

Belloc, Marianna; Drago, Francesco; Galbiati, Roberto

Working Paper

Earthquakes, Religion, and Transition to Self-Government in Italian Cities

CESifo Working Paper, No. 5566

Provided in Cooperation with:

Ifo Institute – Leibniz Institute for Economic Research at the University of Munich

Suggested Citation: Belloc, Marianna; Drago, Francesco; Galbiati, Roberto (2015) : Earthquakes, Religion, and Transition to Self-Government in Italian Cities, CESifo Working Paper, No. 5566, Center for Economic Studies and ifo Institute (CESifo), Munich

This Version is available at:

<https://hdl.handle.net/10419/123190>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.



Earthquakes, Religion, and Transition to Self-Government in Italian Cities

Marianna Belloc
Francesco Drago
Roberto Galbiati

CESIFO WORKING PAPER NO. 5566
CATEGORY 12: EMPIRICAL AND THEORETICAL METHODS
OCTOBER 2015

An electronic version of the paper may be downloaded

- from the SSRN website: www.SSRN.com
- from the RePEc website: www.RePEc.org
- from the CESifo website: www.CESifo-group.org/wp

ISSN 2364-1428

Earthquakes, Religion, and Transition to Self-Government in Italian Cities

Abstract

For a panel of 122 cities observed over 300 years in medieval northern-central Italy, we document that the occurrence of an earthquake retarded institutional transition from the feudal regime to the commune (free city state) in cities where the political and the religious leaders were one and the same person, but not in cities where political and religious powers were distinct. This effect holds both for destructive seismic episodes and for events that were felt by the population but did not cause any material damage to persons or objects. These findings are consistent with the idea that earthquakes represented a positive shock to people's religious beliefs and enhanced the relative ability of politicalreligious leaders to restore social order after a crisis with respect to the emerging communal institutions and civic associations. This interpretation is supported by historical evidence.

JEL-Codes: D700, P160, Z120.

Marianna Belloc
Sapienza University of Rome
Rome / Italy
marianna.belloc@uniroma1.it

Francesco Drago
University of Naples Federico II
& CSEF / Naples / Italy
dragofran@gmail.com

Roberto Galbiati
OSC, CNRS & Sciences Po
Paris / France
galbiatir@gmail.com

October 10, 2015

We thank the Editor and four anonymous referees for comments that greatly improved the paper. We are grateful to Daron Acemoglu, Alberto Alesina, Zsófia Bárány, Milo Bianchi, Sam Bowles, Tatjana Castano, Eric Chaney, Antonio Ciccone, Quoc-Anh Do, Ruben Enikolopov, Oded Galor, Francesco Giavazzi, Pauline Grosjean, Luigi Guiso, Rachel McCleary, Suresh Naidu, Paolo Nobili, Nathan Nunn, Ben Olken, Ugo Pagano, Luigi Pascali, Elias Papaioannou, Maria Petrova, Fabio Schiantarelli, Annalisa Scognamiglio, Dan Treisman, and seminar and workshop participants at EIEF, NBER, Paris School of Economics, Santa Fe Institute, York University Toronto, WZB Berlin, University of Maastricht, University of Siena, and University of Bologna for useful discussion, to Ivàn Torre and Marco Flaccadoro for excellent research assistance, and to Luca Moiana and researchers at the Italian National Institute for Geophysics and Volcanology for assistance with the data. We are indebted to Andrei Shleifer for advice and encouragement at many stages of this project. Finally, the authors wish to thank the Departments of Economics at MIT (Belloc), and the Department of Economics at Harvard and the NBER (Drago) for their generous hospitality during the period when this paper was drafted. Any remaining errors are nevertheless our own.

Introduction

Understanding the determinants of institutional change is one of the thorniest issues in the political economy literature. In particular, empirical investigation of the factors leading to transitions from narrow to broader-based institutions, in both the contemporary world and the past, has recently proved of much interest to economists and social scientists alike (Lipset, 1959; Barro, 1999; Acemoglu and Robinson, 2006). One of the main challenges has been determining how to single out the mechanisms operating in this complicated process and to identify the causality. In this paper, we contribute to this literature by studying how the occurrence of natural catastrophes may impact on the stability of political regimes. We do so by considering an instructive historical case study: the emergence of communes in northern-central Italy during the Middle Ages.

We find that the occurrence of an earthquake reduced the probability of transition from feudal to communal institutions in cities where political and religious powers were in the hands of the same person, but not in cities where they were distinct. This worked similarly for destructive earthquakes and for events that did not provoke any physical damage to people or objects. Our findings are consistent with the view that earthquakes, interpreted in the Middle Ages as manifestations of God's wrath against men, reinforced the authority of religious and political leaders in the *status quo* regime.

In the period between the eleventh and thirteenth centuries, Italian cities underwent profound changes in their political and institutional configurations. This is known as the 'communal movement' whereby the power of the incumbent feudal leaders was challenged, and often replaced, by the bourgeois elite. In the feudal regime, the political leaders were either bishops, in the Episcopal see cities, or secular lords (e.g. counts or marquises), in the non-Episcopal see cities. In the former group, the bishops were simultaneously political leaders, monopolists in the provision of religious services, and the supreme religious authorities. By contrast, in the non-Episcopal cities, religious power was separated from political power. Both bishops and secular leaders ruled, *de facto* and *de jure*, free of checks and balances. In the communal system, political power was exercised by representatives of all the citizens and checked by constitutional limitations and representative assemblies. Hence, the transition from the feudal regime to the commune represented a radical change toward broader-based political institutions.¹

¹ It has been amply documented that cities adopting communal institutions reached higher levels of urbanization and rates of growth than those governed by despotic leaders (Coleman, 1999; Tabacco, 1989; Menant, 2005;

Our analysis is conducted on a unique large panel dataset. Starting from the sample of the largest cities in northern-central Italy for which reliable historical documents on the communal experience are available, we collect information on their political regimes, on whether or not they were seats of bishops in 1000, and on the year in which the change (if any) from feudal regime to communal institutions occurred (as explained in greater detail in Sections 3.1 and 3.2). These data are matched with detailed information on the earthquakes (epicenter, locality, time, intensity) that occurred in northern-central Italy between 1000 and 1300 (see Stucchi et al., 2007, and Section 3.3). To impute possible missing seismic episodes due to inaccurate historical sources, we adopt three different augmenting procedures (detailed in Section 3.4) by exploiting the geographical distribution of the cities hit by the earthquakes and the location of the epicenter. In addition, we are able to distinguish between earthquakes for which physical damage to people, objects, and the earth's surface were reported and earthquakes that did not result in material damage but were still felt by the population.

Exploiting the panel structure of the dataset and the plausible random nature in the timing of the seismic events, we find a strong negative empirical relation between the occurrence of an earthquake and transition to a commune in Episcopal see cities, while no effect is found for non-Episcopal ones. For the former group of cities, an earthquake reduces the probability of transition to zero in the years following the event. The effect is confined to the short period: within ten years after the tremor, it vanishes. Moreover, this empirical relation is also found for non destructive earthquakes. This suggests that the negative effect of seismic events on the transition probability does not depend on the material damage, increase in poverty, deaths, or the (possibly) differential material impact that those events had on the social classes involved in the political transition. We interpret our findings in the following framework.

The feudal regime and the commune can be seen as two alternative institutional configurations with which to ensure social order (e.g. to minimize the welfare losses due to the expropriation of private property from other citizens; see Djankov et al., 2003), the former relying on the obedience of the citizens to the authoritarian leader, the latter on their participation in public decisions. Before the eleventh century, the feudal society of the collapsing Carolingian Empire was characterized by scant civic capital and substantial coordination problems in social and economic relations: in this context, the feudal leader was relatively better able than the civic associations to ensure social order (Cardini and Montesano, 2006). From the eleventh century onwards, the revival of commerce, the

DeLong and Shleifer, 1993). Recent work also suggests that communal institutions had a long-term impact on trust and social capital (Guiso, Sapienza, and Zingales, 2013).

flourishing of economic activity, and the subsequent increase in per-capita income created incentives for citizens to participate in the management of public affairs, to regulate economic transactions, and to secure property rights (Greif et al., 1994). The development of devices with which to accommodate the consequent need for enforceable agreements among individuals, such as written contracts, guilds, private associations, and legal rules, enhanced the effectiveness of civic associations in city government and triggered, in some cases, the transition from feudal to communal institutions (see Sections 2.1 and 2.2). This process came about in both Episcopal see cities, which in the *status quo* were ruled by bishops, and non-Episcopal ones, ruled by secular lords.

Yet one important feature distinguished the secular leader from the bishop: the latter was, besides a political ruler, the head of the local church and the intermediary between the flock of Christians and God (Benvenuti, 2010). Hence, his authority was reinforced by the citizens' obedience to norms of conduct and their adherence to religious principles (e.g. "do unto others as you would have them do unto you"). In the Middle Ages, in Italy as well as throughout Western Europe, earthquakes were seen as mysterious and unforeseeable events that could only be explained as manifestations of God's wrath. This conviction was widespread, and it was maintained at least until the Enlightenment (Guidoboni and Poirier, 2004; Nur and Borgess, 2008; Schenk, 2010). As amply documented in Sections 2.3 and 2.4, after an earthquake, peoples' common reaction was panic, consternation, and an immediate urge for reconciliation with God. This resulted in a sudden increase in attendance at (and thus a greater demand for) religious services, such as collective prayers, processions, and fasts. Consistently with the idea that the earth's tremor represented a positive shock to religiosity, seismic events were likely to reinforce the religious leaders' authority, to increase (as a consequence) their ability to ensure social order and, thus, to impede transition to communal institutions in Episcopal cities. This effect was limited in time, however. Because the process of institutional change induced by improvements in the levels of civic capital, education, and juridical knowledge could not be interrupted indefinitely by an increase in religious beliefs, in the absence of a further shock, the communal movement eventually resumed. Finally, since the negative impact of an earthquake on the probability of transition to the commune is interpreted to work through the effect of the frightening event on religious beliefs (rather than, or in addition to, its physical consequences), it may be expected to have occurred similarly (but perhaps to a different extent) for destructive and non destructive earthquakes (that were felt by the population but caused no damage to people or objects).

Our study relates to two main strands of the economic literature. The first investigates the role of religion in affecting political (Barro, 1999, and Murphy and Shleifer, 2004) and economic (Barro and McCleary, 2003 and 2005; McCleary and Barro, 2006; Becker and Woessman 2009) outcomes.² We contribute to this literature by exploring how religion and the correspondence between religious and political leaders account for the probability of institutional change and the stability of political regimes in the medieval period.

The second strand of analysis studies the effects of economic shocks on political support (e.g. Healy and Malhotra, 2009; Achen and Bartels, 2004) and on institutional change (e.g. Brückner and Ciccone, 2011; Chaney, 2013).³ The historical experiment described in this paper provides, to the best of our knowledge, the first example of how the occurrence of natural catastrophes (through their impact on religious beliefs) may interfere with political and institutional transitions.

The paper proceeds as follows. In Section 2 we outline the historical background. Section 3 describes the data, while Section 4 reports the empirical strategy, the results, and a number of robustness checks. In Section 5 we discuss alternative explanations for our results, finding no compelling and consistent evidence (either historical or empirical) supporting them, and we draw concluding remarks.

2. Historical Background

2.1 The Status Quo Feudal Regime

At the beginning of the eleventh century the northern-central Italian cities were formally part of the Holy Roman-German Empire. They were ruled by either secular lords (non-Episcopal see cities) or bishops (Episcopal see cities). While until the tenth century the secular rulers (e.g. counts or marquises) were directly appointed by the emperor and governed in his name, in the subsequent period they became increasingly autonomous due to the decline in the

² Barro (1999) studies the relation between a country's primary religious affiliation and its electoral rights indicator, interpreted as a degree of democracy. Murphy and Shleifer (2004) highlight the role of core issues (such as religious beliefs) in building social networks and in creating popular support for political leaders. Our results are also in line with those of recent research showing that natural disasters increase people's religiosity and church attendance (Bentzen, 2013, and Penick, 1981). On the economics of religion see, among others, Iannaccone (1991) and Ekelund and Tollison (2011).

³ Healy and Malhotra (2009) show that American voters reward incumbent governments for effective disaster relief spending. Achen and Bartels (2013) find that voters tend to punish incumbent governments for natural disasters. Brückner and Ciccone (2011) offer evidence that negative rainfall shocks are followed by a significant improvement in democratic institutions in contemporary sub-Saharan African countries. Finally, using historical data, Chaney (2013) shows that the probability of change in Egypt's most powerful religious authority decreased during deviant Nile floods.

political influence of the German emperors' central authority on the fringes of the empire. As a consequence, their power over the city, and the territory surrounding the city, came to encompass the social, political, judicial, and economic spheres. In addition, the secular feudal lords obtained the establishment of a system of hereditary rule over the territory allocated (Bloch, 1951, and Ascheri, 2009).

Bishops in Episcopal see cities performed the same political role as secular feudal lords did in non-Episcopal see cities. They also acted as officials of the Empire and the emperor granted them the same rights and power as wielded by secular rulers. Formally, the city bishops were chosen by the local churches, but the elections were actually influenced by the emperors. Once elected, they were appointed to local political and judicial offices and governed the city autonomously (Pellegrini, 2009). While bishops started to hold political power at least since the late Roman Empire (since the Council of Sardica, fourth century A.D.), their authority strengthened during the subsequent centuries when, in the absence of a strong imperial rule, they represented the only recognized local political officers in the cities (Cardini and Montesano, 2006). The bishops also held religious power and were the main local authority in the Catholic Church. They managed – and benefitted for life from – the property of the cathedral (the church that was formally the bishop's see), and they could also benefit from the exercise of local fiscal power and the collection of rents on land and other resources (Ascheri, 2009; Tabacco, 1987). Unlike secular feudal lords, the bishops did not have the right to transfer their temporal power to their heirs. However, they enjoyed life appointments.

Hence, the bishop was at the same time the head of the local church and the supreme local political authority (Cardini and Montesano, 2006). This fact merits particular emphasis since (in northern-central Italy as in the rest of western Europe) the Catholic Church was, in its turn, the monopolist of religion. There was no competition with other religious organizations and, in Episcopal see cities, the bishop was the head of the hierarchy and controlled the provision of all religious services. In cities with no Episcopal see, political power and religious services were more separated: the former was held by secular feudal lords; the latter were provided by several local representatives of the Catholic Church (e.g. parish priests or monks).

2.2 The Emergence of the Commune

During the eleventh century, the northern and central Italian cities experienced an increase in their urbanization rates and economic importance. An urban elite of merchants, entrepreneurs,

and lawyers emerged from this background and became economically prominent. Members of this elite soon started to form groups of individuals who agreed, with a *patto giurato* ('sworn pact'), to provide mutual help and cooperate on issues of common interest (Guiso, Sapienza, and Zingales, 2013). Gradually, more stable institutions emerged, and the citizens signatory to the pact began to be involved in the city's government, from which they had been previously excluded. In this period, citizens learned to regulate their economic and social relations and to settle their disputes in a decentralized manner, thus reducing the need for a central authority and support to authoritarian leaders.

The shift from the rule of secular feudal lords or bishops to the commune brought a dramatic improvement in terms of citizen participation in the political sphere and the emergence of constitutional checks and balances. The representatives of the commune exercised their power in the name of all the citizens. In particular, the city government was based on a general council of citizens and on elected *consules*, who held executive power. The general council's decisions were valid only if taken in the presence of at least a given minimum number of citizens, and resolutions were always recorded (Senatore, 2008). The *consules* exercised executive power within the limits of a constitution: the *statutum*. With the commune, personal freedoms were accorded legal protection against abuses by government officials, whose actions were subject to the control of *ad hoc* institutions, including courts of law to which citizens could appeal (Galizia, 1951). Rules, laws, and formal decisions were always made in the name of the citizens (males of majority age owning a house had political rights; women, servants, Jews, and Muslims were excluded). Overall, the commune proved to have some degree of separation of powers, and checks and balances operated as in contemporary democracies.⁴

2.3 Natural Disasters and Religiosity in the Middle Ages

In the Middle Ages, the belief that God was the ultimate cause of natural events (Le Goff, 1982) was rooted in biblical references. Great thinkers among the early fathers of the Church supported this view. For example, Philastrius, bishop of Brescia in the fourth century, wrote: "*It is a heresy to believe that an earthquake results, not from the will and outrage of God, but from the nature of the elements themselves, thus denying the Holy Scriptures*" (Guidoboni and Poirer, 2004, pp. 130). Isidore of Séville (1960), in his work "*De rerum natura*", maintained

⁴ It is worth noting that when an Episcopal see city experienced a shift from the feudal to the communal regime, the bishop lost his political power but maintained his role as religious leader and mediator between God and the people, his religious authority being granted by the Catholic Church hierarchy (Code of Canon Law, Chapter 2, Art.1 Can. 375).

that God's judgment of sinners (*iudicium peccatores*) was at the origin of earthquakes. Similarly, Thomas Aquinas, whose work represented the synthesis of medieval Christian philosophy, recognized God as the ultimate cause of seismic events (Guidoboni and Poirier, 2004). In 1280, Saba Malaspina, a priest serving in Pope Martin IV's *curia*, described earthquakes as signs of God's wrath (Schenk, 2010). Also in the *corpus iuris civilis*, the collection of legal rules written under the Roman emperor Justinian, earthquakes were described as consequences of sins against God such as blasphemy (Schoell, 1895).

The Catholic liturgy prescribed specific rituals for protection from natural catastrophes. For instance, during the rogation days – the three days of prayer preceding Ascension Day – people took part in processions and fasts and sang litanies beseeching God to protect them from plagues, natural disasters, and earthquakes. Rogation days were introduced in 463 AD by Mamertus (bishop of Vienne) in France immediately after an earthquake, and they were extended to the entire Catholic Church by the Council of Orleans in 511 AD (Geary, 2010).

The belief that earthquakes were caused by God to punish wicked behavior was not limited to Italy but was widespread in Europe. For example, a chronicle describing the life of Otto, bishop of Bamberg in Germany, reports that in 1117 an earthquake was provoked by people's sins and that the Earth was fighting for God against the 'unwise' (Ebbo, 1869). This view persisted in Europe at least until the Enlightenment. A turning point came with the earthquake that almost entirely destroyed Lisbon in 1755. Although this event was still seen by some as a manifestation of divine judgment, most thinkers started to reject this idea (Dynes, 2000).

2.4 Peoples' Reaction After an Earthquake

The common reaction after an earthquake was panic and consternation. Importantly, the earthquakes that did not cause physical damage also frightened people. For example, the chronicles report that in 1279 an earthquake with its epicenter in the Umbria-Marche region was felt to some extent in Rome. When the earthquake shook the earth, the Pope was at dinner. His table, together with the entire palace, moved "miraculously", and all the people believed that this heralded God's judgment (Valensise and Guidoboni, 2000).

After the immediate panic had subsided, there was an urge for reconciliation and an increase in demand for religious services and, in particular, processions. Many medieval chronicles refer to processions as the very first public act in a city after a seismic event, even after episodes that had not caused physical damage (Riera Melis, 2010). Their purpose was to purify the city land, and they were conceived as the first step in the restoration of public

order. The structure of this ritual, in which all citizens participated, was designed to demonstrate that the authority of the religious leaders was still strong, despite the damage to palaces and cathedrals occasionally caused by earthquakes (Guidoboni and Poirier, 2004). For example, in 1222, a violent earthquake hit the city of Modena. The historical records report that the day after the earthquake the bishop led all the clergy and all the citizens of Modena in a procession to purify the city.⁵ The same happened in Pistoia in 1293, where the chronicles report that after an earthquake that repeatedly hit the city for eight days, all the citizens participated in a number of processions (Adrasto Barbi, 1927).

The role of the bishops was crucial, not only because they were the monopolists in the provision of religious services in the Episcopal see cities, but also because there was a widespread belief that, given their role as intermediaries between God and his ‘flock’, the bishops held apotropaic power and could actually influence natural events. An example is provided by Savino, bishop of Piacenza, who ordered (through his official, a notary) the River Po to stop flooding before it invaded the bishop’s lands (Benvenuti, 2010).

3. Data Description

3.1 Sample

Our analysis covers the largest possible number of northern-central Italian cities for which we have been able to verify that they already existed at the beginning of the eleventh century and to collect reliable historical sources documenting their institutional (either communal or feudal) form during the 1000-1300 period. The sample consists of two groups of cities, Episcopal and non-Episcopal see cities, and it was obtained as follows. As regards the first group, we start from the list of the Italian *diocesi* (Episcopal sees) existing today in northern-central Italy as reported in Conferenza Episcopale Italiana (2015) and we examine their history by scrutinizing various sources (e.g. encyclopedia references or the websites of the *diocesi*). Hence, we verify, first, which cities already existed in 1000 and, second, whether or not the chronology of the bishops of each single city reports a bishop’s name in the year 1000. We include in our first group of cities only those that passed the two above filters. However, it is possible that some cities that were autonomous Episcopal sees between 1000 and 1300 lost their status (maybe because they were merged with other *diocesi*) in subsequent periods, so that they are not reported in the current list of Episcopal sees provided by the Conferenza Episcopale Italiana (2015). To minimize the probability of mistakenly excluding these cities

⁵ The episode is recorded in *Codice Capitolare Duomo di Modena* (0 III, n.13) and reported in Dondi (1896).

from our sample, we also implement the following procedure. Like Guiso, Sapienza, and Zingales (2013), we record the cities on the map “Italia Altomedioevale: Sedi Vescovili” (Treccani, 2007), which reports the map of Episcopal see cities in the late Middle Ages. Whenever we find a city that have not been reported in our previous list, we check in the chronology of bishops whether that city was the see of a bishop in 1000. If so we include it in our sample.

As for the non-Episcopal see cities, we consider the union of the sample of northern-central Italian cities offered by Malanima (2005) and that provided by Bairoch et al. (1988). We then carefully study the history of each city in this group by examining a number of alternative sources (e.g., again, encyclopedia entries or the website of the city). We include in our sample only the cities for which we find evidence that they already existed in 1000.

This two-step procedure yields the initial sample of cities from which we start the analysis.

3.2 *Transition to Commune*

For each city in the sample that we select as described above, we collect information on whether or not it had become a commune during the three centuries considered and (if so) the year in which the institutional transition occurred. The date of transition is set as the first year in which the historical sources offer evidence of the presence of the *consules*, the *statutum*, an official document (e.g. a notarial act) signed by the commune’s representatives, or facts identifying the beginning of the communal experience (e.g. imperial charters granting self-government to the city or the description of episodes in which the citizens ejected the feudal leader from the city and established alternative forms of self-government). Since these dates are not systematically available from uniform data sources, we adopt the following criterion. We first consult academic medieval history books or encyclopedia references. When no date for the birth of the commune (including the case that the city never became a commune) can be established on the evidence of these initial sources, we search through a number of books on the history of each city and Wikipedia. Whenever we find discordance between two sources, we track down a third source and opt for a date recorded in at least two of the three sources. If this criterion is not satisfied, we drop the city. This procedure determines the effective number of cities in our sample: 122, 71 Episcopal see cities and 51 non-Episcopal see cities. The city names are listed in Table 1, where we also report whether or not the city

Table 1. Sample and transition dates

<i>City</i>	<i>Year</i>	<i>Episcopal</i>	<i>City</i>	<i>Year</i>	<i>Episcopal</i>	<i>City</i>	<i>Year</i>	<i>Episcopal</i>
Acqui Terme	1135	Yes	Fondi	-	Yes	Pistoia	1105	Yes
Alassio	-	No	Forlì	1182	Yes	Prato	1107	No
Alba	1169	Yes	Fossombrone	-	Yes	Ravenna	1109	Yes
Albenga	1098	Yes	Galliate	-	No	Reggio Nell'Emilia	1136	Yes
Aquileia	-	Yes	Garlasco	-	No	Rieti	1171	Yes
Arezzo	1098	Yes	Genova	1080	Yes	Rovereto	-	No
Ascoli Piceno	1183	Yes	Gorizia	-	No	Rovigo	-	No
Asiago	-	No	Grado	-	Yes	Saluzzo	-	No
Asti	1095	Yes	Grosseto	1204	No	San Colombano Al Lambro	-	No
Bergamo	1098	Yes	Iesolo	-	Yes	San Gimignano	1199	No
Biella	1245	No	Imola	1084	Yes	San Severino Marche	1170	No
Bologna	1116	Yes	Imperia	-	No	Sant'Angelo Lodigiano	-	No
Bolzano	-	No	Ivrea	1171	Yes	Sarsina	-	Yes
Brescia	1127	Yes	La Spezia	-	No	Savona	1191	Yes
Bressanone	-	Yes	Livorno	-	No	Senigallia	-	Yes
Camerino	-	Yes	Lodi	1142	Yes	Siena	1147	Yes
Caravaggio	1182	No	Lucca	1081	Yes	Sora	-	Yes
Carpi	-	No	Lugo	-	No	Soresina	-	No
Castiglione Delle Stiviere	-	No	Macerata	1138	No	Spoletto	1173	Yes
Cento	-	No	Mantova	1115	Yes	Stradella	-	No
Cesena	1176	Yes	Massa	-	No	Subiaco	1193	No
Chiavari	1243	No	Milano	1097	Yes	Sutri	-	Yes
Chieri	1150	No	Modena	1135	Yes	Tolentino	1166	No
Chioggia	-	No	Monselice	-	No	Tortona	1122	Yes
Chivasso	-	No	Montefiascone	-	No	Treia	1157	No
Civitavecchia	-	Yes	Narni	-	Yes	Trento	-	Yes
Codogno	1232	No	Nepi	1131	Yes	Treviglio	-	No
Comacchio	-	Yes	Novara	1116	Yes	Treviso	1150	Yes
Como	1109	Yes	Novi Di Modena	-	No	Trieste	1295	Yes
Corridonia	-	No	Novi Ligure	1135	No	Valenza	1204	No
Crema	1185	No	Numana	-	Yes	Ventimiglia	1149	Yes
Cremona	1098	Yes	Ormea	-	No	Vercelli	1141	Yes
Empoli	-	No	Orvieto	1157	Yes	Veroli	-	Yes
Fabiano	1234	No	Padova	1138	Yes	Verona	1136	Yes
Faenza	1141	Yes	Parma	1149	Yes	Viadana	-	No
Fano	1114	Yes	Pavia	1106	Yes	Vicenza	1147	Yes
Feltre	-	Yes	Perugia	1139	Yes	Viterbo	1099	No
Fermo	1199	Yes	Pesaro	1182	Yes	Vittorio Veneto	-	Yes
Ferrara	1105	Yes	Piacenza	1126	Yes	Voghera	1136	No
Fiesole	-	Yes	Pinerolo	1220	No	Volterra	1170	Yes
Firenze	1125	Yes	Pisa	1081	Yes			

Notes - The list shows all the cities included in our sample. *Year* is the year when the first evidence of the commune, if any, was found in historical sources. ‘-’ denotes the city never becomes a commune within the sample period (1000-1300). *Episcopal* denotes whether the city was seat of a bishop (‘Yes’) or not (‘No’).

was the seat of a bishop and, for the cities that became communes in the sample period, the year of transition.

3.3 Earthquakes

The original data on earthquakes are drawn from the DBMI04, assembled by researchers at the Italian National Institute for Geophysics and Volcanology (Stucchi et al., 2007), which

contains information on earthquakes occurring in Italian cities between 217 BC and 2002. The catalogue, an extraordinarily rich source of information, is the product of a branch of seismology called historical seismology. Historical seismology is a multidisciplinary endeavor which uses historical sources to identify the occurrence and effects of seismic events, even in the remote past (Guidoboni, 2002; Stucchi, 1993). It processes historical information into macroseismic parameters, such as time, epicentral location, and earthquake intensity (Guidoboni and Ebel, 2009). The sources of information range from historical records, including archives of public administrations and institutions, diaries, chronicles, letters, monastic, ecclesiastic and capitular archives, *notulae*, and the archives of notaries, to actual archaeological traces (e.g. damage to churches and buildings and subsequent restorations) left behind by seismic events. In the past three decades, the meticulous approach adopted by historical seismologists has led to a remarkable improvement in the quality of the investigation, and it has enabled acquisition of information on the effects of earthquakes, often with a surprising amount of detail (Stucchi, 1993). The material available through these sources is particularly rich in the case of Italy (Boschi, 2000). The historical records for the period studied here refer to universal chronicles, monastic annals, ecclesiastical and liturgical sources, ancient literary sources, and coeval historiography (Guidoboni, 2000).

The main source for the geographical references is the ENEL-ISTAT catalogue of Italian localities (ENEL, 1978) and updates. In the period (1000-1300) and geographical area (northern-central Italy) considered in this paper, 30 earthquakes occurred, and they hit cities included in our sample 105 times (obviously, a city can be struck by more than one episode). They are reported in Table 2, which indicates, for each earthquake, the year and the name of the city at the epicenter (or the city nearest to the epicenter).⁶ Column (1) reports the number of cities in our sample which registered each of the 30 earthquakes. For instance, in 1005 two earthquakes occurred. The first had its epicenter in Arezzo and was registered in two cities included in our sample, Arezzo and Pistoia; hence the number of cities in the corresponding cell is two (although more than two cities among those not included in our sample were also hit). The second had its epicenter in Cassino and was also registered by two cities, Cassino and Rome, neither of which is included in our sample; this is why the corresponding number of cities in Table 2 is equal to zero.

The intensity (I , hereafter) of a seismic event is registered on the Mercalli-Cancani-Sieberg (MCS, hereafter) scale, which measures the effects brought about by the seismic

⁶ Since the DBMI04 reports the geographical coordinates of the epicenter for each earthquake, we are able to infer the current name of the city closest to it (regardless of whether or not the city existed in 1000).

Table 2. Earthquakes

<i>Epicenter city</i>	<i>Year</i>	(1)	(2)	(3)	(4)	(5)	(6)	(7)
		<i>Registered quakes</i>	<i>Polygon All</i>	<i>Identifying</i>	<i>Epicenter All</i>	<i>Identifying</i>	<i>Circles All</i>	<i>Identifying</i>
Arezzo	1005	2	6	6	17	17	4	4
Cassino	1005	0	2	2	4	4	0	0
Brescia	1065	5	7	7	18	18	4	4
Scardevara	1117	24	93	75	121	100	42	33
Firenze	1148	1	3	1	1	0	4	2
Pisa	1168	1	3	1	1	0	3	1
Ceccano	1170	0	1	1	0	0	3	3
Genova	1182	1	1	0	1	0	1	0
Cesena	1194	2	7	2	14	5	5	2
Pistoia	1196	1	2	0	1	0	3	1
Brescia	1197	8	1	0	1	0	2	1
Genova	1217	1	1	0	1	0	1	0
Lazise	1222	22	52	21	65	30	42	15
San Germano	1231	0	3	3	4	3	1	1
Ferrara	1234	4	1	0	1	0	3	2
Spoletto	1246	1	1	0	1	0	1	0
Modena	1249	4	3	1	3	1	6	3
Treviso	1268	3	3	1	4	2	4	2
Numana	1269	1	1	1	1	1	3	2
Sansepolcro	1270	0	0	0	0	0	1	0
Piacenza	1276	5	29	10	44	14	18	5
Spoletto	1277	1	1	0	1	0	1	0
Cividal Del Friuli	1279	1	4	4	7	6	6	5
Galeata	1279	3	6	1	7	2	7	2
Serravalle Di Chienti	1279	3	13	4	27	9	10	3
Mestre	1284	1	7	4	38	22	7	3
Ferrara	1285	2	1	0	1	0	3	2
Pistoia	1293	1	2	0	1	0	3	1
Chur	1295	4	11	3	25	12	7	1
Poggio Bustone	1298	3	14	4	38	14	10	1
Total		105	279	152	448	260	205	99

Notes - The list shows all the earthquakes included in our data. *Epicenter city* is the city closest to the epicenter of the earthquake according to the geographical coordinates provided by the DBMI04. *Year* is the year in which the earthquake occurred. *Registered quakes* are the seismic events registered for our sample cities in the DBMI04. For each of the three augmenting criteria (*polygon*, *epicenter*, *circles*), the number of cities in our sample hit by a seismic event (*All*) and the number of earthquakes used for identification (*Identifying*) are reported.

event on people, natural objects, buildings and other man-made objects, and the Earth's surface.⁷ In what follows we distinguish between destructive earthquakes (intensity greater

⁷ The scale ranges from 1 to 12: when *I* stands at 1, this means that people did not feel the earthquake; *I* at 2 means that the earthquake was felt by very few persons; *I* from 3 to 5 means that the earthquake was felt by many but did not cause damage; *I* from 6 to 7 indicates that physical damage was reported; *I* from 8 to 10 that human victims were also registered; *I* equal to 11 indicates catastrophic destruction; and *I* equal to 12 total

than 5 on the MCS scale) denoted by D and seismic events that were felt by the population but caused no physical damage (intensity greater than 2 and smaller than or equal to 5) denoted by F . For a number of seismic events, the intensity could not be registered in the original dataset (DBMI04) because of missing or inaccurate historical sources.⁸

3.4 Augmented dataset

A possible concern about the data described above is that not all the seismic events that occurred were originally recorded because of missing or inaccurate historical sources. Consider an earthquake with its epicenter in city j that occurred at time t . Suppose that this earthquake was recorded in the DBMI04 for city j , but not for city i that was also struck by the seismic episode, because the historical sources for this city were not handed down to the most recent periods. To take this possibility into account, we build an augmented dataset according to the three following criteria.

Polygon criterion: For all the cities that in the sample period reported a seismic event with a valid registered intensity (falling in either the D or F category) in the DBMI04, we draw the outer convex polygon and impute an earthquake as occurring in city i at time t if this city was located within the polygon.⁹ Figure 1.A reports an example concerning the earthquake that struck northern Italy in 1222. The empty dots represent the cities hit by the earthquake in the DBMI04. Varese, Treviso, Venezia, Cesena, Genova, and Alessandria represent the vertexes of the outer polygon. The full dots denote the cities that were assigned the earthquake because they were located within the polygon. The epicenter, Lanzise, is denoted by a star. After we augment the dataset by means of this criterion, the total number of seismic episodes increase to 279 (of which 152 hit cities before their transition to communes, if any, see Table 2).

(apocalyptic) destruction. The strongest earthquake in our sample was registered in Verona in 1117 with I equal to 9.

⁸ Of the 105 seismic episodes registered in our sample, 51 caused material damage to buildings or people, 25 were felt by people but did not cause any physical damage, and 29 were registered with unreported intensity.

⁹ Since the cities are identified by pairs of geographic coordinates that are points on the plane, in order to include cities that might be located on the line between two vertex of a polygon we draw the sides of the polygons using buffers with widths equal to 20 km. The results do not change in any significant way if alternative widths are used. For earthquakes that hit just one city we draw a circular area around the city with a radius equal to 20 km. When the earthquake hit two cities only, we draw a rectangular area that cover the two cities and whose shortest side is 40 km wide (20 km on each side of the city).

Figures 1. The earthquake of 1222

Figure 1.A (*Polygon* criterion)

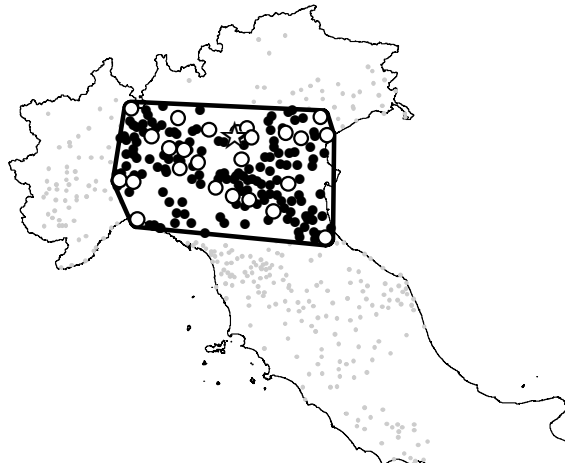
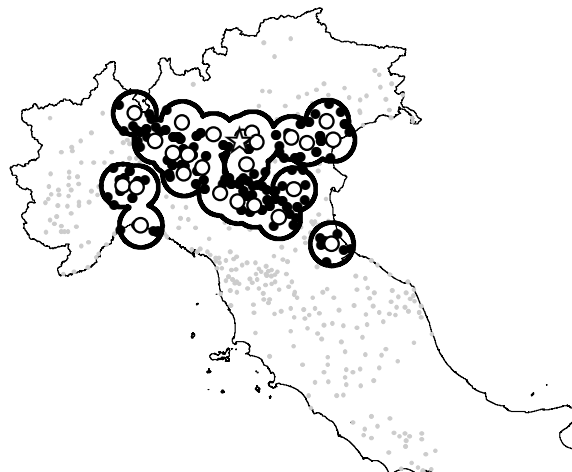


Figure 1.B (*Epicenter* criterion)



Figure 1.C (*Circles* criterion)



Notes – Geographic distribution of the cities hit by the earthquake of 1222. Empty dots represent the cities that reported the earthquake in the DBMI04; full dots denote the cities that were assigned the earthquake by the augmenting criterion (*polygon*, *epicenter*, or *circles*). The epicenter is denoted by a star.

Epicenter criterion: Consider an earthquake that occurred at time t with its epicenter in city j . Here we draw a circumference with city j at the center and with a radius equal to the distance between city j and the farthest city that reports a seismic event with a registered intensity in the DBMI04. We then assign a seismic episode to all the cities located within the circumference. A graphical representation of this criterion is depicted in Figure 1.B, where again the empty dots indicate the cities which registered the episode in the DBMI04, the star denotes the epicenter, and the full dots are the cities imputed by the *epicenter* criterion. The total number of seismic events yielded by this criterion is 448 (of which 260 hit cities before their transition to communes, if any).

Circles criterion: We take all the cities for which the occurrence of an earthquake has been reported in the DBMI04 with a registered intensity and draw an equal number of circles with each of those cities as the center and radius equal to 30 km (we also experiment with alternative threshold distances and obtain no significant differences in the results). We then assign the earthquake to all the cities within the union of these circles. Figure 1.C provides an illustration: the empty dots are the registered episodes in the DBMI04 and the full dots are the events created by the *circles* criterion. The total number of episodes identified by this criterion is 205 (of which 99 hit cities before their transition to communes, if any).

In what follows we will refer to the *polygon* criterion as our preferred augmenting methodology. For all the seismic episodes included in the augmented dataset according to one of the above criteria we also impute intensity, and proceed as follows. Consider an earthquake with epicenter in city i ; we draw around city i a circumference with radius equal to the distance between city i and its closest city struck by that earthquake with intensity equal to D . All the cities included in this circumference are assigned intensity equal to D , while all the cities that lie outside this circumference, but are still assigned an earthquake according to one of the three augmenting criteria, report an intensity equal to F .¹⁰

Table 2 shows, for each of the three augmenting criteria explained above, the total

¹⁰ With this criterion we assign to more cities intensity equal to F than to D . For instance, for the *polygon* criterion, we assign F to 202 cities and D to 77 cities. We believe this criterion to be valid for the following reason. On average, the distance from the epicenter for cities that registered destructive seismic episodes is larger than that for cities that felt only a tremor without reporting any damage. Hence, we assign D to cities inside the circumference and F to those outside it. Since earthquakes do not necessarily spread concentrically, however, in some cases low intensity tremors (that would fall in the F category) in the DBMI04 may be registered closer to the epicenter than destructive episodes. This is why we adopt as a radius of the circumference the minimum distance of a D episode from the epicenter. Note that alternative criteria would not change our conclusions. Finally, the seismic events registered in the original dataset - DBMI04 - with intensity D or F retain the registered intensity.

number of cities in our sample hit by an earthquake (columns (2)-(4)-(6), respectively) and the number of cities in our sample hit before transition (columns (3)-(5)-(7), respectively). Note that in some cases we report earthquakes that were not registered in the cities of our sample but were still detected by our augmenting criteria (for instance, the earthquake that originated in Sansepolcro – not included in our sample – in 1270 was not originally registered in our sample of cities, but was assigned to Arezzo according to the *circles* criterion).

4. Empirical Strategy and Results

4.1 Identification strategy

To analyze the effect of an earthquake on the probability of transition to commune, we start by considering the following regression model:

$$transition_{it} = \alpha_i + \tau_t + \delta_i \cdot t + \sum_{j=0}^{20} \beta_j \cdot quake_{it-j} + \sum_{j=0}^{20} \gamma_j \cdot bishop_i \cdot quake_{it-j} + \varepsilon_{it}, \quad (1)$$

where i denotes the city and t indicates the year. The dependent variable, $transition_{it}$, captures the event of an institutional transition and is equal to one if city i became a commune in year t and is equal to zero otherwise. Since the transition from communal institutions back to the feudal regime was not an option for historical reasons, for a city i which transitioned to a commune in year t , time is not defined after t .¹¹ This means that the transition to communal institutions is an absorbing state: after becoming a commune, the city drops out of the sample. As a consequence, our dataset is an unbalanced panel. $Quake_{it}$ is a dummy variable that is equal to one if a seismic event occurred in city i and in year t (according to our augmented dataset) and is equal to zero otherwise. $Bishop_i$ is also a dummy variable and equals one if city i was the seat of a bishop at time $t=1000$ and zero otherwise. The coefficients $\beta+\gamma$ and β capture, respectively, the effect of a seismic event on the transition probability for the Episcopal and non-Episcopal see cities, while γ indicates the differential effect between the two. α_i , τ_t , and $\delta_i \cdot t$ are respectively the city fixed effects, the year fixed effects, and the city-specific time trends. Finally, ε_{it} is the error term.

¹¹ In the fourteenth century (hence after the end of our sample period) some cities which had previously established communal institutions adopted an authoritarian form of government ruled by the *Signore* (the Lord) and were accordingly named *Signoria*. This transition process was highly heterogeneous across cities, and it related to two phenomena: the emergence of a wealthy class of individuals who took control of the city institutions (e.g. the Medicis in Florence) and the territorial expansion of some communes, which conquered the neighboring cities and established regional states. Consequently, since many cities were governed by the same lord (e.g. Bergamo and Cremona were conquered by Milan under the *Signoria* of the Visconti family), the number of established *Signorie* was remarkably smaller than the number of communes.

In our model specification, city fixed effects take account of the fact that cities may be different in many important permanent unobservable characteristics, which are likely correlated with both the city's seismicity and its probability of an institutional transition (for example, the city's altitude might affect the perception of the earth's tremor and is also a proxy for the city's strategic position and capacity to repel enemies). Time fixed effects absorb any potential event contemporaneous with the earthquake for all the cities (e.g. a famine) which may affect the probability of a transition. Time fixed effects ensure that identification is obtained conditional on shocks common to cities with and without earthquakes in each single year. Finally, the city-specific time trends account for possible slow-moving social and cultural variables (e.g. civic and human capital accumulation) specific to each city in the sample and which are correlated with the probability of both establishing communal institutions and registering an earthquake. In fact, in our data, both a city's probability of becoming a commune (see Table 1) and its probability of registering an earthquake (see Table 2) are positive functions of time. Importantly, these trends may vary from city to city because, for instance, cities experiencing increases in education and the accumulation of civic capital steadily enhance their ability to register earthquakes. The omission of one or both sets of fixed effects or of the city-specific trends would lead to a potential bias in the coefficient of interest. Their inclusion allows us to exploit the random nature of the timing of the seismic episodes that is the central feature of our design.

We explore the dynamic treatment effects by including lagged earthquake variables because we are interested not only in the contemporaneous effect but also in its duration.¹² We consider lagged quake variables up to 20 years because we expect our effect of interest to develop in a relatively short-run period. As we will show, this expectation is confirmed by the data.

Given the large number of fixed effects included, model (1) and its modifications are estimated adopting a linear probability model (LPM hereafter). The limitations of this approach and alternative functional forms are discussed in Section 4.6. To take account of potential spatial correlation of the error terms in an unknown form, we employ Conley's method (Conley, 1999), in which the spatial dependence between two observations in two different cities decreases with the distance between the cities. This method requires a

¹² Moreover, if the effect of a seismic event on the transition probability lasts for a few years after its occurrence, by omitting the lagged earthquake variable, we would include, mistakenly, in the control group observations treated by the seismic event. The estimated coefficient of the contemporaneous effect would, as a consequence, be biased.

threshold distance after which the dependence disappears. Our preferred threshold is 100 km, meaning that error spatial dependence decreases linearly between zero and 100 km and disappears for longer distances. Moreover, for earthquakes registered by multiple cities in the original dataset, the average distance between the epicenter and the farthest city with a registered intensity is 110,4. In our analysis, we will also present standard errors clustered at the city level and Conley's standard errors obtained with alternative threshold distances (200 km or 500 km).

4.2 Diagnostic tests and preliminary evidence

The three criteria described in Section 3.4 (*polygon*, *epicenter*, and *circles*) assign potential missing seismic events to cities by starting from *recorded* earthquakes (respectively, the vertexes of the polygons, the epicenter, the center of the circles). Hence, this augmenting procedure cannot take into account earthquakes that were not registered at all in the DBMI04, because in no city were the relative documents handed down to the historical sources. This may be important in the presence of pre-trends. For instance, if transitions happen during a period of political turmoil or in the presence of other circumstances that negatively influence the probability of registering an earthquake, we would erroneously attribute to a seismic episode a negative impact on the probability of becoming commune, while no true effect exists. If these circumstances last for some years after the transition, we should observe negative effects of the leads of the earthquake variable on the transition. Hence, finding no negative effects of the earthquake on past transitions is consistent with the absence of pre-trends.

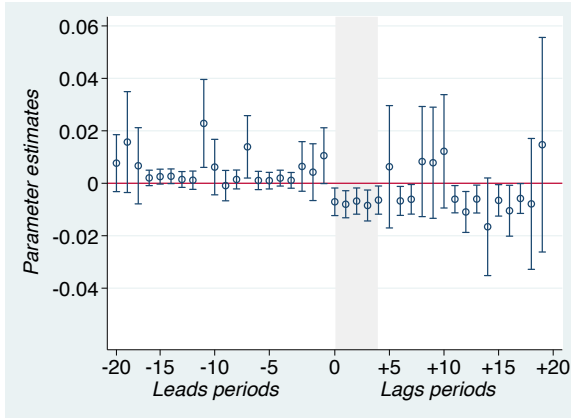
To verify the presence of possible pre-trends and provide preliminary evidence on the effect of earthquakes on the transition probability, we estimate model (1) including both lags and leads in the earthquake variable. Since the outcome is an absorbing state, lead and lag effects must be estimated separately. In estimating the coefficients on the leads, we left the outcome variable equal to one if a transition occurred in city i and at time t and set it equal to zero in the following periods (before t , time is not defined and the city drops).

The results are shown in Figures 2, where, for each augmenting criterion, we plot the estimated coefficients respectively for Episcopal (the estimated $\beta+\gamma$ from model (1)) and non-Episcopal (β from model (1)) see cities and the associated confidence intervals according to the estimated Conley's standard errors with 100 km threshold distance. On the left part of the plot, we report coefficients on the leads as they capture a relation between a present occurrence of an earthquake and past transitions. On the right part, we measure the

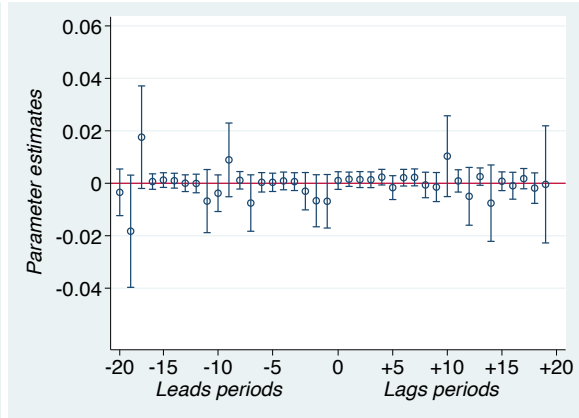
Figures 2. Leads and lags

2.A Polygon criterion

Episcopal see cities

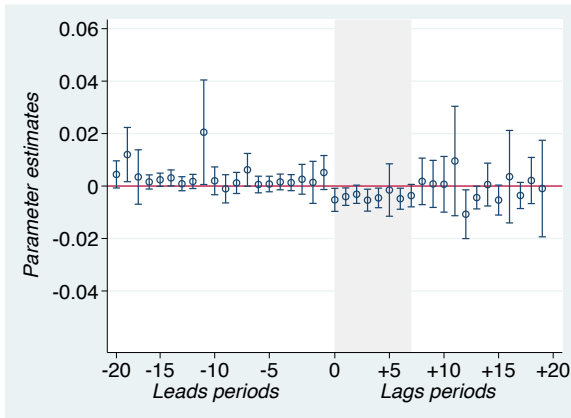


Non-Episcopal see cities

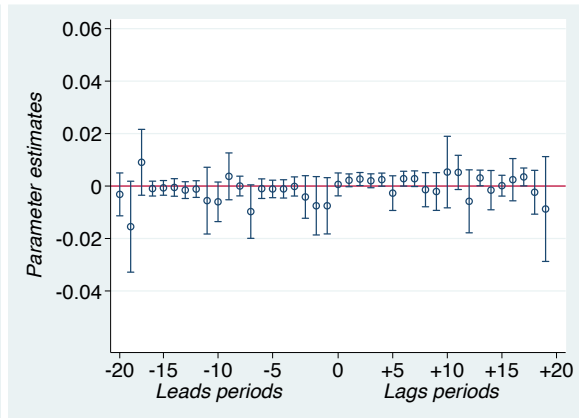


2.B Epicenter criterion

Episcopal see cities

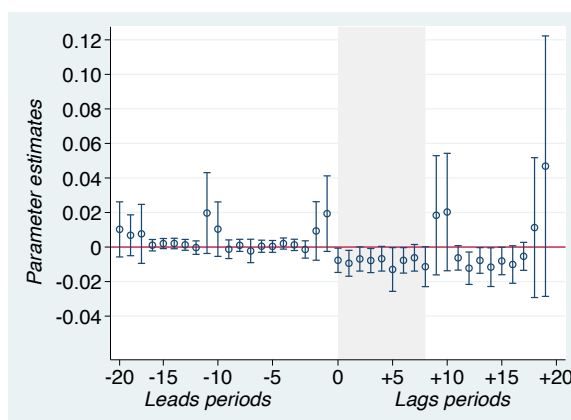


Non-Episcopal see cities

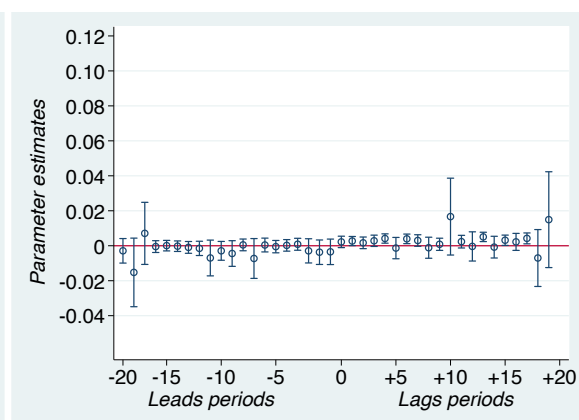


2.C Circles criterion

Episcopal see cities



Non-Episcopal see cities



Notes - Estimation by OLS of model (1) with lags and leads. The dependent variable, *transition*, is =1 if city *i* became a commune at time *t* and =0 otherwise. The independent variable, *quake*, is =1 if an earthquake occurred in city *i* at time *t* and =0 otherwise. The figures for Episcopal (non-Episcopal) see cities report the estimated $\beta + \gamma$ (β). The confidence intervals are computed employing Conley's standard errors (100 km).

contemporaneous coefficient and coefficients on the lags, reflecting the dynamic treatment effects, as they reveal a relation between a current earthquake and future values in the outcome variable.

Three empirical patterns are apparent in Figures 2. First, for Episcopal see cities (Figures 2.A, 2.B, 2.C, left panels), most of the point estimates of the lagged earthquakes are negative, especially in the very short run.¹³ The results suggest that the occurrence of an earthquake retards the transition to communal institutions. The effect appears to last longer when we consider the *circles* augmenting criterion (Figure 2.C, left panel) and to last for a shorter time when we adopt the other two criteria, *polygon* and *epicenter* (respectively Figures 2.A and 2.B, left panels).¹⁴ By contrast, no effect is observed when non-Episcopal see cities are considered (Figures 2.A, 2.B, 2.C, right panels): in this case, the estimated coefficients provide no compelling evidence of an effect of seismic events on the transition probability. Second, for Episcopal see cities, no negative pre-trend appears from the plotted lead effects. If anything, the effects are virtually zero with point estimates slightly above zero. Finally, the large confidence intervals associated with a number of coefficients suggest that they are quite imprecisely estimated. It is likely that exploiting the annual variability in the earthquake variable generates noise in the estimation. In fact, the latter finding advises us to adopt a model that aggregates the effects of the earthquakes across consecutive years that we report in the following sections.

4.3 Aggregate effects and intensity

For reasons of tractability and to gain in efficiency, we give more structure to the model and aggregate the effects of earthquakes on the transition probability in five-year effects. We thus estimate the following regression equation:

¹³ In the Online Appendix (Table A.1) we show the estimated $\beta + \gamma$ from model (1) modified to include up to 25 lagged earthquake dummies (for the *polygon* criterion). The p -values computed from a test of joint significance of lagged effects grouped by five-year periods are also reported. From the table one can see that the effect of an earthquake lasts at most 20 years (i.e. the lag effects between 20 and 25 years are practically insignificant) and that adding a number of lags larger than 20 does not contribute to improving the estimation precision for the coefficients on the previous lags. Consequently, we perform the empirical analysis including lags and leads up to 20 years.

¹⁴ To convey the dynamics better, in the Online Appendix (Figure A.2) we also report the contemporaneous coefficient and coefficients on the *quake* variable lagged up to 40 years. For all the three augmenting criteria, the effect of an earthquake is mainly confined to the two decades following the seismic event, being precisely estimated especially in the first five years of the first decade. Starting from the third decade the effect vanishes and all the coefficients turn out to be not statistically different from zero. This exercise confirms that the effect of the earthquake is confined to the short run.

$$transition_{it} = \alpha_i + \tau_t + \delta_i \cdot t + \sum_{h=0}^3 \beta_{-5h} \cdot quake_{-5h,it} + \sum_{h=0}^3 \gamma_{-5h} \cdot bishop_i \cdot quake_{-5h,it} + \varepsilon_{it}, \quad (2)$$

where $quake_{0,it}$, $quake_{-5,it}$, $quake_{-10,it}$, and $quake_{-15,it}$ are equal to one, respectively, in the first, second, third, and fourth five-year interval following the earthquake, and to zero otherwise (note that while data are annual, the effects are aggregated every five years).

The estimated coefficients in this model represent the average effect of an earthquake over each five-year period. Table 3 presents the results. For each augmenting criterion, we report the effect on the Episcopal and that on the non-Episcopal see cities ($\beta+\gamma$ and β , respectively), as well as the differential effect (γ), which indicates if the impact of a seismic episode on the former group of cities is statistically different from the impact on the latter. Columns (1)–(2)–(3), (4)–(5)–(6), and (7)–(8)–(9) of Table 3 show the results from regression (2) on adopting, respectively, the *polygon*, the *epicenter*, and the *circles* criterion. Standard errors clustered at the city level are reported in square brackets and Conley's standard errors corrected for spatial dependence with thresholds distance of 100 km are shown in round brackets. Statistical significance is indicated with Conley's standard errors, which in most cases are very similar to clustered standard errors.

In Episcopal see cities ($\beta+\gamma$, columns (1)–(4)–(7)), the occurrence of an earthquake has always a negative and statistically significant effect on the dependent variable in the first five years following the event. In particular, the drop in the probability of transition to a commune is equal to 0.7 percentage points when we consider our preferred augmenting criterion (*polygon*): hence, the earthquake pushes the probability to zero. The effect remains negative, but not precisely estimated, in the following years, the sole exceptions being the second five-year period when the *polygon* criterion is taken into account, and the last interval when we consider the *circles* criterion.

As regards the non-Episcopal see cities (β , columns (2)–(5)–(8)), no statistically significant effect is observed, the point estimates being positive and mostly close to zero (the only exception is a positive and statistically significant coefficient estimated for the first five-year interval with the *circles* criterion). Moreover, in the first five years after an earthquake, the impact is statistically different between Episcopal and non-Episcopal see cities, as is apparent on observing that the coefficient on the differential effect (γ , columns (3)–(6)–(9)) is negative and statistically different from zero at any confidence level. Overall, these results corroborate those illustrated in Section 4.2: a seismic event has a negative impact on the probability of transiting to a commune for only the Episcopal cities; the effect is concentrated

Table 3. Main results: 5-year aggregation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	<i>Polygon</i>			<i>Epicenter</i>			<i>Circles</i>		
	<i>Effect on Episcopal cities</i>	<i>Effect on non- Episcopal cities</i>	<i>Difference</i>	<i>Effect on Episcopal cities</i>	<i>Effect on non- Episcopal cities</i>	<i>Difference</i>	<i>Effect on Episcopal cities</i>	<i>Effect on non- Episcopal cities</i>	<i>Difference</i>
	$\beta_{-5h} + \gamma_{-5h}$	β_{-5h}	γ_{-5h}	$\beta_{-5h} + \gamma_{-5h}$	β_{-5h}	γ_{-5h}	$\beta_{-5h} + \gamma_{-5h}$	β_{-5h}	γ_{-5h}
<i>Quake</i> _{0,it} (=1 from <i>t</i> to <i>t</i> -4)	-0.0071*** (0.0023) [0.0020]	0.0015 (0.0011) [0.0009]	-0.0086*** (0.0028) [0.0023]	-0.0046*** (0.0015) [0.0013]	0.0017 (0.0012) [0.0010]	-0.0063*** (0.0019) [0.0016]	-0.0075** (0.0030) [0.0026]	0.0026*** (0.0010) [0.0009]	-0.0101*** (0.0034) [0.0027]
<i>Quake</i> _{-5,it} (=1 from <i>t</i> -5 to <i>t</i> -9)	0.0021 (0.0051) [0.0053]	0.0001 (0.0016) [0.0015]	0.0020 (0.0061) [0.0063]	-0.0015 (0.0025) [0.0023]	-0.0002 (0.0018) [0.0018]	-0.0013 (0.0036) [0.0037]	-0.0038 (0.0054) [0.0056]	0.0011 (0.0015) [0.0014]	-0.0049 (0.0057) [0.0058]
<i>Quake</i> _{-10,it} (=1 from <i>t</i> -10 to <i>t</i> -14)	-0.0050 (0.0039) [0.0041]	0.0001 (0.0032) [0.0036]	-0.0051 (0.0045) [0.0047]	-0.0006 (0.0032) [0.0034]	0.0010 (0.0027) [0.0032]	-0.0016 (0.0037) [0.0040]	-0.0022 (0.0055) [0.0061]	0.0044 (0.0033) [0.0038]	-0.0066 (0.0066) [0.0073]
<i>Quake</i> _{-15,it} (=1 from <i>t</i> -15 to <i>t</i> -19)	-0.0031 (0.0060) [0.0054]	-0.0000 (0.0030) [0.0037]	-0.0031 (0.0078) [0.0070]	-0.0007 (0.0037) [0.0037]	-0.0009 (0.0028) [0.0028]	0.0002 (0.0051) [0.0053]	0.0066 (0.0104) [0.0091]	0.0036 (0.0039) [0.0035]	0.0030 (0.0120) [0.0102]
Year fixed effects		YES			YES			YES	
City fixed effects		YES			YES			YES	
City time trends		YES			YES			YES	
Observations		24,131			24,131			24,131	
R-squared		0.054			0.054			0.054	
Cities		122			122			122	

Notes - Estimation by OLS of model (2) in the text. Columns (1)–(2)–(3), (4)–(5)–(6), and (7)–(8)–(9) report results on adopting, respectively, the *polygon*, the *epicenter*, and the *circles* criterion. The dependent variable, *transition*, is =1 if city *i* became a commune at time *t* and =0 otherwise. The independent variable, *quake*, is =1 if an earthquake occurred in city *i* at time *t* and =0 otherwise. Standard errors clustered at the city level are reported in squared brackets; Conley's standard errors corrected for spatial dependence with threshold distance of 100 km are in round brackets. *** significant at 1%; ** significant at 5%; * significant at 10%. Statistical significance is indicated employing the Conley's standard errors.

in the short run and precisely estimated in the first five years after the episode.

We employ a similar modeling strategy to exploit information on the intensity of seismic events. Here we distinguish between earthquakes that were only felt by the population but did not cause any damage (with intensity in MCS scale greater than 2 and smaller than or equal to 5; F) denoted by $fquake_{it}$ and destructive earthquakes (with intensity greater than 5; D), denoted by $dquake_{it}$, and estimate the following model:

$$\begin{aligned} transition_{it} = & \alpha_i + \tau_t + \delta_i \cdot t + \sum_{h=0}^3 \beta_{-5h}^D \cdot dquake_{-5h,it} + \sum_{h=0}^3 \beta_{-5h}^F \cdot fquake_{-5h,it} + \\ & + \sum_{h=0}^3 \gamma_{-5h}^D \cdot bishop_i \cdot dquake_{-5h,it} + \sum_{h=0}^3 \gamma_{-5h}^F \cdot bishop_i \cdot fquake_{-5h,it} + \varepsilon_{it} \end{aligned} \quad (3)$$

The results are shown in Table 4. Specifically, Panel A reports the estimated coefficients $\beta^D + \gamma^D$ (columns (1)-(4)-(7)) and $\beta^F + \gamma^F$ (columns (2)-(5)-(8)) which capture the effect, for Episcopal see cities, of an earthquake with intensity D and F respectively. The corresponding coefficients, β^D and β^F , for non-Episcopal see cities are shown in Panel B (columns (1)-(4)-(7) and (2)-(5)-(8) respectively). In columns (3)-(6)-(9) (Panels A and B), we also report an F -test of equality of the coefficients on destructive and non destructive earthquakes (Episcopal and non-Episcopal cities, respectively). We find that both D and F seismic events always have a negative effect on the transition probability in the first five years after the earthquake. The point estimate for a seismic event with intensity D is larger, in absolute value, than that associated with intensity F ; however, the F -test does not reject the null hypothesis that the two coefficients are equal (with the exception of the *epicenter* criterion, for which the two coefficients turn out to be different at the 10% level). By contrast, no effect is observed in the sample of non-Episcopal see cities (with the exception of the earthquakes imputed according to the *circles* criterion, in which case the point estimates are positive and marginally significant). Overall, the results in Table 4 suggest that we cannot exclude that earthquakes only felt by the population with no physical damage to human or objects also retarded the establishment of communal institutions in Episcopal see cities.

4.4 Placebo test

To check the robustness of our results, we implement a placebo test in the spirit of Chetty, Looney, and Kroft (2009) adopting our preferred augmenting criterion (*polygon*). In our sample of years and cities, 30 earthquakes took place in northern-central Italy, which (according to the *polygon* criterion) generated 279 city-episodes (the total number of seismic

Table 4. Intensity: 5-year aggregation*Panel A: Effect on Episcopal cities*

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	<i>Polygon</i>			<i>Epicenter</i>			<i>Circles</i>		
	<i>Damage</i>	<i>Felt</i>	<i>F-test</i>	<i>Damage</i>	<i>Felt</i>	<i>F-test</i>	<i>Damage</i>	<i>Felt</i>	<i>F-test</i>
	$\beta^D_h + \gamma^D_h$	$\beta^F_h + \gamma^F_h$	$\beta^D_h + \gamma^D_h \neq \beta^F_h + \gamma^F_h$	$\beta^D_h + \gamma^D_h$	$\beta^F_h + \gamma^F_h$	$\beta^D_h + \gamma^D_h \neq \beta^F_h + \gamma^F_h$	$\beta^D_h + \gamma^D_h$	$\beta^F_h + \gamma^F_h$	$\beta^D_h + \gamma^D_h \neq \beta^F_h + \gamma^F_h$
<i>Quake</i> _{0,it} (=1 from <i>t</i> to <i>t</i> -4)	-0.0151** (0.0067) [0.0042]	-0.0055** (0.0022) [0.0021]	(<i>F</i> =0.159) [<i>F</i> =0.036]	-0.0150** (0.0066) [0.0042]	-0.0034** (0.0015) [0.0014]	(<i>F</i> =0.089) [<i>F</i> =0.007]	-0.0146** (0.0067) [0.0041]	-0.0049* (0.0030) [0.0028]	(<i>F</i> =0.164) [<i>F</i> =0.050]
<i>Quake</i> _{-5,it} (=1 from <i>t</i> -5 to <i>t</i> -9)	0.0019 (0.0186) [0.0186]	0.0021 (0.0054) [0.0057]	(<i>F</i> =0.995) [<i>F</i> =0.995]	0.0010 (0.0185) [0.0186]	-0.0019 (0.0028) [0.0026]	(<i>F</i> =0.884) [<i>F</i> =0.885]	0.0010 (0.0190) [0.0192]	-0.0059* (0.0034) [0.0032]	(<i>F</i> =0.723) [<i>F</i> =0.722]
<i>Quake</i> _{-10,it} (=1 from <i>t</i> -10 to <i>t</i> -14)	-0.0147 (0.0090) [0.0073]	-0.0031 (0.0047) [0.0048]	(<i>F</i> =0.276) [<i>F</i> =0.156]	-0.0133 (0.0090) [0.0073]	0.0004 (0.0033) [0.0036]	(<i>F</i> =0.161) [<i>F</i> =0.077]	-0.0136 (0.0089) [0.0070]	0.0017 (0.0076) [0.0084]	(<i>F</i> =0.242) [<i>F</i> =0.161]
<i>Quake</i> _{-15,it} (=1 from <i>t</i> -15 to <i>t</i> -19)	-0.0015 (0.0162) [0.0193]	-0.0034 (0.0051) [0.0056]	(<i>F</i> =0.900) [<i>F</i> =0.928]	-0.0011 (0.0159) [0.0193]	-0.0005 (0.0037) [0.0042]	(<i>F</i> =0.972) [<i>F</i> =0.978]	-0.0001 (0.0165) [0.0198]	0.0088 (0.0100) [0.0105]	(<i>F</i> =0.523) [<i>F</i> =0.695]

Panel B: Effect on non-Episcopal cities

	<i>Polygon</i>			<i>Epicenter</i>			<i>Circles</i>		
	<i>Damage</i>	<i>Felt</i>	<i>F-test</i>	<i>Damage</i>	<i>Felt</i>	<i>F-test</i>	<i>Damage</i>	<i>Felt</i>	<i>F-test</i>
	β^D_h	β^F_h	$\beta^D_h \neq \beta^F_h$	β^D_h	β^F_h	$\beta^D_h \neq \beta^F_h$	β^D_h	β^F_h	$\beta^D_h \neq \beta^F_h$
<i>Quake</i> _{0,it} (=1 from <i>t</i> to <i>t</i> -4)	0.0006 (0.0009) [0.0010]	0.0017 (0.0013) [0.0011]	(<i>F</i> =0.402) [<i>F</i> =0.453]	0.0006 (0.0009) [0.0010]	0.0019 (0.0012) [0.0010]	(<i>F</i> =0.261) [<i>F</i> =0.314]	0.0018* (0.0010) [0.0016]	0.0027** (0.0011) [0.0010]	(<i>F</i> =0.439) [<i>F</i> =0.629]
<i>Quake</i> _{-5,it} (=1 from <i>t</i> -5 to <i>t</i> -9)	0.0002 (0.0010) [0.0009]	0.0001 (0.0019) [0.0018]	(<i>F</i> =0.959) [<i>F</i> =0.959]	-0.0008 (0.0010) [0.0009]	-0.0002 (0.0020) [0.0020]	(<i>F</i> =0.745) [<i>F</i> =0.748]	0.0010 (0.0011) [0.0012]	0.0011 (0.0016) [0.0016]	(<i>F</i> =0.946) [<i>F</i> =0.949]
<i>Quake</i> _{-10,it} (=1 from <i>t</i> -10 to <i>t</i> -14)	0.0005 (0.0012) [0.0012]	0.0002 (0.0037) [0.0042]	(<i>F</i> =0.919) [<i>F</i> =0.931]	0.0000 (0.0014) [0.0014]	0.0011 (0.0030) [0.0035]	(<i>F</i> =0.638) [<i>F</i> =0.703]	0.0015 (0.0012) [0.0014]	0.0047 (0.0037) [0.0042]	(<i>F</i> =0.318) [<i>F</i> =0.425]
<i>Quake</i> _{-15,it} (=1 from <i>t</i> -15 to <i>t</i> -19)	-0.0049 (0.0051) [0.0044]	0.0010 (0.0033) [0.0043]	(<i>F</i> =0.288) [<i>F</i> =0.312]	-0.0050 (0.0047) [0.0035]	-0.0001 (0.0032) [0.0033]	(<i>F</i> =0.359) [<i>F</i> =0.342]	-0.0028 (0.0047) [0.0038]	0.0044 (0.0043) [0.0039]	(<i>F</i> =0.189) [<i>F</i> =0.158]
Year fixed effects		YES			YES			YES	
City fixed effects		YES			YES			YES	
City time trend		YES			YES			YES	
Observations		24,131			24,131			24,131	
R-squared		0.051			0.051			0.052	
Cities		122			122			122	

Notes - Estimation by OLS of model (3) in the text. Columns (1)–(2)–(3), (4)–(5)–(6), and (7)–(8)–(9) report results on adopting, respectively, the *polygon*, the *epicenter*, and the *circles* criterion. In Panel A we report the effects on Episcopal see cities, in Panel B the effects on non-Episcopal see cities. The dependent variable, *transition*, is =1 if city *i* became a commune at time *t* and =0 otherwise. The independent variable, *quake*, is =1 if an earthquake occurred in city *i* at time *t* and =0 otherwise. *D* indicates earthquakes with intensity between 6 and 10 (physical damage to people or objects); *F* denotes events with intensity between 2 and 5 (no physical damage). Standard errors clustered at the city level are reported in squared brackets; Conley's standard errors corrected for spatial dependence with threshold distance of 100 km are in round brackets. *** significant at 1%; ** significant at 5%; * significant at 10%. Statistical significance is indicated employing the Conley's standard errors.

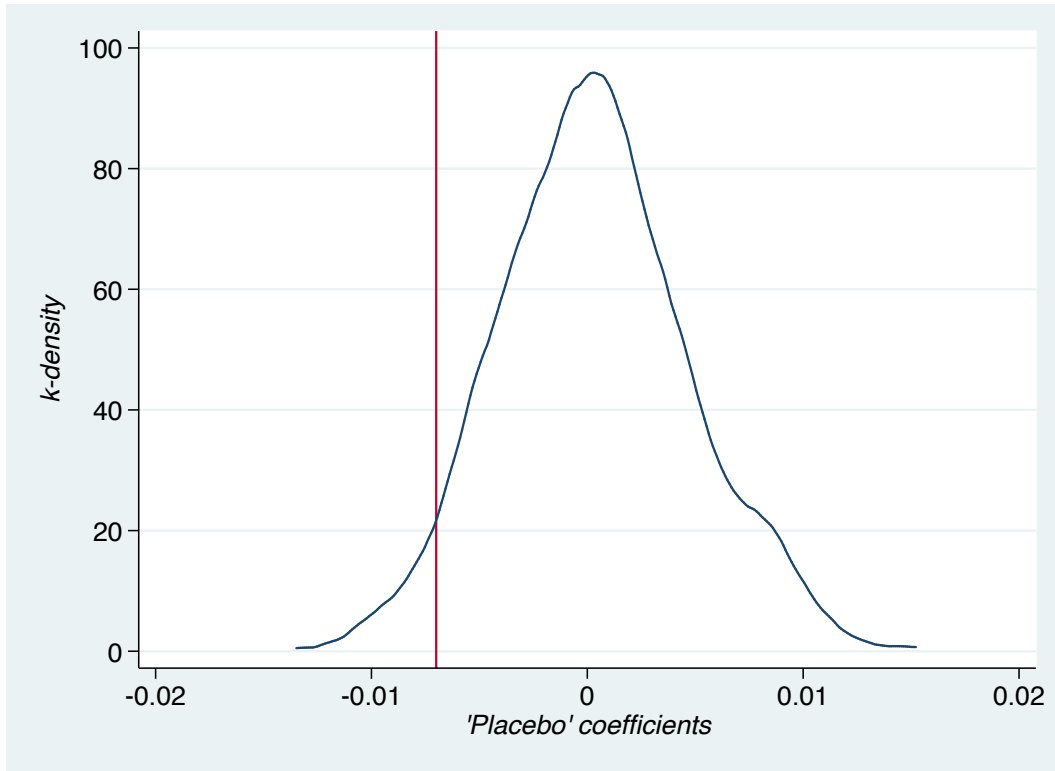
events reported in column (2) of Table 2). We then produce 30 ‘placebo’ earthquakes occurring in 30 random years and assign them to random cities for a total of 279 events. Whilst randomly assigned, the ‘placebo’ earthquakes reflect the true time and space clustering of the real data. The time clustering is obtained every 50 years: for instance, we generate six ‘placebo’ earthquakes between 1150 and 1200, which mimic, in random cities and years, the earthquakes that really occurred in 1168 (three cities), 1170 (one city), 1182 (one city), 1194 (seven cities), 1196 (two cities), and 1197 (one city). The space clustering is produced within circular areas around the real epicenter with radius equal to 100 km: for instance, to mimic the earthquake that originated in Arezzo in 1005, we generate a ‘placebo’ earthquake that is assigned in a random year between 1000 and 1050 to six random cities located within 100 km distance from Arezzo; those cities must have been different from the six cities that were really hit by this earthquake in 1005 according to the *polygon* criterion.¹⁵ Hence, we build the ‘placebo’ earthquake dummy variable and estimate model (2) including it in the place of the real one. We repeat this procedure 1,000 times (employing alternative numbers of replications do not affect our results in any significant way) and save the estimated coefficients. The results, presented in Figure 3, show the probability density function of the 1,000 ‘placebo’ point-estimates, a vertical line indicating our ‘true’ point-estimate for the effect in the first five years after an earthquake (equal to -0.0071, reported in column (1) of Table 3).

The purpose of this test is to check how many times these randomly generated ‘placebo’ point-estimates happen to be smaller or too close to our ‘true’ point-estimate. If in our main results we were erroneously rejecting the null hypothesis that our coefficient of interest is equal to zero (i.e. we were attributing to earthquakes a negative effect that does not exist in reality), we should have observed ‘placebo’ coefficients very close to our ‘true’ estimate. As can be seen from Figure 3, the point-estimates generated in the falsification test are almost always to the right of (meaning larger in value than) the ‘true’ estimated coefficients. This does not obtain in only 3.9% of cases, of which 3.2% are statistically significant at the 5% level, and 1.7% at the 1% level.¹⁶ Overall, this exercise offers considerable evidence that our results are not an artifact of a small number of ‘treated’ cities in the dataset and the potentially correlated nature of the error terms.

¹⁵ The space clustering is not imposed when we mimic the earthquakes that occurred in 1117 and 1222 because they covered very large areas.

¹⁶ On employing the other two augmenting criteria, *epicenter* and *circles*, the conclusions do not change in any relevant way.

Figure 3. Placebo test



Notes - Probability density function of the coefficients obtained by estimating regression (2) including the ‘placebo’ earthquake dummy as independent variable, as explained in Section 4.4, and iterating for 1,000 times. Vertical line indicates our ‘true’ point-estimate (-0.0071) of the first five years following the seismic event, reported in column (1) of Table 3.

4.5 Robustness

We test our results by performing several robustness checks. As is clear from Table 2, a large fraction of the seismic events considered in our exercise are generated by the earthquake that struck northern-central Italy in 1117. In order to verify whether this or other particular episodes are crucial for obtaining our estimation results, we re-estimate model (2) by excluding earthquakes one-by-one. Adopting our preferred imputation criterion, we perform 20 different regressions (20 is the number of events that, according to the *polygon* criterion, hit at least one city before transition to a commune, if any (see column (3) of Table (2)). The estimated coefficients vary across regressions in most of the cases (the results are reported in Table A.2 of the Online Appendix), suggesting that all the earthquakes contribute to estimating the effect of interest, though admittedly these changes are small. Remarkably, when we exclude the earthquake which struck central-northern Italy in 1117 (this earthquake hit 93 out of 122 cities), the point estimate on the *quake* variable in the first five-year interval for the Episcopal cities remains negative (-0.0027 with a *t*-statistics equal to -1.50), indicating

that this is not the only earthquake that matters to generate the regression output.¹⁷ We conclude that the 1117 earthquake is a strong but not the only driver of our results.

We also check whether our findings are robust after we drop cities one by one (this set of 122 regressions is available upon request). No compelling evidence suggests that the results change on the exclusion of some cities in any significant way. To show how sensitive our estimated standard errors are to the thresholds of 100 km employed in the Conley's correction, we compute the spatially corrected standard errors obtained by adopting thresholds of 200 and 500 km (results in Table A.3 - model (2) - and Table A.4 - model (3) - of the Online Appendix). The results are substantially the same as before. Finally, we re-ran our augmenting procedures for the *polygon*, *epicenter*, and *circles* criteria, using only cities hit by earthquakes of intensity greater than 5 (intensity class *D*). The results for Episcopal see cities (presented in Table A.5 of the Online Appendix) were similar to those presented in Table 3 but suggest a somewhat larger effect.

4.6 Alternative functional forms

One potential concern with using a LPM is that this estimation method may provide an imprecise approximation of the marginal effects, especially when there is a mass of zeroes in the dependent variable as in our design.¹⁸ Alternative functional forms are the conditional logit model and duration analysis. We will consider them in turn.

A logit model conditional on city fixed effects makes it possible to obtain consistent slope estimates in our case. However, this method suffers from two substantial limitations: it entails discarding all the information from cities that never transited to communes and does not lead to convergence when one includes year fixed effects and city-specific time trends.¹⁹

¹⁷ On the other hand, if we estimate our regression considering only the earthquake of 1117 we obtain a negative estimated coefficient for Episcopal cities (equal to -0.0105 with a *t*-statistics of -2.70), which is quite different from that obtained when we employ the full dataset (equal to -0.0071 with a *t*-statistics of -3.087, reported in Table 3). Moreover, the estimated effect on the non-Episcopal group when we only use the earthquake of 1117 is positive and not precisely estimated (equal to 0.0015 with a *t*-statistics of 0.61).

¹⁸ Alternative models, such as logit or probit, present serious limitations in our design. In particular, the inclusion of (city or year) fixed effects would be problematic: first, a large set of fixed effects (as in our case) would yield inconsistent slope estimates due to the incidental parameter problem (Wooldridge, 2002); second, including city and year fixed effects would lead to the loss of all the information related to cities that were hit by earthquakes but never experienced a transition and years in which we do not observe a transition. More generally, all the observations for which the independent variable perfectly predicts the transition outcome would be dropped from the analysis (see Zorn, 2005).

¹⁹ These limitations are not minor. Cities that never transited to communes contribute to the identification of our effect of interest as long as they are hit by an earthquake. Year fixed effects and city-specific time trends are also

Nonetheless, it allows estimation of the parameters of interest conditional on city fixed effects and may prove useful for verifying whether or not the negative and statistically significant effect of earthquakes on the transition probability for Episcopal cities was confirmed in a non-linear model. In fact, the conditional logit model yielded results qualitatively similar to those provided by the LPM for Episcopal cities (results are in the Appendix in Table A.6).

By contrast, a duration model would not be appropriate in our context. Indeed, a valuable contribution of our estimation strategy consists in the fact that we are able to exploit the plausible randomness in the occurrence of the seismic events, once we condition on the time and city fixed effects, and to distinguish between short and long run effects of (possibly multiple) earthquakes on the transition probability. A Cox model with no time varying covariates would ignore the panel structure of the data and the randomness of the earthquakes. A Cox model with time varying covariates (i.e. the earthquakes) could not be estimated in our context for two reasons. First, in our design, a duration model could not accommodate time fixed effects, city-specific time trends, and city fixed effects (which are important in our analysis as explained in Section 4.1). Unfortunately there is no conditional logit counterpart (that would address this problem in a logit framework) for the Cox model; hence we cannot even condition on the city effects. Second, the Cox model incurs the same estimation problems as a standard logit whenever the independent variable perfectly predicts the outcomes (see footnote 18). This makes estimation of the dynamics of the effects of earthquakes not feasible when the outcome variable (transition) is always equal to zero in correspondence to the earthquake variable or its lags equal to one.

To conclude, the LPM seems the most appropriate model in our design to exploit the random nature of the timing of earthquakes. This is especially the case when considering the more serious limitations of alternative models (conditional logit or Cox model). At the same time, it is comforting that the results from the conditional logit model are consistent with our main results, suggesting that they do not depend on the mass of zeroes in the data.

5. Concluding remarks

In this paper, we have found that earthquakes retarded the probability of transition to communal institutions in Italian cities ruled by religious-political leaders. Our explanation hinges on the role of the *status quo* leader in dealing with disorder after the crisis. In the Middle Ages, the Earth's tremors were frightening and unpredictable events that provoked

important in our design, as explained in Section 4.1. The problem of convergence with a large set of fixed effects is common in maximum likelihood estimations (Greene, 2004).

panic, consternation, and disorder among the population. In a context of scant civic capital and substantial coordination problems, social order could only be restored by a strong leader. However, our results seem to exclude the possibility that the seismic events strengthened the power of secular feudal leaders and thus impeded institutional transitions in the non-Episcopal see cities. By contrast, in the Episcopal cities, they fortified the power of the bishops, who were simultaneously political and religious leaders. Since, in our period of interest, earthquakes were perceived by the population as manifestations of God's wrath, they can be interpreted as positive shocks to religiosity that reinforced the authority of the incumbent religious-political leaders and, consequently, hampered institutional change. Alternative explanations of our findings seem not to be particularly compelling (from both empirical and historical point of view).

Our findings exclude the idea that the negative effect of earthquakes on the transition probability could be explained by the greater efficiency of authoritarian leaders in the reconstruction process with respect to the communal institutions. To be consistent with the empirical patterns presented in the paper, this explanation would require that bishops, compared with secular lords, were more efficient in the reconstruction and thus received more support from the citizens and that people's support for the existing authoritarian leaders increased also after an earthquake that caused no damage and hence required no reconstruction. In this case, support for the authoritarian political leaders would be an insurance device and would be greater for bishops than for secular leaders. Although we cannot test this explanation directly, historical research (Guidoboni and Poirier, 2004; Guidoboni and Ebel, 2009) indicates that there was no difference between Episcopal see cities and other cities as regards the financing of reconstruction in the period considered. In all the cases, there were no direct transfers from the political authorities to the citizens, and in general the main financial support for reconstruction consisted in tax breaks. Transfers from the government to the citizens are documented only much later, starting with the Medici family, which, in the Grand Duchy of Tuscany in the sixteenth century, granted small loans at low interest rates for the reconstruction of damaged houses (Favier, 2002).

A final possible explanation for the negative effect of earthquakes on the probability of transition to communal institutions is that natural catastrophes increased the cost of contesting the *status quo* political leaders. According to this argument, after a seismic event people devoted their time to rebuilding their properties, thus diverting resources from the process of institutional change. Although plausible, in our case this interpretation would again not be consistent with two facts: first, the impact of an earthquake on the probability of an

institutional transition to a commune holds for Episcopal cities but not for cities that were not seats of a bishop; second, this effect operated even if the earthquake was only felt by people without causing any physical damage to buildings or deaths.

Our findings highlight the important role played by cultural factors such as religiosity in affecting institutional change, and they account for the observation that political institutions controlled by religiously connected leaders have historically proven to be stable. For instance, Ancient Egypt under the rule of the pharaohs, China under the Han dynasty, the Roman Empire, the Papal State in central Italy until the late nineteenth century, the Meiji empire in Japan, and the ayatollah's supreme leadership in Iran were all long-lasting regimes in which the political leader and the religious leader were one and the same person. Some scholars have maintained that religion plays a crucial role in the resilience of political regimes (e.g. North, Wallis, and Weingast, 2009). For instance, Niccolo Machiavelli (1532) argued that religiosity is able to support political stability and ensure social order. On discussing how the sovereign can ensure his power, Machiavelli drew a distinction between ecclesiastical and other principates: in the former, he stated, power is relatively easier to maintain, since the prince can rely on popular support based on religious feelings.

Whilst our paper has focused on a particular historical episode, the mechanisms uncovered may prove important in other historical contexts as well, and their implications call for further investigation in broader settings. Of course, our contribution cannot shed full light on such vast phenomena, nor does it have any ambition to do so. Nonetheless, the findings presented in this paper point to the existence of mechanisms that, to the best of our knowledge, are still largely unexplored in the economic literature and have implications that warrant further exploration.

References

- Acemoglu, D., Robinson, J.A. 2006. *Economic Origins of Dictatorship and Democracy*. Cambridge, UK: Cambridge University Press.
- Achen, C.H., Bartels, L.M. 2013. *Blind Retrospection: Electoral Responses to Drought, Flu, and Shark Attacks*. Center for the Study of Democratic Institutions Vanderbilt University. Working Paper 5-2013.
- Adrasto Barbi, S. 1927. *Storie Pistoiesi*. Città di Castello: Tipi della Casa Editrice S. Lapi.
- Ager, P., A. Ciccone. 2012. *Rainfall Risk and Religious Membership in the Late Nineteenth-Century US*. University Pompeu Fabra.

- Ai, C., Norton, N. 2003. Interaction Terms in Logit and Probit Models. *Economics Letters* 80:123–129.
- Ascheri, M. 2009. *Medioevo del Potere*. Bologna: Il Mulino.
- Bairoch, P., Batou, J., Chevre, P. 1998. *La Population des Villes Européennes de 800 à 1850*. Droz: Centre d'Histoire Economique Internationale.
- Barro, R.J. 1999. The Determinants of Democracy. *Journal of Political Economy* 107(S6): 158-183.
- Barro R.J., McCleary, R.M. 2003. Religion and Economic Growth Across Countries, *American Sociological Review* 68(1): 760-781.
- Barro, R.J., McCleary, R.M. 2005. Which Countries Have State Religions? *Quarterly Journal of Economics* 120(4): 1331-1370.
- Becker, S.O., Woessmann, L. 2009. Was Weber Wrong? A Human Capital Theory of Protestant Economic History. *Quarterly Journal of Economics* 124(2): 531-596.
- Benvenuti, A. 2010. Riti Propiziatori e di Espiazione. In: Matheus, M., Piccinni, G., Pinto, G. and Varanini, G.M., eds. *Le Calamità Ambientali nel Tardo Medioevo Europeo: Realtà, Percezioni e Reazioni*. Firenze: Firenze University Press: 78-86.
- Bentzen, J.S. 2013. *Origins of Religiousness: the Role of Natural Disasters*. University of Copenhagen Discussion Paper 13-02.
- Bloch, M. 1961. *Feudal Society*. London: Routledge and Kegan Paul.
- Boschi, E. 2000. A New Generation of Earthquakes Catalog. In Boschi, E., Guidoboni, E., Ferrari, G., Mariotti, D., Valensise, G., eds. Catalogue of Strong Italian Earthquakes from 461 BC to 1997. *Annals of Geophysics* 43(4): 609-620.
- Brückner, M., Ciccone, A. 2011. Rain and the Democratic Window of Opportunity. *Econometrica* 79(3): 923–947.
- Cardini, F., Montesano, M. 2006. *Storia Medievale*. Firenze: Le Monnier.
- Chaney, E. 2013. Revolt on the Nile: Economic Shocks, Religion and Political Power. *Econometrica* 81(5): 2033-2053.
- Chetty, R., Looney, A., Kroft, K. 2009. Salience and Taxation: Theory and Evidence. *American Economic Review* 99(4): 1145-77.
- Coleman, E. 1999. The Italian communes. Recent work and current trends. *Journal of Medieval History* 25(4): 373–397.
- Conferenza Episcopale Italiana. 2015. *Regioni, Diocesi e Parrocchie*. Chiesa Cattolica Italiana, Official Website.

- Conley, T. G. 1999. GMM Estimation with Cross Sectional Dependence. *Journal of Econometrics*, 92(1): 1-45.
- De Long, J.B., Shleifer, A. 1993. Princes and Merchants: European City Growth before the Industrial Revolution. *Journal of Law and Economics* 6(2): 671-702.
- Dynes, R. 2000. The Dialogue between Voltaire and Rousseau on the Lisbon Earthquake: The Emergence of a Social Science View. *International Journal of Mass Emergencies and Disasters*. 18(1): 97-115.
- Djankov, S., Glaeser, E. La Porta, R., Lopez-de-Silanes, F., Shleifer, A. 2003. The New Comparative Economics. *Journal of Comparative Economics* 31(4): 595–619.
- Dondi, A. 1896. *Notizie Storiche ed Artistiche del Duomo di Modena Raccolte ed Ordinate dal Can. A.D. con l'Elenco dei Codici Capitolari*. Modena.
- Ekelund, R.B., Tollison, R.D., 2011. *Economic Origins of Roman Christianity*. Chicago: University of Chicago Press.
- ENEL. 1978. *Catalogo ENEL-ISTAT 1971 delle Località Abitate Italiane*.
- Favier, M.R. 2002. *Les Pouvoirs Publiques Face aux Risques Naturels dans l'Histoire*. Grenoble: Editions de la Maison des Sciences de l'Homme, Université de Grenoble.
- Galizia, M. 1951. *La Teoria della Sovranità dal Medioevo alla Rivoluzione Francese*. Milano: Giuffrè.
- Geary, P.J. 2010. *Readings in Medieval History: Volume I: the early Middle Ages*. Toronto: University of Toronto Press.
- Greif, A., P. Milgrom, B. Weingast. 1994 Coordination, Commitment, and Enforcement: The Case of the Merchant Guild. *Journal of Political Economy* 102(4): 745-766.
- Greene, W. 2004. The Behavior of the Maximum Likelihood Estimator of Limited Dependent Variable Models in the Presence of Fixed Effects. *Econometrics Journal* 7: 98-119.
- Guidoboni, E. 2000. Method of Investigation, Typology and Taxonomy of the Basic Data: Navigating between Seismic Effects and Historical Contexts. *Annals of Geophysics* 43(4): 621-666.
- Guidoboni, E. 2002. Historical Seismology: the Long Memory of the Inhabited World. In W.H.K. Lee, H. Kanamori, P.C. Jennings, C. Kisslinger, eds. *International Handbook of Earthquake and Engineering Seismology*. London, UK: Academic Press: 775-790.
- Guidoboni, E., Ebel, J.E. 2009. *Earthquakes and Tsunamis in the Past: a Guide to Techniques in Historical Seismology*. Cambridge, UK: Cambridge University Press.
- Guidoboni, E., Poirier, J.P. 2004. *Quand la Terre Tramblait*. Paris: Odile Jacob Sciences.

- Guiso, L., Sapienza, P., Zingales, L. 2013. Long Term Persistence. *Kellog School of Management*.
- Healy, A., Malhotra, N. 2009. Myopic Voters and Natural Disaster Policy. *American Political Science Review* 103(3): 387-406.
- Iannaccone, L.R. 1991. The Consequences of Religious Market Structures: Adam Smith and the Economics of Religion. *Rationality and Society* 3 (2): 156-177.
- Isidore of Séville. 1960. De Natura Rerum. In J. Fontaine, ed. Bordeaux: *Féret, Bibliothèque de l'École des Hautes Études Hispaniques*.
- ISTAT. 2009. *Atlante Statistico dei Comuni*.
- Jaffé, P. 1869. *Ebonis Vita Ottonis Episcopi Bambergensis*. Apud Weidmannos: Berolini.
- Le Goff, J. 1982. *Time, Work and Culture in the Middle Ages*. London: The University of Chicago Press, LTD.
- Lipset, S.M. 1959. Some Social Requisites of Democracy: Economic Development and Political Legitimacy. *American Political Science Review*. 53(1): 69–105.
- Machiavelli, N. 1532. *De Principatibus*. Florence: Antonio Blado d'Asola. English translation: N. Machiavelli. 2005. *The Prince*. Oxford, New York: Oxford University Press.
- Malanima P. 2005. *Urban population (1300-1861). A database of the Italian cities 1300-1861*.
- McCleary, R.M., Barro, R.J. 2006. Religion and Economy. *Journal of Economic Perspectives* 20(2): 49-72.
- Menant, F. 2005. *L'Italie des Communes (1100-1350)*. Paris: Belin.
- Murphy, K., Shleifer, A. 2004. Persuasion in Politics. *American Economic Review* 94(2): 435-439.
- North, D. Wallis, J. Weingast, B. 2009. *Violence and Social Orders*. NewYork: Cambridge University Press.
- Nur, A., Burgess, D. 2008. *Apocalypse: Earthquakes, Archaeology and the Wrath of God*. Princeton, NJ: Princeton University Press.
- Pellegrini, M. 2009. *Vescovi e Città. Una Relazione nel Medioevo Italiano*. Milano: Bruno Mondadori.
- Penick, J.L. 1981. *The New Madrid Earthquakes*. Columbia, MO: University of Missouri Press.

- Riera Melis, A. 2011. *Catastrofe y Sociedad en la Catalunya Medieval*. In: Matheus, M., Piccinni, G., Pinto, G., Varanini, G.M., eds. *Le Calamità Ambientali nel Tardo Medioevo Europeo: Realtà, Percezioni e Reazioni*. Firenze: Firenze University Press.
- Schenk, G.J. 2010. *Disastri, Modelli Interpretativi delle Calamità Naturali dal Medioevo al Rinascimento*. Firenze: Firenze University Press.
- Schoell, R. 1895. *Corpus Iuris Civili: Novellae, vol. III*. Berolini: Weidmann.
- Senatore, F. 2008. *Medioevo: Istruzioni per l'Uso*. Milano: Bruno Mondadori.
- Stucchi, M. 1993. Historical Seismology and Seismic Hazard. *Annals of Geophysics* 36(1): 177-189.
- Stucchi, M., Camassi, R., Rovida, A., Locati, M. Ercolani, E., Meletti, C., Migliavacca, P., Bernardini, F., Azzaro, R. 2007. DBMI04: Il Database delle Osservazioni Macrosismiche dei Terremoti Italiani Utilizzate per la Compilazione del Catalogo Parametrico CPTI04. *Quaderni di Geofisica* 49: 1-38.
- Tabacco, G. 1987. La Città Vescovile nell'Alto Medioevo. In Rossi P. ed. *Forme di Città Strutture e Funzioni Politiche*. Torino: Einaudi.
- Tabacco, G. 1989. *The Struggle for Power in Medieval Italy: Structures of Political Rule, 400-1400*. Cambridge, UK: Cambridge University Press.
- Treccani, 2007. *Atlante Storico, Istituto della Enciclopedia Italiana*. Enciclopedia Italiana Treccani, Roma.
- Valensise, G., E. Guidoboni. 2000. Earthquake of 30 April 1279 Umbria and Marche Apennines. In Boschi, E., Guidoboni, E., Ferrari, G., Mariotti, D., Valensise, G., eds. Catalogue of Strong Italian Earthquakes from 461 BC to 1997. *Annals of Geophysics* 43(4): 815-834.
- Wooldridge, J. 2002. *Econometric Analysis of Cross Section and Panel Data*. Cambridge, MA: MIT Press.
- Zorn, C. 2005. A Solution to Separation in Binary Response Models. *Political Analysis* 13 (2): 157-170.

Appendix A - Online Appendix

Table A.1 – Lag structure

	(1)	(2)	(3)	(4)	(5)
	$\beta_{sh} + \gamma_{sh}$ - Episcopal cities				
$Quake_t$	-0.0049* (0.0027) [0.0017]	-0.0058** (0.0028) [0.0019]	-0.0062** (0.0029) [0.0020]	-0.0071** (0.0032) [0.0022]	-0.0070** (0.0032) [0.0022]
$Quake_{t-1}$	-0.0065** (0.0030) [0.0023]	-0.0075** (0.0031) [0.0024]	-0.0077** (0.0031) [0.0023]	-0.0080** (0.0031) [0.0023]	-0.0078** (0.0032) [0.0023]
$Quake_{t-2}$	-0.0050* (0.0027) [0.0017]	-0.0060** (0.0029) [0.0019]	-0.0064** (0.0030) [0.0020]	-0.0068** (0.0030) [0.0021]	-0.0072** (0.0030) [0.0022]
$Quake_{t-3}$	-0.0065** (0.0032) [0.0022]	-0.0075** (0.0034) [0.0025]	-0.0081** (0.0035) [0.0027]	-0.0085** (0.0036) [0.0028]	-0.0084** (0.0036) [0.0027]
$Quake_{t-4}$	-0.0049* (0.0028) [0.0017]	-0.0046 (0.0031) [0.0018]	-0.0060* (0.0032) [0.0021]	-0.0064** (0.0032) [0.0022]	-0.0063* (0.0033) [0.0022]
$Quake_{t-5}$		0.0067 (0.0125) [0.0126]	0.0067 (0.0142) [0.0144]	0.0063 (0.0142) [0.0144]	0.0064 (0.0141) [0.0144]
$Quake_{t-6}$		-0.0048 (0.0031) [0.0019]	-0.0063* (0.0033) [0.0022]	-0.0067** (0.0034) [0.0023]	-0.0066* (0.0034) [0.0023]
$Quake_{t-7}$		-0.0045 (0.0031) [0.0019]	-0.0056* (0.0034) [0.0023]	-0.0061* (0.0034) [0.0024]	-0.0061* (0.0035) [0.0024]
$Quake_{t-8}$		0.0081 (0.0114) [0.0129]	0.0086 (0.0126) [0.0147]	0.0083 (0.0128) [0.0147]	0.0083 (0.0126) [0.0146]
$Quake_{t-9}$		0.0080 (0.0114) [0.0131]	0.0075 (0.0114) [0.0131]	0.0078 (0.0129) [0.0150]	0.0079 (0.0128) [0.0150]
$Quake_{t-10}$			0.0111 (0.0115) [0.0134]	0.0122 (0.0131) [0.0154]	0.0123 (0.0131) [0.0154]
$Quake_{t-11}$			-0.0047 (0.0031) [0.0022]	-0.0061* (0.0032) [0.0025]	-0.0059* (0.0032) [0.0025]
$Quake_{t-12}$			-0.0089** (0.0044) [0.0039]	-0.0109** (0.0047) [0.0044]	-0.0102** (0.0047) [0.0042]
$Quake_{t-13}$			-0.0046 (0.0031) [0.0022]	-0.0060* (0.0032) [0.0025]	-0.0060* (0.0034) [0.0025]
$Quake_{t-14}$			-0.0164 (0.0113) [0.0106]	-0.0166 (0.0113) [0.0107]	-0.0195 (0.0128) [0.0123]
$Quake_{t-15}$				-0.0065* (0.0036) [0.0027]	-0.0078** (0.0038) [0.0030]
$Quake_{t-16}$				-0.0105* (0.0059) [0.0048]	-0.0122* (0.0064) [0.0054]
$Quake_{t-17}$				-0.0058* (0.0035) [0.0025]	-0.0068* (0.0036) [0.0027]
$Quake_{t-18}$				-0.0079 (0.0152) [0.0175]	-0.0087 (0.0173) [0.0202]
$Quake_{t-19}$				0.0147 (0.0249) [0.0196]	0.0151 (0.0248) [0.0197]
$Quake_{t-20}$					-0.0047 (0.0034) [0.0026]
$Quake_{t-21}$					0.0071 (0.0144) [0.0154]
$Quake_{t-22}$					0.0107 (0.0135) [0.0172]
$Quake_{t-23}$					-0.0099* (0.0054) [0.0044]
$Quake_{t-24}$					0.0294 (0.0219) [0.0247]
P-value: $\sum_{j=0...4}(\beta_j + \gamma_j) = 0$	0.170 [0.060]	0.105 [0.027]	0.090 [0.022]	0.067 [0.015]	0.071 [0.012]
P-value: $\sum_{j=5...9}(\beta_j + \gamma_j) = 0$		0.359 [0.115]	0.294 [0.082]	0.026 [0.073]	0.279 [0.083]
P-value: $\sum_{j=10...14}(\beta_j + \gamma_j) = 0$			0.168 [0.112]	0.082 [0.053]	0.100 [0.061]
P-value: $\sum_{j=15...19}(\beta_j + \gamma_j) = 0$				0.325 [0.188]	0.215 [0.126]
P-value: $\sum_{j=20...24}(\beta_j + \gamma_j) = 0$					0.209 [0.194]
Year fixed effects	YES	YES	YES	YES	YES
City fixed effects	YES	YES	YES	YES	YES
City time trends	YES	YES	YES	YES	YES
Observations	25,473	24,863	24,253	23,643	23,033
R-squared	0.051	0.052	0.054	0.056	0.058
Cities	122	122	122	122	122

Note: Estimation by OLS of model (1) in the paper with a variable number of lags. Results are obtained on adopting the *polygon* augmenting criterion. The dependent variable, *transition*, is =1 if city *i* became a commune at time *t* and =0 otherwise. The independent variable, *quake*, is =1 if an earthquake occurred in city *i* at time *t* and =0 otherwise. Standard errors clustered at the city level are reported in squared brackets; Conley's standard errors corrected for spatial dependence with thresholds distance of 100 km are in round brackets. *** significant at 1%; ** significant at 5%; * significant at 10%. Statistical significance is indicated employing the Conley's standard errors. At the bottom of the table we report the *p*-value of a joint test of significance of the first five lags, second five lags, and so on. In squared brackets we report the *p*-value according to the city-clustered standard errors, in round brackets the *p*-value according the spatially correlated standard errors.

Table A.2: Drop earthquakes one by one

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
	1005			1005bis			1065			1117			1148		
<i>Quake</i> _{<i>s_h,t</i>}	<i>Episcopal</i> $\beta_{s_h+\gamma_{s_h}}$	<i>Non-episcopal</i> β_{s_h}	<i>Difference</i> γ_{s_h}	<i>Episcopal</i> $\beta_{s_h+\gamma_{s_h}}$	<i>Non-episcopal</i> β_{s_h}	<i>Difference</i> γ_{s_h}	<i>Episcopal</i> $\beta_{s_h+\gamma_{s_h}}$	<i>Non-episcopal</i> β_{s_h}	<i>Difference</i> γ_{s_h}	<i>Episcopal</i> $\beta_{s_h+\gamma_{s_h}}$	<i>Non-episcopal</i> β_{s_h}	<i>Difference</i> γ_{s_h}	<i>Episcopal</i> $\beta_{s_h+\gamma_{s_h}}$	<i>Non-episcopal</i> β_{s_h}	<i>Difference</i> γ_{s_h}
<i>Quake</i> _{0,<i>t</i>} (=1 from <i>t</i> to <i>t</i> -4)	-0.0073*** (0.0023) [0.0020]	0.0014 (0.0011) [0.0009]	-0.0087*** (0.0028) [0.0023]	-0.0070*** (0.0023) [0.0020]	0.0015 (0.0009) [0.0011]	-0.0085*** (0.0028) [0.0023]	-0.0070*** (0.0022) [0.0021]	0.0011 (0.0012) [0.0011]	-0.0081*** (0.0029) [0.0024]	-0.0027 (0.0018) [0.0017]	0.0001 (0.0008) [0.0007]	-0.0028 (0.0020) [0.0019]	-0.0072*** (0.0023) [0.0020]	0.0015 (0.0011) [0.0010]	-0.0087* (0.0028) [0.0023]
<i>Quake</i> _{<i>s_h,t</i>} (=1 from <i>t</i> -5 to <i>t</i> -9)	0.0019 -0.0051 [0.0053]	0.0000 (0.0015) [0.0016]	0.0019 (0.0061) [0.0063]	0.0022 (0.0051) [0.0053]	0.0001 (0.0016) [0.0016]	0.0021 (0.0061) [0.0063]	0.0032 (0.0053) [0.0056]	-0.0002 (0.0016) [0.0015]	0.0034 (0.0064) [0.0066]	-0.0018 (0.0020) [0.0018]	0.0005 (0.0008) [0.0008]	-0.0023 (0.0021) [0.0018]	0.0021 (0.0052) [0.0055]	0.0001 (0.0015) [0.0015]	0.0020 (0.0062) [0.0064]
<i>Quake</i> _{<i>s_h,t</i>} (=1 from <i>t</i> -10 to <i>t</i> -14)	-0.0065 (0.0041) [0.0044]	-0.0003 (0.0033) [0.0037]	-0.0062 (0.0046) [0.0049]	-0.0045 (0.0041) [0.0042]	0.0003 (0.0032) [0.0036]	-0.0047 (0.0046) [0.0048]	-0.0044 (0.0043) [0.0044]	-0.0003 (0.0037) [0.0041]	-0.0040 (0.0048) [0.0050]	-0.0028 (0.0027) [0.0026]	0.0020 (0.0038) [0.0047]	-0.0048 (0.0045) [0.0052]	-0.0053 (0.0040) [0.0042]	0.0001 (0.0032) [0.0036]	-0.0053 (0.0045) [0.0048]
<i>Quake</i> _{<i>s_h,t</i>} (=1 from <i>t</i> -15 to <i>t</i> -19)	-0.0043 (0.0064) [0.0058]	-0.0004 (0.0031) [0.0038]	-0.0039 (0.0082) [0.0074]	-0.0026 (0.0062) [0.0057]	0.0001 (0.0030) [0.0037]	-0.0027 (0.0080) [0.0072]	-0.0014 (0.0062) [0.0056]	0.0002 (0.0032) [0.0040]	-0.0017 (0.0082) [0.0074]	-0.0037 (0.0031) [0.0029]	-0.0013 (0.0020) [0.0018]	-0.0024 (0.0029) [0.0026]	-0.0033 (0.0061) [0.0056]	-0.0001 (0.0030) [0.0037]	-0.0032 (0.0079) [0.0071]
	1168			1170			1194			1222			1231		
<i>Quake</i> _{<i>s_h,t</i>}	<i>Episcopal</i> $\beta_{s_h+\gamma_{s_h}}$	<i>Non-episcopal</i> β_{s_h}	<i>Difference</i> γ_{s_h}	<i>Episcopal</i> $\beta_{s_h+\gamma_{s_h}}$	<i>Non-episcopal</i> β_{s_h}	<i>Difference</i> γ_{s_h}	<i>Episcopal</i> $\beta_{s_h+\gamma_{s_h}}$	<i>Non-episcopal</i> β_{s_h}	<i>Difference</i> γ_{s_h}	<i>Episcopal</i> $\beta_{s_h+\gamma_{s_h}}$	<i>Non-episcopal</i> β_{s_h}	<i>Difference</i> γ_{s_h}	<i>Episcopal</i> $\beta_{s_h+\gamma_{s_h}}$	<i>Non-episcopal</i> β_{s_h}	<i>Difference</i> γ_{s_h}
<i>Quake</i> _{0,<i>t</i>} (=1 from <i>t</i> to <i>t</i> -4)	-0.0070*** (0.0023) [0.0020]	0.0017 (0.0012) [0.0010]	-0.0087*** (0.0028) [0.0023]	-0.0070*** (0.0023) [0.0020]	0.0015 (0.0011) [0.0009]	-0.0085*** (0.0028) [0.0023]	-0.0074*** (0.0023) [0.0020]	0.0014 (0.0012) [0.0010]	-0.0088*** (0.0028) [0.0023]	-0.0072*** (0.0023) [0.0020]	0.0019 (0.0013) [0.0011]	-0.0091*** (0.0029) [0.0023]	-0.0071*** (0.0024) [0.0021]	0.0015 (0.0011) [0.0009]	-0.0086* (0.0029) [0.0023]
<i>Quake</i> _{<i>s_h,t</i>} (=1 from <i>t</i> -5 to <i>t</i> -9)	0.0021 (0.0051) [0.0053]	0.0001 (0.0016) [0.0015]	0.0020 (0.0061) [0.0064]	0.0021 (0.0052) [0.0055]	0.0001 (0.0015) [0.0015]	0.0021 (0.0062) [0.0065]	0.0023 (0.0052) [0.0055]	0.0002 (0.0016) [0.0015]	0.0021 (0.0062) [0.0065]	0.0021 (0.0051) [0.0054]	0.0001 (0.0019) [0.0019]	0.0020 (0.0064) [0.0066]	0.0023 (0.0055) [0.0058]	0.0002 (0.0015) [0.0014]	0.0021 (0.0064) [0.0067]
<i>Quake</i> _{<i>s_h,t</i>} (=1 from <i>t</i> -10 to <i>t</i> -14)	-0.0049 (0.0039) [0.0041]	0.0003 (0.0033) [0.0037]	-0.0052 (0.0045) [0.0048]	-0.0049 (0.0040) [0.0042]	0.0002 (0.0032) [0.0036]	-0.0051 (0.0046) [0.0048]	-0.0049 (0.0040) [0.0042]	0.0002 (0.0033) [0.0037]	-0.0052 (0.0046) [0.0048]	-0.0054 (0.0040) [0.0041]	-0.0013 (0.0028) [0.0028]	-0.0041 (0.0044) [0.0046]	-0.0047 (0.0042) [0.0044]	0.0003 (0.0033) [0.0036]	-0.0050 (0.0047) [0.0049]
<i>Quake</i> _{<i>s_h,t</i>} (=1 from <i>t</i> -15 to <i>t</i> -19)	-0.0031 (0.0060) [0.0054]	0.0000 (0.0031) [0.0038]	-0.0031 (0.0079) [0.0071]	-0.0032 (0.0061) [0.0056]	-0.0001 (0.0030) [0.0037]	-0.0032 (0.0078) [0.0072]	-0.0033 (0.0061) [0.0056]	-0.0001 (0.0031) [0.0038]	-0.0031 (0.0080) [0.0072]	-0.0033 (0.0060) [0.0055]	-0.0003 (0.0039) [0.0048]	-0.0030 (0.0084) [0.0076]	-0.0033 (0.0064) [0.0059]	-0.0001 (0.0030) [0.0037]	-0.0032 (0.0081) [0.0073]

Table A.2: Drop earthquakes one by one (cont.)

	1249			1268			1269			1276			1279		
	<i>Episcopal</i>	<i>Non-episcopal</i>	<i>Difference</i>	<i>Episcopal</i>	<i>Non-episcopal</i>	<i>Difference</i>	<i>Episcopal</i>	<i>Non-episcopal</i>	<i>Difference</i>	<i>Episcopal</i>	<i>Non-episcopal</i>	<i>Difference</i>	<i>Episcopal</i>	<i>Non-episcopal</i>	<i>Difference</i>
	$\beta_{sh}+\gamma_{sh}$	β_{sh}	γ_{sh}	$\beta_{sh}+\gamma_{sh}$	β_{sh}	γ_{sh}	$\beta_{sh}+\gamma_{sh}$	β_{sh}	γ_{sh}	$\beta_{sh}+\gamma_{sh}$	β_{sh}	γ_{sh}	$\beta_{sh}+\gamma_{sh}$	β_{sh}	γ_{sh}
<i>Quake</i> _{0, it} (=1 from <i>t</i> to <i>t</i> -4)	-0.0071*** (0.0023) [0.0020]	0.0016 (0.0012) [0.0010]	-0.0086*** (0.0028) [0.0023]	-0.0073*** (0.0023) [0.0020]	0.0015 (0.0011) [0.0009]	-0.0087*** (0.0028) [0.0023]	-0.0073*** (0.0023) [0.0021]	0.0014 (0.0011) [0.0009]	-0.0087*** (0.0028) [0.0023]	-0.0071*** (0.0022) [0.0020]	0.0017 (0.0013) [0.0011]	-0.0088*** (0.0029) [0.0023]	-0.0076*** (0.0024) [0.0021]	0.0014 (0.0012) [0.0010]	-0.0090*** (0.0029) [0.0024]
<i>Quake</i> _{.5, it} (=1 from <i>t</i> -5 to <i>t</i> -9)	0.0021 (0.0051) [0.0053]	0.0001 (0.0016) [0.0016]	0.0020 (0.0061) [0.0063]	0.0021 (0.0052) [0.0055]	0.0001 (0.0015) [0.0015]	0.0020 (0.0062) [0.0064]	0.0021 (0.0052) [0.0055]	0.0001 (0.0015) [0.0015]	0.0021 (0.0062) [0.0064]	0.0021 (0.0050) [0.0053]	0.0002 (0.0018) [0.0017]	0.0020 (0.0063) [0.0065]	0.0022 (0.0054) [0.0057]	0.0002 (0.0016) [0.0015]	0.0021 (0.0064) [0.0066]
<i>Quake</i> _{.10, it} (=1 from <i>t</i> -10 to <i>t</i> -14)	-0.0050 (0.0039) [0.0041]	0.0001 (0.0033) [0.0037]	-0.0051 (0.0045) [0.0048]	-0.0051 (0.0040) [0.0042]	0.0001 (0.0032) [0.0036]	-0.0052 (0.0045) [0.0048]	-0.0051 (0.0040) [0.0042]	0.0001 (0.0032) [0.0036]	-0.0052 (0.0045) [0.0048]	-0.0050 (0.0039) [0.0041]	0.0001 (0.0037) [0.0041]	-0.0051 (0.0047) [0.0051]	-0.0053 (0.0042) [0.0043]	0.0001 (0.0033) [0.0037]	-0.0053 (0.0047) [0.0049]
<i>Quake</i> _{.15, it} (=1 from <i>t</i> -15 to <i>t</i> -19)	-0.0031 (0.0060) [0.0054]	-0.0001 (0.0031) [0.0038]	-0.0031 (0.0078) [0.0071]	-0.0032 (0.0061) [0.0056]	-0.0001 (0.0030) [0.0037]	-0.0031 (0.0079) [0.0071]	-0.0032 (0.0061) [0.0056]	-0.0001 (0.0030) [0.0037]	-0.0031 (0.0079) [0.0071]	-0.0028 (0.0059) [0.0054]	0.0009 (0.0033) [0.0041]	-0.0037 (0.0081) [0.0074]	-0.0030 (0.0062) [0.0057]	0.0001 (0.0030) [0.0037]	-0.0031 (0.0081) [0.0073]
	1279bis			1279ter			1284			1295			1298		
	<i>Episcopal</i>	<i>Non-episcopal</i>	<i>Difference</i>	<i>Episcopal</i>	<i>Non-episcopal</i>	<i>Difference</i>	<i>Episcopal</i>	<i>Non-episcopal</i>	<i>Difference</i>	<i>Episcopal</i>	<i>Non-episcopal</i>	<i>Difference</i>	<i>Episcopal</i>	<i>Non-episcopal</i>	<i>Difference</i>
	$\beta_{sh}+\gamma_{sh}$	β_{sh}	γ_{sh}	$\beta_{sh}+\gamma_{sh}$	β_{sh}	γ_{sh}	$\beta_{sh}+\gamma_{sh}$	β_{sh}	γ_{sh}	$\beta_{sh}+\gamma_{sh}$	β_{sh}	γ_{sh}	$\beta_{sh}+\gamma_{sh}$	β_{sh}	γ_{sh}
<i>Quake</i> _{0, it} (=1 from <i>t</i> to <i>t</i> -4)	-0.0071*** (0.0023) [0.0020]	0.0015 (0.0012) [0.0010]	-0.0086*** (0.0028) [0.0023]	-0.0077*** (0.0024) [0.0021]	0.0014 (0.0011) [0.0009]	-0.0091*** (0.0029) [0.0024]	-0.0070*** (0.0023) [0.0020]	0.0018 (0.0012) [0.0010]	-0.0088*** (0.0028) [0.0023]	-0.0069*** (0.0023) [0.0020]	0.0019 (0.0012) [0.0010]	-0.0088*** (0.0028) [0.0023]	-0.0074*** (0.0024) [0.0020]	0.0014 (0.0012) [0.0010]	-0.0089*** (0.0029) [0.0023]
<i>Quake</i> _{.5, it} (=1 from <i>t</i> -5 to <i>t</i> -9)	0.0021 (0.0051) [0.0053]	0.0001 (0.0016) [0.0015]	0.0020 (0.0061) [0.0064]	0.0023 (0.0056) [0.0058]	0.0002 (0.0015) [0.0014]	0.0021 (0.0065) [0.0067]	0.0021 (0.0051) [0.0053]	0.0001 (0.0016) [0.0015]	0.0020 (0.0061) [0.0063]	0.0022 (0.0051) [0.0053]	0.0002 (0.0016) [0.0016]	0.0020 (0.0061) [0.0064]	0.0021 (0.0051) [0.0053]	0.0001 (0.0016) [0.0015]	0.0020 (0.0061) [0.0063]
<i>Quake</i> _{.10, it} (=1 from <i>t</i> -10 to <i>t</i> -14)	-0.0050 (0.0039) [0.0041]	0.0003 (0.0033) [0.0036]	-0.0051 (0.0045) [0.0048]	-0.0054 (0.0042) [0.0044]	0.0001 (0.0032) [0.0036]	-0.0054 (0.0047) [0.0049]	-0.0050 (0.0039) [0.0041]	0.0002 (0.0032) [0.0036]	-0.0051 (0.0045) [0.0047]	-0.0049 (0.0040) [0.0041]	0.0003 (0.0034) [0.0038]	-0.0052 (0.0045) [0.0048]	-0.0050 (0.0039) [0.0041]	0.0001 (0.0032) [0.0036]	-0.0051 (0.0045) [0.0047]
<i>Quake</i> _{.15, it} (=1 from <i>t</i> -15 to <i>t</i> -19)	-0.0031 (0.0060) [0.0054]	0.0000 (0.0030) [0.0037]	-0.0031 (0.0079) [0.0071]	-0.0030 (0.0064) [0.0058]	0.0000 (0.0030) [0.0037]	-0.0030 (0.0082) [0.0074]	-0.0031 (0.0060) [0.0054]	-0.0000 (0.0030) [0.0037]	-0.0031 (0.0078) [0.0070]	-0.0032 (0.0059) [0.0054]	0.0000 (0.0030) [0.0038]	-0.0032 (0.0077) [0.0071]	-0.0032 (0.0060) [0.0054]	-0.0001 (0.0030) [0.0037]	-0.0031 (0.0078) [0.0070]

Notes - Estimation by OLS of model (2) in the paper by adopting the *polygon* augmenting criterion. The seismic event excluded from the regression is indicated with the year (in the header of each group of three columns representing a regression) in which it occurred. The dependent variable, *transition*, is =1 if city *i* became a commune at time *t* and =0 otherwise. The independent variable, *quake*, is =1 if an earthquake occurred in city *i* at time *t* and =0 otherwise. Standard errors clustered at the city level are reported in squared brackets; Conley's standard errors corrected for spatial dependence with thresholds distance of 100 km are in round brackets. *** significant at 1%; ** significant at 5%; * significant at 10%. Statistical significance is indicated employing the Conley's standard errors.

Table A.3: Alternative threshold distance for Conley's s.e. (200 and 500 km) – Main results

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	<i>Polygon</i>			<i>Epicenter</i>			<i>Circles</i>		
	<i>Effect on Episcopal cities</i>	<i>Effect on non- Episcopal cities</i>	<i>Difference</i>	<i>Effect on Episcopal</i>	<i>Effect on non- Episcopal</i>	<i>Difference</i>	<i>Effect on Episcopal</i>	<i>Effect on non- Episcopal</i>	<i>Difference</i>
	$\beta_{-5h} + \gamma_{-5h}$	β_{-5h}	γ_{-5h}	$\beta_{-5h} + \gamma_{-5h}$	β_{-5h}	γ_{-5h}	$\beta_{-5h} + \gamma_{-5h}$	β_{-5h}	γ_{-5h}
<i>Quake</i> _{0,it} (=1 from <i>t</i> to <i>t</i> -4)	-0.0071*** (0.0023) [0.0022]	0.0015 (0.0012) [0.0009]	-0.0086*** (0.0028) [0.0025]	-0.0046*** (0.0016) [0.0014]	0.0017 (0.0012) [0.0011]	-0.0063*** (0.0020) [0.0017]	-0.0075** (0.0030) [0.0029]	0.0026** (0.0011) [0.0010]	-0.0101*** (0.0034) [0.0034]
<i>Quake</i> _{-5,it} (=1 from <i>t</i> -5 to <i>t</i> -9)	0.0021 (0.0045) [0.0038]	0.0001 (0.0014) [0.0012]	0.0020 (0.0053) [0.0044]	-0.0015 (0.0023) [0.0020]	-0.0002 (0.0016) [0.0014]	-0.0013 (0.0031) [0.0027]	-0.0038 (0.0054) [0.0054]	0.0011 (0.0014) [0.0011]	-0.0049 (0.0054) [0.0054]
<i>Quake</i> _{-10,it} (=1 from <i>t</i> -10 to <i>t</i> -14)	-0.0050 (0.0039) [0.0040]	0.0001 (0.0032) [0.0035]	-0.0051 (0.0043) [0.0043]	-0.0006 (0.0031) [0.0031]	0.0010 (0.0026) [0.0028]	-0.0016 (0.0037) [0.0035]	-0.0022 (0.0051) [0.0054]	0.0044 (0.0032) [0.0035]	-0.0066 (0.0062) [0.0065]
<i>Quake</i> _{-15,it} (=1 from <i>t</i> -15 to <i>t</i> -19)	-0.0031 (0.0026) [0.0044]	-0.0000 (0.0027) [0.0017]	-0.0031 (0.0034) [0.0040]	-0.0007 (0.0035) [0.0033]	-0.0009 (0.0021) [0.0018]	0.0002 (0.0037) [0.0036]	0.0066 (0.0079) [0.0091]	0.0036 (0.0036) [0.0033]	0.0030 (0.0076) [0.0078]
Year fixed effects		YES			YES			YES	
City fixed effects		YES			YES			YES	
City time trends		YES			YES			YES	
Observations		24,131			24,131			24,131	
R-squared		0.054			0.054			0.054	
Cities		122			122			122	

Notes - Estimation by OLS of model (2) in the paper. This table replicates results reported in Table 3 in the paper but in that it shows Conley's standard errors corrected for spatial dependence with threshold distance of 200 km in round brackets and of 500 km in squared brackets. *** significant at 1%; ** significant at 5%; * significant at 10%. Statistical significance is indicated employing the Conley's standard errors with threshold distance of 200 km.

Table A.4: Alternative threshold distance for Conley's s.e. (200 and 500 km) – Intensity

<i>Panel A: Effect on Episcopal cities</i>									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	<i>Polygon</i>			<i>Epicenter</i>			<i>Circles</i>		
	<i>Damage</i>	<i>Felt</i>	<i>F-test</i>	<i>Damage</i>	<i>Felt</i>	<i>F-test</i>	<i>Damage</i>	<i>Felt</i>	<i>F-test</i>
	$\beta^D_h + \gamma^D_h$	$\beta^F_h + \gamma^F_h$	$\beta^D_h + \gamma^D_h \neq \beta^F_h + \gamma^F_h$	$\beta^D_h + \gamma^D_h$	$\beta^F_h + \gamma^F_h$	$\beta^D_h + \gamma^D_h \neq \beta^F_h + \gamma^F_h$	$\beta^D_h + \gamma^D_h$	$\beta^F_h + \gamma^F_h$	$\beta^D_h + \gamma^D_h \neq \beta^F_h + \gamma^F_h$
<i>Quake</i> _{0,it} (=1 from t to t-4)	-0.0151** (0.0068) [0.0069]	-0.0055*** (0.0021) [0.0022]	(F=0.162) [F=0.176]	-0.0150** (0.0067) [0.0068]	-0.0034** (0.0016) [0.0014]	(F=0.094) [F=0.099]	-0.0146** (0.0069) [0.0069]	-0.0049* (0.0028) [0.0026]	(F=0.162) [F=0.165]
<i>Quake</i> _{-5,it} (=1 from t-5 to t-9)	0.0019 (0.0176) [0.0173]	0.0021 (0.0052) [0.0048]	(F=0.994) [F=0.994]	0.0010 (0.0174) [0.0172]	-0.0019 (0.0028) [0.0027]	(F=0.880) [F=0.879]	0.0010 (0.0181) [0.0179]	-0.0059* (0.0035) [0.0032]	(F=0.706) [F=0.698]
<i>Quake</i> _{-10,it} (=1 from t-10 to t-14)	-0.0147 (0.0160) [0.0092]	-0.0031 (0.0047) [0.0046]	(F=0.294) [F=0.280]	-0.0133 (0.0093) [0.0091]	0.0004 (0.0032) [0.0034]	(F=0.172) [F=0.176]	-0.0136 (0.0091) [0.0090]	0.0017 (0.0073) [0.0076]	(F=0.248) [F=0.245]
<i>Quake</i> _{-15,it} (=1 from t-15 to t-19)	-0.0015 (0.0162) [0.0174]	-0.0034 (0.0051) [0.0029]	(F=0.906) [F=0.910]	-0.0011 (0.0156) [0.0167]	-0.0005 (0.0040) [0.0039]	(F=0.973) [F=0.975]	-0.0001 (0.0164) [0.0176]	0.0088 (0.0073) [0.0083]	(F=0.567) [F=0.574]
<i>Panel B: Effect on non-Episcopal cities</i>									
	<i>Polygon</i>			<i>Epicenter</i>			<i>Circles</i>		
	<i>Damage</i>	<i>Felt</i>	<i>F-test</i>	<i>Damage</i>	<i>Felt</i>	<i>F-test</i>	<i>Damage</i>	<i>Felt</i>	<i>F-test</i>
	$\beta^D_h + \gamma^D_h$	$\beta^F_h + \gamma^F_h$	$\beta^D_h + \gamma^D_h \neq \beta^F_h + \gamma^F_h$	β^D_h	β^F_h	$\beta^D_h \neq \beta^F_h$	β^D_h	β^F_h	$\beta^D_h \neq \beta^F_h$
<i>Quake</i> _{0,it} (=1 from t to t-4)	0.0006 (0.0008) [0.0007]	0.0017 (0.0013) [0.0011]	(F=0.316) [F=0.298]	0.0006 (0.0008) [0.0007]	0.0019 (0.0013) [0.0011]	(F=0.207) [F=0.177]	0.0018* (0.0009) [0.0016]	0.0027** (0.0011) [0.0010]	(F=0.249) [F=0.629]
<i>Quake</i> _{-5,it} (=1 from t-5 to t-9)	0.0002 (0.0009) [0.0007]	0.0001 (0.0016) [0.0014]	(F=0.950) [F=0.944]	-0.0008 (0.0010) [0.0007]	-0.0002 (0.0018) [0.0015]	(F=0.714) [F=0.673]	0.0010 (0.0010) [0.0012]	0.0011 (0.0015) [0.0016]	(F=0.935) [F=0.949]
<i>Quake</i> _{-10,it} (=1 from t-10 to t-14)	0.0005 (0.0011) [0.0009]	0.0002 (0.0037) [0.0040]	(F=0.919) [F=0.926]	0.0000 (0.0013) [0.0011]	0.0011 (0.0029) [0.0031]	(F=0.625) [F=0.649]	0.0015 (0.0011) [0.0014]	0.0047 (0.0036) [0.0042]	(F=0.313) [F=0.425]
<i>Quake</i> _{-15,it} (=1 from t-15 to t-19)	-0.0049 (0.0043) [0.0040]	0.0010 (0.0029) [0.0015]	(F=0.189) [F=0.136]	-0.0050 (0.0038) [0.0035]	-0.0001 (0.0024) [0.0021]	(F=0.271) [F=0.247]	-0.0028 (0.0039) [0.0038]	0.0044 (0.0039) [0.0039]	(F=0.101) [F=0.158]
Year fixed effects		YES			YES			YES	
City fixed effects		YES			YES			YES	
City time trend		YES			YES			YES	
Observations		24131			24131			24131	
R-squared		0.051			0.051			0.052	
Cities		122			122			122	

Notes - Estimation by OLS of model (3) in the paper. This table replicates results reported in Table 4 in the paper but in that it shows Conley's standard errors corrected for spatial dependence with threshold distance of 200 km in round brackets and of 500 km in squared brackets. *** significant at 1%; ** significant at 5%; * significant at 10%. Statistical significance is indicated employing the Conley's standard errors with threshold distance of 200 km.

Table A.5: Only destructive earthquakes (intensity larger than 5)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	<i>Polygon</i>			<i>Epicenter</i>			<i>Circles</i>		
	<i>Effect on Episcopal cities</i>	<i>Effect on non- Episcopal cities</i>	<i>Difference</i>	<i>Effect on Episcopal</i>	<i>Effect on non- Episcopal</i>	<i>Difference</i>	<i>Effect on Episcopal</i>	<i>Effect on non- Episcopal</i>	<i>Difference</i>
	$\beta_{-5h} + \gamma_{-5h}$	β_{-5h}	γ_{-5h}	$\beta_{-5h} + \gamma_{-5h}$	β_{-5h}	γ_{-5h}	$\beta_{-5h} + \gamma_{-5h}$	β_{-5h}	γ_{-5h}
<i>Quake</i> _{0,it} (=1 from <i>t</i> to <i>t</i> -4)	-0.0135*** (0.0048) [0.0027]	0.0026* (0.0015) [0.0013]	-0.0160*** (0.0054) [0.0031]	-0.0048* (0.0025) [0.0022]	0.0044*** (0.0015) [0.0014]	-0.0092*** (0.0029) [0.0025]	-0.0102*** (0.0036) [0.0026]	0.0023* (0.0012) [0.0011]	-0.0125*** (0.0041) [0.0028]
<i>Quake</i> _{-5,it} (=1 from <i>t</i> -5 to <i>t</i> -9)	0.0041 (0.0130) [0.0143]	0.0007 (0.0022) [0.0020]	0.0034 (0.0141) [0.0151]	0.0072 (0.0065) [0.0072]	0.0036* (0.0020) [0.0017]	0.0036 (0.0074) [0.0078]	-0.0044 (0.0067) [0.0069]	0.0009 (0.0016) [0.0015]	-0.0053 (0.0072) [0.0073]
<i>Quake</i> _{-10,it} (=1 from <i>t</i> -10 to <i>t</i> -14)	-0.0016 (0.0101) [0.0114]	0.0043 (0.0046) [0.0055]	-0.0059 (0.0118) [0.0130]	-0.0032 (0.0056) [0.0060]	0.0026 (0.0046) [0.0054]	-0.0057 (0.0060) [0.0064]	-0.0035 (0.0070) [0.0078]	0.0050 (0.0041) [0.0047]	-0.0085 (0.0085) [0.0094]
<i>Quake</i> _{-15,it} (=1 from <i>t</i> -15 to <i>t</i> -19)	0.0158 (0.0194) [0.0170]	0.0033 (0.0057) [0.0051]	0.0125 (0.0219) [0.0187]	0.0199* (0.0112) [0.0110]	0.0128*** (0.0049) [0.0054]	0.0071 (0.0113) [0.0115]	0.0100 (0.0134) [0.0117]	0.0048 (0.0049) [0.0044]	0.0052 (0.0158) [0.0132]
Year fixed effects		YES			YES			YES	
City fixed effects		YES			YES			YES	
City time trends		YES			YES			YES	
Observations		24,131			24,131			24,131	
R-squared		0.054			0.054			0.054	
Cities		122			122			122	

Notes - Estimation by OLS of model (3) in the paper. This table replicates results reported in Table 3 in the paper but in that it shows results on adopting only earthquakes with an intensity greater than 5 (i.e. it excludes earthquakes only felt by the population and associated with no physical damage). Standard errors clustered at the city level are reported in squared brackets; Conley's standard errors corrected for spatial dependence with threshold distance of 100 km are in round brackets. *** significant at 1%; ** significant at 5%; * significant at 10%.

Table A.6: Conditional logit

	<i>Polygon</i>		<i>Epicenter</i>		<i>Circles</i>	
	(1)	(2)	(3)	(4)	(5)	(6)
<i>Quake</i> _{-5, it}	<i>Effect on Episcopal cities</i>	<i>Effect on non-Episcopal cities</i>	<i>Effect on Episcopal cities</i>	<i>Effect on non-Episcopal cities</i>	<i>Effect on Episcopal cities</i>	<i>Effect on non-Episcopal cities</i>
<i>Quake</i> _{0, it} (=1 from <i>t</i> to <i>t</i> -4)	-12.3114*** (0.2329)	-13.7522*** (0.3076)	-13.5693*** (0.1931)	-13.6544*** (0.2628)	-12.8032*** (0.3535)	-12.0687*** (0.7507)
<i>Quake</i> _{-5, it} (=1 from <i>t</i> -5 to <i>t</i> -9)	1.2556* (0.6649)	-13.7522*** (0.3076)	0.8241 (0.6265)	-13.6544*** (0.2628)	0.7973 (1.0924)	-12.0687*** (0.7507)
<i>Quake</i> _{-10, it} (=1 from <i>t</i> -10 to <i>t</i> -14)	0.1249 (1.0307)	0.6376 (1.0991)	0.6500 (0.6328)	0.2591 (1.0468)	0.7723 (1.0748)	3.1049* (1.6263)
<i>Quake</i> _{-15, it} (=1 from <i>t</i> -15 to <i>t</i> -19)	1.2399* (0.6479)	1.3553* (0.8011)	1.2326** (0.5333)	0.9697 (0.7862)	1.9002** (0.7405)	3.1573** (1.5420)
Observations	6,226	3,319	6,226	3,319	6,226	3,319
Cities	51	20	51	20	51	20

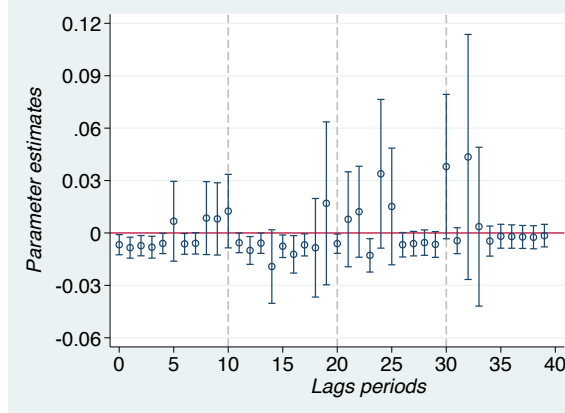
Notes - Estimation by conditional logit (grouped by cities) of model (2) in the paper. The dependent variable, *transition*, is =1 if city *i* became a commune at time *t* and =0 otherwise. The independent variable, *quake*, is =1 if an earthquake occurred in city *i* at time *t* and =0 otherwise. Coefficients for Episcopal and for non-Episcopal see cities are estimated separately. Standard errors clustered at the city level are reported in parentheses. *** significant at 1%; ** significant at 5%; * significant at 10%.

Model (2) is here estimated separately for Episcopal and non-Episcopal cities to avoid interaction terms, since the estimated coefficients in non-linear models may turn out to be biased (Ai and Norton, 2003). Table A.6 reports coefficients from the conditional logit model and not the marginal effects, since estimation of the latter would have been problematic (see Wooldridge, 2002). Finally, it is worth noting that the results for non-Episcopal cities are based on 20 cities and suggest a negative effect of the earthquake on the transition probability. However, these findings are driven by the absence of year fixed effects, since for this group of cities we observe many periods in which an earthquake hit most of the cities and no transition occurred. Furthermore, the point estimates cannot be compared across groups of cities without information on the distribution of the fixed effects (again, Wooldridge, 2002).

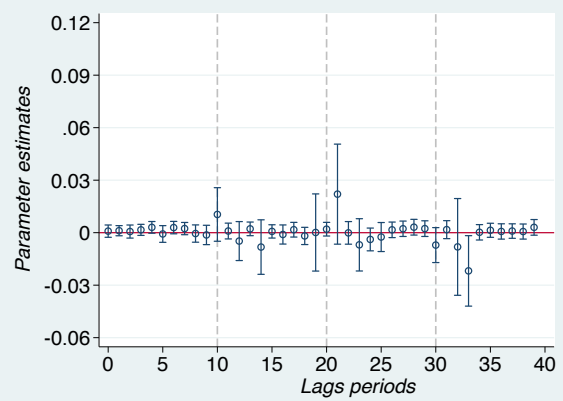
Figures A.1: Lags (40 years)

A.1A Polygon criterion

Episcopal see cities

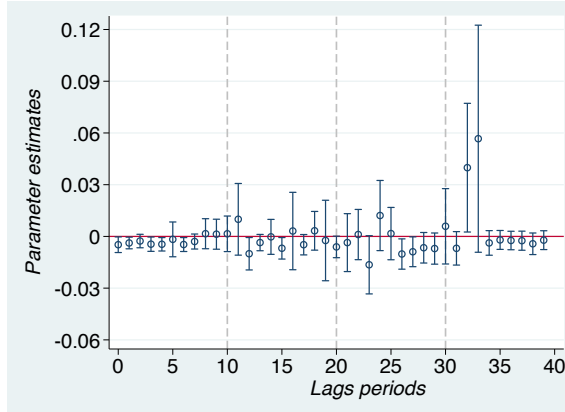


Non-Episcopal see cities

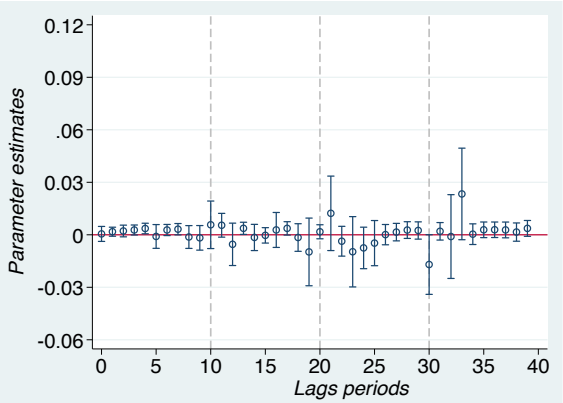


A.1B Epicenter criterion

Episcopal see cities

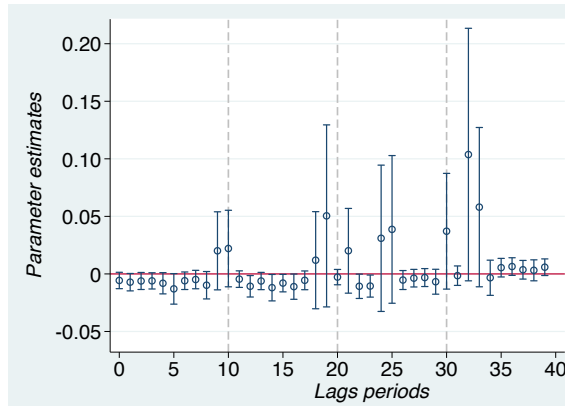


Non-Episcopal see cities

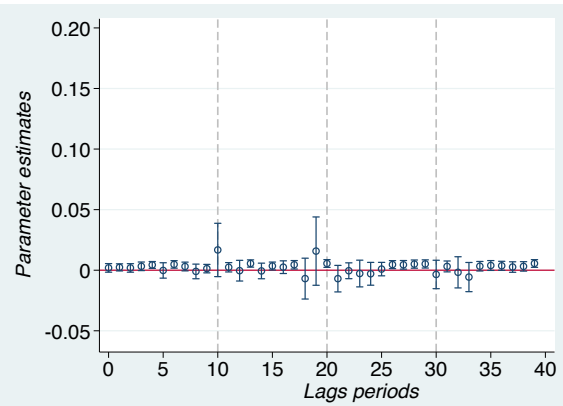


A.1C Circles criterion

Episcopal see cities



Non-Episcopal see cities



Notes - Estimation by OLS of model (1) with 40 lags. The dependent variable, *transition*, is =1 if city *i* became a commune at time *t* and =0 otherwise. The independent variable, *quake*, is =1 if an earthquake occurred in city *i* at time *t* and =0 otherwise. Statistical significance is indicated employing the Conley's standard errors. The figures for Episcopal (non-Episcopal) see cities report the estimated $\beta + \gamma$ (β) coefficients. The confidence intervals are computed employing Conley's standard errors (100 km).