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Research

Praying for rain, resilience, and social stability in Murcia (southeast Spain)

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ABSTRACT. We analyze the case of pro-pluvia rogations (PPR) performed by the Catholic Church in Murcia, Spain since 1600. PPR were ceremonies to ask God for rain. We show a structural break in the prayer data during the 1830s, coinciding with the end of the ancien régime in Spain. PPR responded to environmental shocks and were used by the civil and ecclesiastical authorities to control the population, ensure stability, and maintain the status quo. Thus, PPR in Murcia have acted as a social resilience instrument. At the same time, PPR highlight the conflict between civil and religious authorities and within religious authorities. Understanding the motives, timing, and other characteristics of religious rituals is crucial to understand the evolution of institutions, the persistence of beliefs and strategies for social adaptation to the environment over the long run.

Key Words: *adaptability; conflict; drought; religiosity; resilience; social control*

INTRODUCTION

Human interest in controlling weather can be traced back to, at least, the discovery of agriculture and the establishment of sedentary societies (Fagan 2009). Human societies have tried to reduce the uncertainty of crop yields in order to better adapt to their environment. In pre-industrial societies, leaders could be replaced if they did not take weather changes seriously or respond effectively (Chaney 2013). The connection between weather, God, and humans is present among all Christian denominations (Donner 2011). Within the Christian faith, prayers for rain (pro-pluvia rogations, henceforth PPR) are performed mainly by Catholics. For centuries, each Catholic Church recorded the incidence and characteristics of these official ceremonies. These church records show a very detailed picture of elite motivations and aspirations and provide invaluable insights into the social structure of pre-modern and modern Europe. Despite this research potential, only paleoclimatologists have used these sources to reconstruct climate series (Domínguez-Castro et al. 2008), and only the annual or seasonal series at that, leaving a significant portion of these historical sources untapped. In this article, we show the methodological possibilities of the PPR as a data source for social, economic, and environmental history.

Recent works show that throughout the last 10 millennia, droughts increased the risk of conflict (Hsiang et al. 2013). The mechanisms that explain this relationship, however, are still unclear. Surely, adaptation actions are bound up with power relations, social structures, technologies, economies, beliefs, values, and narratives. Leaders of pre-industrial societies usually used two types of strategies to reduce conflict and maintain social stability and the status quo. First, public works, such as dams, canals, and aqueducts, and political institutions, such as public granaries and farmers' guilds, increased productivity or reduced variance in agricultural output. Second, they used religious institutions that condition beliefs on the likelihood of rainfall: religious leaders would increase the likelihood of rain in case of drought or reduce it in case of floods (Gómez-Baggethun et al. 2012). In any case, both types of strategies were, or could be, very costly to implement. Cost was an especially important consideration in times of need. The trade-off that societies faced when deciding which strategies to implement was far from trivial; it could be life-or-death for individuals, and even for civilizations (Wittfogel 1957).

Whereas implementation of public works and, to a lesser degree, political institutions was restricted by a society's technological knowledge, beliefs were not. A society with little technological knowledge to regulate extreme weather variability was left with little choice but to ask the divine for intervention (Easterling et al. 2000). Beliefs were usually organized around a division between heaven, where deities lived, and earth, where humans lived (Donner 2007). Peasants can change the earth through work, but only the divine can alter the sky. That is, humans sent a message from this world to the other asking God to be merciful (Fleming 2012). Leaders, who were intermediaries between the two worlds, took the only possible course of action to prevent a famine. In this sense, as Jost et al. (2013) point out, religion provided an ideological justification of the existing social order. Peasants perceived institutions and laws to be legitimate and fair, and continued to obey and preserve the system. There is a growing concern in the academic literature regarding the relationship between religion and climate. Jenkins et al. (2018) argue that the Little Ice Age played a crucial role in the cultural and religious wars in Europe during the 16th and 17th centuries. Thus, it is interesting to consider religious practices as a social catalyzer used to deal with climatic extremes. In this regard, Gómez-Baggethun et al. (2012) argue that in southwestern Spain, as least during the last 500 years, local religious beliefs acted as a social galvanizer during long droughts. These beliefs, particularly PPR, then allowed the society to build resilience in the context of disturbances of varying intensity and operating at different frequencies or time scales. Along the same lines, Von Heland and Folke (2014) argue that religious rituals in Madagascar reinforce group cohesion because religious rituals are social events where individuals address common concerns. Similarly, Murphy et al. (2016), show that religious rituals play a key role in the transmission of institutional memory and support for communal action. Understanding these notions is not only useful to improve our knowledge of historical societies. On the contrary, we believe it is key to understand current issues such as the role of religion

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on individual beliefs of anthropogenic climate change. Jenkins et al. (2018) argue that current climate change could stimulate changes in religious beliefs and practices and that such changes could, in turn, affect human participation in the climatic systems. This effect is particularly important considering the arguments in Murphy et al. (2016), that changes in religious beliefs and religious practices could affect the adaptation capacity of a given society.

In this theoretical framework, we now see an atavistic notion of resilience, where the survival capability of a given society depends on its capacity to withstand and deal with episodes of environmental stress (Reyers et al. 2018). This capacity of a society to withstand impacts has much to do with its ability to absorb situations ranging from social unrest and political upheaval to environmental shocks and economic instability (Adger 2000). Along these lines, we understand resilience as the social capacity to transform or reorganize itself in response to a shock, keeping essentially intact its original structure and functionality (Folke 2006). This is particularly true in historical agrarian societies that suffered from important technological limitations to undertake technological improvements to palliate the effects of droughts and famine. This notion also includes the social capacity to learn how to live with a changing environment and how to use it (Folke 2016). In this regard, given the scope of the present work, we should emphasize that we are only analyzing resilience from the point of view of non-structural elements that a society uses to mitigate the impact of stress shocks. Therefore, in our setting, social resilience refers to the non-structural mechanisms that elites implemented to sustain the society during times of environmental stress triggered by hydric deficits.

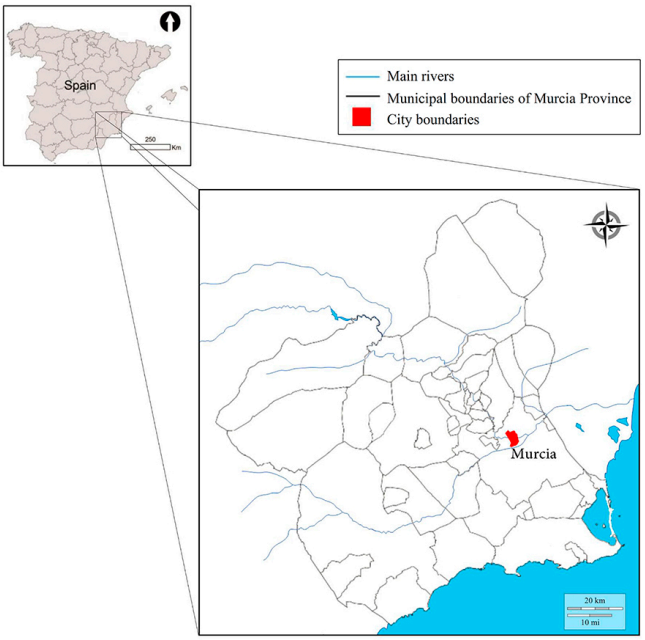
Understanding the mechanisms that maintained social stability in the past can prepare us for future droughts (Gil-Guirado et al. 2016). This is especially true in regions where rain is limited and volatile, such as the Mediterranean, South Africa, Australia, the Middle East, and the U.S. South (IPCC 2014). Economic development in these regions is heterogeneous, and less developed regions will suffer more from climate change (Morton 2007). Therefore, a historical case study could help us anticipate and understand changes in institutions and beliefs in developing regions (Jenkins et al. 2018). In order to examine these processes of change, we need high-resolution data for long time periods. Most data on popular religiosity and climate variability over time is limited and discontinuous. Hence, it is difficult to understand how religiosity and rainfall in general are related in the long run, and harder still to track social institutions in particular.

The aim of this article is to better understand the PPR. The frequency and intensity of PPR are influenced by social factors, in addition to environmental factors. We emphasize that our starting point is the hypothesis that the PPR are an instrument of social resilience used by the society to deal with climatic variability, while keeping social unrest at acceptable levels. We argue that one of the main causes of the survival of the PPR is their utility for the elites to maintain low levels of social unrest. For this aim, first, we want to understand how exogenous (war, epidemic, institutional changes) and endogenous (social unrest and conflict, changes in religious beliefs, changes in technology and economic system) factors affected the PPR demand over time. Second, we want to understand the main motivations behind the PPR. Who would benefit from them? How would they help stabilize the society during an environmental crisis due to hydric stress? Finally, we want to understand how the PPR changed over time to adapt to changes occurring both in the society and the natural environment.

HISTORICAL BACKGROUND IN STUDY AREA

The city of Murcia is located in the Segura River basin in southeastern Spain, the driest region in Europe (see Fig. 1). The city was founded by Abd al-Rahman II, emir of Cordoba, in 825 AD. The agrarian character of the city and its surroundings structured economic activities and politics in the city. The environment is arid, averaging less than 300 mm of annual rainfall. The distribution of rain is asymmetric, and torrential rains are not uncommon. Climatic conditions, together with topographic and edaphic characteristics, i.e., a flat, fertile alluvial plain, define the space in which people make decisions. Societal adaptive responses have been determined by the presence of fertile lands in the valley and their location near the only stable river in the region, the Segura River (Gil-Guirado 2013).

Fig. 1. Study area.



Droughts are recurrent and occur once every four or five years, reducing harvests below subsistence levels. Lemeunier (1990) argues that three elements provoked subsistence crises in Murcia during the pre-industrial era, resulting in strict control of trade and distribution of grains: (i) dry and volatile weather; (ii) the crop mix, with many small farms and orchards and a systematic deficit of grains; (iii) the political system, with a rent-seeking elite focused on exports. The main consumption crops grown on non-irrigated lands surrounding the city were barley, wheat, grapes, and olives. This crop mix was common to Mediterranean towns at the time. In the irrigated orchards, located partially within city walls, farmers grew a mix of vegetables for consumption and cash

crops like white mulberry leaves for the silk industry (Chacón Jiménez 1978). Unlike in other parts of Europe, bread was traditionally made with wheat. However, local wheat production was insufficient to satisfy local demand. In an average year, local wheat production could only feed the city for three months, with the remaining nine-month supply imported (Pérez Picazo et al. 1979). Thus, in the pre-industrial period, Murcia's population could only grow when irrigable land increased. Each demographic expansion was accompanied by an expansion in large landholdings (Calvo Garcia Tornel 1972).

Murcia specialized in trading with the interior of Castile and with other European and Mediterranean cities through the nearby port of Cartagena. The city suffered heavily from the European trade crisis during the 17th century after the Wars of Religion (Pérez Picazo et al. 1979). After the plague epidemic of 1648, which stopped population growth, the economic crisis worsened. Population growth, however, quickly rebounded during the first half of the 18th century (Lemeunier 2004). At the time, the War of Spanish Succession (1701–1714) spurred a broader economic recovery that supported the demographic boom. Loyal to the victorious Bourbons, Murcia enjoyed government influence and trading privileges when the war ended (Pérez Picazo and Lemeunier 1984). During the interbellum period between the War of Spanish Succession and the Peninsular War (1808–1814), Murcia again grew its population and economy. As Murcia fully embraced Enlightenment ideas and Bourbon reforms, the region achieved the highest literacy rate in Spain during the 18th century, with 14% of the population literate at the beginning of the century and 31% at the end (Soubeyroux 1985). This *belle époque*, however, came to an end at the beginning of the 19th century due in part to increasing negative environmental shocks like droughts and floods. Environmental frailty, combined with a relative loss of position in international markets, meant disaster during another international crisis at the turn of the 19th century (Pérez Picazo 2007). A weak economy compounded by the Peninsular War and epidemic diseases created a mortality crisis at the beginning of the 19th century (Marset Campos et al. 1981). Until the 1860s, when the region experienced frequent droughts and floods, its slow recovery after the Peninsular War was uneventful (Gil-Guirado et al. 2016).

Spain's neutrality during WWI led to a temporary boom in exports of agricultural products. The end of the war, however, meant a reduction in exports and a subsequent economic crisis, which lasted until the Spanish Civil War (1936–1939) erupted. The war did not directly impact Murcia, because of the lack of fighting in the region (González Martínez 1999). During the Franco dictatorship that followed the war, the city of Murcia grew both in population and income per capita as developmental policies promoted exports in addition to loans for farmers and small businesses (Espín-Sánchez 2017).

Gil-Guirado (2013) analyzes the history of Murcia's cereal prices from 1600 to 1900, showing price spikes occurred during wars and epidemics. The largest shock came during the Peninsular War when French troops invaded and ransacked Murcia in 1810 and again in 1812 (Melendreras Gimeno 2000).

As the Peninsular War ended, so did Spain's *ancien régime*. The new institutional framework created unprecedented conflicts between religious and civil authorities. The Enlightenment ideas advanced by the local elite in Murcia during the 18th century received a new embrace during the *Liberal Triennium* (1820–1823), which intensified this intra elite conflict between church and state (Lemeunier 1990). Moreover, the first half of the 19th century also witnessed the two largest shocks to the Spanish Catholic church during the modern age: The Ecclesiastical Confiscation of Mendizábal (1836–1845) and the abolition of tithes (1937). Villabona-Blanco (1993) shows that the confiscation represented a loss of 80% of the church's real estate properties in the region. At the same time, the local bourgeoisie benefited tremendously from low real estate prices. In the city of Murcia alone, the confiscation covered 2229.96 ha. When the Church lost the right to collect tithes, its main source of income disappeared (Pérez Picazo and Lemeunier 1984). The Church had collected taxes equal to 10% of all agricultural production, including meat, leather, wool, honey, and fish.

SOURCES AND METHODOLOGY

The Christian rogations have their origin in the pagan *Robigalia* ceremonies of processions and rogations to Roman deities. During the Concilium of Orleans in 511, the rogations asking for rain or pro-pluvia rogations (PPR) were imposed on European Catholic countries. In Spain, the Concilium of Gerona recommended their use in Visigoth churches in 517. Although Pope Leon III approved PPR at the beginning of the ninth century for all Catholic countries (Turonensis 1951), they were only fully incorporated into the Catholic faith at the beginning of the 17th century, by Saint Gregory the Great (de Olalla 1696). On 14 July 1600, Pope Clement VIII signed the *Caeremoniale Episcoporum*, a letter with very specific descriptions of approved ceremonies and rites, and punishments for deviating from them.

Environmental conditions determined the frequency and type of rogations. In areas with light rainfall and mild temperatures, such as Mediterranean countries, precipitation and water availability are the determining factors for human activity. There are several studies related to pro-pluvia rogations in Spanish cities as well other Catholic countries in Europe and in Latin America (Brázdil et al. 2018). The literature focuses on using the pro-pluvia rogations as a proxy for extreme hydric events (Domínguez-Castro et al. 2008). Until recently these sources have only been used in paleoclimatology and only with yearly frequency. The literature focuses on using the pro-pluvia rogations as a proxy for extreme hydric events (Martín-Vide and Barriendos Vallvé 1995, Domínguez-Castro et al. 2008, Machado et al. 2011). The most common rogations in Spain were pro-pluvia rogations (Gil-Guirado 2013). In Murcia between 1600 and 2009, there were 796 pro-pluvia rogations and only 36 for all other environmental events.

The institutional framework of rogations was so widespread that it applied to other extreme environmental events (Cortés Peña 1995). In particular, pro-serenitate rogations aimed to stop rain, typically after heavy rainfall or during hail storms (Martín-Vide and Barriendos Vallvé 1995). Moreover, scholars have examined rogations against locust plagues (Alberola Romá 2003), earthquakes (Alberola Romá 2012), flooding (Gil-Guirado 2013), and epidemics (Peñafiel Ramón and Peñafiel Ramón 1988). In addition to rogations performed in response to environmental

events, it is also worth acknowledging rogations for victories on the battlefield and for queens' successful pregnancies (Cortés-Peña 1995).

Even though each city might have different customs and cults of saints, specific and clear PPR rules require prayers to be performed the same way in cities worldwide (Martín-Vide and Barriendos Vallvé 1995). Hence, the process is homogeneous across time and space. The number and quality of written sources from Murcia's pre-modern period is extraordinary (Espín-Sánchez et al. 2019). We used a high-resolution database from the past 400 years to validate our claims about rogations. The data allowed us to understand how elites used peoples' beliefs to influence their behavior, and how the system changed and adapted over time. We are the first to derive PPR characteristics from textual analysis, creating a much richer picture of the uses of rituals.

We analyzed elites' social control strategies during droughts and how and why PPR lasted for so long. First, we examined the relationship between exogenous shocks and the persistence of PPR over the long run. We show how elites' use of PPR adapted to a new reality during the 1830s after the end of the *ancien régime*. Second, we modeled popular religiosity and conflict over time from underlying instruments in the PPR process. The sources' richness allowed us to differentiate three types of conflict: (i) elites vs citizens or peasants; (ii) civil vs religious elites; (iii) intra-religious. We discuss how and why conflicts emerged and how the system's resilience facilitated conflict resolution among stakeholders with minimal to no violence.

Sources and pro-pluvia rogations classification

In order to analyze aspects of climate, religion, society, culture, and the economy through PPR, it is essential to develop a methodology that transforms qualitative data into quantitative data. The main PPR sources in Murcia are the Civil *Actas Capitulares* (CAC) and Ecclesiastical *Actas Capitulares* (EAC). The CAC was an official document of Christian Spain dating back to the late 13th century. The CAC contain records of decisions and discussions from Municipal Council (*Concejo*) meetings, which were held at least once a week. The maximum authority of the *Concejo* was the *corregidor* (Mayor), in addition to *jurados* and *regidores*. Whereas the *corregidor* and the *regidores* were members of the nobility, *jurados* were wealthy and influential individuals, but not necessarily of noble origin (Cremades Griñán 1981). In addition, extraordinary meetings were held on any day of the week. From the CAC, we can learn people's motivations to perform a PPR.

The EAC is an official Catholic Church document containing records and minutes from Ecclesiastical Chapter (*Cabildo*) meetings since the Middle Ages. The *Cabildo* is the highest ecclesiastical administrative organ in a cathedral. The *Cabildo* was structured in three estates, from higher to lower rank, *dignidades*, *canónigos*, and *racioneros*. *Dignidades* should hold major orders (appointments of high responsibility within the cathedral) and have a university degree on theology and canon law. *Canónigos* had a university degree, but not a major order, and they became so either by examination or with a Papal bull. Finally, *racioneros* did not have a university degree, but their vote was limited to minor issues (Cánovas-Botía 1994). We obtained information from the EAC about the characteristics of a prayer ceremony such as whether it was a PPR.

Droughts recur in regions with high rainfall variability such as semi-arid climate regions. However, the greater or lesser adaptability of societies determines their impact (Dai 2011). Perhaps because drought is the natural hazard that affects the most people and regions in the world, the Catholic Church performed a variety of ceremonies to pray for rain (Spinoni et al. 2014). Domínguez-Castro et al. (2008) classify the religious ceremonies in five different levels from level 1, the most common and simplest, to level 5, the rarest and most complicated. These levels are determined by the intensity and duration of the drought. We have adapted this classification to fit the local customs in Murcia:

1. Simple ceremonies: masses of joy, rogation masses, pro-pluvia collections, litanies, *novenas*, *octavas*, votive masses, or cloister procession.
2. Public processions or simple ceremonies with one figure, typically, the exhibition of a figure such as the Lignum Crucis or the Blessed Sacrament.
3. Public procession with exactly two figures: procession with one figure and simple ceremony with a different figure, cloister procession with two additional simple ceremonies, cloister procession with a figure, and simple ceremony with a different one, exhibition of the Lignum Crucis with different figures, exhibition of the Blessed Sacrament with two or more additional simple ceremonies or additional figures.
4. Blessing of fields, multiple public processions, e.g., two different processions on the same day, processions with three figures, or processions with two figures and several simple ceremonies.
5. When previous levels occur simultaneously, the intensity of each ceremony is added. Additionally, for each new figure or type of simple ceremony a new point of intensity is added. If the sum is equal to or higher than 5, we classify it as level 5.

We used both the religious and the civil *Actas Capitulares* to determine all characteristics related to the PPR. We have information about the date of the rogations, the requesting entity (civil or religious authority), the type of ceremony, and therefore, the intensity level of the rogation (see Table 1). Level 1 ceremonies were costless. However, the higher the level of the ceremony, the higher the cost. Level 2 ceremonies usually involved big candles and their cost was about 500 *reales* for a single ceremony (This was enough money to feed a person for five years). Higher level ceremonies costs thousands of *reales*.

Most of the qualitative variables (Blame, Dedication, Type of Ceremony) as well as the date of the ceremony come from the EAC, but Motivation comes from the CAC. The "Blame" variable takes three values that are almost always exclusive. There are three instances in the data (0.36%) where blame was attached to both God and humans. Table 1 shows the constructed variables, their possible categories, and a short explanation. We now explain the variables in more detail.

Table 1. Socioeconomic variables. We construct the "Blamed," "Dedication," and "Type of Ceremony" variables using the Ecclesiastical *Actas Capitulares*. We construct the "Motivation" variables using the Civil *Actas Capitulares.* For the variables "Blame," "Dedication," and "Motivation" we constructed a set of binary variables with values 1 or 0. If there are two images used in a given ceremony, we count each image as 1, not as 1/2. The variable "Type of ceremony" takes numerical values 1-5 and each category is exclusive. See the text for a detailed description of each value.

Source	Variable	Categories
Ecclesiastical AC	Blamed	1- Humans are blamed
		2- God or saints are blamed
		3- Unspecified blame
	Dedication	1- Virgin of the *Fuensanta*
		2- Virgin of the *Arrixaca*
		3- Blessed Souls of the Purgatory
		4- Jesus of Nazareth
		5- Holy Sacrament
		6- *Lignum Crucis*
		7- Other
		8- Without distinction
	Type of ceremony	1- Silent prayer
		2- Sung masses
		3- Procession into the Church
		4- Procession through the town
		5- Pilgrimage to a Sanctuary, or combinations of lower levels
Civil AC	Motivation	1- Agricultural
		2- Industry
		3- Discontent of the population
		4- General public health
		5- Livestock
		6- Poor people
		7- Rural areas
		8- Urban areas
		9- Without distinction

We differentiated between human blame, divine blame, natural blame, and unspecified blame in the religious sources. If humans are blamed, the Catholic rite of atonement could be used as an individual mechanism to absorb environmental shocks. Whom each ceremony is dedicated to signals assignment of responsibility for positive effects and blame for negative effects from the PPR. We also categorized the specific religious figure, statue, icon, symbol, or relic used in each ceremony. Often, these objects portrayed or represented a Catholic saint with a connection to Murcia. Each ceremony was promoted by different groups, usually religious orders within the Catholic Church. As the conflict regarding the Arrixaca and the Fuensanta figures described below shows, each group used people's devotion to a figure to exert political power and obtain economic benefits. Therefore, we should look very carefully at figure choices and how they change with the drought cycle. Although we do not have textual evidence of the figure selection process, we can identify several church strategies by looking at ceremony timing and type for each figure. In this way, we could explain the persistence of the cult of certain saints. Therefore, we could assess whether popular devotion has been modeled, or supplied, by public institutions or demanded by the people. Because more important ceremonies would have more visibility than less important ones, the prominence of the religious object used is related to the type of ceremony. Hence, it is necessary to make a clear distinction between ceremony types.

Civil sources contain information about the motivation for each prayer ceremony, which were part of a paternal socioeconomic order. Following Erben and Güneşer (2008) we understand paternalism as a cultural characteristic typical of societies with a rigid social structure based on familial and feudal order. In these societies, people think that it is the state's responsibility to protect and take care of them. Therefore, society is organized hierarchically in social classes, with elites in charge of the paternalistic state. The most important duty of Murcia's elite was drought management. We specify why each rogation was requested, i.e., we define who the intended beneficiary was. We are interested in which group, for example, farmers or landlords, lobbied the Municipal Council (MC) or the Ecclesiastical Chapter (EC) to perform a particular ceremony. Alternatively, we consider which group these authorities wanted to curry favor with. The category "Discontent of the population" is an indicator of general social unrest rather than a response to any particular group's lobbying. Likewise, the category "General public health" represents an epidemic in the city, and the need of rain to clear out stagnant water.

We used a variety of statistical methods to analyze the quantitative data we extracted from civil and ecclesiastical texts. First, we assessed the homogeneity of the data. Second, we showed the temporal distribution of the rogations. Third, we explain how different characteristics of each rogation can be used to understand the mechanisms and politics behind their performance. We used a non-parametric test to determine possible structural changes in the PPR series, and thus whether it is homogeneous. This test identifies a single structural change in the data series. The homogeneity assessment includes the Pettit Test, the most widely used homogeneity test in climate studies (Pettit 1979).

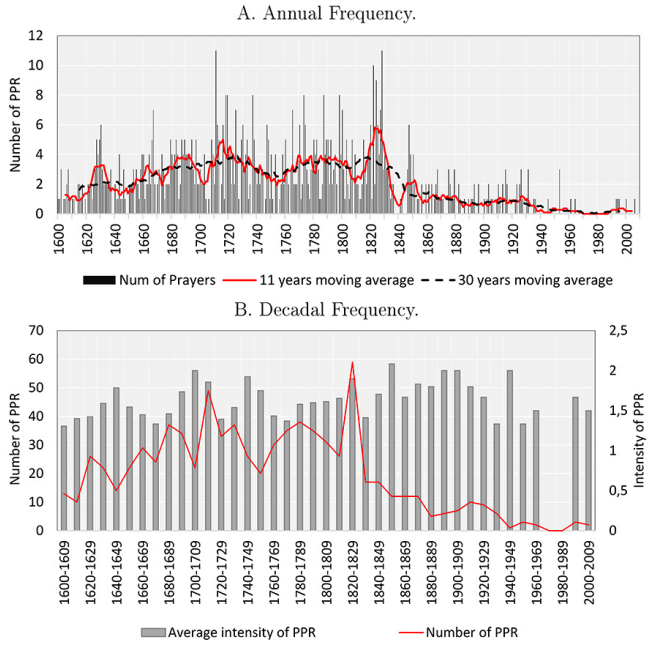
RESULTS

Figure 2A shows the numbers of PPR per year in the city of Murcia, including 11-year and 30-year moving averages. We see an increase in the number of PPR during the 17th century, coinciding with the dry periods in southeastern Spain that some authors have reconstructed from the data (Creus Novau and Saz Sánchez 2005, Machado et al. 2011). These authors attribute the greater persistence of drought at the end of the 17th century to low sunspots and high volcanic activity during the late Maunder (1675–1715) Minimum. The same authors claim that the dry period of the early 19th century was caused by a reduction in solar activity during the Dalton Minimum (1790–1830). These two periods coincide with the two peaks of activity in our series, as can be seen in Figure 2B. Therefore, we could attribute these peaks to environmental rather than social phenomena. Figure 2B shows, however, that there is no clear relationship between the number of PPR and their average intensity, measured on the 1–5 scale shown above.

Institutional conflict and pro-pluvia rogations structure in Murcia

The main motivation to perform a PPR was agricultural. The *Gremio de Labradores* (Farmers' Guild) lobbied the MC to ask

Fig. 2. Pro-pluvia rogation (PPR) variability by year and by decade. Panel A: Annual frequency. Panel B: Decadal frequency. The decadal average for average intensity of PPR for the whole period is 1.6. The average number of PPR by decade for the whole period is 19.4 per decade.



the EC for a PPR. Even in Mediterranean cities, Farmers' Guilds were uncommon. In Murcia, where rain was important and farmers were powerful, we would expect the seasonal distribution of PPR to correspond with farmers' water needs. In other words, PPR would be performed in typically rainy seasons, when crops needed water, but only in years when not enough rain fell.

Usually, each PPR cycle began with an official request from the Municipal Council. From that moment on, the Ecclesiastical Chapter was responsible for defining the ceremony, including its type and date. Notice that the MC initiates the PPR. Moreover, the MC, or some of its wealthiest and most illustrious members, usually pay the costs associated with the PPR. However, it is the EC who decides how much the PPR costs. This tension between payment and planning frequently led to conflicts between the MC and the EC about the timing and type of rogations to perform.

Church and state continued to vie for control as the PPR process became increasingly bureaucratic. In 1694, it was decided that only the MC could make a PPR request to the EC, which would be responsible for deciding the type of ceremony and figures to use. Thus, the EC had an exclusive legal role as an intermediary between God and the people. Despite this codification, tensions between the MC and the EC continued over time. For example, on 17 December 1740, the MC wrote to the EC that a drought continued despite the rogations prayed, and as a result, the peasants were anxious. The MC asked the EC to say a new rogation with the figure of the Fuensanta, the patron saint of Murcia. The EC, however, refused this request and performed a new rogation with a different virgin. Justifying its decision, the EC referenced a law from 20 February 1709, stating that the MC had no authority to suggest types of rogations. At the MC's insistence and, above all, out of fear of popular riots, the EC agreed to the request months later on 15 January 1741, and held a procession with the Fuensanta. Similar conflicts between civil and religious authorities broke out in 1740–1741, 1764–1765, 1778, 1798, 1801, 1825, and 1831, but not after. This could be due to the decreased frequency of PPR, or the diminished role that the Church played after the liberal revolutions. In any case, the fact that the Church retained the prerogative regarding the figures after every conflict suggests that they did not face any serious substitutes before the 1830s.

Perhaps continuous pressure worked, as the number of PPR increased during these conflicts. In years with conflicts between the EC and the MC the number of PPR were 89% higher than in the two previous and two following years for the same season. Compared to this 5-year moving average, the 11-year moving average showed a 98% increase in PPR, and the 25-year moving average a 134% increase. This evidence is consistent with the argument that conflict between Murcia and church leaders was more likely under conditions of environmental duress caused by drought (Miguel et al. 2004, Hsiang and Burke 2014).

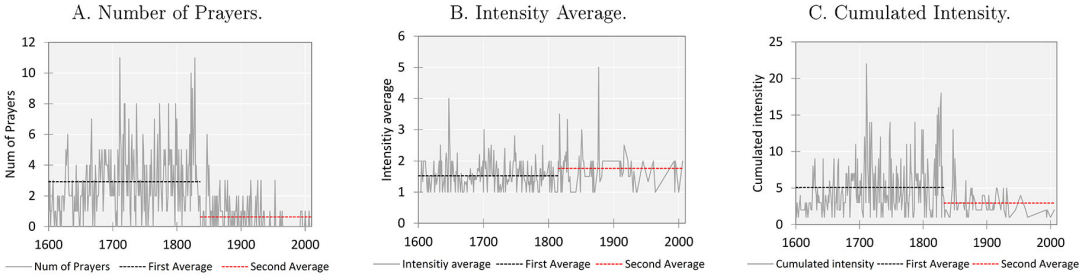
These conflicts were constant throughout the 18th century and the first third of the 19th century, and they led the EC to control an increasingly greater part of the PPR. In other words, climate created conflicts and the resolution further entrenched the Church's role in religious rituals. This cycle paralleled the spread of the Enlightenment across Europe and was an early sign of growing conflicts between civil and ecclesiastical authorities during the liberal revolutions of the 19th century. If the MC could dictate when and how to perform a PPR, the Catholic Church worried it could be replaced.

Pro-pluvia rogations variability and exogenous shocks

Throughout the study period, several exogenous factors influenced the variability of rogations. Figure 3 shows several breakpoints based on the variable of interest in the data during the 1830s. Thus, we should be cautious when extrapolating conclusions from results in the pre-1830s period to the post-1830s period. The main break in the annual number of PPR occurs in 1836 (see Fig. 3A). From that point on, the annual number of PPR drastically decreased from an average of 2.9 between 1600 and 1835 to just over 0.6 per year.

In Figure 3B, we see that the structural change in average intensity happened in 1814, right after Spain's War of Independence. Notice that the change in intensity happened before the change in the number of prayers. Moreover, the average PPR intensity was higher after the change, increasing from 1.5 to 1.8. This increase in intensity is related to the decrease in incidence of PPR. The evidence is consistent with a threshold model in which PPR are performed when a certain threshold in the drought cycle is reached. A decrease in available funds, or in PPR benefits, would imply that this threshold was higher after the 1830s. A higher threshold, combined with an unchanged cost per ceremony, also implies fewer but more intense PPR. In other words, given their higher relative cost after 1830s, the PPR were performed more selectively. Figures 3A and 3B, however, do not relate to the total cost, or total intensity of the PPR. Whereas a higher number of PPR means a higher total intensity, a lower average intensity

Fig. 3. Homogeneity test to detect single breakpoints. Panel A: Annual pro-pluvia rogation (PPR) number. Panel B: Average of the sum of the PPR annual intensity values. Panel C: Sum of the PPR annual intensity values. The table shows the results of the Pettit homogeneity test (Pettit 1979). We compute the p-value using a Monte Carlo with 10,000 simulations. P-values equal or lower than 0.05 confirm the alternative hypothesis of a structural change in that particular year, with a 95% confidence. 1st Mean refers to the average over the period previous to the breaking point, while the 2nd Mean corresponds to the average for the period after it.



	A)	B)	C)
Year	1836	1845	1832
p-value	<0.0001	0.0003	0.05
1^{st} Mean	2.9	1.5	5.1
2^{nd} Mean	0.6	1.8	2.9

means a lower total intensity. In Figure 3C we can see how the former effects dominate, i.e., the total intensity is lower after the 1830s, dropping from 5.1 to 2.9. This result is also consistent with the PPR becoming more selective after the 1830s. We see that there was not much change to higher level PPR, but that some lower level PPR common before the 1830s were no longer performed. Overall, accumulated intensity was lower.

The structural break in the PPR data series during the 1830s coincides with two important financial events for the Spanish Catholic Church: the abolition of tithes (1837) and the Mendizábal Confiscation (1836–1845). Both events represented the two major reductions on the sources of financing for the Spanish Catholic Church. Tithes were abolished with the law of 29 July 1837, also promoted by Mendizábal. It was confirmed and irreversible with the law of 31 August 1841. Since 1823 the tithal income was decreasing because of the refusal of many farmers to pay it (Pérez Picazo and Lemeunier 1984). The Church owned large agricultural estates and many urban properties in Murcia (Villabona-Blanco 1993), and many of them were confiscated. Nonetheless, its main source of income was the tithe (Pérez Picazo and Lemeunier 1984), a 10% tax on agricultural production. Since medieval times, European Catholics tithed a portion of their annual income to the church, which acted as an intermediary between God and humans. After invading Spain in 1808, Napoleon imposed tax reform with a goal of abolishing tithes to weaken the Spanish Catholic Church and strengthen the state (Barbastro-Gil 2008). However, it was not until the Liberal Triennium (1820–1823) that Spain abolished tithes with the support of a liberal bourgeoisie that considered the tithe an unfair institution inherited from the *ancien régime* and a threat to economic development (del Peral 1976).

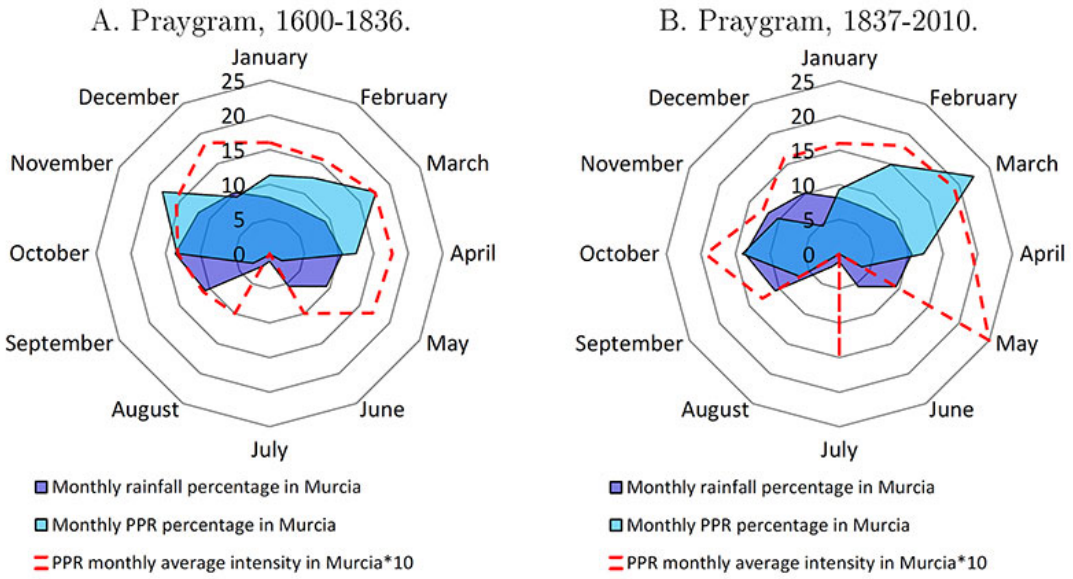
We attribute the change in PPR to the role of the liberal revolutions. This produced both a direct and an indirect effect. The relationship between the Municipal Council (MC) and the Ecclesiastical Chapter (EC) was damaged as a consequence of the liberal revolutions. This had a direct effect on people's religious beliefs. We argue below that the diminished interest by the civil elites in the legitimacy of the church might have affected religious beliefs. In addition to that, the liberal revolutions had an indirect effect by diminishing the revenue available to the Church to keep up the rituals in the same way as before. The Church adapted and survived, faced with a new reality.

Weather, agriculture, and prayers

In Figure 4, we construct two "praygrams" for the city of Murcia, i.e., a seasonal graph showing the distribution of prayers throughout the year. We overlay the distribution of prayers with the distribution of rain. We also overlay the average monthly PPR intensity. We use the praygram to test whether the PPR system was adapted to the local climatic conditions, i.e., high seasonal overlap between PPR and rain would be consistent with a system of beliefs well-adapted to agricultural production. Notice that it could be the case that crops' seasonal water needs do not correspond exactly with the seasonal distribution of rain. Only in resilient environmental systems (Adger 2000) are social needs adapted to the environmental capabilities of the system (Smit and Wandel 2006). Therefore, substantial seasonal differences between rain and crops' water needs are evidence of a society that was not well adapted to its environment.

Figure 4A shows that in Murcia there was a close relationship between PPR and rain, which is indicative of a society whose cultural and religious institutions were well adapted to its environment. The legitimacy of the Church depended on whether the people believed that they were the true representatives of God. The higher the temporal correspondence between praying and rain, the higher the legitimacy. Both series have bimodal distributions that roughly coincide with spring and fall. The first peak in PPR occurred in early spring, the second rainiest season. These spring prayers were preventive measures designed to bring

Fig. 4. "Praygrams" for the city of Murcia, 1600–2010. Panel A: Data from Murcia, 1600–1836. Panel B: Data from Murcia, 1837–2010. The purple area represents the percentage of total rainfall that precipitates in each month, using all the available data for Murcia, 1863–2010. The climatic data for the city of Murcia come from the historical station of AEMET (Spanish State Meteorological Agency). This station is one of the most extensive in Spain. However, it is necessary to consider the climate data only for comparative purposes, because the climatic data are only contemporaneous with the rogations data for the period after 1863. The blue area represents the percentage of total pro-pluvia rogation (PPR) performed in each month; the red line represents the average intensity of PPR. The values are multiplied by 10 to make them visible in the graph.

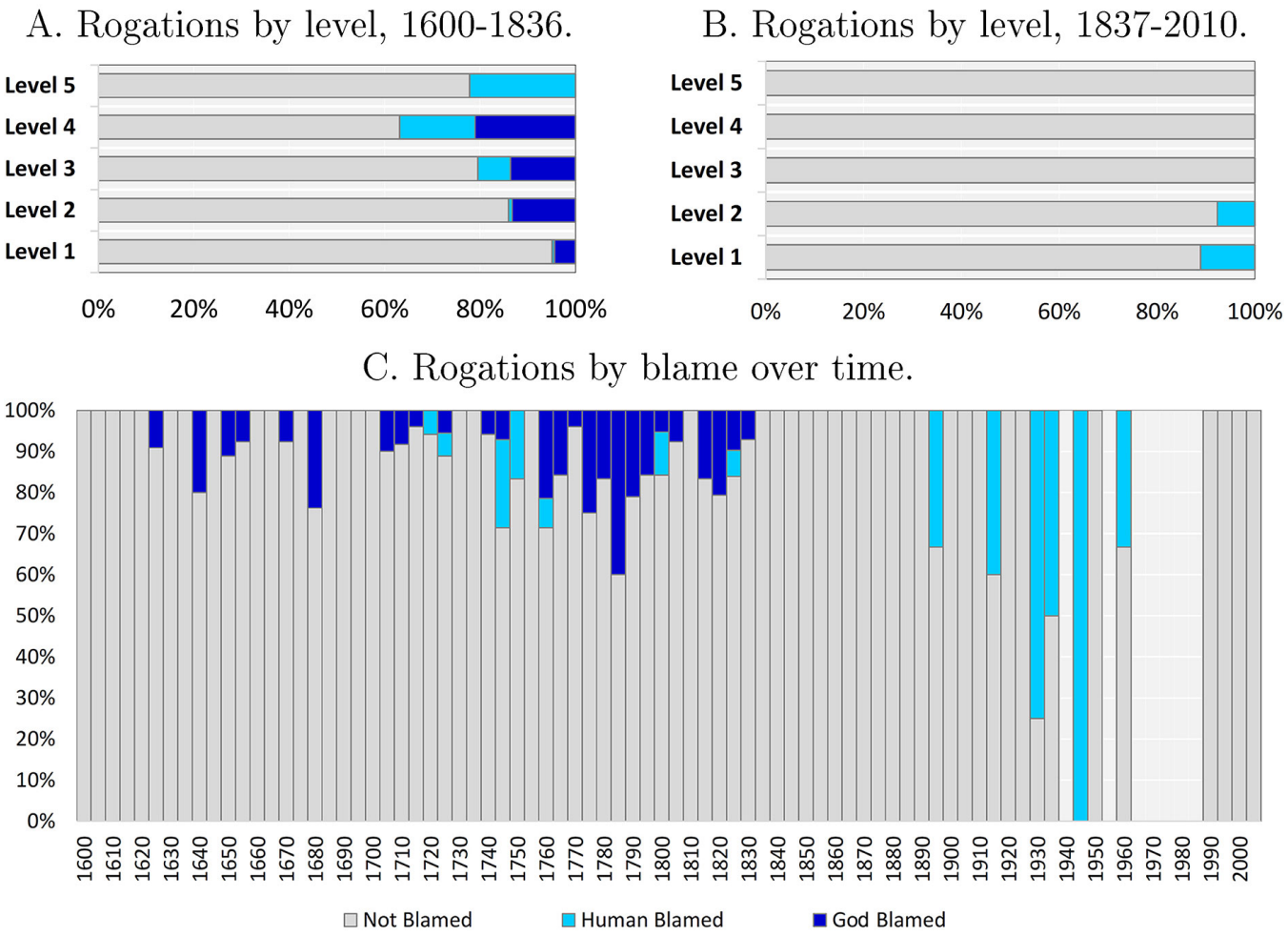


water during the dry summer months and were more common after a particularly dry winter. If little rain fell after a dry winter, civil and religious authorities organized a preventive PPR in March or April. Notice that these preventive PPR usually "worked" such that there were few PPR in May. However, in the few instances when a PPR was performed in May, it was of higher intensity. Moreover, we can see average intensity continuously increasing from January to May. The second peak in PPR came during the rainiest season, the fall, but not in the rainiest month. Rather, PPR were performed in November, right after the rainiest month of October. The fall peak was lower than the spring. Similarly as before, if October was abnormally dry and little rain fell in early winter, then a more intense PPR was performed in December to prepare for the winter planting. As with the spring cycle, the relatively low numbers of PPR in December indicates that the early fall prayers usually brought rain.

As argued above, the seasonality of PPR is related to a city's economic structure. Therefore, changes in an urban economy would produce changes in the seasonality of PPR. In Murcia, we can see how the seasonality of PPR changed after 1836. In Figure 4B, we see PPR spread throughout spring (February and March, May and June) and concentrate in early fall (September). There is also a significant reduction in PPR in winter (November, December, and January). In other words, PPR became more useful in spring and fall. After 1836, it is remarkable how little overlap between PPR and rain we observe during winter. This relates to the new role that the Church played after 1830s because when civil authorities decide when to perform a PPR they are not interested in timing. Before 1830s, and despite recurrent conflicts, there was a symbiotic relation between the civil and religious authorities. The civil authorities had an interest in the Church maintaining legitimacy, and that could explain the close temporal (seasonal) relation between praying and rain. After 1830s, the symbiotic link between the civil and religious authorities is broken, which could explain the lack of seasonal relation between praying and rain. The Church responded to that decrease in temporal relation by increasing the intensity of the PPR precisely during the rainiest months. The increase in intensity documented above occurred because of a very high increase of intensity during the rainiest months.

Changes in agricultural technology and productivity were too slow and too small to explain the structural change in the 1830s. Nonetheless, they are part of a slow-moving process that affected the relation between the church and the farmers. During the 19th century, Murcia underwent a process of technological agricultural improvements and expansion of irrigable land (Pérez Picazo and Lemeunier 1990). This technological change created an increase in the hydric stress threshold, i.e., how long a given farmer could endure a drought, which could explain the decline in winter PPR given their preventive nature. Moreover, because farmers with access to irrigation were less exposed to drought, the expansion of irrigable land meant that fewer farmers would request PPR, or only at a higher threshold. Changes in the main crops planted in Murcia during the 19th century could also have

Fig. 5. Assigned blame in pro-pluvia rogations in Murcia, 1600–2010. Panels A and B: Decomposition of blame by intensity level. Panel C: Evolution of blame by five-year intervals.



affected how PPR were performed. Whereas Ortiz (1999) finds farmers planted barley, which is better suited to drought than wheat (Ruiz et al. 2001), throughout the 19th century, Pérez Picazo and Lemeunier (1990) emphasize farmers reduced their grain acreage to plant trees and vines instead.

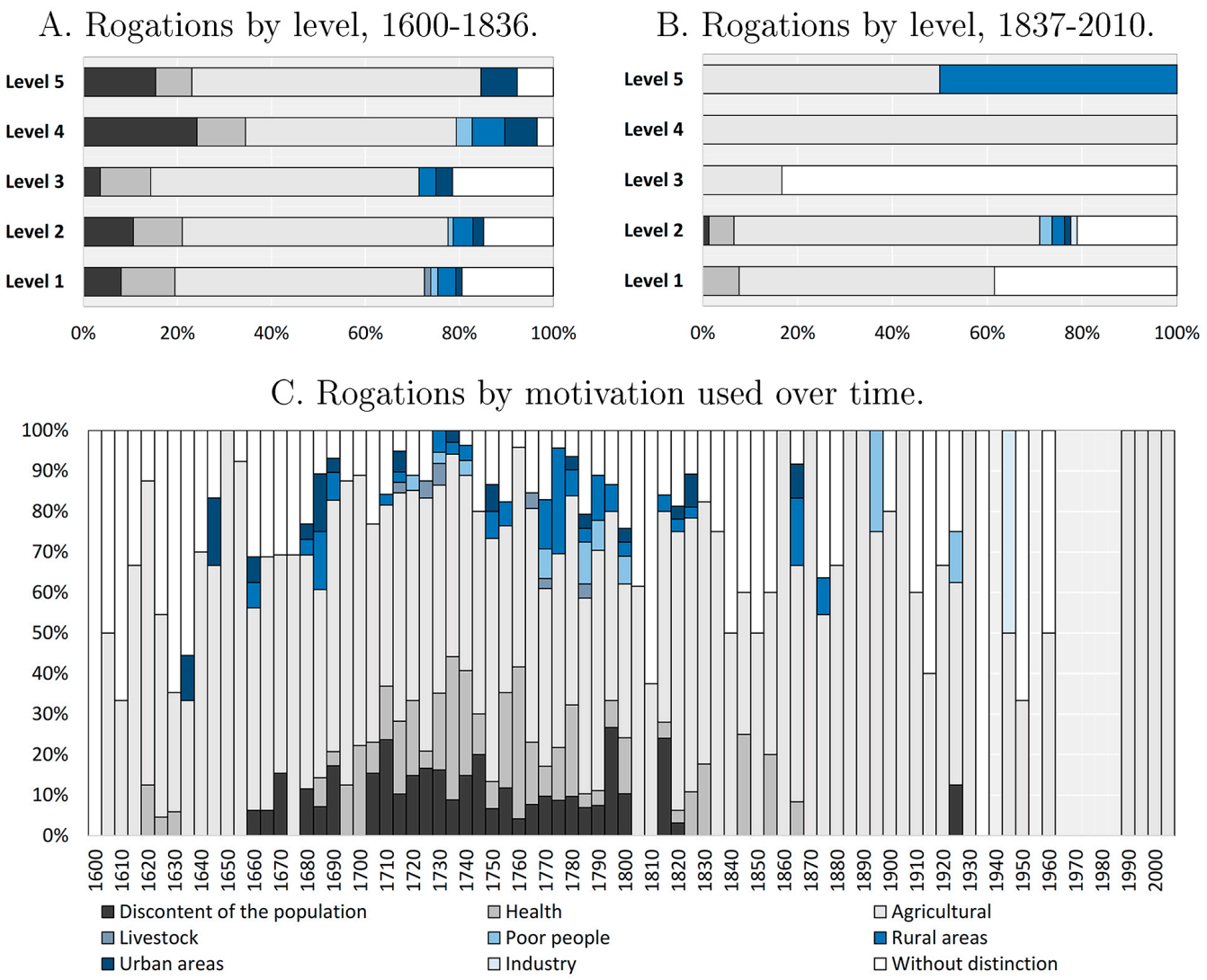
Nonetheless, as Figure 4B shows, the average intensity of PPR was even more closely associated with months when rain was most likely. The average PPR intensity increased in spring (February, March, April, and May) and in early fall (September and October). The increase was largest in October, the rainiest month in Murcia. Therefore, the association between prayer and rain in this period comes though the intensive margin (intensity), rather than the extensive margin (number of PPR), as was the case before 1836. This result is consistent with our hypothesis outlined above. Because PPR were relatively more expensive, due to the new role the Church played, the ecclesiastical authorities put even more emphasis on their precise timing and thus their accuracy.

In summary, after the 1830s the seasonal timing of PPR and weather were increasingly disconnected. Because civil authorities decided when to ask for a PPR, this disconnection could have been due to the unimportance of precise timing for the civil authorities after 1830s. At the same time, we see an increase in the intensity of PPR in months with large amounts of rain. Once the date was set, ecclesiastical authorities decided the intensity of the PPR, and largely offset the decreased incidence of ceremonies by increasing their intensity during rainy months. Given the many changes in Murcia and Spain during the 1830s, it is hard to disentangle whether the lack of seasonal correlation was due to technological change or to the new role of the Church.

Paternalism and pro-pluvia rogations

Both civil and religious authorities searched for a scapegoat to explain the lack of rain when requesting or performing a PPR. Authorities usually turned water crises into opportunities to place blame and responsibility on someone else, and thereby gain the people's favor (Guinn 1904). The identity of the scapegoat, however, varied depending on local culture (Messerli et al. 2000). Figure 5 shows that in most cases in Murcia, prayer dedications did not attach blame to anyone. However, Figure 5A shows that before 1837, higher level PPR meant someone was more likely to be blamed. Figure 5B shows that this was not the case after 1837.

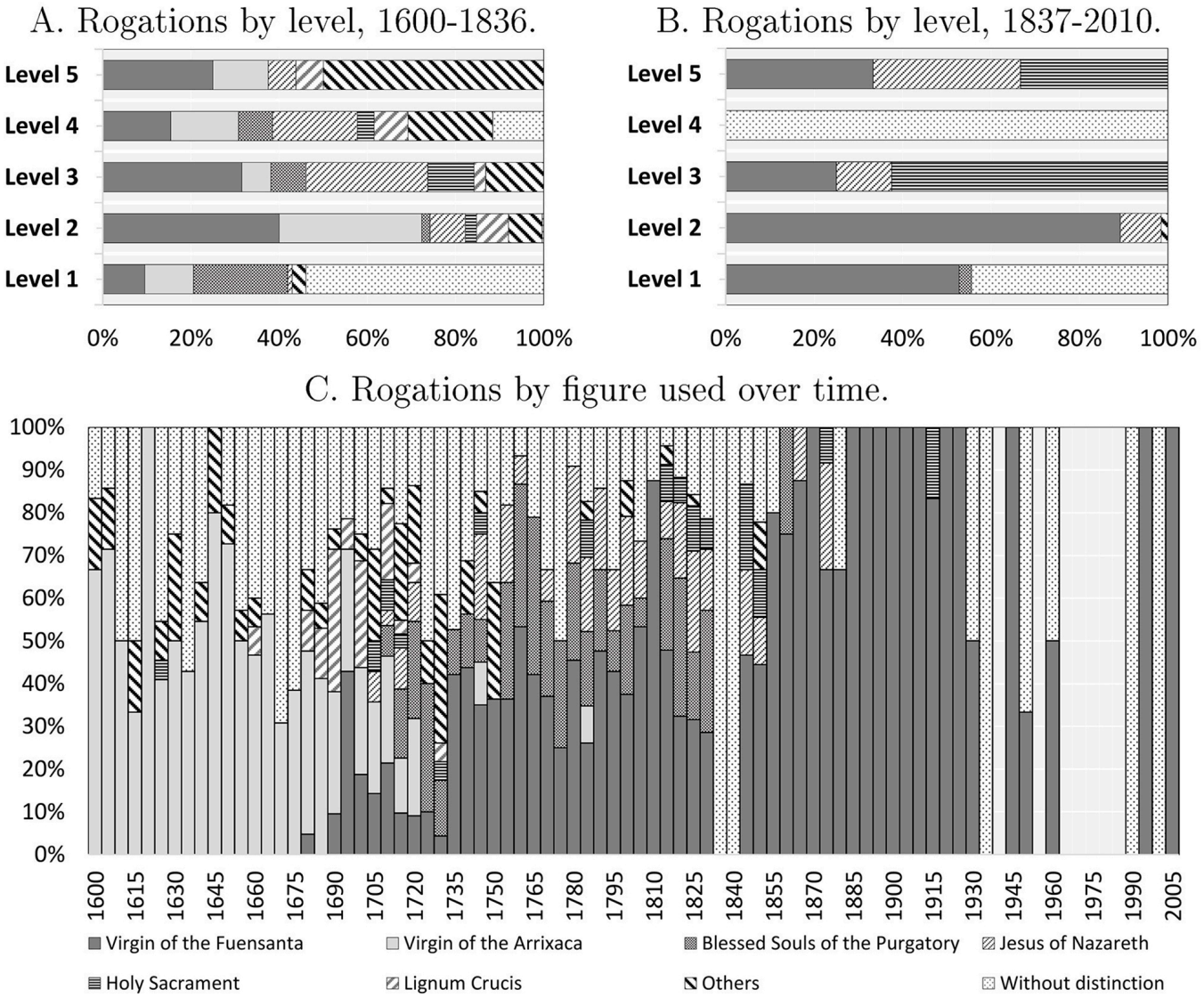
Fig. 6. Specific motivations of pro-pluvia rogations in Murcia, 1600–2010. Panels A and B: Decomposition of motivations by intensity level. Panel C: Evolution of causes by five-year intervals.



Remarkably, God was never blamed after 1837, and humans were blamed rarely, and only in lower level PPR. Before 1837, blame was assigned during the most important PPR. Finally, God was more likely to be blamed in higher level PPR, but not the highest level PPR. Distinctions in divine blame were very subtle. Although God created all droughts, religious authorities sometimes could not find specific reasons, and at other times, explicitly faulted sinful Murcia citizens. Therefore, we can talk about a dual system that both reinforced the idea that God controlled the weather and shifted responsibility for uncontrollable environmental phenomena away from religious and civil authorities and onto humans.

Motivations for prayer were also linked to blame. There were other PPR, however, with more paternalistic goals. Following motivations over time shows how elites' roles and society at large changed. In Figure 6A, we see the relationship between prayer motivation and intensity before 1837. The most common motivation for a PPR was, as mentioned above, agricultural, i.e., so that rain would increase crop productivity. We do not see a relationship between intensity and the proportion of agricultural PPR. We do see a positive relationship between prayer intensity and people's discontent, especially for level 4 and 5 PPR, and a slight negative relationship between public health and intensity. It is not surprising that higher level PPR were said for reasons of popular discontent. High-level PPR were performed rarely, and only after long droughts, which is precisely when we would expect the population to be on the verge of rioting. Notice that PPR were always intended to ask God for rain. But in some instances, the motivation was that rain would help a particular segment of the population (the poor), a particular area of the region (urban or rural), or a particular aspect of welfare (health). Figure 6B, shows a very different pattern. Today, the heterogeneity in causes is lower,

Fig. 7. Specific motivations of pro-pluvia rogations in Murcia, 1600-2010. Panels A and B: Decomposition of motivations by intensity level. Panel C: Evolution of causes by five-year intervals.



and most of the PPR relate to agriculture or have no stated motivation.

Figure 6C, displays how motivations for PPR change over time. Whereas agricultural motivations were usually the most common, from the second half of the 17th century until the 1830s, many PPR intended to improve the health of the community or lessen the discontent of the population. PPR were next performed for the discontent of the population a century later, in the years before the Spanish Civil War (1936–1939). This finding that there are leading indicators of conflict is similar to the results in Battilossi et al. (2021) who found changes in stock prices before the outbreak of the Spanish Civil War. Along the same lines, the only two instances in the last two centuries when PPR were performed to help the poor happened just prior to the Spanish Civil War, and during the 1898 Spanish-American War. In this regard, we see how PPR could be a warning sign of deep popular unrest that could lead to crisis or conflict.

Although the Vatican enforced a rigid liturgical structure, some aspects of PPR were customizable. In addition to varying levels of intensity determined by the number and length of prayers, ceremonies also used different figures of saints or virgins represented by statues and relics. Many figures were local patrons of a given town (Galiano 1791, Christian 1976). The figures were sometimes linked to an occupation or guild, e.g., the Virgin of Carmen is the patroness (or local protector) of fishermen, and protected many fishing towns, each with their own figure of the virgin to revere. Figure 7A shows that for the city of Murcia, about half of the level 1 rogations were performed without a figure. Higher level rogations, however, were almost always performed using at least one figure. Whereas most level 2 PPR were

performed using a virgin (Arrixaca or Fuensanta), the higher the level, the more likely "rarer" figures were used.

Miura-Andrades (2003) shows that, during the Middle Ages, there were many miracles in Andalusia, all coinciding with local epidemics and environmental disasters. These miracles helped to secure religious beliefs in particular saints and virgins. Rojo Vega (2014) also mentions how miracles coinciding with droughts in western Andalusia and Extremadura contributed to the funding of specific figures. Alberola Romá (2003) emphasized how many of the patrons in towns in Alicante were chosen because of the miracles they performed during the plagues of locusts during the 18th century. Finally, Fernández Montes (2001) argues that San Isidro is the patron of Madrid, precisely because of his many miracles during droughts.

In the city of Murcia, the patroness was the Virgin of the Arrixaca until the 1690s, and after, the Virgin of the Fuensanta. The urban legend has it that the patroness changed when, after a series of "unsuccessful" prayers to the Arrixaca, the citizens of Murcia prayed to the "new" Virgin of the Fuensanta and it finally rained. Antón-Hurtado (1996), however, argues that the change had more to do with internal politics than with the perceived success of the Fuensanta. Using primary sources, Antón-Hurtado (1996) shows that a conflict between the Ecclesiastical Chapter (EC) and the Bishop of Murcia resulted in a change of patroness. The figure of the Arrixaca belonged to the Augustinian Order supported by the bishop, whereas the Fuensanta belonged to the Capuchin Order, supported by the EC. The figure of the Arrixaca was under the care of the city of Murcia until 9 November 1514, when it was donated to the Augustinian Order (Antón-Hurtado 1996). In addition to the figure, the Augustinians got the San Sebastian Shrine, belonging to the EC. The EC only accepted after receiving pressures from the Bishop and Cardinal Don Mateo de Lang. This episode created an enmity between the chapter on one side, and the Augustinians and the bishopric on the other. Despite the bishop's attempt to excommunicate the EC and the Capuchins from the church, the EC won the power to decide which figure was used in PPR. In Figure 7B, we see that virtually none of the prayer ceremonies were performed with minor figures ("others"). This is a direct consequence of the virtual monopoly the Fuensanta established during the 19th century. As we can see in Figure 7C, the Arrixaca's privileged position had already weakened by the first half of the 18th century. Notice that even though the change in power happened suddenly, the Arrixaca was still the most commonly used figure for many decades. This might be due to persistent popular preferences. Figure 7C most clearly shows the evolution of internal ecclesiastical politics among different orders in Murcia, beginning with a period of dominance by the Arrixaca, then continuing with a period of intense competition between religious orders and officials. Shortly after a "truce" called as the *ancien régime* collapsed during the 1830s, the Fuensanta emerged as the sole victor.

This slow and peaceful change in the figure of adoration need not be the norm. The transition could happen suddenly and violently. Lombardi (1989) shows how in Spain and Italy, people destroyed icons because of the perceived "ineffectiveness" of the virgin or saint they depicted. These situations were not programmed by authorities, but rather were a spontaneous response from the society as a whole. In this regard, evidence regarding the selection of images and the timing of ceremonies could reflect uncertainty regarding the ritual's precise mechanism ("The Lord works in mysterious ways").Thus, it is possible that elites tried to better understand the effect of rituals on weather and fine-tuned each element to maximize efficiency. Murcia elites attributed the virgin swap to the Virgin of Arrixaca's failure, showing how they adapted to changing times. In extreme situations, figures of saints and virgins were scapegoated, freeing authorities from responsibility. After a prolonged drought or natural disaster, social and institutional structures remained virtually unchanged, except for a new name or "image" for the Order or family in power. Ultimately, whether the change was peaceful or violent, the underlying structure remained. Using saints' images and relics, religious beliefs promised to redeem the sinful in Murcia and throughout the Catholic world more generally. Prayers and other personal sacrifices were a key component of religious rituals in other cultures. Schoffeleers (1992) argues that in equatorial Africa, snakes were ritually decapitated to symbolize the role of a human martyr and redeemer.

DISCUSSION

Myths and beliefs explaining and, in theory, increasing rainfall shaped pre-industrial societies (Berkes et al. 2000). In agrarian societies, the common people have observational knowledge of the climate (Anandaraja et al. 2008, Lefale 2010, Enock 2013) that collectively makes them what we could call climate forecasters. However, their forecasts are far from perfect (Ayal et al. 2015, Reyes-García et al. 2018) and societies have entrusted specific elite people, groups, or activities with reducing uncertainty. Rainmakers also contributed to state formation. Lan (1985) argues that rainmakers alongside politicians and guerrillas influenced Zimbabwe's independence process. Other studies have revealed the role that rainmakers played during peasant revolts. Spierenburg (2004) argues spirit mediums in Zimbabwe supported anti-government positions on agrarian reform.

Along the lines of recent work on the subject (Gómez-Baggethun et al. 2012, Von Heland and Folke 2014), we argue that the survival of these religious rituals is partly due to its role in preventing conflict between elites and peasants and avoiding peasant revolts during episodes of hydric stress. However, PPR were not the only stabilization mechanism in the study area. Another factor that may have reduced revolts was Murcia's low population density (Espín-Sánchez et al. 2019). Pérez Picazo and Lemeunier (1994) argue that low population density since the Reconquista explains the absence of a Malthusian Trap that would collapse social structures. Finally, other social institutions were designed precisely to prevent such extreme events. In our opinion, other institutions like public granaries (*Pósitos*), which regulated cereal markets during prolonged droughts, complemented religious institutions. *Pósitos* regulated cereal prices, bought cereals from other regions, or countries, and provided seed to farmers at subsidized prices (Caro Lopez 1985). Whereas the *Pósitos* and other formal institutions worked by ordering the economy and the physical world, rogations eased peoples' minds by providing a silver lining during catastrophic events. We can thus see rogations as a public display of good will that elites understood the severity of the situation and were doing everything they could to remedy it, from imposing price controls to communicating with the Divine. We believe that, given the paternalistic nature of the social contract in Murcia, peasants did not consider the elites as

oppressors, unlike in Scott (2008), but rather as protectors Thus, we follow Pérez Picazo (1995). Of course, this does not mean that the peasants fully acquiesced with the status quo. As Lemeunier (1976) shows, Murcia peasants had other weapons at their disposal. In particular, they stopped paying taxes (tithes) or reduced their payments to show displeasure.

Despite technological developments in atmospheric science and weather forecasting, in addition to new religious traditions, beliefs persist. Throughout history, there have been many examples of very pious men of science. The prime example is Isaac Newton who did not see a conflict between science and religion. He rather saw the universe as the creation of God, and mathematics as the language to understand its meaning (Mokyr 2017). In any case, it is unlikely that science will fully substitute for religion. Even if science could eliminate all uncertainty regarding the physical world, there is still the metaphysical world. Advances in technology, weather forecasting, and also crop insurance reduce both the incidence of famine and extreme harvest failure and their consequences for farmers. Because rituals were costly, it is unsurprising that advances in science and technology are correlated with a reduction in the number of rituals. In any case, as we document, rituals persisted but were mostly dedicated to extreme events that new technology is still not able to fully account for. This finding is consistent with the idea of a higher tolerance threshold for hydric events. Thus, rituals to modify the weather may have introduced and deepened other religious beliefs (Ager and Ciccone 2014). We document how rituals changed after the end of the *ancien régime*. As elites became more selective in performing rituals, rituals were on average less frequent but more intense. The religious-civic system changed but continues to have an important role in society.

In southern Spain, where prolonged droughts increased the risk of revolt, beliefs took the form of praying for rain. This is an important and overlooked insight. If this intuition is true, regions with an "endowment" of geographical characteristics that are easy to "superstitionalize" will become more religious than otherwise similar regions. In wet regions, rain was so common that peasants saw it when there were no rituals and gained no big advantage from controlling it. In dry regions, rain was so rare that, even when controlling it was a huge advantage for peasants, priests could not coordinate rituals with rain. Regions like the Mediterranean, where rain was uncommon but not rare, present an intermediate case. In those regions, rain was so uncommon it greatly benefited whoever controlled it, but common enough such that it could rain after a ritual. In semi-arid regions, we would expect religious beliefs and rituals to become a central part of public life. We would also expect religious beliefs to be more entrenched and heresies less persuasive. Finally, as we show, the organizations and institutions perpetuating the belief adapted to a new industrial society, thereby continuing to exert influence. This mechanism for religious persistence is worth exploring in detail.

Murcia's institutional management of drought risk demonstrates the importance of religious ideas and culture rather than coercive political force. Despite the extreme environment, serious popular revolts or revolutions did not occur in Murcia (Pérez Picazo et al. 1979). Like many after them, Braudel (1984) argued that regions with ancient irrigation works could only be governed by dictatorial power structures, which prevented revolution. However, this typical explanation is merely a conjecture, and the specific mechanism of control has not been studied in depth. Moreover, the ideas proposed by Braudel (1984) and spearheaded earlier by Wittfogel (1957), applied to ancient hydraulic empires such as Egypt, Babylon, and to a lesser extent China, not to the western Mediterranean setting of small rivers and self-governing irrigation communities (Espín-Sánchez 2017). Here, we provide an alternative to Wittfogel (1957). Rather than a threat of coercive force, an internalized system of beliefs preserved the social stability, even during prolonged droughts. In Murcia, peasants believed that God controlled environmental phenomena. Crucially, the Church maintained a position of privilege, even after civil revolutions and in the face of resistance from the government and civic elite. This insight opens a new area of research on why institutions, good or bad, persist that is based on systems or "cultural institutions" whose goal is to shape citizens' behavior through cultural and religious beliefs, rather than "incentives" or "punishments." Notice that here there is a clear mechanism, and the beliefs are both in God and on the Church, as an institution/organization with the exclusive contact with God. This contrasts with other articles in the literature where the persistence is documented, but the mechanism is absent or unclear (Nunn and Wantchekon 2011, Voigtländer and Voth 2012).

Historical relationships that protected farmers' labor on the land have outlasted environmental change. Recent studies focus on why farmers and sheepherders seem to be more conservative than other social groups (Lafuente 2005). Duflo (2006) argue that individuals living in subsistence conditions are more conservative because they have more to lose. In a similar vein, Richardson and McBride (2009) argue that religious extremism is more likely in societies with significant mortality shocks. However, an alternative explanation is that these agricultural groups were historically under the protection of religious authorities and still rely on them today, making farmers and herders more conservative and even reactionary. It is not whether they are close to subsistence today that matters, but that they were close to subsistence historically, when they depended on religious and public authorities during disasters.

In the vast literature on religious conflict, disagreements internal to the faith have been understudied. Closest to our approach, Leeson and Russ (2018) study the Reformation using witch trials as an expression of belief. Religious conflict usually means conflict between religions (Christianity vs Islam) or between denominations within the same religion (Catholic vs Protestants). There is, however, a subtler conflict in every religion that occurs within the same denomination, and whose goal is not eradication of opposition, but gathering the largest share of resources (Murphy et al. 2016). In the case of Murcia, we show how intra-religious (or intra-denominational) conflict led to competition and an eventual winner. We thus open an avenue for new research.

CONCLUSIONS

We analyze pro-pluvia rogations, a religious ceremony used by elites in Murcia. In this regard, we conclude that the survival until today of such ceremonies is due in part to their capacity to prevent conflict between elites and peasants and avoiding revolts. PPR stabilized social relations in Murcia because they confirmed, again and again, the Catholic Church as the only intermediary

between God and humans. We document a structural change during the 1830s coinciding with the fall of the *ancien régime* in Spain after which we observe fewer but more intense PPR. Cultural shifts, church financial losses, and technological improvements may explain this change. Given the confluence of factors during the 1830s, it is difficult to separate social and technological factors from purely political factors. However, it is remarkable how despite conflicts among different groups, the institutional status quo prevailed almost intact and without a revolution.

In addition to revolts, i.e., conflict between elites and peasants, the rich Murcia sources allow us to analyze conflict between other groups. We show how conflict among elites was more likely during prolonged droughts and large environmental shocks. Therefore, religious practices can be an early predictor of institutional failure during periods of environmental stress, particularly in developing countries that lack formal institutions to manage environmental shocks. Religious practices requiring intermediation between God and religious leaders, like Catholicism, would reinforce religious beliefs, respect for authority, and collective work for the common good during times of environmental stress. By contrast, places where religious practices dispense with such intermediation would suffer from miscoordination and opportunistic behavior, exacerbating the crisis. Competition between different orders of the Catholic Church shaped the way the PPR were performed. It is an open question whether cities with more intra-religious competition perform PPR better suited to the environment, which would further increase the persistence of religious beliefs after industrialization. Rituals that give comfort and hope to everyone during a crisis increase social resilience.

Responses to this article can be read online at:
https://www.ecologyandsociety.org/issues/responses.php/12875

Author Contributions:

Both authors have contributed equally. Authors are listed alphabetically.

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Data Availability:

The data/code that support the findings of this study are available on request from the corresponding author, [SGG]. The data/code are not publicly available because of restrictions e.g., their containing information that could compromise the privacy of research participants.

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