significant response to the effects of the disaster event. This absence of a robust response would likely result in more pronounced negative economic consequences, reflected in a comparison of GDP per capita post-treatment to its counterpart.

4 Literature review

Earthquake events have long plagued communities worldwide, with their destructive impacts documented since ancient times. Research across various scientific disciplines has delved into

understanding these phenomena. In this section, our focus is to describe the academic endeavors within relevant fields to our research, as well as to highlight our own academic contribution.

4.1 Research on institutional quality and economic resilience

Research on institutional quality and economic resilience primarily focuses on adverse financial events. The scope of observation varies among research papers. Some delve into economic disparity affecting vast areas, such as significant recessionary periods for economic zones, while others focus on hits affecting restricted areas.

Vast economic shocks, like those witnessed after the global financial crisis, are typically best examined through the lens of larger economic entities. Ezcurra and Rios (2018) provide insight by analyzing the impact of the 2008 Great Recession on the economic zone of the European Union (EU). Given the interconnectedness of capital and financial markets, shocks can swiftly propagate among economies, making the EU particularly vulnerable due to its shared currency and trade system. Employing Spatial Autoregressive and Spatial Durbin models, their paper effectively captured regional spillover effects from the recession. The presented empirical findings underscored a significant link between the quality of government and regional economic resilience. Rios further explored the repercussions of the Great Recession on European economies in his subsequent work with Gianmoena (2020). In contrast to his earlier study, this paper incorporated additional data points such as technological innovation and socio-economic demography. Utilizing the Bayesian Model Averaging technique to address cross-regional resilience, the results once again highlighted the substantial impact of governmental quality on economic resilience.

Localized economic shocks are typically rare due to the interconnected nature of modern-day economies. Nevertheless, the random and sporadic attributes of natural disasters coupled with the restrictiveness of the regions affected by them, makes observing individual disaster events with minimal spillover a productive strategy. Raschky (2008) examines the impact of institutional quality on recovery from natural disasters. The study analyzes various large-scale natural calamities spanning from 1984 to 2004 across diverse regions. The breadth of their research and the diversity of their data enable the derivation of generalized conclusions on the subject. Their conclusive findings suggest a robust correlation between governmental stability and an economy's susceptibility to natural disasters. While economic development offers protection against such events, their data suggests a non-linear relationship between these

variables, indicating diminishing effects over time. Moreover, the study conducted by Bos et al. (2022) delved into an analogous examination of institutional quality and natural disasters across various global regions. Utilizing stochastic frontier models, their research distinctively pinpoints the "optimal" conditions for economies confronting natural disasters. In alignment with the conclusions drawn by Raschky (2008), they ascertain that economic maturity coupled with high institutional quality creates the most favorable conditions for a society to minimize the impact of disaster damages.

4.2 Measuring the economic impact of natural disaster events

Localized economic shocks in the form of natural disasters have also been investigated through narrower lenses, as some papers examine specific events and their impact on particular economies. The methodology for measuring economic effects following disaster events varies across publications. Researchers such as Kroll et al. (1991) investigated the economic impacts of the destructive Loma Prieta earthquake of 1989 by analyzing business data before and after the event. Although their paper lacked statistical methods, it recounted observable economic effects from the event and supplemented this with survey data from affected business owners, providing a qualitative perspective. While such simple methods couldn't establish statistical significance, they did enable the researchers to map out the proliferation of earthquake effects and offer substantial insights into the region's natural disaster preparedness.

Employing more sophisticated methods, Wu et al. (2011) investigated the economic effects of the 2008 Wenchuan earthquake by utilizing the Adaptive Regional Input-Output (ARIO) model. While relevant agencies had already made measurements of the direct effects of the disruptive events, the ARIO model proved suitable for highlighting indirect effects. ARIO was employed to capture changes in production, labor, and capital related to the shock. This model, closely linked to the Leontief inverse model, focuses specifically on changes in production capacity due to the loss of productive capital, thereby better encapsulating adaptive behaviors of economic actors following natural disasters. Despite some limitations in their study, the researchers were able to estimate indirect losses and provide predictions for the reconstruction period.

More relevant to our own paper is research aimed at analyzing differences in economic impact based on predetermined circumstances, making comparative studies highly pertinent. However, such comparisons are often challenging due to the difficulty in finding perfect peer groups facing

similar circumstances and shocks. One intriguing solution to this issue is the synthetic control model, which enables the creation of computer-generated peers based on preset input data.

The paper by Barone and Mocetti (2014) on two earthquake events in Friuli (region north of Italy) and Irpinia (region south of Italy) greatly inspired our own studies. They specifically examine earthquake events that occurred in the 1970s and 1980s. By treating the disaster events as treatment effects on two regions within the same country, they offer a unique perspective within-country perspective. Their study focuses on investigating the effect of institutional quality on economic outcomes post-disaster. Similar to our own paper, Barone and Mocetti (2014) highlight the inherent societal differences between the Mezzogiorno and northern Italy. Following the rationale described earlier, they employ the synthetic control model as their method of measurement. Their study reveals significant long-term effects, demonstrating a positive recovery for the northern region post-disaster, while the southern region experiences an economic decline after treatment. They attribute the difference in results to the varying levels of previous institutional quality. Their synthetic groups were modeled to represent peers with similar prerequisites before the treatment but without exposure to the treatment post-disaster. This suggests that the efficiency and strength of government prior to a natural disaster event are crucial in preventing economic consequences as well as facilitating an efficient recovery in the aftermath.

4.3 Using the Solow growth model to rationalize post disaster outcomes

To comprehend the economic outcomes of disaster events and highlight significant anomalies, our paper employs economic growth models. Economic growth models provide insights into how economies typically evolve and how they cope with shocks. The main model utilized in our paper is the growth model from Solow (1956), also called, the Solow growth model. It offers a theoretical understanding of economic development based on capital accumulation. Given that our research focuses on localized shocks in the form of earthquakes, the primary consequence of the treatment for the affected regions will be a reduction in capital, justifying our use of the Solow model.

The model introduced neoclassical growth theory, which explains that economic growth can occur based on three factors: capita, labor, and total factor production (*TFP*). While the economy's access to labor and capital is limited, the contribution to growth from *TFP* can be

unlimited. This is illustrated in the model by incorporating exponents that lead to diminishing returns for capital and labor but not for *TFP*. *TFP* can be simply defined as the economy’s efficiency in producing output with the given inputs. In our paper, it can describe the quality of institutions and overall societal development. Weaker institutional quality may contribute to poorer educational systems, weak safety nets, and an unstable legal system, all of which lower *TFP* levels.

The model can be summarized by the below equation where Y represents total GDP output, A represents *TFP*, L represents labor and K represents capital. The exponent, $1/3$, is described as the output elasticity of capital, which can be seen as the share of economic output attributed to capital. The indexed t describes time period.

$$Y_t = \bar{A} K_t^{\frac{1}{3}} L_t^{\frac{2}{3}}$$

Moreover, the per capita format is shown below.

$$y_t = \frac{Y_t}{L_t} = \frac{\bar{A} K_t^{\frac{1}{3}} L_t^{\frac{2}{3}}}{L_t}$$

The paper by Barone and Mocetti (2014) utilizes the Solow growth model in a growth accounting exercise to investigate the observed reactions in their results. Through this analysis, they conclude that observable differences in GDP growth mirrors disparities in *TFP* quality. This finding further bolsters the notion that divergent post-earthquake trends can be attributed to differences in pre-treatment institutional quality.

5 Methodology

To evaluate the effect of a disaster such as an earthquake requires an unaffected control. In both Emilia-Romagna and Abruzzo’s cases, finding such regions that represent a credible counterfactual case is difficult. Therefore a synthetic counterfactual for both Abruzzo and Emilia-Romagna is constructed, using a weighted combination of other Italian regions following Abadie and Gardeazabal, 2003; Abadie et al., 2010. This section lays out the reason for using the Synthetic Control Method for studies of regional differences and a detailed description of the procedure of creating a synthetic control.

5.1 Regional Studies Using Synthetic Control Method

Regional natural disasters are commonly decade-defining occurrences. This infrequency generally makes regression based models inappropriate to study economic fallout in regional cases such as Emilia-Romagna and Abruzzo. Therefore a more appropriate approach has been to compare disaster-affected regions with other similar regions not exposed to the treatment. This is most commonly done through the difference-in-difference approach. However, it also yields a unique set of challenges. In a difference-in-difference (DiD) analysis, a certain set of criteria have to be fulfilled to maintain validity, namely a control group, which is not affected. This control region must also maintain parallel trends, meaning that in the absence of the treatment, the trends in outcomes for the treatment and control groups would have followed a similar path over time. This is essential for attributing any differences in outcomes to the event itself rather than pre-existing differences between the two. Thirdly, it is crucial to control for any other factors that may confound the relationship between the treatment and the outcome of interest, such as institutional differences or pre-existing economic conditions. The second condition for DiD is impacted by the fact that other regions in Italy have also suffered earthquakes. Therefore limiting the amount of options for a DiD analysis.

However, the third condition is especially relevant for the case of Emilia-Romagna and Abruzzo. Emilia-Romagna, a northern region, might be compared to other northern regions, but this would risk not accounting for the differing compositions of regional economies. This argument becomes even more important when considering Abruzzo, a southern region in terms of historical definitions and institutional quality, IQI for Abruzzo is markedly lower compared to Emilia-Romagna. It is important to note that Abruzzo is significantly more industrialized than many of its counterparts in Southern Italy. Comparing Abruzzo to other southern regions is therefore difficult because its industrial resources and higher GDP per capita set it apart from the rest of the South, making it challenging to find a suitable peer for DiD analysis. This issue is also compounded due to our exclusion criteria of border regions around Abruzzo which were also struck by earthquakes in 2016.

Therefore the only remaining option to studying the effect of the earthquake is to create a synthetic counterfactual not exposed to earthquakes.

5.2 Construction of a Synthetic Control

The following section outlines the creation of a synthetic control as presented by Abadie, Diamond and Heinmuller (2015).

To construct synthetic controls, both a studied region and a number of donor regions are required. The number of total observed units is defined as $J + 1$, where the first unit, $j = 1$, represents the studied region, and all subsequent regions up to $j = J + 1$ are donor regions that can potentially be used to construct the synthetic comparison unit. For the comparison unit to optimally imitate the region of interest pre-treatment, it is pivotal that the donor pool includes regions with outcome values driven by a similar structural process to that of region $j = 1$. It is for this reason that we include all other Italian regions in our donor pool, ensuring that institutional and economic frameworks remain similar across units. However, three regions, Marche, Umbria, and Lazio are excluded due to exposure to 6 $\frac{1}{2}$ Richter magnitude earthquakes in the post-treatment period. Furthermore, one region, Trentino Alto Adige, is excluded due to lack of data.

The span of years stretches from 1 to T , with T_0 marking the period where treatment occurred. All years preceding the treatment where no effect of treatment occurs are those within the range of $1 < T_0$, and all those exposed to the effect of treatment are within the $T_0 < T$. The Abruzzo earthquake treatment identifies T_0 as 2009 while the Emilia-Romagna T_0 period is identified as 2012.

The purpose of building a comparison pool is to create a synthetic control for improved research capabilities. To construct synthetic controls, a mixture of characteristics are collected from some members within the donor pool to produce an optimal comparison unit. This is done by assigning weights to donors at a proportion of w . The proportion assigned to each donor is always within the range of $0 \leq w_j \leq 1$ and the total assigned weights, W , outlines a specific synthetic control composition.

To select the optimal weights for the control, we aim to find a combination that minimizes the difference between the pre-earthquake outcome values of the treated region and the non-treated regions. Let X_1 be a vector representing the pre-treatment outcome values ($K \times 1$) of the treated regions, Abruzzo or Emilia-Romagna. Let X_0 be a matrix containing the outcome values ($K \times J$) for the regions in the donor pool. A vector of $X_1 - X_0W$ thus represents the difference in pre-earthquake characteristics between the treated and donor region group. The

synthetic group W that produces the smallest gap for the vector would thus be the synthetic of choice. To calculate this, let X_{1m} represent the $m : th$ value of the region exposed to treatment while X_{0m} represent the values of the non-treated regions. Lastly, the variable v_m represent the predictive power on the outcome of interest. It is described as weight of importance assigned to the $m : th$ value. The calculation below describes the strategy of finding the optimal synthetic, W^* .

$$Y_{1t} - \sum_{j=2}^{J+1} w_j^* Y_{jt}$$

To obtain a synthetic control estimation of treatment effect. We must observe the gap between the outcomes from treated regions and comparable regions. Let Y_{1t} be a $(T_1 \times 1)$ vector representing the post-earthquake values of the treated regions. Let Y_{jt} be a $(T_1 \times J)$ vector representing the post-earthquake values of the non-treated regions. To perform adequate calculations, we need to compare Y_{1t} to Y_{jt} during the period preceding the disaster event, as shown below.

$$\sum_{m=1}^k v_m (X_{1m} - X_{0m}W)^2$$

Computation of synthetic controls is done accordingly, using the Dataprep function in R to create the matrices, and the synth package to construct a subsequent synthetic control. Both packages are created by and attributed to Abadie and Heinmuller.

5.3 Data

All economic data was sourced from Istituto Nazionale di Statistica (ISTAT)

To comprehensively investigate the economic ramifications of the treatment events, our study will delve into an array of key metrics. Specifically, we will analyze GDP per capita, employment, population density, and sector-based value-added figures for each region affected. By scrutinizing employment and population data, we aim to gain a nuanced understanding of the labor force's status both before and after the occurrence of the disaster event. Additionally, our analysis of sector-based value-added data will offer valuable insights into the distinctive characteristics of the economy in question, thereby aiding in the delineation of a suitable peer

universe for comparative analysis. Moreover, the utilization of GDP per capita figures as a primary dependent variable across all regions under study holds significance. This comprehensive metric encapsulates not only the overall productivity but also the collective output of the respective regions while accounting for the size of population. By incorporating GDP as a fundamental component of our analysis, we aim to capture the holistic economic impact of the treatment events.

Additionally, we will also use variables to capture institutional differences across regions. To encapsulate institutional quality, we will be using the Institutional Quality Index (IQI) data for Italy. The data encapsulates a vast range of data points into a regional figure from 0.0 to 1.0, with 0.0 being the lowest institutional quality grade and 1.0 being the highest. IQI uses data sets which covers accountability, government effectiveness, regulatory quality, rule of law and corruption.

6 Results

The following section reports the main findings for Emilia-Romagna and Abruzzo respectively, with corresponding weights, synthetic control characteristics and robustness checks.

6.1 Emilia-Romagna

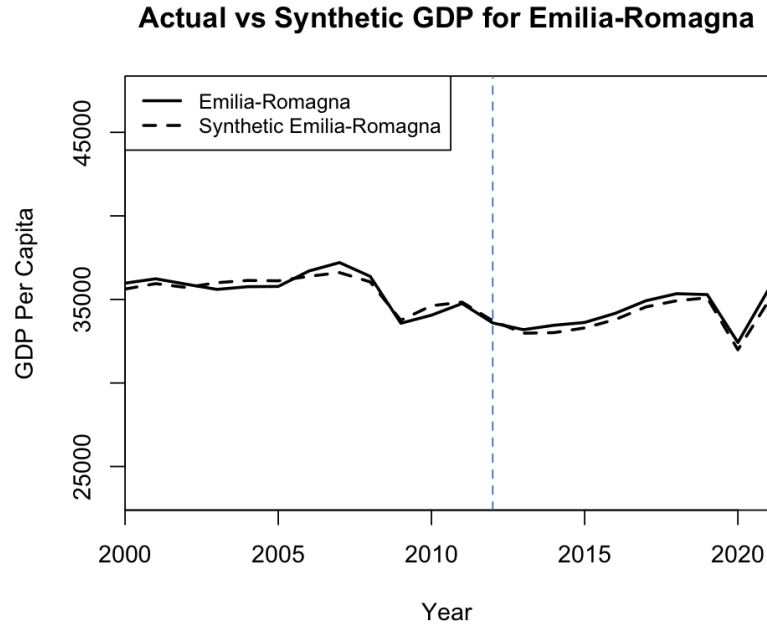


Figure 1: Synthetic Control of Emilia-Romagna

Data Sources: ISTAT, IQI

Figure 1 depicts the outcomes of a synthetic Emilia-Romagna that replicates the GDP per capita trend before the intervention. Although there are some disparities before the intervention, the synthetic control generally mirrors the actual Emilia-Romagna trajectory. The post-intervention trajectory of Emilia-Romagna does largely seem to follow that of the synthetic control, although with a slightly higher GDP per capita level after the earthquake.

Region	Weights (w.weights)
Vallée d’Aoste	0.113
Lombardia	0.312
Veneto	0.575

Table 1: Regions Included in Synthetic Control for Emilia-Romagna

Data Sources: ISTAT, IQI

Table 1 reports the composition of the synthetic control which consist of three states, with the northern state of Veneto standing for 57.5% of the control. This is reasonable considering its close resemblance to Emilia-Romagna in terms of industrialisation level as well economic composition, where agricultural production, industry and tourism stand for large shares of the economic output in both cases. The remainder of the control consists of Vallée d’Aoste and Lombardia, at 11.3% and 31.2% respectively.

	c			
	Treated	Synthetic	Sample Mean	Predictor weights (v.weights)
Employment	2015	2658	1283	0.014
Net disposable income	84123	104899	49575	0.025
GDP per Capita lag (2007)	37206	36606	28080	0.822
Population density	185	273	186	0.01
IQI	0,753	0.775	0.504	0
Value Added services	75588	106138	48890	0.001
Value Added Agriculture	3188	2644	1633	0.11
Value Added Manufacturing	25996	35496	12021	0.018

Table 2: Emilia-Romagna Balancing Properties

Data Sources: ISTAT, IQI

The pre-intervention discrepancies are evident in the sub optimal fit of a the balancing properties seen in Table 2, particularly regarding value added per sector, population density, and overall employment. Another differing predictor is the value added in the agricultural sector, but this is unsurprising given that the region ranks among Italy’s top agricultural producers. Thus, variability in this particular variable is anticipated, as the model may struggle to

generate a synthetic fit from a donor pool with lower values. Notably, the variable with the highest predictor weight is GDP lag from 2007 (0.822), which is consistent with expectations, as post-intervention GDP size would logically hinge heavily on pre-intervention levels. Another factor to consider is the low or zero predictor weights assigned to certain variables. However, this does not imply that these variables are useless in constructing the synthetic control, as they are still considered and optimized for during the model construction process. Importantly, there is a close alignment observed between the synthetic and real Emilia-Romagna in terms of GDP per capita and IQI. Also, the synthetic control approach demonstrates superior balancing properties compared to the sample mean comparisons. The models ability to to evaluate the effects of an earthquake on Emilia-Romagna are further explored in the discussion.

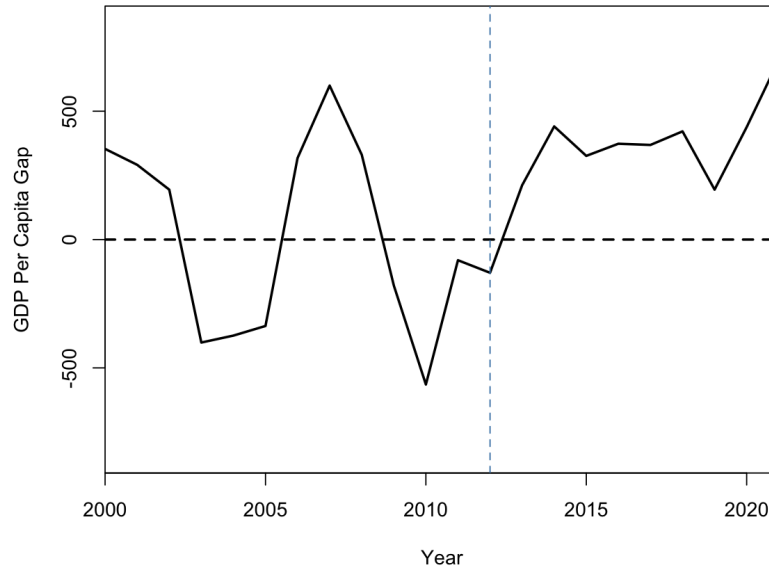


Figure 2: GDP gap plot for Emilia-Romagna

Data Sources: ISTAT, IQI

The slightly higher level of GDP levels for Emilia-Romagna seen in Figure 1 can be further illustrated by plotting the GDP gap to its synthetic control. Figure 2 shows that Emilia-Romagna has consequently higher GDP per capita in all post-earthquake periods compared to its synthetic peer. At the highest this difference amounts to approximately 500 euro. If true, this would indicate that the earthquakes had positive effects on overall GDP-levels. However,

conducting further significance tests is imperative to validate these effects.

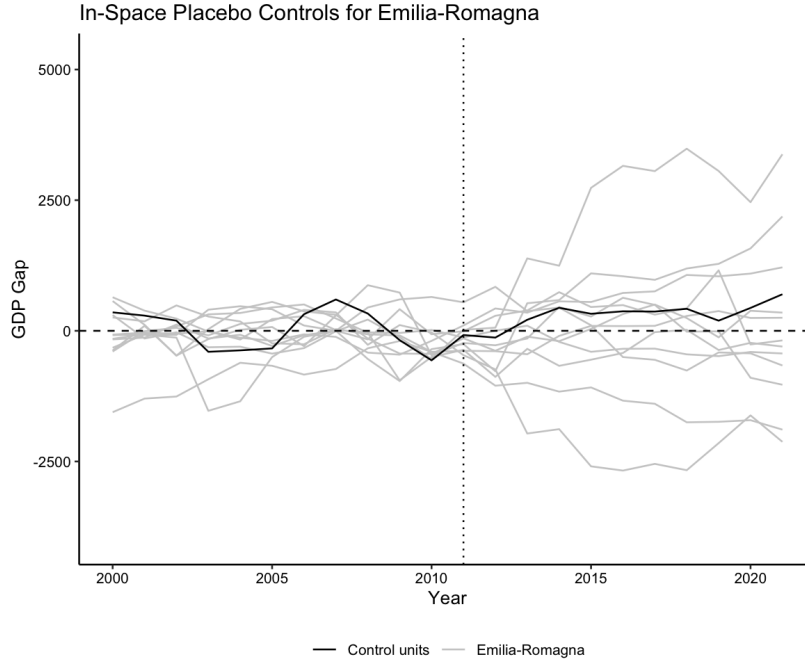


Figure 3: In Space Placebos for Emilia-Romagna

Data Sources: ISTAT, IQI

The initial stage of inferential analysis in synthetic controls involves conducting placebo tests. These tests serve to validate the effectiveness of the synthetic control method and are conducted in two primary ways: in-space and in-time.

An in-space placebo test, such as the one in Figure 3, the treatment-status is assigned to donor regions that have not been affected by the earthquake. Subsequently, a synthetic control is constructed for these unaffected regions. The goal is to compare the GDP-gap between the unaffected regions and their synthetic counterparts. This allows for comparison of the spread of the GDP gap of Emilia-Romagna to states which have not been affected by the earthquake.

Optimally, if the positive effect seen in Figure 2 is true, then there should not be that many regions who have an equal or higher GDP gap to Emilia-Romagna when assigned treatment status. However Figure 3 shows that there are 3-5 regions which equal or supersede Emilia-Romagna in GDP gap over the time period. This is detrimental to inference and likely means that the positive effect seen is not due to the earthquake. Furthermore, P-value range can be

approximated by visually estimating that 3-5 regions out of 15 have a higher GDP gap during the post-treatment period. Giving a P-value range of 0.2-0.33.

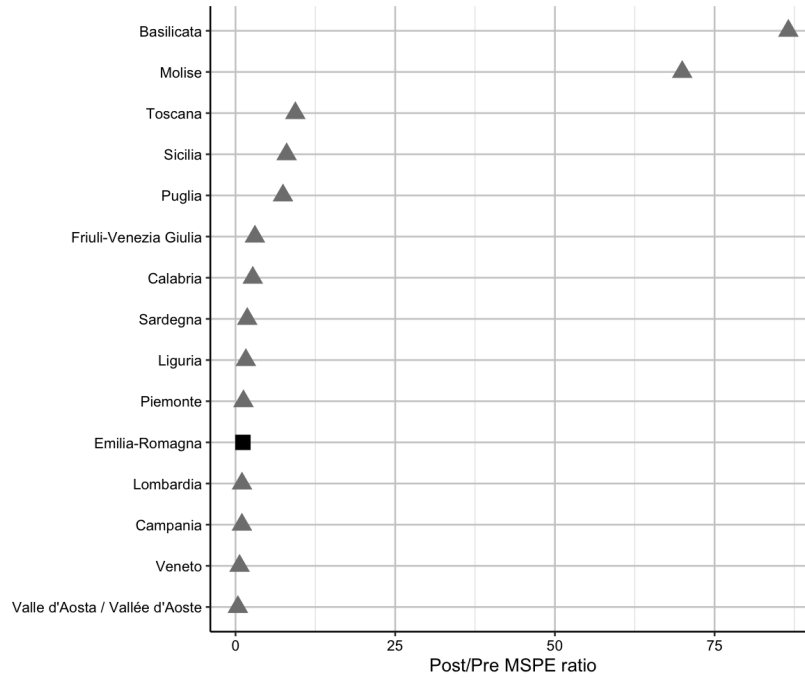


Figure 4: MSPE Ratio for Emilia-Romagna and Donor Regions

Data Sources: ISTAT, IQI

The robustness of the model can be further examined by looking at the ratio of MSPE before and after the treatment. A high value of the MSPE ratio would entail a significant effect, since it means that the prediction error of the unaffected regions increased when Emilia-Romagna is subjected to the treatment. However this is not the case as shown by Figure 4. There are 10 regions with a higher MSPE ratio than Emilia-Romagna. The MSPE ratio also enables us to construct a P-value through simply dividing the amount of states with a higher ratio with that of the donor pool. In this case, a P-value of 0.75 for the estimated effect.

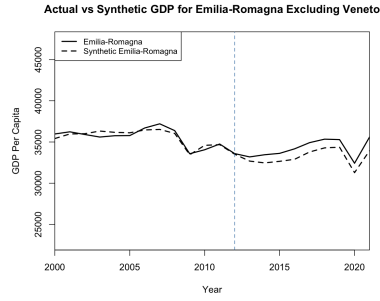


Figure 5: Leave-one-out Analysis Excluding Biggest Donor Region
Data Sources: ISTAT, IQI

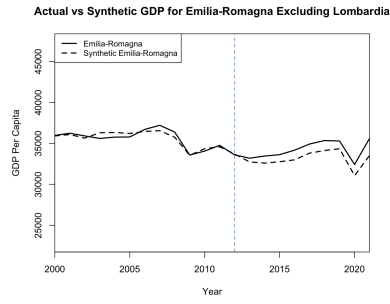


Figure 6: Leave-one-out Analysis Excluding Second Biggest Donor Region
Data Sources: ISTAT, IQI

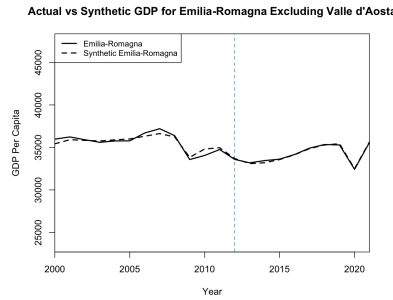


Figure 7: Leave-one-out Analysis Excluding Third Biggest Donor Region
Data Sources: ISTAT, IQI

As a final test of the models robustness, a leave-one-out analysis is conducted. This is done by systematically excluding the top 3 weighted region for Emilia-Romagna one at a time. Doing this ensures that the results seen in the complete model are not driven by only one donor. That is, it tests for the possibility that all the effects seen might be due to one of the weighted regions being an outlier in terms of GDP per capita. The positive effect seen in the original model is maintained and even increased when excluding the two highest weighted regions, indicating that none of them are solely driving the change seen. However, when excluding Valle d'Aosta, the positive effect seen post-treatment drops, leading Emilia-Romagna to be in parity with its synthetic counterpart. This implies, that Valle d'Aosta might be solely driving the positive effect seen in the original model which will be another detrimental factor for the model's inferential ability.

The above calculated P-values, tests and effects seen in the synthetic models indicated inconclusive results regarding the effects of the 2012 earthquakes on Emilia-Romagna. The model does show a positive effect but it fails to hold true under robustness testing. Interestingly, the positive effect disappears when excluding one region, Valle d'Aosta, further impacting the models reliability. Further robustness tests could be done through in-time placebo tests and exclusions of border regions, however this would still not amend the models inability for inference. Especially considering that it fails in MSPE ratios and in-space placebo tests, two commonly used methods used for inference testing.

6.2 Abruzzo

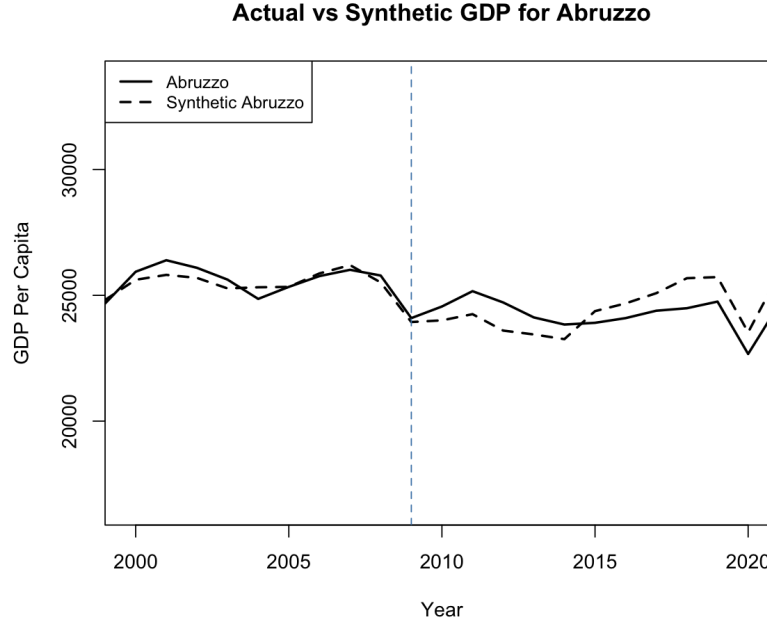


Figure 8: Synthetic Control for Abruzzo

Data Sources: ISTAT, IQI

Figure 8 shows the results of a synthetic Abruzzo that mimics the GDP per capita trend pre-treatment. The model exhibits a worse pre-treatment fit in the beginning of the period especially compared to that of Emilia-Romagna. This misfit might be expected considering that Abruzzo is institutionally closer to the southern regions, while fostering stronger economic capacity, more similar to the northern regions. This might create difficulties in finding a synthetic peer. However, the model does still mimic Abruzzo well in the years leading up to the earthquake. Abruzzo does pull away post-intervention, exhibiting positive economic effects leading up to 2014, whereupon the trend reversed and turns negative instead.

Table 3 shows the weights assigned to different regions included in the synthetic control for Abruzzo. Basilicata, a southern region, stands for about 52.4% whilst Friuli-Venezia Giulia, a northern region, stands for 21.8%, while the rest of the donor pool accounts for smaller fractions of the weight. This is a sensible distribution considering that Abruzzo is a southern region with some northern characteristics. Therefore a blend of southern and northern regions with some

Region	Weights (w.weights)
Piemonte	0.003
Valle d'Aosta / Vallée d'Aoste	0.106
Liguria	0.001
Lombardia	0.001
Veneto	0.008
Friuli-Venezia Giulia	0.218
Toscana	0.04
Campania	0.086
Puglia	0.042
Basilicata	0.524
Sicilia	0.003
Sardegna	0.004

Table 3: Regions Included in Synthetic Control for Abruzzo

Data Sources: ISTAT, IQI

traits from the rest of Italy is a reasonable composition for a synthetic peer.

	Treated	Synthetic	Sample Mean	v.weights
Employment	510	506	1271	0.235
Net disposable income	17671	17712	47623	0.127
GDP per Capita lag (2004)	25336	25336	27508	0.174
Population density	118	117	185	0.011
IQI	0,479	0.543	0.502	0
Value Added services	15362	15527	43388	0.246
Value Added Agriculture	793	797	1663	0.204
Value Added Manufacturing	4654	3834	12024	0.003

Table 4: Abruzzo Balancing Properties

Data Sources: ISTAT, IQI

Considering the balancing properties of synthetic Abruzzo, variables such as employment, net disposable income, GDP per capita lag (2004), population density, and value added services exhibit a good level of balance. The differences between the treated unit and the synthetic control group are minimal, suggesting a high degree of similarity in these aspects. This does enforce the reliability of the model. However, there is a slight deviation in IQI. While this difference may not be significant, it might again be explained by Abruzzo’s unique positioning as a southern region with strong industrial and economic performance. The same reasoning might also explain the difference in value added of manufacturing. Also notable is that IQI has a weight of zero, however when excluding IQI it does impair the synthetic model’s fit, therefore including an index for institutional quality seems to be relevant. All in all, the model does a good job of capturing the dynamics of the region better than comparisons with the mean.

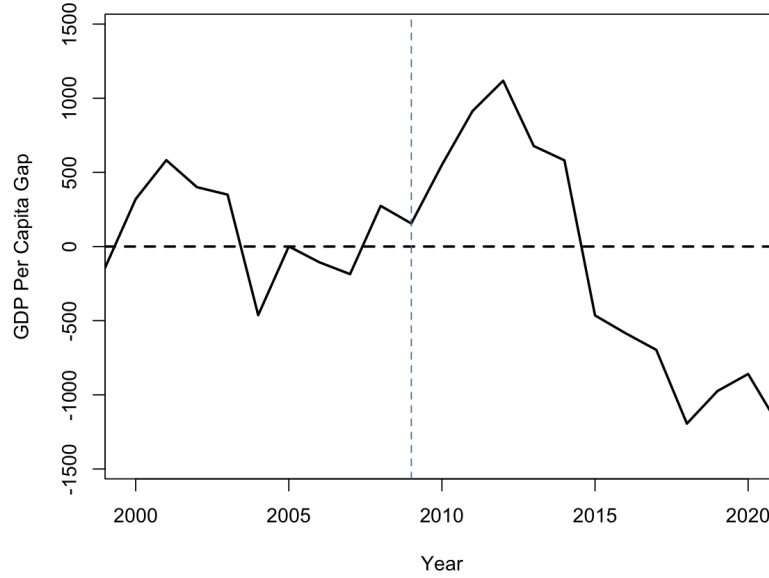


Figure 9: GDP per Capita Gap for Abruzzo

Data Sources: ISTAT, IQI

The post-treatment trend for Abruzzo in Figure 8 shows a positive and then negative effect on GDP following the earthquake. This is better visualised in Figure 9 with a GDP gap plot. Likewise, a positive effect in the short run, at its highest in 2012 reaching approximately 1100 Euros can be seen. This follows up to 2014 where it subsides and eventually turns into a negative gap. This does indicate a positive short-run effect which seems to disappear in the long-run. However, as with our results in Emilia-Romagna, robustness checks are pertinent.

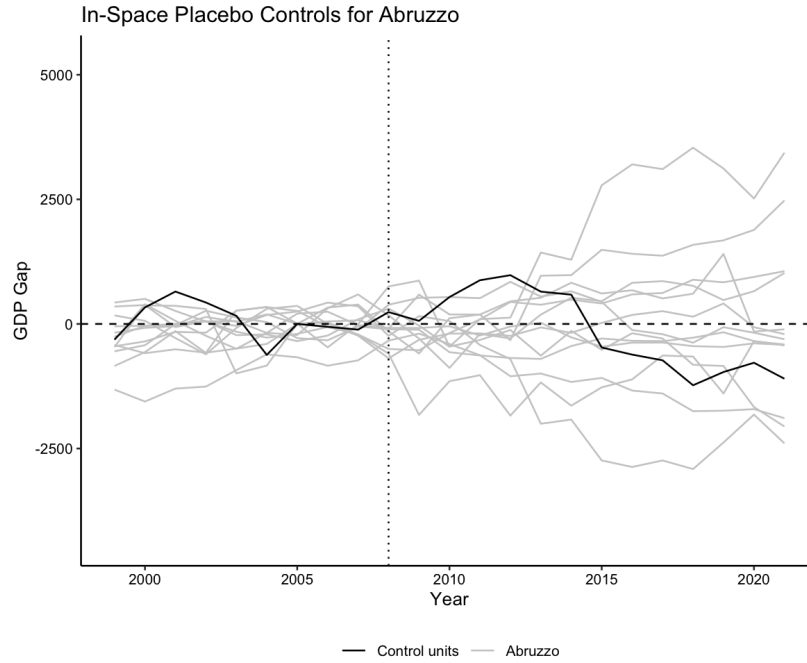


Figure 10: In-Space Placebo Abruzzo

Data Sources: ISTAT, IQI

Figure 10 plots the placebo controls for Abruzzo. P-values can be estimated following the same reasoning in the section for Emilia-Romagna. Considering the short run positive effects leading up to 2014 there is at any time 0-4 regions which show a larger positive gap than Abruzzo. Leading to a visually estimated P-value range of 0.01-0.25 in the short-term. Longer term, Abruzzo exhibits a negative gap compared to its synthetic. A P-value for this negative effect can also be approximated visually. At any time, there are 3-4 regions with a more negative gap, leading to a visually estimated P-value range of 0.1875-0.25, which does not support the models ability for inference.

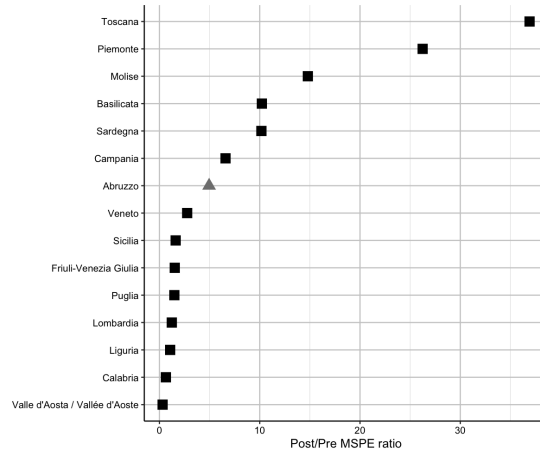


Figure 11: Short-Term MSPE Ratio for Abruzzo

Data Sources: ISTAT, IQI

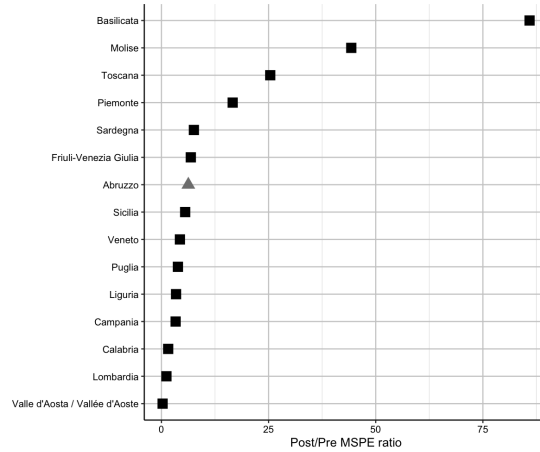


Figure 12: Long-Term MSPE Ratio for Abruzzo

Data Sources: ISTAT, IQI

Further robustness checks can again be made using the MSPE ratio. This time, both short-term and long-term MSPE effects are considered. In the case of Abruzzo, we evaluate MSPE ratios for both the short-term (up to 2014) positive and long-term negative effects respectively. Again, following our reasoning in the previous Emilia-Romagna section, P-values can be deduced from the MSPE ratio. In the short-term, there are 6 regions with higher ratios than Abruzzo, indicating a P-value of 0.4. In the long-term, 6 regions exhibit higher MSPE ratios than Abruzzo, also giving a P-value of 0.4.

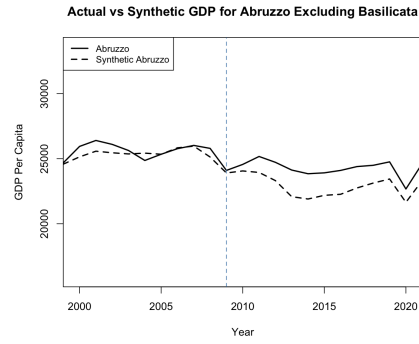


Figure 13: Leave-one-out Analysis Excluding Biggest Donor Region

Data Sources: ISTAT, IQI

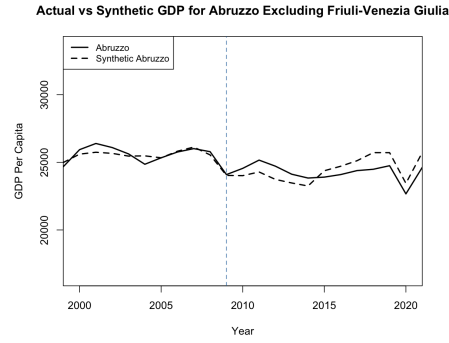


Figure 14: Leave-one-out Analysis Excluding Second Biggest Donor Region

Data Sources: ISTAT, IQI

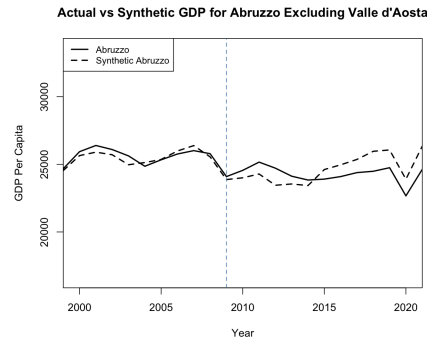


Figure 15: Leave-one-out Analysis Excluding Third Biggest Donor Region

Data Sources: ISTAT, IQI

Finally, a leave-one-out analysis is conducted for Abruzzo as well, by excluding the top three weighted regions. There is no considerable change in results for Valle d’Aosta and Friuli-Venezia Giulia. However when excluding Basilicata, the negative long-term effect vanishes. Implying that the negative long-term consequences are primarily driven by one region. This is again detrimental to the models robustness, and implies that the long-term negative effects seen are unreliable.

Therefore, the results for Abruzzo show positive trends in the short-run following the earthquake, and negative trends in the long-run. However the inferior P-values returned from the robustness checks hinder any inference to be made regarding the economic impact of the earthquake. Furthermore, leave-one-out analysis seem to point out that the long-term effects seen are driven solely by the outcome of one donor region. Thus, as in the case of Emilia-Romagna, our analysis is inconclusive as to the effects of the 2009 earthquakes. Likewise, further robustness checks can be made with in-time placebos and expanded exclusion analysis, however these would be in vain considering the failure of the model in passing both in-space and MSPE ratio checks.

7 Discussion

In this section we will further elaborate on our results and the limitations we have encountered. First, we will discuss the limitations of our models and the causes of our inability for inference in the cases of both earthquakes. Secondly, we will discuss the findings in relation to our hypothesis and previous literature.

7.1 Limitations and Obstacles for Inference

The reliability of the observed effects in our model is subject to scrutiny due to several factors. Primarily, the pre-treatment fit exhibits sub optimal performance, a concern particularly highlighted in the case of Abruzzo, where noticeable gaps in the pre-treatment periods are evident. While the synthetic control model does not strictly require common trends, significant gaps still impact the model’s reliability in accurately predicting outcomes. Without common trends in the pre-treatment period, establishing a causal link between any post-treatment differences and the event becomes uncertain. Therefore, the presence of pre-treatment gaps is considered detrimental to the reliability of the analysis. For the Abruzzo results, a visual inspection of

the synthetic control reveals diminished reliability due to the presence of two significant gaps in the pre-treatment period. However, despite this limitation, the synthetic control closely mirrors Abruzzo in terms of balancing properties, indicating proficiency in capturing Abruzzo’s characteristics selected for the model. Therefore, the observed disparities in the pre-treatment period may not be attributable to differences in the synthetic control but rather to fluctuations in GDP per capita across the studied regions.

Conversely, Emilia-Romagna presents an inverse challenge. Visual inspection suggests a generally favorable trend, albeit with slight gaps in the pre-treatment period, but these are deemed acceptable. However, the balancing properties of Emilia-Romagna diverge from its synthetic control, indicating a disparity in attributes while maintaining similarity in trends.

Transitioning to more foundational obstacles in inference, concerns arise regarding data quality, spill-over effects, and treatment effect size. The data utilized in our model, sourced exclusively from ISTAT, Italy’s national statistical institute, is considered highly reliable. Likewise, IQI serves as a dependable proxy for institutional quality. However, the absence of key variables, notably investment rates and shares of graduates, may have influenced the model’s fit and balancing properties, impeding the construction of viable synthetic control regions.

Spill-over effects represent another area of concern. Both earthquakes were geographically isolated on the region-level in terms of damages, with the Abruzzo earthquake predominantly affecting the L’Aquila municipality and leaving other regions unaffected. Similarly, Emilia-Romagna experienced an isolated earthquake event. To mitigate potential spill-over effects, regions with earthquakes of similar magnitudes in the post-treatment period were excluded from the analysis. However, addressing the impact of reduced trade between regions due to damaged industries was beyond the study’s scope. To have done this, we would have to exclude regions whose trade was affected by the earthquake. This would be difficult primarily due to data limitations and also the broad exclusion criteria required, significantly reducing the donor pool.

Finally, the issue of treatment size effects emerges. While both earthquakes constituted significant destructive events, their magnitude may have been relatively small compared to the scale of larger regional economies, potentially rendering their negative impact negligible in comparison. Examining effects at a municipal level could provide additional insights, however, data availability at this level, particularly concerning financial and institutional data poses notable limitations.

7.2 The Economic Effects

7.2.1 Emilia-Romagna

The observations regarding Emilia-Romagna revealed that the region consistently held a position above its synthetic comparable during the observed post-earthquake period. The positive gap difference was never too broad, which aligns with our hypothesis. However, in contrary to our expectations, upon thorough examination it was found that the results lacked statistical significance.

Given the similarity of our research methodology to that of Barone and Mocetti (2014), it is intriguing to compare our results with theirs. Their study on the northern region, Friuli, revealed a consistent positive deviation from its synthetic group. In contrast to our exclusion tests, theirs observed region consistently displayed a positive gap. However, akin to our own in-space placebo controls, their region did not notably differ from its control group. Therefore, their results left some room for arguing in favor of significance, while still constraining a definitive conclusion. The Friuli earthquake occurred in close proximity to a densely populated area and registered at a higher magnitude on the Richter scale compared to the Emilia-Romagna event. Thus, the ensuing consequences from these events vary significantly, potentially accounting for the differences in results observed. Factors such as institutional quality and economic robustness of these regions could have influenced the mitigated consequences following their respective disaster events.

Our findings do not show any discernible change in GDP per capita growth, which was anticipated based on the Solow (1956) theory of economic growth. In contrast, the Friuli results do indicate some positive increase in economic growth post-disaster compared to its comparable synthetic. This divergence might be attributed to the earthquake's proximity to urban centers; the Emilia-Romagna event occurred at a greater distance from any city, suggesting less capital destruction. Consequently, with less capital destruction, the economy might not deviate significantly from its initial position, thereby not contributing to increased growth.

7.2.2 Abruzzo

The Abruzzo results showed, in contrast to our expectations a positive gap to its synthetic during the first 5 years post-earthquake event, then proceeding to cross and continue at a negative gap. Abruzzo stands out from other southern Italian regions due to its comparatively

stronger industries and consequential economic capacity. We have not found any reasons related to other parts of the region that could contribute to the uplift post-earthquake event. The positive short-term reaction could potentially be explained by a combination of the region’s economic capacity and the additional influx of economic aid following the earthquake event. Strong economic interests for investors and the state could incentivize effective mobilization of resources to bring production back to normal. Combined with external aid, these results could lift up the output of the region. If so, it would suggest that under certain circumstances, a lack of institutional quality could be partially mitigated by strong economic capacity in the recovery from disaster events.

The subsequent negative growth in GDP per capita from around 2012 to 2015 is more pronounced for Abruzzo compared to its counterparts. This could suggest that the earthquake had a detrimental effect on the region’s resilience to the concurrent Great recession crisis that began one year before the earthquake event. Even during periods of general economic prosperity, Abruzzo did not exhibit similarly robust growth, nor did it surpass the synthetic at any point post-2015. This could lend support to the hypothesis that weaker institutional quality influences general economic resilience following a crisis.

However, when observing the pre-treatment period, Abruzzo, and its synthetic control fail to align properly, indicating potential statistical insignificance. This suggestion gains further credence when considering our robustness checks. In contrast to the findings of Barone and Mocetti (2014), who studied the Irpinia event in southern Italy, our in-space placebo does not exhibit any significant negative deviation when compared to the comparison donor pool. However, it does stand out with a positive deviation in the short-term. Additionally, the exclusion tests reveal substantial differences in the overall results when the largest donor region is excluded, suggesting non-significant results. Considering these factors, it becomes challenging to draw any definitive conclusions regarding our findings.

8 Conclusion

Earthquake events and their aftermath have long left profound impacts on the regions they affect. Italy, with its intricate history and domestic institutional and economic diversity, has provided fertile ground for numerous research endeavors. Its geographical location, while unfortunately exposing it to devastating natural disasters, has also rendered research efforts related

to seismic events highly intriguing.

The objective of our paper was to examine the influence of institutional quality on an economy's ability to withstand shocks. By utilizing a natural disaster event as our shock treatment, we were able to leverage a natural experiment to make contributions to the field of economics. Though other studies have been made in the field using Italian prospects, we distinguished ourselves by minimizing economic disparity between the studied regions. Our findings revealed divergent effects compared to similar research endeavors. Observations of the output data related to Abruzzo suggested that at least in the short-term and under certain circumstances, the effect of low institutional quality on economic resilience may be offset by general economic capacity and external influences. However, due to various constraints outlined in the discussion, our results did not demonstrate statistical significance, making it challenging to justify firm conclusions.

For future research endeavors exploring the connections between institutions and economic outcomes using earthquake events as treatment, we have three recommendations. Firstly, we suggest utilizing municipality-level data rather than regional-level data. Regional data are aggregate of all municipalities within it, even though it can be argued that significant earthquake events would effect neighboring municipalities, localizing the observations, would allow researchers to better discern the effects at its epicenter. However, this approach carries a higher risk of spillovers, which should be carefully considered if a synthetic control using other municipalities in close proximity is used. Secondly, we recommend using a longer time span to improve the accuracy of the pre-treatment synthetic control and to provide more comprehensive observations of the effects. This could enable researchers to draw subsequent conclusions regarding any divergence in effects between the short and long-term. Lastly, we encourage research efforts in this field to incorporate a wider range of economic and institutional variables. This would not only help to better align comparable units but also allow for more nuanced conclusions regarding outcomes. We firmly believe that the research field we've explored holds significant potential for further investigation. Furthermore, we anticipate more studies to utilize the unique situation of the Italian peninsula in their research, and we hope for our paper to be of assistance in any such endeavors.

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