On Self-Organization: The Formation of Volunteer Fire Brigades in 19th-Century Baden*

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This Version: August 31, 2025
Preliminary and Incomplete
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Abstract

How does self-organization emerge? We study the formation of a formal institution for local public goods provision in 19th-century Baden, which at the time was an autonomous state in what is now Germany. During this period, many, but not all, communities established volunteer fire brigades, a form of bottom-up collective action that persists to this day. We find that self-organization emerged where local shocks interacted with pre-existing social structures. Specifically, a major fire significantly increased the likelihood of establishing a fire brigade, but only in communities that already had a singing or gymnastics club.

Keywords: self-organization, collective action, public goods provision

*We thank Davide Cantoni, Esther Chevrot, Matthias Dewatripont, Andreas Fahrmeir, Erik Hornung, Felix Kersting, Michael Kosfeld, Oliver Kubitza, Max Müller, Navid Sabet, Paul Seabright, and Nikolaus Wolf for valuable feedback. We are grateful for the comments of seminar participants at Goethe University, University of Innsbruck, Toulouse Summer School, Barcelona Summer Forum, SIOE 2025, the 6th Congress GSWG Congress at Humboldt University, and the committee on the history of fire protection of the Vereinigung zur Förderung des Deutschen Brandschutzes (vfdb). Luisa Esper, Anton Hantel Lisa Harner, Jessica Paul, Jana Raich, Luca Schöpfe, and Andrea Stolz provided excellent research assistance.

1 Introduction

The ability of communities to solve collective action problems is a fundamental source of wealth and economic development (Ostrom, 1990; Putnam, 1993). However, collective action is hampered by free-rider behavior and coordination failure (Olson, 1965; Hardin, 1982). Despite these obstacles, Ostrom (2000, p. 138) highlights there is ample evidence that "individuals in all walks of life and all parts of the world voluntarily organize themselves so as to gain the benefits of trade, to provide mutual protection against risk, and to create and enforce rules that protect natural resources". Empirical work on self-organization covers many different types of challenges of a community and has shown that self-organization can take many forms (Ostrom, 1990; Baland and Platteau, 1996; Ostrom, 2010; Rustagi et al., 2010). The studies we are aware of take a cross-sectional perspective; they look at existing institutions for self-organization and then analyze which community attributes make self-organization more or less successful. Often, the time at which an institution was created is not part of the observation period because the institution already emerged decades or even centuries ago.

Our paper takes a different but complementary approach. We zoom in on a relatively short period of time (1852 to 1889) during which numerous, though not all, communities in the autonomous state of Baden in southwest Germany established volunteer fire brigades. What makes the formation of volunteer fire brigades so interesting is that it illustrates the emergence of a formal and long-lived institution of bottom-up collective action (Charnysh, 2019) dedicated to fighting one of the most harmful threats for a community at the time. Until today, volunteer fire brigades dominate firefighting in Germany and many other countries. Their organizational form stands in sharp contrast to the top-down created public fire brigades that emerged around the same time, for instance, in Prussia or France. Our study is among the first to provide field evidence on the *emergence* of self-organization.[1]

Firefighting, then as now, requires both cooperation and coordination. It is subject to a collective action problem for two main reasons. First, the benefit of firefighting is a public good that is enjoyed even by those who decide not to contribute (Ostrom, 2010).[2] Second, establishing and operating a firefighting organization requires a good degree of coordination.

[1] There exists of course a sizable literature that studies the emergence of self-organization in the laboratory. See, for example, Kosfeld et al. (2009) or Markussen et al. (2014). Dannenberg and Gallier (2020) provide a review.

[2] Some have argued that the fire brigades which were run by fire insurance companies in London since the late 17th century let buildings burn if they were not insured by their company (see, for example, Gillespie (1922) or Haines (1926)). However, a closer look at the literature reveals that this is rather a myth. Insurance company fire brigades did not only fight fires of buildings which were not insured by their company but also cooperated with each other (Trebilcock, 1986; Wright, 2008).

In particular, citizens will be more inclined to form a fire brigade if they expect that more of their fellow citizens will participate as well.

We present a conceptual framework that models the formation of a volunteer fire brigade as a coordination game with multiple equilibria. While there always exists an equilibrium in which nobody cooperates and self-organization fails, there is a second equilibrium in which the establishment of a volunteer organization is possible if enough citizens enjoy a high benefit from being member of this organization. We argue that whether the benefit of membership in a community is high can be inferred from whether other social clubs exist. Which equilibrium is selected hinges on citizens' expectations about what others will do. We argue that these expectations can be shifted by a local shock, which therefore allows for a transition from one equilibrium to another. In the context of self-organization of fire protection, such a shock, for example, can be a fire in the own or a neighboring community.

Our conceptual framework yields several testable predictions. First, fire brigades should be more frequent in communities in which other social clubs exist. Second, a local shock in the form of a fire in the community itself, a fire in an adjacent community, or the foundation of a fire brigade in an adjacent community should increase the probability that a fire brigade is established. And third, the effect of such local shocks should be larger in communities in which other social clubs exist. We test these predictions using a panel that covers all 1,577 municipalities in the Grand Duchy of Baden from 1852 until 1889. Our panel includes nearly the full set of volunteer fire brigades, singing clubs (*Gesangsvereine*), and gymnastics clubs (*Turnvereine*) that were established over this period. Moreover, to measure the occurrence of fires, we hand-collected data from Baden's public fire insurance institution, under which all buildings were insured.

To estimate the causal effect of local shocks on the probability a fire brigade is established, we apply a difference-in-differences analysis based on local projections (Dube et al., 2023), which can flexibly deal with the specific nature of our treatment (staggered and repeated). Using this approach, we find that a fire in the municipality itself or the foundation of a fire brigade in a neighboring municipality more than triples the probability that a volunteer fire brigade is established. This effect, however, is not homogeneous across municipalities. As our conceptional framework predicts, it is substantially larger in municipalities in which a singing or gymnastics club exists. Other than expected, however, a fire in a neighboring municipality has no effect.

While we study the emergence of volunteer fire brigades, we do not address the related but distinct question why it was exactly in the 19th century that firefighting in Germany became to be organized. Several of the factors that were conducive to the rise of associations more generally may be important in this regard: the emergence of liberalism as dominant

ideology, the transformation from a hierarchical to a civil society combined with the rise of the bourgeoisie, the reinterpretation of the role of citizens vis-à-vis the state, especially in taking up tasks that so far had been the monopoly of the state, and the introduction of liberal association laws (Nipperdey, 1972; Gundelach, 1984). We do not have data to further explore the role of these certainly interrelated factors. Therefore, we take the formation of the first fire brigade in 1846 as given and investigate why some municipalities followed suit, while others did not.

Related literature. In a seminal paper, Coase (1974) documents that lighthouses—though frequently cited as a classic public good—were often funded privately. This nicely illustrates that even in a situation in which significant externalities exist but the state remains absent, alternative private institutions may develop (Coase, 1960; Dixit, 2004). For example, it has been argued that the Sicilian mafia emerged in the 19th century as a provider of private protection because publicly provided security was scarce (Gambetta, 1993; Bandiera, 2003; Buonanno et al., 2015). Similarly, we show a case in which communities started to self-organize to provide a public good—fire protection—which the state only provided on a limited level. Different from the mafia, which represented a market-based solution to the lack of public law enforcement, the fire brigades we study were the result of community-level self-organization and provided their service free of charge.

We are of course not the first to analyze how communities manage to overcome collective action problems by self-organization. Greif (1989, 1993), Milgrom et al. (1990), and Greif et al. (1994) show how merchants in the Middle Ages were able to maintain collective action by establishing both formal and informal institutions that facilitated market exchange. Moreover, there exists a large literature that studies self-organization of communities to manage common pool resources (Ostrom, 1990; Baland and Platteau, 1996; Ostrom, 2010). Some studies also look at self-organization in public goods provision (Smith et al., 1995; Miguel and Gugerty, 2005). While these studies usually analyze institutions that are already in place, we focus on the *emergence* of self-organization.

Other studies that deal with the emergence of self-organization are Koyama (2012, 2014) on prosecution associations in industrial revolution England and Suesse and Wolf (2020) on credit cooperatives in 19th century Germany. However, these associations provided law enforcement and credit to members only. In contrast, the volunteer fire brigades we analyze provided fire protection also to non-members and even to neighboring communities. In this sense, volunteer fire brigades were similar to the voluntary lifeboat crews of the Royal National Lifeboat Institution established in 1824, which often saved lives of strangers from shipwreck. However, different from volunteer firefighters, lifeboatmen received payment for both launches and exercises (Guiga, 2024).

Dittmar and Meisenzahl (2020) show how citizen-led political action in German cities during the Protestant Reformation resulted in the introduction of laws favorable to public goods provision. While they study the emergence of a legal institution (church ordinances), we analyze the emergence of a formal organization that provided a public good directly. Moreover, Dittmar and Meisenzahl (2020) adopt a broad definition of public goods that also encompasses quasi-public and even private goods, such as education and health care.

Finally, our paper also relates to the literature on state capacity (Besley and Persson, 2009; Acemoglu et al., 2015). We document the emergence of voluntary associations that created a dense network of local firefighting organizations on which the state could later build. In 1938, a legal reform under the Nazi regime mandated all German municipalities to set up a fire brigade if they not already had one. All fire brigades, including the already existing volunteer fire brigades, were integrated into the police (Jarausch, 2012). After the Second World War, volunteer fire brigades were re-established as municipal organizations. Nevertheless, until today, 94% of firefighters in Germany are unpaid volunteers (DFV, 2025). We hence, document a case in which initial bottom-up organization of citizens increased the state's capacity to provide a public good on a large scale and in a cost-effective manner.

The paper proceeds as follows. Section 2 explains the historical and institutional background. Section 3 lays out a conceptual framework. Section 4 presents our data and provides some descriptive statistics. Section 5 analyzes how the existence of fire brigades correlates with municipality characteristics, in particular the existence of social clubs. Section 6 explains our empirical strategy and explores the role of a local fire shock in enabling collective action. Section 7, in turn, considers the effect of shocks that occur in neighboring municipalities. Finally, Section 8 concludes.

2 Historical Background

2.1 Grand Duchy of Baden

At the beginning of the 19th century, southwestern Germany consisted of several hundred independent territories, a fragmented political landscape that had persisted for over 500 years (Miller and Taddey, 1980). Under the reign of Napoleon, almost all of these territories were consolidated to form the Kingdom of Württemberg and the Grand Duchy of Baden in 1805 and 1806, respectively. Baden remained a sovereign state until 1871, when it became part of the German Empire, in which it retained only partial autonomy. With a population

of around 1.5 million in 1871, it was the sixth largest state in the German Empire.[3] Figure 1 shows the location of Baden in the German Empire. When the German Empire collapsed after World War I, Baden was transformed into a republic in 1918. Today it is part of the German state of Baden-Württemberg, one of the most prosperous regions in the world and home to many of Germany's most productive corporations



Figure 1: Location of Baden in German Empire

Notes: Geographical location of the Grand Duchy of Baden in the German Empire as of 1871. The administrative region in the west of Baden is the Imperial Territory of Alsace–Lorraine, which was ceded by France to the German Empire in 1871. Source: https://de.wikipedia.org/wiki/Gro%C3%9Fherzogtum_Baden.

In the mid 19th century, Baden comprised around 1,600 municipalities. With a median number of just about 600 inhabitants in 1852, the vast majority of these were small, rural villages. There were just four cities with more than ten thousand inhabitants. The largest two of them, Mannheim and the capital Karlsruhe, had only a little more than 24,000 inhabitants. Baden's economy still relied heavily on agriculture. While there were some

[3]The five largest states of the German Empire were, in decreasing order, Prussia, Bavaria, Saxony, Württemberg, and the Imperial Territory of Alsace-Lorraine.

early signs of industrialization, especially in textile production, it was not until the end of the 19th century that Baden's economy industrialized on a larger scale (von Hippel, 1992).

Poverty among the population was widespread. There were several waves of significant emigration in the 19th century, with the United States being one of the major destination countries. Up until 1860, emigration was even subsidized by the government in an effort to alleviate the general misery in the population. Politically, Baden was rather liberal. It was the geographic origin of the German Revolution 1848-1849 and public support for democratic and nationalistic ideas was stronger in Baden than in most other German states.

2.2 Firefighting

Urban conflagrations are a rare phenomenon in modern settlements—so rare that we may forget that not long ago, fire represented a major risk to material wealth and human life. Many, if not most, European cities experienced a large fire at least once during their history. Some of them burned down entirely, and some repeatedly. Among the most well-known examples are the Great Fire of London in 1666, which destroyed more than 13,000 houses (Ager et al., 2024), and the Great Fire of Hamburg in 1842, which demolished around a quarter of the city (Schubert, 2012).

To prevent devastating fires, already in the late Middle Ages, most cities put rules in places that regulated, for example, how houses are to be built, what materials are to be used in construction, and how fire is to be handled in everyday life. Municipal fire regulations focused heavily on fire prevention, while relatively little was regulated in the area of firefighting (Cathiau, 1876). The basic rule was that all citizens had to show up at the fire scene to fight the fire jointly. Fines could be levied on those who did not show up. However, since fires were infrequent events, occurring perhaps once in a decade, and since citizens never trained, their efforts were quite ineffective.[4] Instead of directly attacking the fire, their measures were focused on keeping the fire from spreading by wetting down surrounding buildings or tearing them down in advance (Strumpf, 2014). Moreover, citizens were normally commanded by a local authority, such as the mayor, who had no special expertise in firefighting (Cathiau, 1876). Even worse, in some cases, different authorities claimed command at the fire scene and gave conflicting orders.

In the 19th century, criticism of the current approach to firefighting in Germany increased (Engelsing, 1990). For example, Volz (1847, p. 350) laments the lack of coordination.

There are still completely raw and untrained, mutually interfering and canceling

[4] Garrioch (2017, 2019) argues that the traditional way of firefighting was more effective than many authors claim. However, he further notes that its effectiveness decreased in the 18th and 19th century due to new forms of fire hazards.

forces everywhere at our fire scenes; a regulated cooperation is never to be thought of, and this not only in small, but in the largest cities in Germany.[5]

A lack of coordination is also what Faber (1864, p. 3) criticizes when describing how the efforts of untrained citizens at the fire scene typically looked like.

There is nothing but raving, shouting and scolding, for everyone wants to make their good advice heard; compliments are said to each other, the witty composition of which should increase the German language in the most peculiar way, and the calm, unbiased spectator would have to laugh heartily at such chaos if the bitter seriousness of the matter were to arouse anything other than indignation in him.

This quote certainly bears some exaggeration given that Faber was the co-founder of a volunteer fire brigade in the city of Leipzig (Saxony) and generally advocated the idea that firefighting should be the task of disciplined and well-trained volunteers. Nevertheless, the quote illustrates that critics at the time perceived the ad hoc approach to firefighting as chaotic and uncoordinated. Besides coordination failure, lack of cooperation was often regarded as another major deficiency. For example, in a description of the situation in rural Austria, where the same ad hoc approach to firefighting was common, Niernsee (1869) notes:

It is truly incredible what carelessness, disorder, negligence and apathy prevail among the inhabitants of most villages, who are only concerned with saving their own belongings or stand idly by and watch the fire instead of helping to contain it.

Despite some negligible regional disparities, the approach of fires being fought by untrained citizens in a more or less ad hoc way describes the norm of firefighting in all German states since the Middle Ages up until the middle of the 19th century. The first fire brigade in Germany was formed in 1846 in the Baden city of Durlach, which today is part of Karlsruhe (Jarausch, 2009; Strumpf, 2014).[6] It was composed of ordinary, un-paid citizens but differed markedly from the previous approach of firefighting in that the firemen (i) had clearly defined

[5] All direct quotes in this subsection are own translations.

[6] Where the first (volunteer) fire brigade in Germany was formed is actually subject to discussion. Wucke (1995) claims that the first fire brigade was formed 1841 in Meissen (Saxony). Others argue that the brigade in Meissen, although consisting of volunteers, did not fight fires differently than the conventional brigades composed of untrained citizens (Strumpf, 2014). Leaving the discussion of whether the first fire brigade in Germany was founded in Meissen or Durlach aside, the Durlach fire brigade undoubtedly had a much bigger influence in inducing other municipalities to establish a similar organization. This was partly because of the wide press coverage it received after its outstanding performance in fighting a devastating theater fire in Karlsruhe in 1847 (Magirus, 1877; Wucke, 1995).

tasks that were divided up-front, (ii) trained these tasks regularly, and (iii) were commanded by a knowledgeable leader.[7]

Over the following decades, thousands of volunteer fire brigades were set-up in several German states, especially in Baden, Bavaria, Saxony, and Württemberg (Magirus (1877); see Figure 2 for the foundations in Baden). Although exclusively composed of volunteers, they were formal organizations. They all had a clear set of rules, the fire brigade's statutes, which governed, inter alia, who could become member, how the leaders were elected, and what fines would be levied on those not showing up to training sessions. Moreover, they had a well-defined organizational structure, with firemen assigned to specific subdivisions based on the tasks they performed (e.g., rescuing, firefighting, pumping). Finally, they had a clear command structure and hierarchy, usually consisting of a commander, a deputy, department heads, and their deputies. Once established, volunteer fire brigades generally persisted, although a few cases exist in which volunteer fire brigades dissolved (Magirus, 1877). Fire brigades consisting of paid professionals remained the exception in Germany. The first one was set up in Berlin (Prussia) in 1851 as part of the police. Until the end of our observation period in 1889, no more than 33 fire brigades consisting of paid professionals were established in all German states combined, almost all of them in Prussia and none of them in Baden (Strumpf, 2012).

That the fire service in Germany would evolve into a largely volunteer-based system was by no means obvious, however. This is illustrated by how differently firefighting became to be organized in other countries. In Britain, the first fire brigades were set up by private insurance companies in London in the late 17th century (Pearson, 2004; Wright, 2008). Due to rising cost, many insurance companies eventually transferred responsibility for firefighting to the local government, so that in 19th century Britain, there was a colorful mix of insurance company fire brigades, municipal fire brigades, firefighting units of the police, and some volunteer fire brigades (Ewen, 2018). In Paris, a brigade composed of paid firemen existed since 1716, which was integrated into the military in 1810 (Garrioch, 2017). In the United States, fire protection in all major cities was provided by volunteer fire brigades, of which the first one was established in Boston in 1718.[8] However, in the second half of the 19th century, municipal and state governments replaced them by paid professionals (Greenberg, 1998).[9]

[7] In the case of Durlach, the men serving in the fire brigade were selected by the municipality among those who had applied for citizenship and therefore, strictly speaking, were not volunteers. The first fire brigade exclusively consisting of volunteers was established only a year later, in 1847, in the neighboring municipality Karlsruhe (Strumpf, 2014).

[8] In 1736, no other than Benjamin Franklin himself founded a volunteer fire brigade in Philadelphia.

[9] Most American cities were not served by a single uniform volunteer fire brigade but by several volunteer fire companies. These companies often competed, sometimes violently (Greenberg, 1998). McChesney

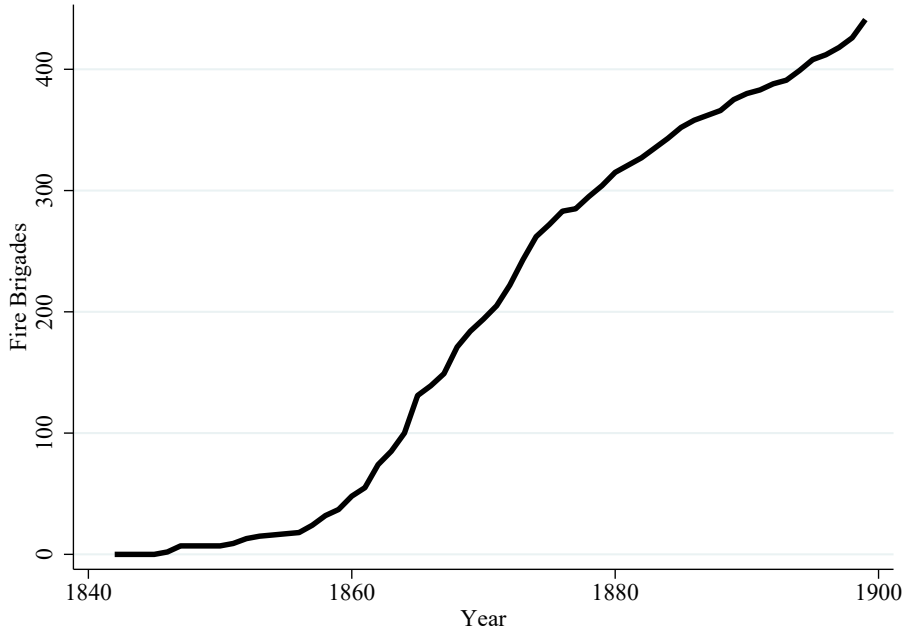


Figure 2: Cumulative Number of Municipalities with Fire Brigade Foundation

Notes: Cumulative number of municipalities by year of first establishing a fire brigade. See section 4.2 and Appendix B for details.

While in the Grand Duchy of Baden, the decision whether to set up a fire brigade always remained at the discretion of the municipality, having a fire brigade eventually became mandatory for all German municipalities through a law passed by the Nazi regime in 1938.[10] Today, the vast majority of German municipalities fulfill their legal obligation to provide fire protection by maintaining a volunteer fire brigade. Only in large cities, usually those with more than 100,000 inhabitants, the fire service is mainly provided by paid professionals. As a result, 94% of the one million firefighters in Germany are unpaid volunteers (DFV, 2025). While the absolute number of firefighters in the United States is about the same, only 65% of them are volunteers (Fahy et al., 2022). In England, in turn, all of the 35,000 firefighters are paid, although a third of them is working on-call (Home Office, 2025).

(1986) argues that it was not the violent competition between fire companies, however, which led city governments to replace volunteers by paid professionals. Rather, the transition took place because it provided a benefit to all interest groups directly involved. Volunteer firemen could resume paid work as civil servants, city politicians received additional votes from an increasing number of public employees, and insurance companies made higher profits because they no longer had to provide financial support or pay rewards to volunteer fire companies.

[10] The corresponding law was called *Gesetz über das Feuerlöschwesen*, also known as *Reichsfeuerlöschgesetz*, and was passed on the 23rd of November 1938.

2.3 Social Clubs

The volunteer fire brigades that formed in 19th-century Germany were organized as clubs. Their emergence hence needs to be understood in light of the large-scale diffusion of social clubs that occurred at the beginning of the 19th century across the German states (Nipperdey, 1972). In Baden, the first clubs that were formed around the turn of the century were dominated by the traditional elites—aristocrats, military officers, civil servants, and clergymen—and served primarily as venues for entertainment and socializing (Nolte, 1994). It was not until the 1830s that a significant number of clubs emerged whose membership was largely drawn from the middle and even lower bourgeoisie. Among the largest and most widespread were singing clubs (*Gesangsvereine*) and gymnastics clubs (*Turnvereine)* (Düding, 1984; Langewiesche, 2000). Although devoted to choral singing and practicing gymnastics, respectively, these clubs had, as almost all clubs of that time, a political character (Nolte, 1994). In the first half of the 19th century, when political associations were banned, they became gathering places for liberal citizens who supported the idea of creating a unified German nation-state. Members of the gymnastics clubs, the *Turners*, were especially active in the German revolution of 1848-1849 (Düding, 1984).[11] The government therefore dissolved all gymnastics clubs after the revolution's defeat in 1849. Figure 3 shows that no gymnastics clubs and very few singing clubs were established during the politically restrictive period of the 1850s. Only in 1860, after the Grand Duke of Baden adopted a policy of liberal reforms, the *Turners* were able to resume their activities, with many gymnastics clubs being re-established or newly founded (Becht, 2009). The political role of singing and gymnastics clubs, however, already began to decline in the 1860s, partly because political associations now were permitted (Langewiesche, 2000; Becht, 2009). After the founding of the German Empire in 1871, the German nation-state movement had lost its immediate purpose, leading singing and gymnastics clubs to increasingly focus on their non-political functions and on providing opportunities for sociability (Langewiesche, 2000).

3 Conceptual Framework

We model the collective action problem of forming a volunteer fire brigade as a coordination game among N citizens. We present a tipping model (Schelling, 1978) in which the likelihood that a fire brigade is established depends on how many citizens participate. More specifically,

[11] Dippel and Heblich (2021) show that leaders of the German revolution 1848-1849 who were expelled to the United States after the revolution had failed, also known as "Forty-Eighters", took a key role in organizing antislavery campaigns and mobilizing volunteers for the Union Army, partly through establishing local gymnastics clubs.

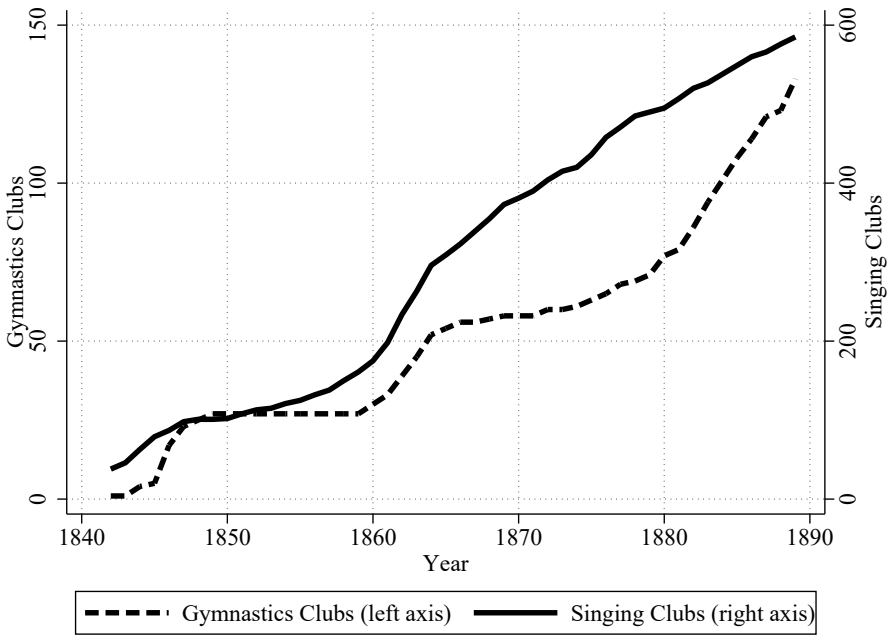


Figure 3: Cumulative Number of Municipalities with Singing and Gymnastics Club Foundation

Notes: Cumulative number of municipalities by year of first establishing a singing or gymnastics club. See Appendix B for details.

we use the framework presented in Medina (2007).

Consider the case of a municipality with N citizens. Each citizen faces a binary participation decision: The citizen can either participate in forming a fire brigade or refrain from doing so. Let γ be the share of citizens who decide to participate. The probability that the fire brigade is successfully established is given by the function F. As a higher level of participation makes success more likely, F is an increasing function of γ. Moreover, let $F(0) = 0$ and $F(1) = 1$, which captures the reasonable assumption that the foundation fails with certainty if nobody participates but succeeds with certainty if all citizens participate.

Payoffs. The existence of a fire brigade generates a benefit to all citizens in the municipality. However, the size of this benefit depends on whether the citizen participates, that is, is a member of the fire brigade, or not. Both members and non-members benefit from the non-excludable public good that the fire brigade produces—fire protection. Apart from that, the fire brigade also produces a club good, which refers to all the excludable benefits that are only enjoyed by its members. For example, the fire brigade provides a network of potentially valuable social contacts to which only members have access. Moreover, members of the fire brigade may gain from social status (Willer, 2009; Briese, 2015) or from the warm

glow they receive from serving in a fire brigade (Andreoni, 1990).[12] Let $b > 0$ be the benefit of a fire brigade that accrues to all citizens, while $s_i > 0$ is the additional benefit that accrues to members only. The subscript shows that s_i potentially varies by citizen. The total benefit of a fire brigade to a member is thus $v_i = b + s_i$.

Choosing to participate, however, is costly. It is reasonable to assume that this cost is higher if the fire brigade is actually established. If establishing the fire brigade fails, the cost is $c^F > 0$, which, for example, involves the effort of finding out whether the new organization is viable. If establishing the fire brigade is successful, the cost is c^S. Because participating in a standing fire brigade also requires regular training, $c^S > c^F$.

Participation Decision. When deciding whether to participate in the fire brigade or not, each citizen compares the expected payoffs. Let m_i be the number of *other* citizens who citizen i expects to participate. Then the condition for participation of citizen i is

$$F\left(\frac{m_i+1}{N}\right)(b+s_i-c^S)+\left[1-F\left(\frac{m_i+1}{N}\right)\right](-c^F) \geq F\left(\frac{m_i}{N}\right)b, \tag{1}$$

where the left hand side is the expected payoff from participating and the right hand side is the expected payoff from abstaining. If F is continuous and N grows large, the difference between $F\left(\frac{m_i+1}{N}\right)$ and $F\left(\frac{m_i}{N}\right)$ becomes negligible. Intuitively, this means that no individual citizen has an influence on whether the attempt of founding a fire brigade is successful. With $\lim_{N\to\infty}\left(F\left(\frac{m_i+1}{N}\right)-F\left(\frac{m_i}{N}\right)\right)=0$, Equation 1 becomes

$$F(\hat{\gamma}) \geq \frac{c^F}{s_i - c^S + c^F}, \tag{2}$$

where $\hat{\gamma}$ is the *expected* share of citizens who participate. This is the participation constraint of a citizen for whom $s_i > c^S$. A citizen for whom $s_i < c^S$, in contrast, will never participate, irrespectively of $\hat{\gamma}$. The expression on the right hand side is the probability of a fire brigade being established that makes citizen i exactly indifferent between participating and abstaining. It is an individual-specific threshold of participation. Note that this threshold is independent of b, which means that the non-excludable benefit the fire brigade brings to both members and non-members plays no role in citizen i's decision. This is because it is only the *difference* in payoffs between participating and not participating that matters for the citizen's decision. Given that the probability of a successful foundation depends on the aggregate participation level γ, what citizen i will do depends on how many other citizens he expects to participate. This mirrors our insight from the two-citizen coordination game.

Equilibria. Note that the participation constraint (Equation 2) can also be written as

[12] Carpenter and Myers (2010) look at a sample of U.S. volunteer firefighters and show that the decision to volunteer in the fire service correlates positively both with altruism and concern for social reputation.

$$s_i - c^S \geq c^F \frac{1 - F(\hat{\gamma})}{F(\hat{\gamma})}. \tag{3}$$

The expression on the left hand side is the payoff of participating relative to not participating in the case the fire brigade is successfully established. In the following, we refer to it as θ_i. It can be interpreted as the type of citizen i. A citizen who attaches a higher value to being a member of the fire brigade will have a higher θ_i. The distribution over types in the municipality is given by the distribution function H. So, if all citizens expect the aggregate participation level to be $\hat{\gamma}$, a share of $1 - H\left(c^F \frac{1-F(\hat{\gamma})}{F(\hat{\gamma})}\right)$ citizens will choose to participate. The game reaches an equilibrium where the expected participation level equals the actual participation level, that is, where

$$\hat{\gamma} = 1 - H\left(c^F \frac{1 - F(\hat{\gamma})}{F(\hat{\gamma})}\right). \tag{4}$$

Values of $\hat{\gamma}$ that solve Equation 4 represent an equilibrium. One such equilibrium that always exists is the no-participation equilibrium $\hat{\gamma} = 0$. The intuition is straightforward: Given that the probability of a successful foundation is zero if nobody participates, not participating is the best response. Hence, no citizen participates. Whether apart from this no-participation equilibrium additional equilibria exist depends on the exact shape of the functions F and H. In tipping games such as the one we study here, it is usually assumed that actual participation as a function of expected participation has an S-shape. In this case, it can be shown that either one or three equilibria exist.[13] This is illustrated in Figure 4. An equilibrium exists where the curve that describes actual participation as a function of expected participation intersects the 45-degree line, that is, where expected and actual participation are equal. In the case of Curve A, this yields an unstable equilibrium at $\hat{\gamma}'$ and a stable equilibrium at $\hat{\gamma}''$ besides the no-participation equilibrium at $\hat{\gamma} = 0$, which is also stable. For any expectation $\hat{\gamma} < \hat{\gamma}'$, actual participation is lower than expected and the game will eventually settle in the no-participation equilibrium $\hat{\gamma} = 0$. Conversely, for any expectation $\hat{\gamma} > \hat{\gamma}'$, participation will gradually increase until the high-participation equilibrium $\hat{\gamma}''$ is reached. Expectations thus play a crucial role in equilibrium selection. Curve B shows the second possible case, in which only the no-participation equilibrium exists. For any expected level of participation above zero, the actual level of participation falls short of expectations until the equilibrium in which nobody participates is reached.

Comparative Statics. We now use our simple tipping model to explore which mu-

[13] Medina (2007) shows that the S-shaped curve conventionally assumed in tipping games can be generated by assuming that the distribution function F is concave and that the types θ_i are normally distributed. He continues to show that under these assumptions, the game has either a unique equilibrium (that is stable) or three equilibria (two stable and an unstable one).

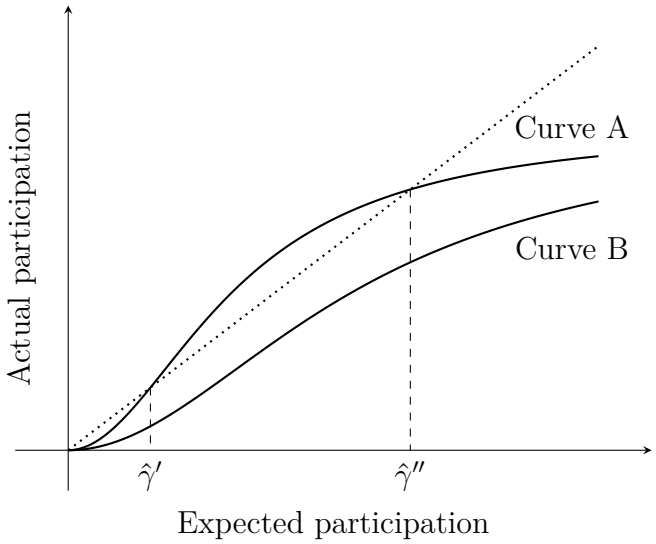


Figure 4: Tipping Game with One and Three Equilibria

Notes: Tipping game with two different relationships between expected and actual participation as depicted by curves A and B. An equilibrium is reached where the participation profile intersects the 45-degree line.

nicipalities stick to the traditional ad hoc approach to firefighting and which municipalities transition to a more organized state by establishing a volunteer fire brigade. For this purpose, we allow for differences in the distribution of citizens' types across municipalities. Specifically, we assume that in each municipality m, citizens' types follow a normal distribution $\theta_i \sim \mathcal{N}(\mu_m, \sigma^2)$, where μ_m is a municipality-specific mean and σ is the standard deviation. In the context of our model, μ_m is the average net benefit that citizens of municipality m attach to being a member of a volunteer fire brigade. For example, municipalities in which citizens derive a higher benefit from connections to other citizens or in which citizens have lower opportunity cost of investing time in club activities are expected to have a higher μ_m.[14]

For simplicity, we assume that the probability of successful collective action is given by the (weakly) concave function $F(\gamma) = \gamma$. With F concave and H the cumulative distribution function of the normal distribution, actual participation as a function of expected participation has the conventional S-shape and Equation 4 has exactly one or three solutions (Medina, 2007). Figure 5 presents numerical simulations for different values of μ_m.[15] As in Figure 4, equilibria exist where the S-shaped participation profile intersects the 45-degree line. Figure 5 shows that for low values of μ_m, there is only the no-participation equilibrium

[14]Both benefits and costs may in turn be a function of the municipality's occupational structure. The fact that voluntary associations first developed in urban centers and only later spread to rural areas has been attributed, among other things, to the traditional social structure of agricultural communities, which hardly allowed for voluntary associations besides existing social ties (Wallner, 1973; Kanitz, 1978).

[15]See Appendix Figure A.1 for numerical simulations with varying σ.

at $\hat{\gamma} = 0$. As μ_m increases, at some point the game switches from one to three equilibria, of which the equilibrium at the intermediate participation level is the unstable one. Importantly, the higher μ_m, the lower is the participation level $\hat{\gamma}'$ in the unstable equilibrium. This means that the range of expectations that lead to the high-participation equilibrium widens. Moreover, the higher μ_m, the higher the share of citizens who participate in the high-participation equilibrium. In the context of our model, this has two implications. First, the formation of a fire brigade is possible only in municipalities in which citizens, on average, attach a sufficiently high value to becoming member of the association. Second, in municipalities in which this value on average is higher will establish a volunteer fire brigade with higher likelihood.

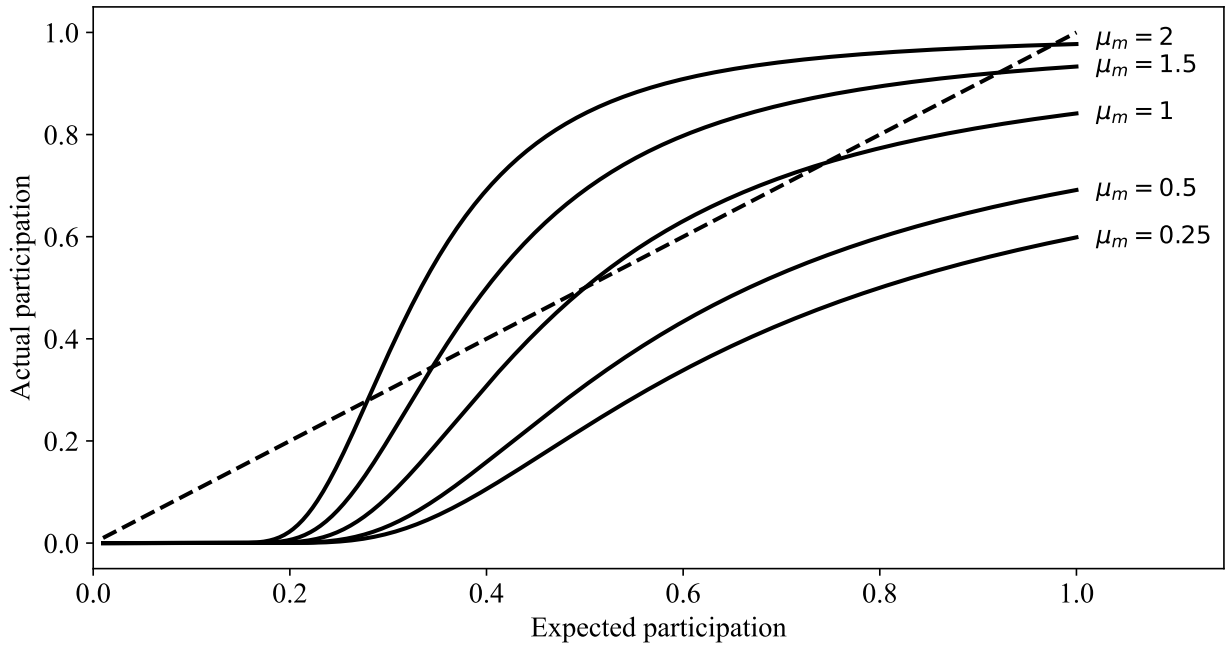


Figure 5: Numerical Simulations Varying μ_m in the Distribution of θ

Notes: Actual participation as a function of expected participation for $F(\gamma) = \gamma$, $c^F = 1$, and $\theta_i \sim \mathcal{N}(\mu_m, 1)$. An equilibrium is reached where the participation profile intersects the 45-degree line.

In municipalities in which μ_m is sufficiently high such that multiple equilibria exist, which equilibrium will actually be selected? This is where expectations come into play. But what determines citizens' expectations about how many others will participate? On a general level, recent events both in the own and in adjacent municipalities provide a potentially important source (Wood, 2003). Even seemingly small events can matter given that a minor shift in expectations may be sufficient to move participation beyond the tipping point (Kuran, 1995). In the founding reports of volunteer fire brigades, an event that is frequently mentioned as

central stimulus is a major fire in the municipality.[16] This is in line with the observation by historians that large fires often acted as a catalyst of change, bringing about improvements in both firefighting and fire prevention. As Bankoff et al. (2012, p. 12) note in their historical collection of urban fires

> *(...) there is nothing like a major conflagration or two to help focus people's minds on the need to reform existing practices, improve the city's firefighting capabilities, and find better ways to share the losses. Building codes, emergency services, and insurance are all innovations if not born out of flames at least warmed by their heat.*

Although a fire in the municipality itself certainly has a greater impact in shifting expectations, fires in neighboring municipalities likely also play a role. Especially in smaller municipalities, in case of fire, so-called fire riders were sent to all surrounding municipalities to call for help (Jakob, 1878). Citizens therefore also took part in fighting fires in neighboring communities. Another event that probably has an impact on shifting expectations about how many fellow citizens will participate in establishing a fire brigade is the successful foundation of a volunteer fire brigade in a neighboring municipality.

Note that citizens' types and events that provide a positive expectation shock are complements. Only if citizens attach sufficiently high value to being a member of a fire brigade, a high-participation equilibrium exists, such that expectations can be shifted in a way that a fire brigade is established. Moreover, even if a high-participation equilibrium exists, a given upward-shift in expectations will more likely surpass the tipping point if the distribution of types is such that this tipping point is rather low. As shown in Figure 5, this is the case if the average value citizens attribute to membership in the fire brigade is relatively high.

While our conceptual framework delivers several predictions, in order to test them, we need to come up with a measure for μ_m, the average value that citizens attach to being a member of a volunteer fire brigade. This value is difficult if not impossible to observe. We therefore propose to use the existence of other clubs as a proxy. The idea is that much of the benefits a citizen derives from becoming a member of a club are not specific to the club's activity and could also be provided by a different club. For example, membership in a club satisfies the need for sociability, but this need may be satisfied in a similar way by membership in the volunteer fire brigade or the local singing club. In municipalities in which citizens derive a high value from becoming member of a fire brigade, citizens will also

[16] For 211 of the 375 fire brigades in our sample, we were able to gather information about their founding through an online search. While most sources do not mention a specific reason for the establishment of the brigade, when a reason is given, the most frequently cited one is a fire or series of fires in the municipality itself (in 18% of the 211 cases).

gain more from membership in a club more generally. Citizens in such municipalities are therefore generally expected to have a strong tendency to associate and other clubs besides a fire brigade will likely exist. In our analysis, we specifically focus on the existence of singing clubs and gymnastics clubs. First, the emergence of these clubs predated that of volunteer fire brigades because singing and gymnastics clubs started to spread in Baden in the 1830's and 1840's, respectively. Second, already in the 19th century, singing and gymnastics clubs reached mass scale and were open to broad segments of the male population (Düding, 1984; Langewiesche, 2000; Nathaus, 2009). Other than more specialized clubs, singing clubs in particular were common even in rural areas. So, if a municipality had one or several clubs in the middle of the 19th century, there usually was also a singing or gymnastics club.

Although the preceding discussion suggests that the existence of fire brigades correlates with that of singing and gymnastics clubs because municipalities differ in their underlying tendency to associate, a singing or gymnastics club may of course also *causally* foster the establishment of a fire brigade. It is well documented that gymnastics clubs in particular played an important role in the spread of fire brigades in Germany (Leupold, 2003; Kubitza, 2011; Briese, 2015). Even before the first fire brigades were established, gymnastics clubs in some municipalities actively participated in firefighting—for example, by operating one of the municipality's fire pumps. When the first fire brigades were later founded, many *Turners* joined them and took on the physically demanding tasks, such as climbing ladders. This matches the general observation that social capital facilitates collective action (Putnam, 1993; Ostrom, 2000; Ostrom and Ahn, 2009). While we do not explicitly consider the existence of other clubs in our conceptual framework, one may assume that citizens face lower costs of participation if a social club already exists, for example, because it provides knowledge about how to set up an organization. However, since we are unable to verify whether a correlation between the existence of fire brigades and singing and gymnastics clubs is in fact causal, we remain agnostic about the nature of the underlying relationship.

To summarize, we make the following predictions:

1. Municipalities in which a singing or gymnastics club exists are more likely to also have a fire brigade.

2. All of the following events cause an increase in the probability that municipality i establishes a volunteer fire brigade:

   (i) A fire in municipality i.

   (ii) A fire in a neighboring municipality j.

   (iii) Foundation of a fire brigade in a neighboring municipality j.

3. The effect of all of the aforementioned events is larger if municipality i has a singing or gymnastics club.

4 Data

In this section, we present our data and provide some descriptive statistics. See Appendix B for a list of all data sources and a detailed description of how we constructed our data set.

4.1 Sample

In our analysis, we include the 1,577 municipalities that existed in Baden according to the census conducted in December 1852 (Badisches Ministerium des Innern, 1855) and remained independent over our observation period.[17] Figure 6 shows how the municipalities are distributed over Baden.

Each municipality was assigned to an administrative district, of which there were 74 in 1852. During our observation period, three administrative reforms occurred, each reducing the number of districts. The final reform, in 1872, decreased the number of districts to 52 (see Figure 6). As an additional administrative level between districts and the state, there existed four counties. Following one of the administrative reforms, they were replaced by eleven counties in 1864.

4.2 Dependent Variable: Fire Brigades

To retrieve the founding dates of all fire brigades in Baden, we use a list that was compiled for the national fire brigade association of Baden (*Badischer Landesfeuerwehr-Verband*) and published in Müller (1917). The list includes all fire brigades as of 1914 with their year of foundation. Around a quarter of municipalities in Baden had formed a fire brigade by the end of our observation period in 1889. Because our source of founding years is a list from 1914, there are two reasons for missing data. First, if a municipality was incorporated into another municipality before 1914 and the fire brigades of the two municipalities merged, then only the older fire brigade appears on the list. Second, the list does not include fire brigades that dissolved before 1914. To address the first issue, we find all municipalities that were incorporated between 1890 and 1914 and check through online search whether they had already established a fire brigade before losing their independence. This leads us

[17] We do not include six municipalities that were incorporated into another municipality and four municipalities that were newly established after separating from another municipality during our observation period. See Appendix B for details.



Figure 6: Municipalities in Sample

Notes: Geographical location of the 1,577 Baden municipalities in our sample. The map also shows the boundaries of the 52 districts as of 1872.

to add five fire brigades to our sample. Unfortunately, there is little we can do to address the second issue. As a partial remedy, we compare our sample with a list of all fire brigades that existed in 1876 according to Cathiau (1876). The list from Cathiau (1876), however, does not include founding years. As a result of the comparison, we add another six fire brigades to our sample, for which we found evidence through online search confirming they were established before 1889. Another 23 municipalities are not listed in Müller (1917) but had a fire brigade in 1876 according to Cathiau (1876). For these municipalities, though, we were unable to find any confirmation that a fire brigade actually existed in 1876 or earlier. It is possible that in some of these municipalities a fire brigade actually existed but was later dissolved. In the absence of any information on their year of foundation, we treat these municipalities as never having had a fire brigade during our observation period. In 1876, we have 284 fire brigades in our sample, meaning that we are potentially missing around 8%. See Appendix B for details.

4.3 Independent Variables

4.3.1 Fires

To measure fires, we leverage the fact that all buildings in Baden had to be insured with the public fire insurance institution.[18] The public fire insurance institution had been established by the margrave of Baden already in 1785. Until 1808, it was expanded to cover the whole Grand Duchy of Baden.[19] The insurance compensated for damages caused by fire or lightning strikes. However, compensation was subject to various conditions to avoid insurance fraud. First, only four-fifths of the damage was reimbursed. Second, all the compensation had to be used to rebuild the house in the same form and its exact same place. Third, the compensation was fully paid out only after the reconstruction had been finished. And fourth, no compensation was paid if the fire was caused by the house owner intentionally or through negligence. Damages caused by wars were not covered either.

The insurance operated on a balanced-budget principle. All compensations resulting from fires in a given year were levied on all house owners in the spring of the following year. The insurance premium was calculated as a fraction of the house's value and was around one per mil for most owners. However, the exact fraction varied across municipalities because each year, municipalities were assigned to one of four insurance classes depending on how much fire compensations had been caused by fires on their territory during the previous year. If there was no fire or fires had caused compensations of less than 0.1% of the municipality's total property value, the municipality was assigned to the default class 1. If fires had caused compensations between 0.1% and 0.5% of total property value, the municipality was assigned to insurance class 2. See Table 1 for the other two insurance classes. Assignment to a higher insurance class had immediate financial consequences because all of the municipality's house owners had to pay a higher insurance premium in that year (see Table 1). Hence, establishing a fire brigade was potentially attractive to reduce the probability of being assigned to a higher insurance class. Nevertheless, since insurance premia also depended on the fire activity in the whole country, citizens' ability to control them was limited.

Each year in spring, a list was published in the government law gazette, showing which municipalities were assigned to insurance classes 2, 3, and 4, along with their total fire compensation and property value.[20] We use these lists to construct a relative measure of fire

[18] The only buildings excluded were the castles of the Grand Duke and the mediatized houses, powder mills and powder magazines, as well as buildings with a low value of less than 50 Gulden. Moreover, insuring event buildings without residential purposes was voluntary.

[19] The history of the Baden fire insurance institution is covered in Hahn (1912) and Kistner (1958). For the institutional details, see the law on the public fire insurance institution published in Baden (1852).

[20] See *Grossherzoglich Badisches Regierungsblatt* until 1868 and *Staatsanzeiger für das Grossherzogtum Baden* thereafter. Appendix Figure B.1 provides an example page.

Table 1: Fire Insurance Classes

Class	Last year's compensations as % of municipality's total property value	Insurance premium per 100 Gulden property value		
		Baseline	Additional	Total
1	< 0.1	x	0	x
2	between 0.1 and 0.5	x	$\frac{1}{3}x$	$\frac{4}{3}x$
3	between 0.5 and 1.5	x	$\frac{2}{3}x$	$\frac{5}{3}x$
4	> 1.5	x	x	$2x$

Notes: Each year, x is set such that the budget of the fire insurance institution is balanced. The unit of the insurance premium is Kreuzer. 60 Kreuzer amount to one Gulden.

activity at the municipality level. We define that a municipality experienced a *significant fire* if it was assigned to insurance class 2, 3, or 4. This means that at least 0.1% of its total property value was destroyed.[21] In principal, this can be the result of a single large fire or several smaller fires. In most cases, however, it is a single large fire that makes a municipality jump from the default insurance class 1 to a higher class.[22]

Note that a municipality's total fire compensation we observe and which is decisive for the assignment to an insurance class is close but not identical to the fire compensation caused by fires in the same year. This is because fires that occurred towards the end of the year were sometimes included in the insurance budget of the following year. We looked at very large fires for which we were able to retrieve the exact date to verify that this happened rarely, though.

4.3.2 Singing and Gymnastics Clubs

To determine which municipalities had a singing or gymnastics club, we draw on lists that were kindly provided by the umbrella associations *Badischer Chorverband* and *Badischer Turner-Bund*. In our analysis, we use a dummy that is one starting in the year the first singing or gymnastics club was founded. Importantly, the dummy stays one even if the club dissolves. This is important especially with respect to gymnastics clubs, which were abolished after the German revolution's failure in 1849 and could resume their activity only in 1860. Some municipalities establish more than one singing or gymnastics club but we limit our attention to the first foundation only.

[21] Remember that the actual fraction of property destroyed is higher since the fire insurance only compensated 80% of the damages.

[22] We were able to verify this using a second source of fire activity, which provides information even on the level of the individual insurance claimants and is available for 1852 until 1870. See Appendix E for details.

4.3.3 Control Variables

We obtain population statistics from the ten censuses that took place over our observation period and linearly impute the population for the years in which no census was conducted.[23] For this purpose, we also consider the census that immediately followed the end of our observation period in 1890. From the censuses in 1855 and 1885, we also obtain the number of inhabitants by religious affiliation as well as, for 1855, the share of the population that is female and more than 14 years old. From the census in 1864, we take the number of households and the number of buildings. The latter comprises both residential buildings, including annex buildings, as well as (a mostly negligible number of) other buildings. Finally, we obtain a municipality-level measure of the overall capital stock in 1854 from a publication of the Baden Statistical Office (Badisches Ministerium des Innern, 1858, 1859). This measure includes landholdings, buildings, operating capital, and financial capital.

In each district, the district administration is located in one of its municipalities, which we refer to as district capital. Some of the data we use are only available at the level of districts. This applies, for example, to the share of buildings with a wooden or thatched roof. We obtain this district-level data from the Statistical Yearbook for the Grand Duchy of Baden, which was published annually by the Baden Statistical Office starting from 1868.

4.4 Descriptive Statistics

Table 2 provides descriptive statistics for some of our variables. Panel A, which presents municipality-level data, shows that most municipalities are rather small. At the start of our observation period in 1852, the median municipality had just 599 inhabitants. The overall population of Baden grew moderately from 1.4 million in 1852 to 1.7 million in 1890. However, this growth was concentrated in larger cities, while rural areas experienced significant emigration abroad and internal migration to urban centers. As a result, the median number of inhabitants actually fell to 592 inhabitants in 1889. When judging the size of the pool of citizens who could potentially serve in the volunteer fire brigade, it has to be kept in mind that only adult men, usually above the age of 18, were eligible. Because half of the population was female and around one third was less than 14 years old, the pool of suitable men was less than a third of a municipality's population. Since the statutes of a volunteer fire brigade often also specified a maximum age limit, the pool was normally even smaller.

While Catholics made up around two thirds of the population in Baden, the Grand Duke himself as well as the ruling class were Protestant. Municipalities were clearly divided with

[23] Censuses took place in December of 1852, 1855, 1858, 1861, 1864, 1867, 1871, 1875, 1880, and 1885.

Table 2: Descriptive Statistics

	Mean	SD	Min	Median	Max	N
Panel A: Municipality-level data						
Population 1852	855.8	1,249.8	66	599	24,316	1,577
Population 1889	1,043.0	3,194.9	39	592	75,501	1,577
Share female 1855	0.52	0.03	0.33	0.52	0.62	1,577
Share >14 years old 1855	0.68	0.05	0.32	0.68	0.86	1,577
Share Catholic 1885	0.71	0.40	0	0.97	1	1,577
Share Protestant 1885	0.28	0.39	0	0.02	1	1,577
District capital 1852	0.05	0.21	0	0	1	1,577
Buildings 1864	216.4	233.9	15	148	3,156	1,577
Households 1864	178.0	291.1	7	116	5,855	1,577
No. of significant fires 1852-1889	3.62	2.91	0	3	19	1,577
Never significant fire 1852-1889	0.10	0.30	0	0	1	1,577
Fire brigade 1889	0.24	0.43	0	0	1	1,577
Singing club 1889	0.37	0.48	0	0	1	1,577
Gymnastics club 1889	0.08	0.28	0	0	1	1,577
Panel B: District-level data						
Population 1852	18,238.5	7,471.6	6,193	16,597	39,796	74
Population 1889	31,631.4	21,260.3	9,697	23,845	104,152	52
No. of municipalities 1852	21.3	9.4	1	21	47	74
No. of municipalities 1889	30.3	14.1	8	29	74	52
Share flammable roofs 1889	0.12	0.19	0.00	0.01	0.78	52

Notes: Table presents descriptive statistics. See Appendix B for a detailed list of data sources and a description of how the data were constructed.

respect to the religious affiliation of their inhabitants. Two thirds of municipalities were almost exclusively Catholic, while around a fifth were almost exclusively Protestant. Only 10% of municipalities were somewhat mixed in the sense that neither confession accounted for more than 80% of its inhabitants.

Table 2 shows that significant fires were an infrequent event. Over our 38-year observation period, municipalities, on average, experienced 3.6 significant fires, that is, around one significant fire per decade. Nevertheless, significant fires were widespread. Only 10% of municipalities were never hit by a significant fire. Despite the fact that large fires were ubiquitous, only 24% of municipalities established a fire brigade until 1889. This compares to 37% of municipalities that created a singing club and 8% that established a gymnastics club until 1889.

Turning to the district-level data in Panel B, the median district had 21 municipalities and around 17,000 inhabitants in 1852. Due to the reduction in the number of districts, the median district in 1889 was larger, comprising 29 municipalities and around 24,000 inhabitants. Panel B also includes the share of buildings with wooden or thatched roof. The prevalence of buildings with such roofs was a key determinant of fire hazard. Buildings in Baden had roofs that were covered with either tiles, wooden shingles, or straw.[24] Other than tiled roofs, which were considered fire-resistant, wooden and thatched roofs allowed fires to spread quickly. Unfortunately, data on the number of buildings by type of roof are only available at the district level. Even at the district level, however, there is a significant degree of regional variation. While in most districts, the fraction of buildings with wooden and thatched roofs is close to zero, in around 15% of districts, those located in the Black Forest and the Odenwald region, they account for more than a third of all buildings. In line with the notion that wooden and thatched roofs made fires much more devastating, the latter districts also exhibit significantly higher fire damages—a relationship contemporary observers were well aware of (Cathiau, 1876; Hahn, 1912). In Appendix C, we use district-level data to show that the share of buildings with wooden and thatched roofs indeed is strongly associated with fire damages, the number of buildings damaged, the degree to which buildings were damaged, and the relative size of fires.

[24] A fourth group of buildings was covered by roofing felt. This type of roofing was mostly limited to the larger cities Karlsruhe, Mannheim, and Heidelberg, and even there, never accounted for more than 3% of buildings until 1889.

5 Correlation Between Fire Brigades and Municipality Characteristics

The purpose of this section is to test the first prediction of our conceptual framework, which is that municipalities which have a singing or gymnastics club are more likely to have a fire brigade. Besides, this section also shows how having a fire brigade correlates with other municipality characteristics. Although the evidence presented in this section is purely correlational, we believe that it is nevertheless of interest given the paucity of field evidence on the emergence of community-level self-organization for public goods provision.

Table 3 presents linear probability models, in which the dependent variable is a dummy that is one if the municipality has a fire brigade in 1889 and zero otherwise. All models include fixed effects to control for regional differences. We use county fixed effects in all but the last column. While county fixed effects are less fine-grained than district fixed effects, they allow us to use the share of flammable roofs as control variable, which is only available at the district level.

In column 1, we include as our main independent variable of interest a dummy that is one if the municipality has a singing or gymnastics club in 1889. As population size is expected to be a strong predictor of the existence of clubs in general, we also include the log of population in 1889 as control. Holding population size constant, we find that municipalities that have a singing or gymnastics club are 6.1 percentage points more likely to also have a fire brigade. Given that around a quarter of municipalities have a fire brigade in 1889, this corresponds to a sizable relative increase of around 26%. Hence, we find strong support for our first prediction. Column 1 also shows that, as expected, population size is a strong and highly significant predictor of having a fire brigade. If population size increases by 10%, the likelihood that a fire brigade exists by 1889 increases by around 2.5 percentage points.

In column 2, we add wealth (as measured by the log of the per capita value of the taxable capital stock in 1854) and the municipality's status as district capital before 1864 as control variables.[25] Whether a municipality is a district capital in 1852 is another strong and highly significant predictor. District capitals have a 32 percentage point higher likelihood of having a fire brigade in 1889. In contrast, whether a municipality is wealthy, as measured by its capital stock per capita, has no effect.

In column 3, we add two measures of fire hazard as control variables. The first is the building density in 1864, which we obtain by dividing the total number of buildings in 1864 by the municipality's area.[26] The second measure is the share of buildings with wooden or

[25] One municipality is excluded because of missing data on the capital stock.

[26] We use the municipality's area in 1854, which is the only year for which this information is available. The

Table 3: Association Between Existence of Fire Brigade and Singing or Gymnastics Club in 1889

	(1)	(2)	(3)	(4)	(5)
Singing or gymnastics club	0.061**	0.059**	0.065**	0.068***	0.059**
	(0.027)	(0.025)	(0.025)	(0.024)	(0.024)
ln(Population)	0.263***	0.223***	0.224***	0.219***	0.225***
	(0.016)	(0.019)	(0.019)	(0.019)	(0.020)
District capital		0.324***	0.305***	0.291***	0.291***
		(0.051)	(0.050)	(0.050)	(0.051)
ln(Capital stock per capita)		0.003	0.037	0.040	0.036
		(0.034)	(0.031)	(0.033)	(0.033)
Building density			0.104	0.087	0.005
			(0.143)	(0.140)	(0.182)
District share flammable roof			0.310**	0.304**	
			(0.119)	(0.119)	
Share Catholic				0.030	0.030
				(0.041)	(0.043)
Religious fragmentation				0.131	0.170
				(0.105)	(0.108)
County FE	Yes	Yes	Yes	Yes	No
District FE	No	No	No	No	Yes
N	1,577	1,576	1,558	1,558	1,558
R^2	0.323	0.343	0.350	0.352	0.390

Notes: The dependent variable is a dummy that is one if the municipality has established a fire brigade by 1889 and zero otherwise. The unit of analysis is the municipality. All regressions are estimated by OLS. Explanatory variables include a dummy that is one if the municipality established a singing or gymnastics club before 1889, the log of population in 1889, a dummy that is one if the municipality was a district capital in 1852, the log of the taxable capital stock per capita in 1854, the number of buildings as of 1864 divided by the municipal area in 1854, the share of buildings with flammable roofs in the district in which the municipality is located in 1889, the share of inhabitants that are Catholic in 1885, and an index of religious fragmentation in 1885. Regressions in columns 1 to 4 include county fixed effects, with county borders as of 1864. Column 5 includes district fixed effect, with district borders as of 1889. Standard errors clustered at the district level as of 1889 in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

thatched roof. Remember that this measure is available only at the district level, though, and therefore is the same for all municipalities located in the same district. Results reveal that having a fire brigade in 1889 is uncorrelated with building density, which, of course, may be due to the crude nature of our measure. In particular, our density measure may not well reflect how closely buildings stand together given that a large part of a municipality's area is covered by agricultural land or forest. Having a fire brigade becomes more likely, however, if a larger fraction of the district's buildings have roofs made of flammable materials. More specifically, if the district's share of buildings with wooden or thatched roofs increases by 10 percentage points, the municipality is around 3 percentage points more likely to have a fire brigade in 1889. This amounts to a relative increase in the probability of having a fire brigade by roughly 13%.

In column 4, we include the municipality's share of Catholics in 1885. However, following Alesina and La Ferrara (2000), one may expect that what matters more than whether a municipality is mainly Catholic or mainly Protestant is the degree of religious heterogeneity. More specifically, municipalities with a high degree of religious heterogeneity may exhibit a lower level of cooperativeness and therefore may be less likely to establish a fire brigade. We therefore include an index of religious fragmentation (Vigdor, 2004; Esteban et al., 2012), which is computed as

$$fragmentation_i = 1 - \sum_{k=1}^{K} \left(\frac{N_{k,i}}{N_i} \right)^2, \tag{5}$$

where N_i is the overall population and $N_{k,i}$ the number of individuals of religious group k in municipality i. The fragmentation index can be interpreted as the probability that two randomly selected inhabitants of municipality i are of different religious affiliation (Vigdor, 2004). We use data from the census in 1885, in which there were five religious groups (Catholic, Protestant, other Christians, Israelites, others). In most municipalities, however, there were only Catholics and Protestants. The results in column 4 reveal that whether a municipality has a fire brigade is unrelated to its share of Catholics.[27] Likewise, no association exists between the existence of a fire brigade and the municipality's degree of religious fragmentation. This is in line with Suesse and Wolf (2020), who show that the emergence of credit cooperatives in 19th century Prussia was unrelated to religious and ethno-linguistic fragmentation.

Finally, in column 5, we verify that our results are unchanged if we use district fixed

area in 1864 is almost identical to the area a decade before because there were only four cases between 1854 and 1864 where municipalities separated or were incorporated. However, note that area is missing for 18 municipalities, which are therefore dropped from the sample.

[27] The same conclusion is reached if instead of the share of Catholics, we include dummies for whether the majority or at least 80% of the municipality's inhabitants are Catholic or Protestant.

effects as opposed to county fixed effects. The share of buildings with flammable roofs is dropped in this specification because it is only available at the district level.

Overall, Table 3 shows that there is a robust correlation between the existence of a fire brigade and the existence of a singing or gymnastics club. As in our conceptual framework, municipalities seem to differ in their tendency to associate. Municipalities in which this tendency is strong are more likely to have both: a fire brigade and a singing or gymnastics club.

6 Effect of Local Fires

In this section, we test whether the effect of a fire in the municipality is in line with the second and third prediction of our conceptual framework. According to the second prediction, a fire should increase the probability that a fire brigade is established; and according to the third prediction, this effect should be stronger in municipalities in which a singing or gymnastics club exists.

6.1 Methodology

To estimate the effect of a fire on the probability of having a fire brigade, we use the local projections difference-in-differences (LP-DiD) approach proposed by Dube et al. (2023). As this approach is based on running simple regressions, it is easy and computationally fast to implement and its results are straightforward to interpret. While this is an appealing feature in its own right, our main reason for choosing the LP-DiD approach is that it accommodates the specific nature of our treatment. The treatment we analyze—a local fire—is both staggered and repeated. It is staggered because municipalities experience fires at different points in time; and it is repeated (non-absorbing) because a municipality may be hit by a fire more than once. In fact, 74% of municipalities experience more than one significant fire over our observation period (see Appendix Table E.1).

A recent literature documents that in settings in which treatment is staggered but treatment effects are dynamic and vary across units or time, the conventional two-way fixed effects estimator can be biased (de Chaisemartin and D'Haultfœuille, 2020; Goodman-Bacon, 2021; Sun and Abraham, 2021).[28] The bias arises because previously treated units—still potentially experiencing delayed treatment effects—are used as controls for newly treated units. The LP-DiD approach addresses this issue by introducing a 'clean control' condition (Cengiz et al., 2019). The clean control condition ensures that 'unclean' observations, whose out-

[28] See Roth et al. (2023) for an overview.

come dynamics may still be influenced by a past treatment, are dropped from the estimation sample (Dube et al., 2023). Given that in our setting, we cannot rule out that the effect of a fire varies across municipalities or time, we also introduce a clean control condition to rule out 'unclean' comparisons. Moreover, following Dube et al. (2023), we tailor this condition to accommodate our repeated treatment by assuming that the dynamic effect of a fire stabilizes after L periods. This *effect stabilization assumption* implies that municipalities need to be dropped from the sample for L periods after experiencing a fire but can re-enter the sample in the period thereafter. As a result, a municipality that, for example, is hit by a fire twice also enters the treatment group twice, provided that the two fires are at least L periods apart.

We use the following LP-DiD regression specification:

$$FB_{i,t+h} - FB_{i,t-1} = \beta_h D_{i,t} + \gamma^h_{d(i)} + \gamma^h_t + \delta^h ln(population)_{i,t} + \varepsilon^h_{i,t}, \tag{6}$$

where $FB_{i,t}$ is a dummy that is one if municipality i has a fire brigade in year t and zero otherwise. The dependent variable hence is the change in the existence of a fire brigade between period $t-1$ and period $t+h$. The main independent variable of interest is the treatment dummy $D_{i,t}$. In this section, it is defined to be one if municipality i is hit by a significant fire in year t and zero otherwise. In terms of controls, Equation 6 includes the municipality-level population (in logs) as well as district and year fixed effects,γ^h_d and γ^h_t.[29] Due to differencing, there are no municipality fixed effects. When estimating Equation 6, we are interested in β_h, which gives the effect that a significant fire in period t has on the change in the existence of a fire brigade between period $t-1$ and period $t+h$. For each time horizon h, we need to run a separate regression. In our analysis, we use an estimation window that is symmetric around treatment, ranges from $h=-10$ until $h=10$, and leaves out the year before treatment, that is, $h=-10,-9,-8,...,-2,0,1,...,9,10$. Hence, we run 20 separate regression (one for each h) to estimate the treatment effects (for $h \geq 0$) and test for parallel trends (for $h \leq -2$). The estimation sample is restricted according to the following clean control condition:

$$\begin{cases} \text{treated} & D_{it}=1; D_{i,t-j}=0 \text{ for } 1 \leq j \leq L \text{ and } FB_{i,t-10}=0, \\ \text{clean controls} & D_{it}=0; D_{i,t-j}=0 \text{ for } 1 \leq j \leq L \text{ and } FB_{i,t-10}=0, \end{cases} \tag{7}$$

where L is the number of years after the treatment effect is assumed to have stabilized. Mu-

[29] District fixed effects reflect district borders as of 1852.

nicipalities that experience a significant fire in t are part of the treatment group, while municipalities without significant fire in t are in the control group. The clean control condition ensures that no municipality is included, neither as treated nor as control, that experienced a fire between period $t-L$ and $t-1$. Under the effect stabilization assumption, this implies that no municipality is still subject to delayed treatment effects in t and 'unclean' comparisons are avoided. Municipalities that experienced a fire in $t-j$, with $j > L$, in turn, are included in the sample as "not-anymore" treated units.[30] In our analysis, we assume $L = 4$. Clearly, setting L involves a tradeoff. While setting a higher L allows for a longer time frame over which the treatment effect can stabilize, it also reduces the number of municipality-year observations that qualify for inclusion into the sample. In particular, setting $L = 4$ has two noteworthy implications. First, the first four years of our observation period (1852–1855) are never part of the estimation sample. Second, we are unable to study if a series of fires has a different effect than a single fire.

The clean control condition also excludes municipalities that already had a fire brigade at the start of the estimation period in $t-10$. This is because these municipalities can no longer be affected by a fire given that having a fire brigade is an absorbing state in our data. While the same holds true for municipalities that establish a fire brigade between $t-9$ and $t-1$, these municipalities remain part of the sample to test for parallel pre-treatment trends.

The LP-DiD specification in Equations 6–7 allows us to estimate the causal effect a fire in period t has on the probability of having a fire brigade in period $t+h$ relative to period $t-1$ under three key assumptions. One is the effect stabilization assumption already discussed above. The other two assumptions are the same as in the canonical difference-in-differences setting: no anticipation and parallel trends. In our setting, the parallel trends assumption requires that, conditional on control variables, the trend to establish a fire brigade for municipalities hit by a fire in t would have evolved parallel to that of the control group (here: never, not yet, and "not-anymore" treated municipalities) if no fire had occurred.

Although the observation period of our data set only extends from 1852 to 1889, we collect all founding years of fire brigades up to 1899. This is important because to determine our dependent variable, we need data on the existence of fire brigades for up to $10-L$ years before and 10 years after the observation period. With this information available, the sample size of the regressions we run is the same for all horizons h. Furthermore, in all regressions we use robust standard errors clustered at the municipality level.

[30] In fact, even in studies that claim to use a clean control group consisting of "not yet" treated units only, an effect stabilization assumption is often made implicitly by ignoring events that happened before the start of the observation period.

6.2 Main Effect

Figure 7 plots the estimated coefficients $\hat{\beta}_h$ from our LP-DiD specification (Equations 6–7). In essence, the coefficients represent the change in the existence of fire brigades between period $t-1$ and period $t+h$ among treated municipalities relative to the change among control municipalities. Intuitively, for $h \geq 0$, a positive coefficient means that treated municipalities established relatively more fire brigades than control municipalities between period $t-1$ and period $t+h$. Results show that in the year of the fire, treated municipalities are around one percentage point more likely to found a fire brigade than control municipalities. This effect is economically large since the yearly baseline probability to found a fire brigade is only 0.5%. Thus, a significant fire triples the probability of establishing a fire brigade in the year of the fire. In the following years, the effect stabilizes rather quickly and does not increase further from the second year after the fire onward. However, in the later years of the estimation window, the effect eventually decreases and becomes insignificant, meaning that control municipalities catch up. This is not surprising given that the dependent variable is absorbing: Once a fire brigade has been established, no more founding activity is possible.

In the time prior to the fire, we do not see evidence for selection into the treatment group. The coefficients in the pre-treatment period are all statistically indistinguishable from zero and no clear pattern or trend emerges. Moreover, as additional placebo test, Appendix Figure A.2 shows that fires had no effect on the founding of singing clubs, gymnastics clubs, or credit cooperatives.

The LP-DiD approach allows us to explore the effect of a fire as repeated treatment by imposing an effect stabilization assumption. In Appendix F, we estimate the effect of the first fire a municipality experienced during our observation period as robustness check. Because the first fire by construction is an absorbing treatment, we can study its effect in the LP-DiD framework without imposing an effect stabilization assumption. The effect of the first fire can also be estimated applying the heterogeneity-robust estimator proposed by Callaway and Sant'Anna (2021), which is applicable to absorbing treatments only. Overall, the effect of the first fire is in line with what we find when studying the effect of a fire as a non-absorbing treatment. The main difference is that the effect of the first fire is significant only when looking at the period from 1860 onward. This probably owes to the fact that still very few fire brigades were established in the 1850s (see Figure 2) so that most fires in the 1850s did not yet trigger any change.

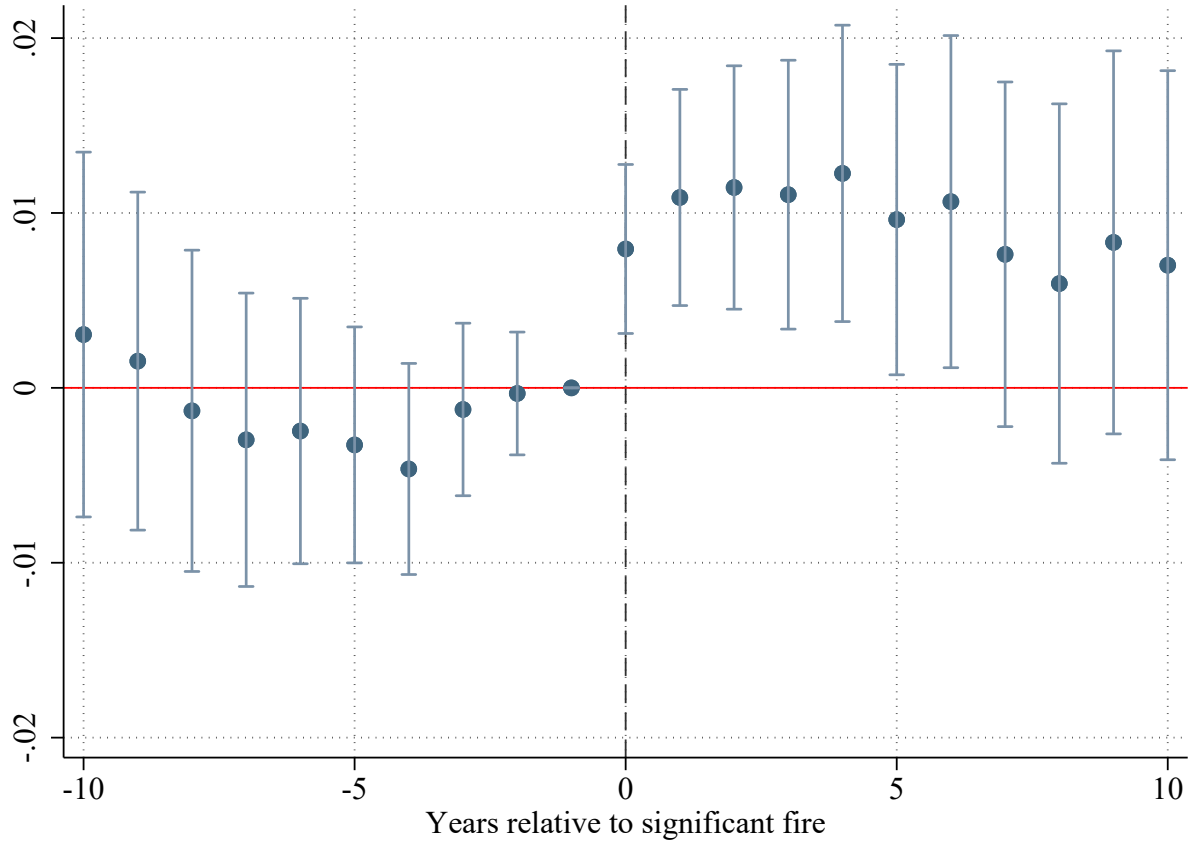


Figure 7: Effect of Significant Fire on Probability of Having a Fire Brigade

Notes: Figure plots regression coefficients β_h of Equation 6. Estimates are obtained from 20 individual regressions for each $-10 \leq h \leq 10$, $h \neq -1$, restricting the sample according to Equation 7 with $L = 4$. Error bands indicate 95% confidence intervals with standard errors clustered at the municipality level.

6.3 Complementarity with Social Clubs

Although we found that a fire has a large effect on the probability of establishing a fire brigade, our conceptual framework illustrates that not all municipalities are expected to react to a fire shock. In municipalities in which citizens only attach a low value to being member in a fire brigade, a stable equilibrium in which a fire brigade is established may not exist. This matches the observation that only a quarter of the municipalities in our sample set up a fire brigade until 1889 although almost 90% experienced a significant fire over the observation period. Our conceptual framework predicts that municipalities that do establish a fire brigade after being hit by a fire should predominantly be those that have a singing or gymnastics club. Figure 8 shows that this is indeed the case. It graphically depicts the effect of a significant fire on the probability of having a fire brigade for subsamples of municipalities that differ in whether they have a singing or gymnastics club and whether

they have such a club already at the time of the fire. In the upper part, the sample is split in those municipalities that establish a singing or gymnastics club until the end of our observation period (Panel A) and those that do not (Panel B).

The comparison shows that the effect of a fire is essentially limited to municipalities that have a singing or gymnastics club by 1889. In those municipalities, a fire increases the probability of having a fire brigade by almost two percentage points in the year of the fire, representing a fivefold increase of the yearly baseline hazard that a fire brigade is established. The effect further rises in the following two years and then persists until ten years after the fire. While a fire also seems to increase the probability of having a fire brigade in municipalities without a singing or gymnastics club, the effect is so small that it fails to reach statistical significance.

The lower part of Figure 8 further splits the subsample of municipalities analyzed in Panel A into those that already had a singing or gymnastics club in the year of the fire (Panel C) and those that established the club only after the fire (Panel D). Clearly, the effect observed in Panel A seems to be driven by municipalities that already had a singing or gymnastics club when the fire struck.[31] The effect observed in Panel C is slightly larger but overall similar in magnitude compared to the effect in Panel A, whereas the effect in Panel D is insignificant. Although we cannot make a causal claim, it seems that the existence of a singing or gymnastics club facilitates collective action in the case of a local fire shock.

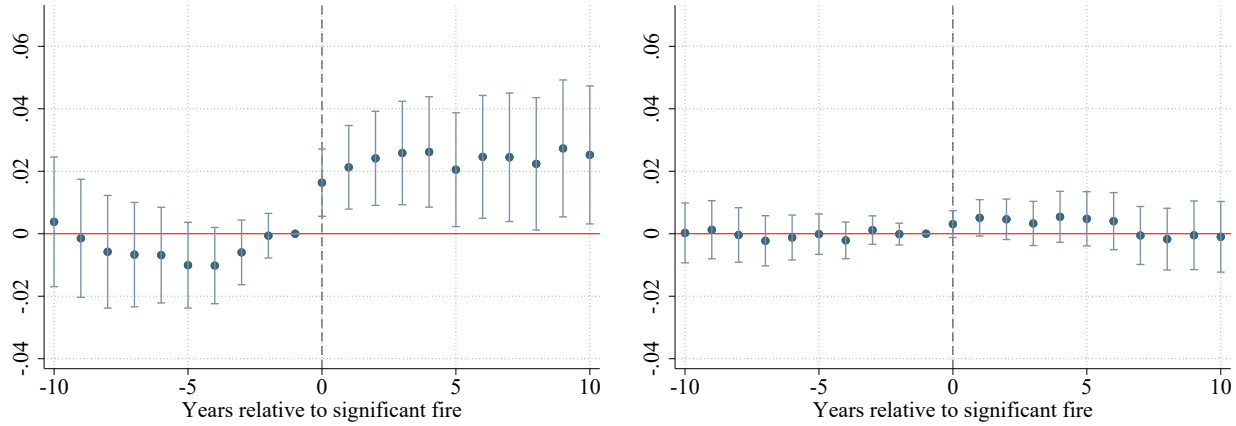
7 Spillovers

In the previous section, we have focused on fires in the municipality as shocks that lead to the foundation of a fire brigade. In this section, we explore whether the establishment of a fire brigade can also be triggered by similar events that happen in a neighboring municipality. More specifically, we investigate what happens if a neighboring municipality is hit by a significant fire or establishes a fire brigade.

Panel A of Figure 9 presents estimates of Equation 6 with $D_{i,t}$ now being a dummy that is one if a neighboring municipality experiences a significant fire in t and zero otherwise. A neighboring municipality is defined to be a municipality that is located within a linear distance of five kilometers. We continue to use a clean control condition with $L = 4$. That is, a municipality is defined to be treated if at least one neighboring municipality experiences a significant fire in t but no neighboring municipality is hit by a fire in the four periods before. A municipality is part of the control group if there is no significant fire within five kilometers

[31] Appendix D shows that the result is the same when using regressions with interaction terms instead of a sample split.

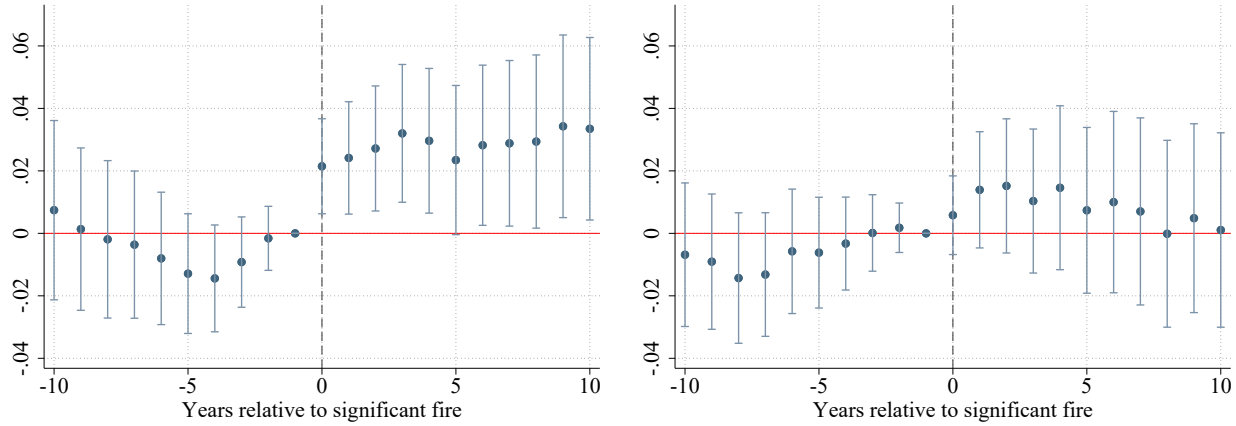
Ever vs. never singing or gymnastics club until 1889



(A) Municipalities with club until 1889

(B) Municipalities without club until 1889

Singing or gymnastics club before vs. after fire



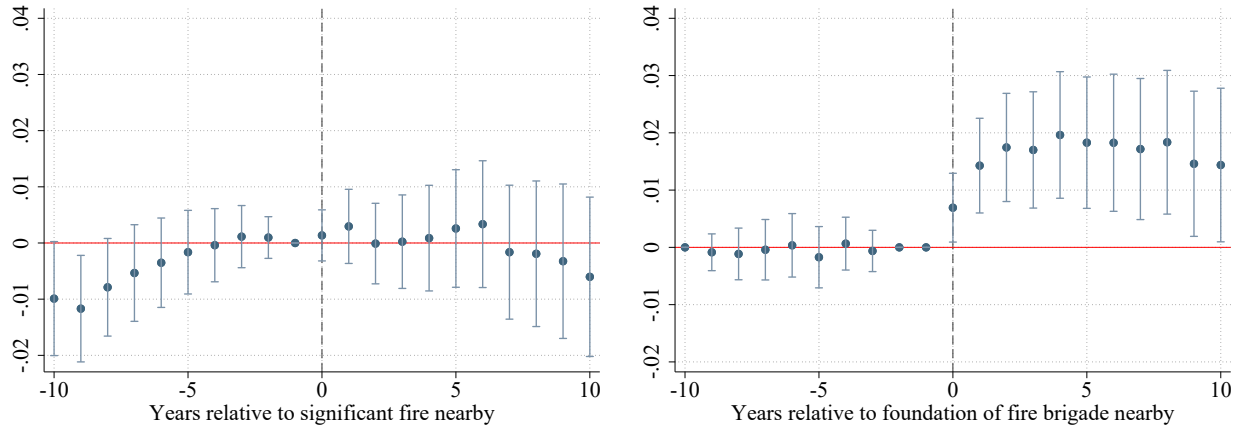
(C) Municipalities with club when fire occurred

(D) Municipalities without club when fire occurred but with club until 1889

Figure 8: Effect of Significant Fire on Probability of Having a Fire Brigade in Subsamples Differing by Existence of Singing and Gymnastics Clubs

Notes: Panels A to D plot regression coefficients β_h of Equation 6. Estimates are obtained from 20 individual regressions for each $-10 \leq h \leq 10,\ h \neq -1$, restricting the sample according to Equation 7 with $L = 4$. Error bands indicate 95% confidence intervals with standard errors clustered at the municipality level. In the upper part, the sample is split into municipalities that establish a singing or gymnastics club (Panel A) and those that have no such club until 1889 (Panel B). In the bottom part, the sample of of Panel A is further split into those municipalities that already had a singing or gymnastics club at the time of fire (Panel C) and those that did not yet have such club by that time but established one until 1889 (Panel D).

between $t-4$ and t. As before, we drop from the sample all municipalities that already had a fire brigade at the start of the estimation window in $t-10$. The results reveal that a significant fire in a neighboring municipality has no effect on the probability to establish a fire brigade. This conclusion is robust to using higher or lower distances in defining what municipalities are considered to be neighboring municipalities.



(A) Effect of significant fire nearby

(B) Effect of foundation of fire brigade nearby

Figure 9: Effect of Fire and Foundation of Fire Brigade in Neighboring Municipality on Probability of Having a Fire Brigade

Notes: Figure plots regression coefficients β_h of Equation 6 when $D_{i,t}$ is a dummy that is one if a neighboring municipality within five kilometer distance experiences a significant fire (Panel A) or establishes a fire brigade (Panel B). In addition, two lags of the dummy $FB_{i,t}$ are added to Equation 6 in Panel B. Estimates are obtained from 20 individual regressions for each $-10 \leq h \leq 10$, $h \neq -1$, restricting the sample according to Equation 7 with $L = 4$. Error bands indicate 95% confidence intervals with standard errors clustered at the municipality level.

Next, we explore what is the effect of a neighboring municipality establishing a fire brigade. As before, a neighboring municipality is defined to be a municipality that is located within a linear distance of five kilometers. We estimate Equation 6 with the treatment dummy $D_{i,t}$ now being one if at least one neighboring municipality establishes a fire brigade in t and zero otherwise. One concern when estimating the effect of a foundation in a neighboring municipality using Equation 6 is reverse causality. The foundation of a fire brigade in a neighboring municipality may itself have been caused by the establishment of a fire brigade in the municipality under consideration. We hence face a similar challenge as Acemoglu et al. (2019), who estimate the effect of democratization on GDP per capita and observe that democratizations tend to be preceded by a dip in GDP. We follow their approach in dealing with this issue by including lags of the dummy that specifies whether a fire brigade exists, $FB_{i,t}$. The LP-DiD approach is very flexible in this regard considering that most other heterogeneity-robust difference-in-differences estimators do not allow for the inclusion

of lagged outcome variables.

Panel B of Figure 9 presents the results when including the two lags $FB_{i,t-1}$ and $FB_{i,t-2}$. The clean control condition is the same as before. Note that the regression coefficient β_{-2} now is exactly zero given that the lags perfectly explain the change in the existence of fire brigades between $t-2$ and $t-1$. Likewise, as the sample is restricted to municipalities without fire brigade in $t-10$, β_{-10} also becomes zero given that the change in fire brigades between $t-10$ and $t-1$ is perfectly explained by the first lag. The estimate of β_0 shows that the foundation of a fire brigade in a neighboring municipality increases the probability of having a fire brigade by roughly 0.7 percentage points in the year in which the foundation in the neighboring municipality takes place. This effect is only slightly smaller than the effect of a fire in the municipality itself. Moreover, the effect tends to increase over the following years and stays significantly positive until the end of the observation window. Additional analyses show that the effect is not driven by foundations that are the first in the municipality's neighborhood. If anything, foundations that take place when there already exists another fire brigade within five kilometers have a larger effect (see Appendix Figure A.3). Moreover, varying distance in the definition of what municipalities are considered to be neighboring municipalities has the expected effect. Restricting the analysis to foundations in municipalities that are closer results in a larger estimated effect (see Appendix Figure A.4).

Of course, we cannot rule out that there is a common cause that makes both the municipality under consideration as well as the municipalities in its neighborhood more likely to establish a fire brigade. There is some evidence that speaks against this concern. If we limit the analysis to foundations that take place in neighboring municipalities that in the same year are hit by a significant fire and therefore could be regarded as being more exogenous, we find that these have an even larger effect. Nevertheless, the most conservative interpretation of the evidence presented in Panel B of Figure 9 is that foundations tend to be clustered in time and space.

In the next step, we test the third prediction of our conceptual framework, which is that the effect of the foundation of a fire brigade in a neighboring municipality should be stronger in municipalities in which a singing or gymnastics club exists. In Figure 10, as we have done when exploring whether a local fire and social clubs are complements, we look at different subsamples that differ in whether and when a singing or gymnastics club exists. In the upper part, the effect of a foundation in a neighboring municipality is depicted separately for the subsample of municipalities that establish a singing or gymnastics club until 1889 (Panel A) and those that do not (Panel B). In line with our prediction, the effect of a foundation of a fire brigade in a neighboring municipality is much stronger in municipalities that establish a singing or gymnastics club before 1889. In the lower part of Figure 10, we again split

the subsample of municipalities that establish a singing or gymnastics club before 1889 into two groups: those that already have such a club when a neighboring municipality founds a fire brigade (Panel C), and those that establish a singing or gymnastics club only after the neighboring municipality sets up a fire brigade (Panel D). Similar to what we observed with respect to the effect of a fire in the municipality itself, the foundation of a fire brigade in a neighboring municipality has a much bigger effect if the municipality already has a singing or gymnastics club by that time. Although, again, we stress that we cannot make a causal claim, the evidence seems to suggest that the existence of a social club facilitates collective action in setting up a volunteer fire brigade.

8 Conclusion

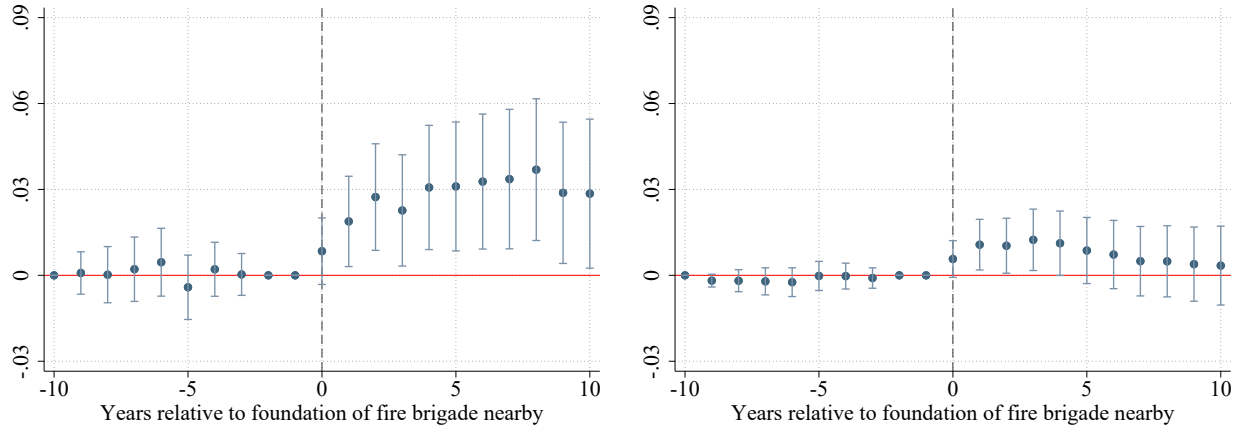
In our study of community-level self-organization the novel focus is to identify under which conditions a community succeeds in founding a long-lived organization to fight fires. This is different from the extant literature that takes the existence of such organizations as given and compares communities with and without such organizations. We argue that very little is known about how self-organization arises in the first place. Because institutional change is typically slow, identifying a case in which a large number of communities voluntarily transition from an unorganized to an organized state requires turning to a historical setting.

The institutional environment we look at was one in which state-provided fire protection was largely absent. Hence, communities either organized firefighting through bottom-up collective action, or kept a rather ineffective ad-hoc approach to fire fighting. The model which some, but far from all municipalities adopted until the late 19th century led to the formation of a powerful and widespread model of community-level fire protection that persists to this day.

Our analysis focuses on which municipalities established a volunteer fire brigade and under what conditions. Local fire shocks significantly increased the likelihood a fire brigade was established, but only in municipalities that already had a singing or gymnastics club. Where no such club existed, a fire shock had no detectable effect. We also document geographic spillovers. The founding of a fire brigade in a neighboring municipality had a similar effect to a local fire, again primarily in places where social clubs were already present. Together, our findings suggest that pre-existing social structures play an important role in enabling local self-organization in the face of collective risks.

Much remains to be done. The time period we look at follows the advent of the first democratic revolution in what became Germany. We are now looking at a data base on revolutionaries who could have the leadership skills of coordinating people, but many of

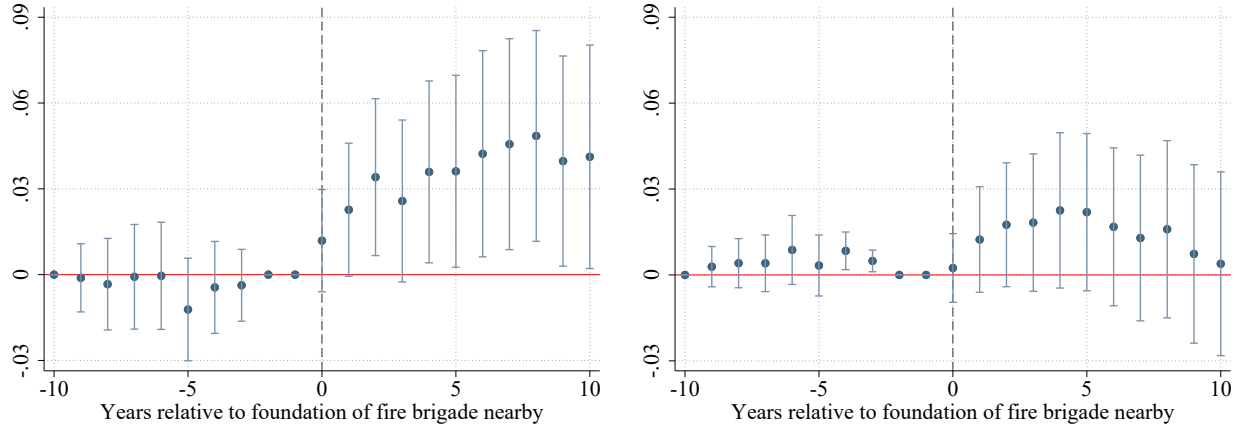
Ever vs. never singing or gymnastics club until 1889



(A) Municipalities with a club until 1889

(B) Municipalities without club until 1889

Singing or gymnastics club before vs. after fire



(C) Municipalities with club when fire occurred

(D) Municipalities without club when fire occurred but with club until 1889

Figure 10: Effect of Foundation of Fire Brigade in Neighboring Municipality on Probability of Having a Fire Brigade in Subsamples Differing by Existence of Singing and Gymnastics Clubs

Notes: Panels A to D plot regression coefficients β_h of Equation 6 when $D_{i,t}$ is a dummy that is one if a neighboring municipality within five kilometer establishes a fire brigade and adding two lags of the dummy $FB_{i,t}$. Estimates are obtained from 20 individual regressions for each $-10 \leq h \leq 10,\ h \neq -1$, restricting the sample according to Equation 7 with $L = 4$. Error bands indicate 95% confidence intervals with standard errors clustered at the municipality level. In the upper part, the sample is split into municipalities that establish a singing or gymnastics club (Panel A) and those that have no such club until 1889 (Panel B). In the bottom part, the sample of of Panel A is further split into those municipalities that already had a singing or gymnastics club at the time a neighboring municipality establishes a fire brigade (Panel C) and those that did not yet have such club by that time but established one until 1889 (Panel D).

whom were forced to emigrate or would find themselves in jail. We are also looking at the foundation documents of some of the fire brigade to understand how these were related to each other, providing a potential explanation for regional spillovers. And we are digging deeper into differences between catholic and protestant communties in founding fire brigades which only began to emerge after the German unification, a time in which protestants became a leading group in the German Reich.

In many ways, we believe that this setting provides an intriguing lab that allows for the identification of forces that make self-organization possible in the absence of profit motives and capitalist entrepreneurs.

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Appendix for

On Self-Organization: The Formation of Volunteer Fire Brigades in 19th-Century Baden

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August 2025

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A Additional Figures

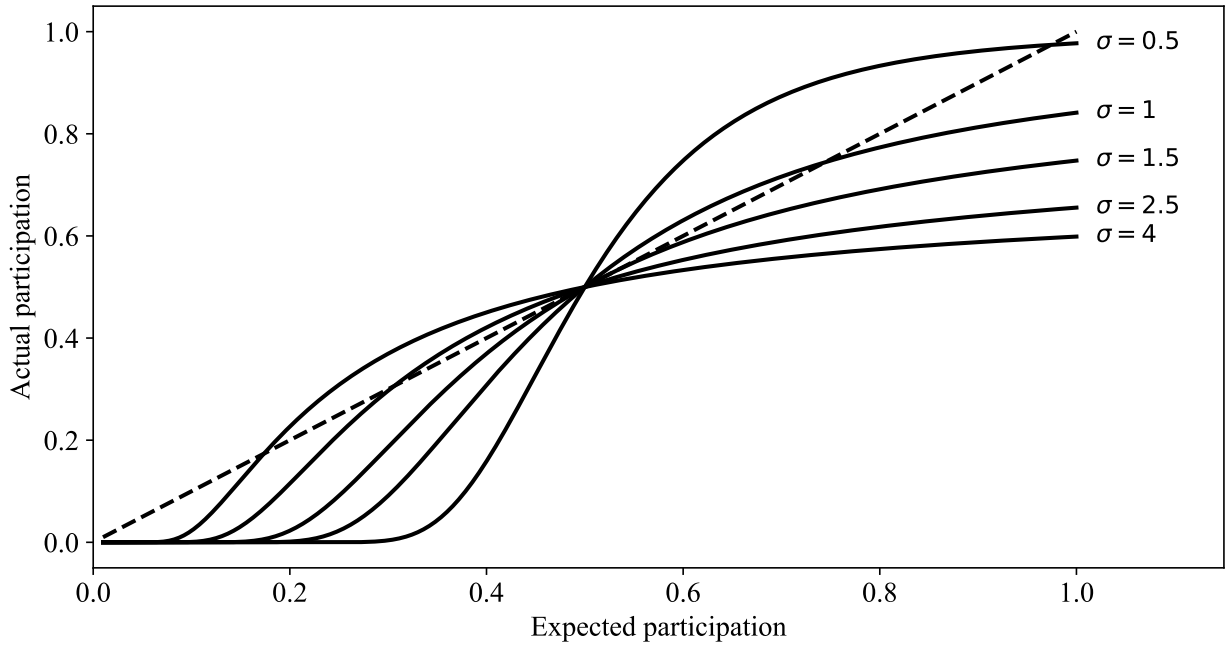
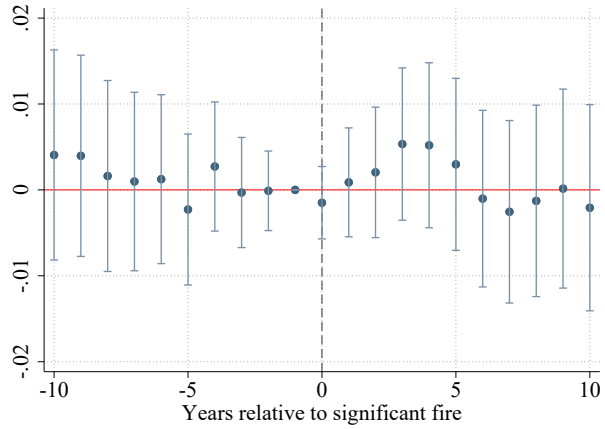
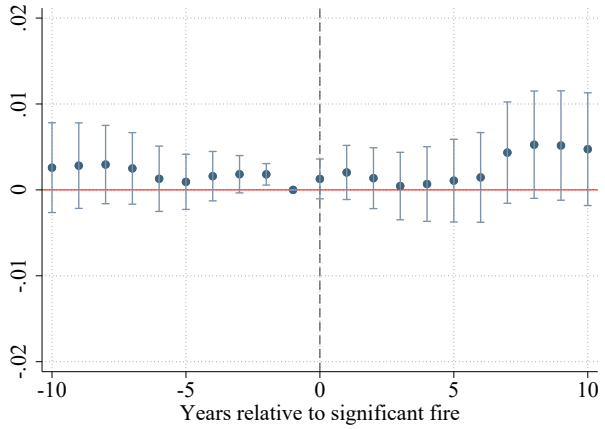


Figure A.1: Numerical Simulations Varying σ in the Distribution of θ

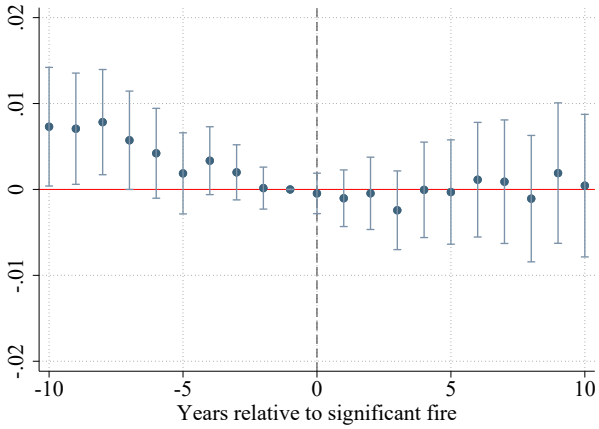
Notes: Actual participation as a function of expected participation for $F(\gamma) = \gamma$, $c^F = 1$, and $\theta_i \sim \mathcal{N}(1, \sigma^2)$. An equilibrium is reached where the participation profile intersects the 45-degree line.



(A) Effect on singing club



(B) Effect on gymnastics club



(C) Effect on credit cooperative

Figure A.2: Effect of Significant Fire on Probability of Having a Singing Club, Gymnastics Club, or Credit Cooperative

Notes: Panels A to C plot regression coefficients β_h of Equation 6 with the dependent variable being $Club_{i,t+h} - Club_{i,t-1}$, where $Club_{i,t}$ is a dummy that is one if municipality i has established a singing club (Panel A), gymnastics club (B), or credit cooperative (Panel C) at time t and zero otherwise. Estimation in Panel C excludes 53 municipalities for which the exact year of foundation of the credit cooperative is unknown. See Section B. 3 for details on the data on credit cooperatives. Estimates are obtained from 20 individual regressions for each $-10 \leq h \leq 10$, $h \neq -1$, restricting the sample according to Equation 7 with $L = 4$ but with $Club_{i,t-10} = 0$ instead of $FB_{i,t-10} = 0$. Error bands indicate 95% confidence intervals with standard errors clustered at the municipality level.

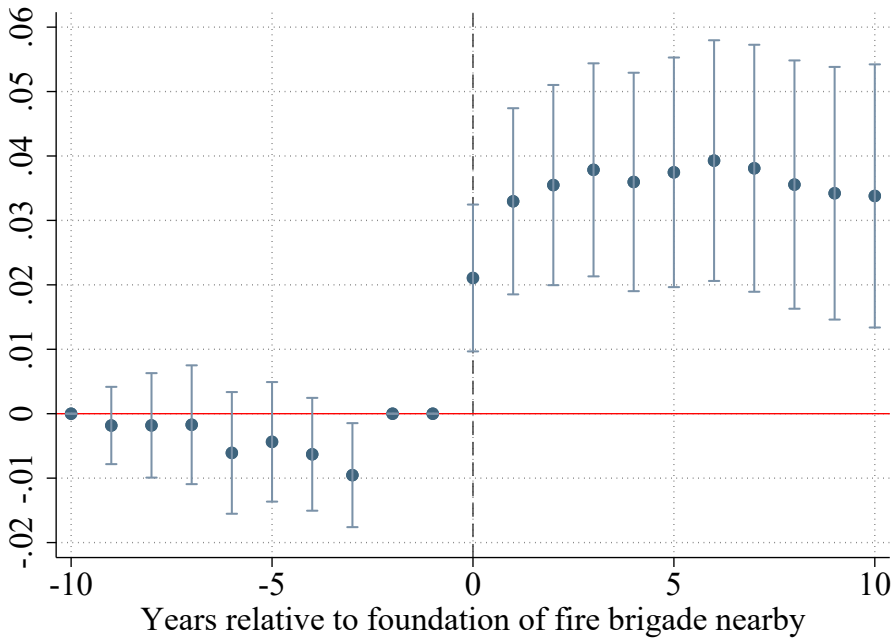
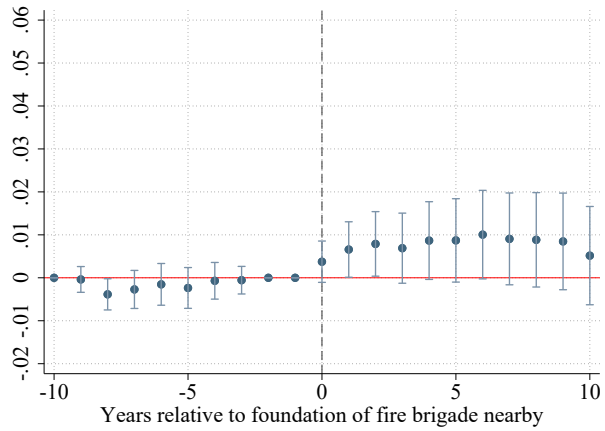
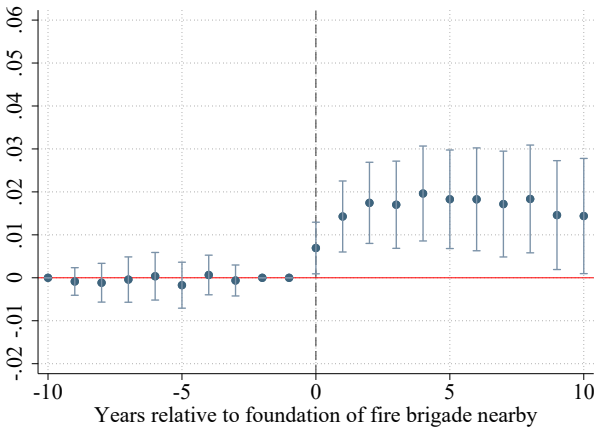


Figure A.3: Effect of Foundation of Fire Brigade in Neighboring Municipality on Probability of Having a Fire Brigade When Other Fire Brigade in Neighborhood Was Present Before

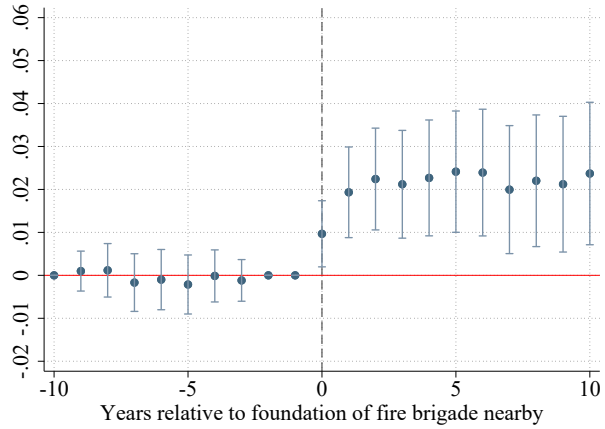
Notes: Figure plots regression coefficients β_h of Equation 6 with a treatment dummy $D_{i,t}$ that is one if a neighboring municipality within five kilometer distance establishes a fire brigade but there already existed a fire brigade in another neighboring municipality within five kilometer distance in the year before. In addition, two lags of the dummy $FB_{i,t}$ are added to Equation 6. Estimates are obtained from 20 individual regressions for each $-10 \leq h \leq 10,\ h \neq -1$, restricting the sample according to Equation 7 with $L = 4$. Error bands indicate 95% confidence intervals with standard errors clustered at the municipality level.



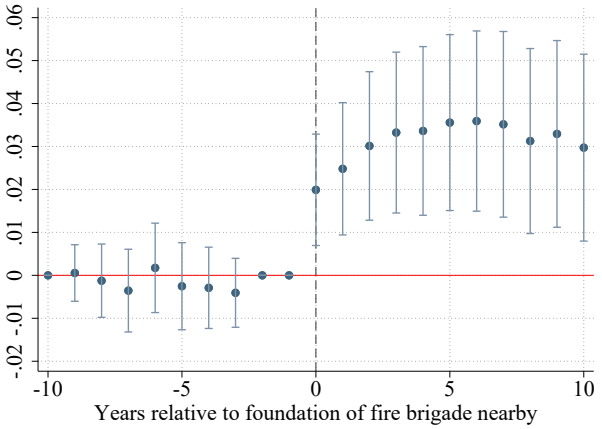
(A) Effect of foundations within 6 km



(B) Effect of foundations within 5 km



(C) Effect of foundations within 4 km



(D) Effect of foundations within 3 km

Figure A.4: Effect of Foundation of Fire Brigade in Neighboring Municipality of Varying Distance on Probability of Having a Fire Brigade

Notes: Panels A to D plot regression coefficients β_h of Equation 6 with a treatment dummy $D_{i,t}$ that is one if a neighboring municipality within six (Panel A), five (Panel B), four (Panel C), or three (Panel D) kilometers establishes a fire brigade. In addition, two lags of the dummy $FB_{i,t}$ are added to Equation 6. Estimates are obtained from 20 individual regressions for each $-10 \leq h \leq 10,\ h \neq -1$, restricting the sample according to Equation 7 with $L = 4$. Error bands indicate 95% confidence intervals with standard errors clustered at the municipality level.

B Data

This appendix provides additional details on the data we use. Table B.1 lists the data sources. Further below, we explain how we constructed the sample (Section B. 1), the dependent variable (Section B. 2), and the independent variables (Section B. 3).

Table B.1: Data Sources

	Year	Source
Municipality characteristics		
Population	1852	Badisches Ministerium des Innern (1855)
	1855	Badisches Ministerium des Innern (1856)
	1858, 1861	Badisches Handels-Ministerium (1862)
	1864	Badisches Handels-Ministerium (1867)
	1867, 1871	Badisches Handels-Ministerium (1874)
	1875	Badisches Handels-Ministerium (1878)
	1880, 1885	Statistisches Bureau Baden (1888)
	1890	Statistisches Bureau Baden (1893)
Area	1854	Badisches Ministerium des Innern (1858), Badisches Ministerium des Innern (1859)
Share of women	1855	Badisches Ministerium des Innern (1856)
Share of population above 14	1855	Badisches Ministerium des Innern (1856)
Share of population by religion	1855	Badisches Ministerium des Innern (1856)
	1885	Statistisches Bureau Baden (1888)
District capital	1855	Badisches Ministerium des Innern (1856)
Number of buildings	1864	Badisches Handels-Ministerium (1867)
Number of households	1864	Badisches Handels-Ministerium (1867)
Taxable capital stock	1854	Badisches Ministerium des Innern (1858), Badisches Ministerium des Innern (1859)
District characteristics		
Share of buildings by type of roof	1868-1889	Statistisches Bureau Baden (1869-1891)
Fire brigades and social capital		
Founding dates of fire brigades	until 1899	Müller (1917)
Founding dates of gymnastics clubs	until 1889	Badischer Turner-Bund e.V.
Founding dates of singing clubs	until 1889	Badischer Chorverband e.V.
Credit cooperatives	until 1889	Statistisches Bureau Baden (1869-1891)
Fires		
Allocation to insurance classes	1852-1867	Baden (1853-1868)
	1868-1870	Baden (1869-1871)
Total fire compensation	1852-1867	Baden (1853-1868)
	1868-1870	Baden (1869-1871)

B. 1 Sample: Municipalities

In the Grand Duchy of Baden, municipalities represented the lowest administrative level. Besides municipalities, a small fraction of the population was living in so-called colonies.

Colonies were small settlements or even just single farms that were not part of any municipality. They were further distinguished depending on who was responsible for local supervision. The first group of colonies were fully independent in the sense that they were supervised by a local authority (*Stabhalter*). We call these *independent colonies*. The second group of colonies were supervised by the mayor of a neighboring municipality. We call these *associated colonies*. In 1852, there were 39 independent and 157 associated colonies. In our analysis, we generally exclude independent colonies but include associated colonies by subsuming the latter under the municipality whose mayor is the local supervisor. In any case, given their small size, colonies are of only minor importance for the purpose of our study. In 1852, for example, the overall population of Baden was around 1.4 million, of which only 4,571 were living in independent colonies and 3,388 in associated colonies.

To build our sample, we started with the list of 1,583 municipalities that were included in the 1852 census. Of these, we dropped the following six municipalities that were incorporated into another municipality during our observation period (year of incorporation and incorporating municipality in parentheses): Siedelbach (1860, Breitnau), Fernach (1872, Oberkirch), Seehof (between 1871 and 1874, became colony, supervized by mayor of Windischbuch), Thengenhinterburg (1876, Thengen), Niederemmendingen (1883, Emmendingen), Mühlburg (1886, Karlsruhe).

There were another four municipalities that formed during our observation period by separating from another municipality (year of becoming independent and municipality of origin in parentheses): Alb (1858, Schachen), Kleingemünd (1860, Neckargemünd), Rorgenwies (1862, Heudorf), Steinfurt (1882, Hardheim). We also exclude these newly formed municipalities from our analysis.

Moreover, we treat as one municipality the following villages that merged during our observation period: Unternesselried and Obernesselried (merged to Nesselried in 1871), as well as Dillstein and Weißenstein (merged to Dill-Weißenstein in 1890).

When retrieving data from various sources, it needs to be taken into account that some municipalities renamed (year of renaming and new name in parentheses): Beuern (1863, Lichtenthal), Döttelbach (1863, Griesbach), Efritzweiler (between 1861 and 1864, Kluftern). Other municipalities are referred to in various names in the documents we use (alternative name in parentheses): Kleinlaufenburg (Laufenburg), Thengendorf (Thengen), Nollingen (Rheinfelden), Binau (Neckarbinau), Kappelwindeck (Kappel), Ettenheimmünster (Münsterthal).

Each municipality in Baden was assigned to a district (*Bezirksamt*). There were 74 such districts in 1852. As several municipalities have the same name (e.g., there are four municipalities called Weiler) but the combination of a municipality and its district is unique, a

municipality's district is an important identifier when retrieving data from different sources. There were three major administrative reforms over the course of our observation period, however, that changed districts and the allocation of municipalities across districts. As a result of these reforms, the number of districts was reduced to 64 in 1857, to 59 in 1864, and finally to 52 in 1872.[32] The details of these reforms can be found in the corresponding law that was published in the government law gazette. Another helpful source is Redecker and Schöntag (1976). Apart from these major reforms, several minor changes took place, where single municipalities were reassigned from one district to a neighboring one. These changes are also documented in the government law gazette, although harder to find. We retrieve the allocation of municipalities across districts from the ten censuses that took place over our observation period. In case a municipality changes district from one census to the next, we obtain the exact switching date from the government law gazette. In general, the allocation of municipalities across districts we use reflects the state at the end of the year.

In our empirical analysis, we use district fixed effects. The district fixed effects we use in our LP-DiD regressions correspond to the 74 districts that existed between 1849 and 1857. Given that no changes took place in the assignment of municipalities across districts between 1852 and 1857, we obtain the assignment of municipalities across these districts from the 1855 census.

In our analysis of geographical spillovers, we use geocodes of municipalities to compute the distance between any two municipalities. Most sources of geocodes on municipalities in today's borders are unsuitable for this purpose because many municipalities of our sample merged in the course of community reforms, especially in the second half of the 20th century. Therefore, we use data from the commercial provider *Lexwelt UG* (`www.geolex.de`), which provides geocodes even on the level of urban districts. Many of the municipalities of our sample are urban districts of larger municipalities today and are therefore covered in this data set. For 317 municipalities, however, no matching was possible. We manually obtained their location by searching them on Google Maps.

B. 2 Dependent Variable: Fire Brigades

To retrieve the founding dates of all fire brigades in Baden, we use a list that was compiled for the national fire brigade association of Baden (*Badischer Landesfeuerwehr-Verband*) and published in Müller (1917). It contains all fire brigades in Baden as of July 1914 ordered by their year of foundation. The list only includes the name of the municipality but does not mention its district. As several municipalities have the same name, however, 14 of the fire

[32] In addition, there was a major administrative reform in 1849, that is, three years before the start of our observation period.

brigades that formed until 1889 could not be matched in the first step. We contacted the fire brigades of all municipalities that were a potential match to determine to which of the possible candidates the founding date belongs.

The list also includes the founding dates of 12 factory fire brigades (*Fabrikfeuerwehren*) and 13 fire brigades that operated in train stations (*Bahnhofsfeuerwehren*). We do not consider these brigades in our analysis as their main purpose was to protect the factory or train station in which they were operating. It is questionable whether the men serving in these brigades were volunteers (Briese, 2015). Moreover, in almost all of these cases, the foundation of the private fire brigades operating in factories or train stations was preceded by the establishment of a volunteer fire brigade serving the general public. The list also includes the foundation of two fire brigades in villages (Badenscheuern and Oberharmersbach-Dorf) that were part of a larger municipality in which another fire brigade had already been formed before. We hence do not consider these additional fire brigades in the analysis either.

As our source of fire brigades' founding years is a list that reflects the state in 1914, there are two reasons for missing data. First, if a municipality was incorporated into another municipality before 1914 and their fire brigades merged, then only the older fire brigade appears on the list. Second, the list does not include fire brigades that dissolved before 1914. To address the first issue, we determine which municipalities were incorporated into another municipality between 1889 and 1914. As incorporations were implemented by a law, we do so by browsing the government law gazette. In total, 27 municipalities were incorporated between 1890 and 1914.[33] We check through online search whether they had already established a fire brigade before losing their independence. We find that this was the case in five of the 27 municipalities and add their fire brigades to our sample (founding date in parentheses): Neuenheim (1862), Handschuhsheim (1864), Stetten (1871), Feudenheim (1874), and Käferthal (1874). Unfortunately, there is not much we can do to address the second issue of fire brigades that are missing because they dissolved before 1914. We compare our sample with an overview of all fire brigades that existed in 1876 according to a list published by Cathiau (1876). The list in Cathiau (1876) contains 29 fire brigades not already part of our sample. As the list in Cathiau (1876) does not mention founding years, however,

[33]The municipalities are (year of incorporation and incorporating municipality in parentheses) Güntersthal (1890, Freiburg), Haslach (1890, Freiburg), Neuenheim (1890, Heidelberg), Neidelsbach (1892, Eubigheim), Käferthal (1897, Mannheim), Oedengesäß (1897, Nassig), Neckar-Wimmersbach (1899, Eberbach), Neckarau (1899, Mannheim), Handschuhsheim (1903, Heidelberg), Brötzingen (1905, Pforzheim), Zähringen (1906, Freiburg), Kleingemünd (1907, Neckargemünd), Beiertheim (1907, Karlsruhe), Rüppurr (1907, Karlsruhe), Rintheim (1907, Karlsruhe), Betzenhausen (1908, Freiburg), Altwiesloch (1908, Wiesloch), Stetten (1908, Lörrach), Beuern/Lichtenthal (1909, Baden), Grünwinkel (1909, Karlsruhe), Daxlanden (1910, Karlsruhe), Feudenheim (1910, Mannheim), Schwarzhalden (1911, Schönenbach), Dill-Weißenstein (1913, Pforzheim), Bestenheid (1913, Wertheim), Sandhofen (1913, Mannheim), and Littenweiler (1914, Freiburg).

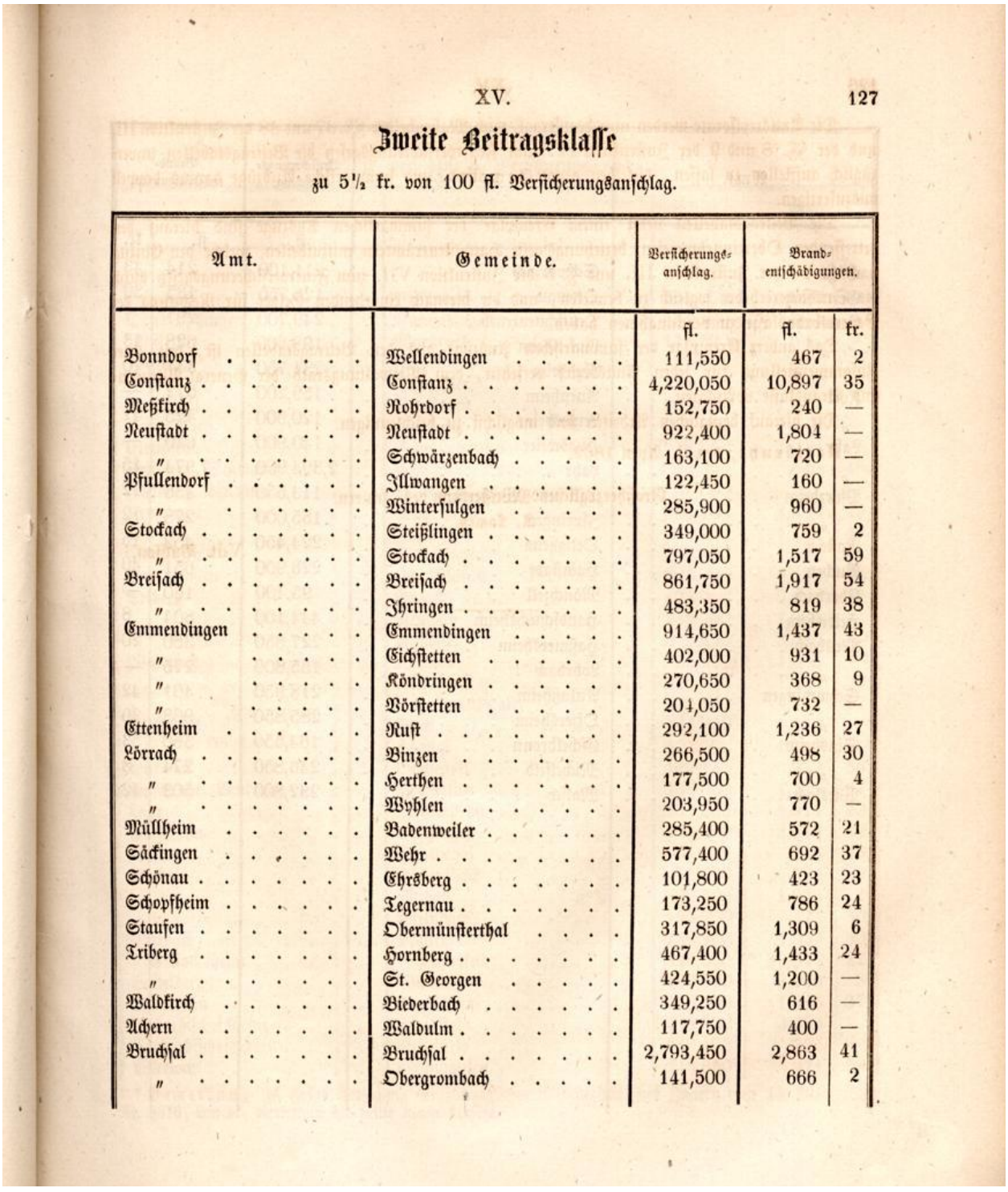
we need to search for them online. We were able to find the year of foundation for six of the 29 brigades and add them to our sample (founding date in parentheses): Wössingen (1861), Buchheim (1865), Adelsheim (1865), Kleinlaufenburg (1865), Walldürn (1866), and Söllingen (1873). In two of these cases (Walldürn and Söllingen) we actually find evidence that the fire brigade temporarily dissolved. For the other 23 municipalities that are listed in Cathiau (1876) but are not part of our sample, we were unable to find any information that a fire brigade in 1876 or earlier actually existed.[34] In fact, for 15 of these municipalities, we found a founding year after 1889, typically in the first half of the 20th century. We cannot rule out that in some of these municipalities a fire brigade actually existed and later dissolved. However, in the absence of any information of their year of foundation, we are unable to include them in our analysis. Therefore, we treat these municipalities as never having had a fire brigade over our observation period.

B. 3 Independent Variables

Fires

Our main data source of fires are the annual lists showing the assignment of municipalities across fire insurance classes 2, 3, and 4. The lists were published in the government law gazette and are available for 1852 until 1889. They and were published in *Grossherzoglich Badisches Regierungsblatt* until 1868 and in *Staatsanzeiger für das Grossherzogtum Baden* thereafter. The list for a given year typically appeared in the government law gazette in March of the following year. See Figure B.1 for an example page.

[34] The municipalities are (with their district as of 1855) Heimbach (Emmendingen), Köndringen (Emmendingen), Hattingen (Engen), Busenbach (Ettlingen), Neuburgweier (Ettlingen), Bombach (Kenzingen), Spöck (Landamt Carlsruhe), Huttingen (Lörrach), Istein (Lörrach), Menningen (Meßkirch), Mauchen (Müllheim), Ebersweier (Offenburg), Zell (Offenburg), Büchenbronn (Pforzheim), Ispringen (Pforzheim), Schienen (Radolfzell), Weiler (Radolfzell), Au am Rhein (Rastatt), Bergalingen (Säckingen), Niedergebisbach (Säckingen), Niederschwörstadt (Säckingen), Pfaffenweiler (Staufen), Unterlauchringen (Waldshut).



XV. 127

Zweite Beitragsklasse

zu 5½ kr. von 100 fl. Versicherungsanschlag.

Amt.	Gemeinde.	Versicherungs-anschlag.	Brand-entschädigungen.	
		fl.	fl.	kr.
Bonndorf	Wellendingen	111,550	467	2
Constanz	Constanz	4,220,050	10,897	35
Meßkirch	Rohrdorf	152,750	240	—
Neustadt	Neustadt	922,400	1,804	—
"	Schwärzenbach	163,100	720	—
Pfullendorf	Illwangen	122,450	160	—
"	Wintersulgen	285,900	960	—
Stockach	Steißlingen	349,000	759	2
"	Stockach	797,050	1,517	59
Breisach	Breisach	861,750	1,917	54
"	Ihringen	483,350	819	38
Emmendingen	Emmendingen	914,650	1,437	43
"	Eichstetten	402,000	931	10
"	Köndringen	270,650	368	9
"	Vörstetten	204,050	732	—
Ettenheim	Rust	292,100	1,236	27
Lörrach	Binzen	266,500	498	30
"	Herthen	177,500	700	4
"	Wyhlen	203,950	770	—
Müllheim	Badenweiler	285,400	572	21
Säckingen	Wehr	577,400	692	37
Schönau	Ehrsberg	101,800	423	23
Schopfheim	Tegernau	173,250	786	24
Staufen	Obermünsterthal	317,850	1,309	6
Triberg	Hornberg	467,400	1,433	24
"	St. Georgen	424,550	1,200	—
Waldkirch	Biederbach	349,250	616	—
Achern	Waldulm	117,750	400	—
Bruchsal	Bruchsal	2,793,450	2,863	41
"	Obergrombach	141,500	666	2

Figure B.1: Example Page from List Showing Assignment of Municipalities Across Fire Insurance Classes

Notes: Grossherzoglich Badisches Regierungsblatt, April 16, 1862, Nr. XV, page 127.

Over our observation period (1852–1889), the register has 5,743 entries. Each entry

mentions the municipality, the district, the overall value of the municipality's insured real estate value, and the fire compensation that was caused by fires in this municipality in this year.[35] Moreover, the list is organized by fire insurance classes. Each municipality appearing on the list is assigned to exactly one of the insurance classes 2, 3, or 4, while all municipalities that do not appear on the list are assigned to the default class 1. Generally, the assignment of municipalities to insurance classes follows from the amount of fire compensation relative to the value of the insured real estate. For example, municipalities in which fires have caused compensation claims of more than 0.1% but less than 0.5% of the insured real estate value are assigned to insurance class 2 (see Table 1). However, in 82 cases in which a municipality normally would have been assigned to class 3 or 4 given its fire compensation claims, the Baden Ministry of Interior decided to assign it to insurance class 3 or 2. Such reassignment was possible in the case of extraordinary fire incidents according to § 62, section 4, of the fire insurance law of 1852. Such cases of reassignment are marked in the list explicitly, either by a note in parenthesis or a footnote. As we are interested in the actual fire damage, we use the allocation of municipalities to insurance classes *before* any reassignment by the Ministry of Interior.

Eleven entries refer to a village that by the time it was listed was not independent but was part of a larger municipality. In these cases, we assign the whole municipality to the corresponding fire insurance class even though the fire compensation caused in the associated village may not have resulted in the same insurance class when compared to the total real estate value of the municipality on the whole.

Another 36 entries refer to colonies. We here distinguish between independent and associated colonies (see Section B. 1). We ignore fires in independent colonies (8 entries). In contrast, we include fires in associated colonies (28 entries) by assigning the supervising municipality to the insurance class to which the colony was assigned.

Population

To obtain population data, we draw on the results of the census. These were published by the Baden Ministry of Interior or the Baden Ministry of Commerce in the publication series *Beiträge zur Statistik der inneren Verwaltung des Großherzogtums Baden* or by the Baden Statistical Office (*Statistisches Bureau Baden*) in the publication series *Beiträge zur Statistik des Großherzogtums Baden*. More specifically, we consider all censuses that took place during our observation period by digitizing the following volumes of the aforementioned publication series (with the census it covers in parentheses): volume 1 (1852), volume 13 (1858 and 1861),

[35] If a fire happened late in a year, the compensation was sometimes pushed to the following year. We do not generally observe, however, when this is the case.

volume 24 (1864), volume 35 (1867 and 1871), volume 39 (1875), and volume 47 (1880 and 1885). We estimate population counts for the years in which no census took place by linearly imputing from the censuses that preceded and followed the year under consideration. For this purpose, we also digitize the census from 1890, which is covered in volume 52.

An exception applies to the imputation of the population counts for 1886 through 1889 for the following four municipalities: Güntersthal, Haslach, Neuenheim, and Neidelsbach. The reason is that these municipalities were incorporated into a neighboring municipality in 1890 or 1892 (see footnote 33). Consequently, when the results of the census 1890 were published in Statistisches Bureau Baden (1893), their population was already subsumed under the population of the incorporating municipality. We therefore estimate the population in 1886 through 1889 for these municipalities by linearly extrapolating from the population growth between 1880 and 1885. Note that we do not apply the same procedure for the incorporating municipalities as these are substantially larger than the villages they incorporate.

The census usually provides population counts separately for municipalities and independent colonies. The census 1852 is an exception in this regard as it provides population counts separately not only for municipalities and independent colonies but also for associated colonies. In line with our approach of subsuming associated colonies under the supervising municipality (see Section B. 1), we add the population count of associated colonies to the population count of the municipality whose mayor is the colony's local supervisor.

Singing clubs

Our data source is a list of singing clubs with their year of foundation that we obtained from the umbrella association *Badischer Chorverband*. Importantly, the list includes both active clubs as well as inactive clubs that already dissolved in the past. In total, the list includes 642 singing clubs that were founded before 1889. We dropped three clubs located in a municipality that over our observation period did not belong to Baden but to a neighboring state. Moreover, we excluded a catholic choir (Katholischer Kirchenchor Münchweier), which, according to the list, was already established in 1769. Because this was more than six decades before the diffusion of singing clubs in Baden started, the nature of this choir was likely quite different from that of the singing clubs established from the 1830s onward. The oldest singing club we include in our analysis is a choir that was established in Mappach in 1830.

The list only includes the name of the club but not the location where it was founded. In case the club's name matches the name of several municipalities in our sample, we determine through online search which of our municipalities is the founding location. Unfortunately,

this procedure failed for three clubs, which we therefore had to exclude.[36] In all of these cases, the singing club today is located in a city that was formed after 1889 by the merger of two formerly independent municipalities. Neither through online search nor through contacting the club via email directly, however, we were able to determine in which of the two municipalities it was established. On the other hand, we added a singing club that according to our online search was missing on the list (Sängerbund Kehl, established in 1863 in Kehl, Dorf).

In several municipalities, more than one singing club was established before the end of our observation period. We only consider the first singing club and classify the municipality as having a singing club starting in the year in which the first singing club was established.

Gymnastics clubs

Our data source is a list of gymnastics clubs with their year of foundation that we obtained from the umbrella association *Badischer Turner-Bund* (BTB). In total, the list includes 144 gymnastics clubs that were established before 1889. The oldest one was established in Pforzheim in 1834. We dropped two clubs located in a municipality that over our observation period did not belong to Baden but to a neighboring state.

We validated the correctness of the list obtained from the BTB using an overview of gymnastics clubs that appears in the Statistical Yearbook of the Gymnastics Clubs of Germany (*Jahrbuch der Turnvereine Deutschlands*), which was published by Georg Hirth in 1863, 1865, and 1871. In 45 cases, the founding date mentioned in the BTB list did not align with the founding date mentioned in the Yearbook. In most cases (29), the founding year mentioned in the Yearbook was later than that mentioned in the BTB list. Researching these cases online revealed that the BTB list includes the initial founding date, whereas the Yearbook mentions the year of re-establishment after all gymnastics clubs were temporarily abolished following the German Revolution in 1848/49. After almost a decade of oppression, gymnastics clubs could resume their activity only starting from 1860. Given that in our study, we are interested whether a municipality ever had a gymnastics club, we keep the earlier founding date mentioned in the BTB list in all of the aforementioned 29 cases. More specifically, a municipality is classified as having a gymnastics club starting from the fist year in which a gymnastics club was established, even if this club was temporarily abolished during the 1850s.

In the remaining 16 cases, in which the founding year mentioned in the BTB list is later than the founding year mentioned in the Yearbook, we tried to verify the correct founding

[36] These clubs are MGV Eintracht Schallstadt-Wolfenweiler e.V., Just Singing e.V., and Gem.Chor Sängerlust Glashütte 1889 e.V.

year through online search. In three cases, we decided to adjust the founding date to the year that is mentioned in the Yearbook (founding year according to Yearbook in parentheses): Renchen (1860), Lörrach (1862), and Weinheim (1860).

Credit cooperatives

Our source for credit cooperatives is the Statistical Yearbook for the Grand Duchy of Baden (*Statistisches Jahrbuch für das Großherzogtum Baden*), which was published annually starting from 1868. The Yearbook covers two forms of credit cooperatives: urban credit cooperatives, called *Vorschussvereine*, and rural credit cooperatives, called *Ländliche Kreditvereine*. In 1889, there were 104 urban and 121 rural credit cooperatives.

While the Yearbook lists urban credit cooperatives since 1868, rural credit cooperatives were only listed from 1880 onward. Moreover, for either type of credit cooperative, no years of foundation are mentioned. Therefore, we classify a credit cooperative as having been founded in the year in which it is first listed in the Yearbook. This procedure, however, does not yield a founding year for the 41 urban credit cooperatives listed for the first time in 1868 and the 36 rural credit cooperatives listed for the first time in 1880. For 24 of the urban credit cooperatives that already existed in 1868, we were able to find the actual year of foundation through online search. For the rural credit cooperatives, only in one case we were able to find the exact founding year. The lower success rate in searching the founding year for rural credit cooperatives has probably be attributed to the fact that they were much smaller. However, four urban credit cooperatives that were still listed in 1879 were reclassified as rural credit cooperatives in 1880 (Königsbach, Eggenstein, Knielingen, Liedolsheim). Therefore, for these rural credit cooperatives, the founding year is actually known. Hence, in total, the founding year is missing for 17 urban and 31 rural credit cooperatives.

While the Yearbook lists both the municipality and the district for rural credit cooperatives, it only lists the municipality for the urban ones. For most urban credit cooperatives, matching them to the municipalities in our sample nevertheless is easy as they were normally established in larger municipalities, which are often uniquely identified by their name. However, in three cases (Hornberg, Oberhausen, Stein), we were unable to determine, even through additional online search, in which of two possible municipalities the credit cooperative was established.

In our regressions in which we analyze the formation of credit cooperatives, we deal with the problem of missing founding years and ambiguous matching by dropping all municipalities for which the founding year or the existence of a credit cooperative is unclear.

C Association Between Type of Roofing and Fire Activity

In this appendix, we show that fires are more frequent, larger, and more damaging in districts in which a greater fraction of roofs is made from flammable materials. In the 19th century, the majority of buildings in Baden were covered with tiles, but in some regions, especially in the Black Forest and the Odenwald, a significant number of buildings still had thatched and shingled roofs. Such roofs were associated with a higher fire risk for at least two reasons. Starting in the 18th century, official regulations required that chimneys were built into thatched roofs. Although this requirement was actually intended to prevent fires, in practice it often had the opposite effect. Sparks that reached the outside through the chimney could fall onto the roof and ignite the straw (Schnitzer, 1989). A second reason for a connection between flammable roofs and fire risk was that fires often spread through firebrands (Cathiau, 1876; Magirus, 1877). This refers to the phenomenon that fires can spread over long distances because small pieces of burning material are carried by the wind or the thermally conditioned air. If neighboring buildings have wooden or thatched roofs, falling sparks can therefore easily lead to subsequent fires.

As data on the number of buildings by type of roof is only available at the district level, our unit of analysis is the district. Our main source of district-level data is the Statistical Yearbook for the Grand Duchy of Baden (Statistisches Bureau Baden 1869–1891), which was published from 1868 onward. Hence, our observation period covers the years 1868 until 1889. We measure the prevalence of flammable roofs by the district's share of buildings covered by wooden shingles or straw as opposed to tiles or roofing felt.

Table C.1 presents panel regressions with different measures of fire activity as dependent variable. For example, in column 1, the dependent variable is the number of fires per 1,000 buildings. Besides our main explanatory variable of interest, which is the share of buildings with wooden or thatched roofs, we also include the following three controls: population, the insured property value per building, and the taxable capital stock per capita. All controls are log-transformed. Moreover, to control for regional differences, we include county fixed effects. Standard errors are clustered on the district.

Column 1 reveals that going from a district in which all buildings have fire-resistant roofs to a district in which all buildings have flammable roofs result in one more fire per 1,000 buildings. Given that, on average, there is slightly less than one fire per 1,000 buildings in the overall sample, this means that the number of fires per 1,000 buildings doubles.

Table C.1: Association Between Share of Buildings with Flammable Roofs and Fire Activity

	(1)	(2)	(3)	(4)	(5)	(6)
Share with flammable roof	1.068**	0.236	2.642***	0.054	0.039***	0.163**
	(0.458)	(0.151)	(0.800)	(0.039)	(0.012)	(0.068)
ln(Population)	-0.036	-0.028	-0.072	0.014*	0.003	0.023
	(0.061)	(0.039)	(0.139)	(0.008)	(0.003)	(0.014)
ln(Value per building)	0.462***	0.051	0.028	0.001	0.006	0.015
	(0.137)	(0.054)	(0.308)	(0.013)	(0.004)	(0.023)
ln(Capital stock per capita)	-0.394*	-0.035	-0.253	-0.044*	0.002	-0.068*
	(0.208)	(0.057)	(0.427)	(0.023)	(0.006)	(0.034)
County FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
N	1,172	624	1,172	1,172	1,172	1,172
R^2	0.494	0.146	0.135	0.270	0.320	0.327

Notes: The dependent variable is number of fires per 1,000 buildings in column 1, the share of buildings damaged by a fire that were completely destroyed in column 2, the amount of fire compensation paid by the state fire insurance relative to 1,000 currency units of the total building value in column 3, the share of municipalities assigned to fire insurance class 2, 3, or 4 in column 4, the share of municipalities assigned to fire insurance class 4 in column 5, and the average fire insurance class across the district's municipalities in column 6. All regressions are estimated by OLS and include county and year fixed effects. The unit of analysis is the district. Standard errors clustered on the district level in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

In column 2, the dependent variable measures the proportion of buildings damaged by fire that were completely destroyed. Note that the number of damaged buildings was reported separately by degree of destruction only from 1878 onward. Therefore, the sample size in this column is cut in half. Relative to a district in which there are no flammable roofs, in districts with flammable roofs only, this share is 20 percentage points (50%) higher. Although sizable, this difference fails to reach statistical significance.

In column 3, the dependent variable is the amount of fire compensation paid by the state fire insurance relative to 1,000 currency units of the total building value it insures. If all relative to no buildings have flammable roofs, this amount increases by 2.6 currency units (Gulden or Mark, depending on whether before or after the currency reform). Given that the mean value in the overall sample is just 1.3, this means that it doubles.

Columns 4 and 5 explore to what extent wooden and thatched roofs are associated with the prevalence of significant and very large fires. In column 4, the dependent variable is the share of municipalities that experience a significant fire, that is, the share of municipalities that are assigned to a fire insurance class higher than the default class 1 in that year. In column 5, the dependent variable is the number of municipalities that are assigned to fire

insurance class 4, that is, the highest possible insurance class. If all of a district's roofs are flammable relative to all roofs being fire-resistant, the share of municipalities that are at least in insurance class 2 increases by 5 percentage points (or 45%)—a sizable difference, which, however, is not statistically significant. At the same time, the share of municipalities that are in insurance class 4 increases by 4 percentage points, which amounts to a relative increase of 215%. Consequently, wooden and thatched roofs appear to be associated with a much higher likelihood of very large fires in particular.

In column 6, the dependent variable is the district's average fire insurance class over all its municipalities. In districts in which all roofs are flammable this average is predicted to be 0.16 (14%) higher than in districts in which all roofs are fire-resistant.

D Analysis with Interaction Terms

Figure D.1 shows the results of estimating the following regression equation, which separates the effect of a fire by whether a municipality had established a singing or gymnastics club at the time of the fire or not.

$$\begin{aligned} FB_{i,t+h} - FB_{i,t-1} = & \beta_h^{club} D_{i,t} \mathbb{1}(club_{i,t} = 1) + \\ & \beta_h^{\overline{club}} D_{i,t} \mathbb{1}(club_{i,t} = 0) + \\ & \gamma_{d(i)}^h + \gamma_t^h + \delta_1^h ln(population)_{i,t} + \delta_2^h club_{i,t} + \varepsilon_{i,t}^h, \end{aligned} \tag{D.1}$$

where the variables are defined as in Equation 6 and $club_{i,t}$ is a dummy that is one if municipality i has a singing or gymnastics club in t and zero otherwise. The estimation sample is restricted according to Equation 7.

In line with Figure 8, the results suggest that the effect of a fire is centered in those municipalities that already have a singing or gymnastics club at the time of the fire.

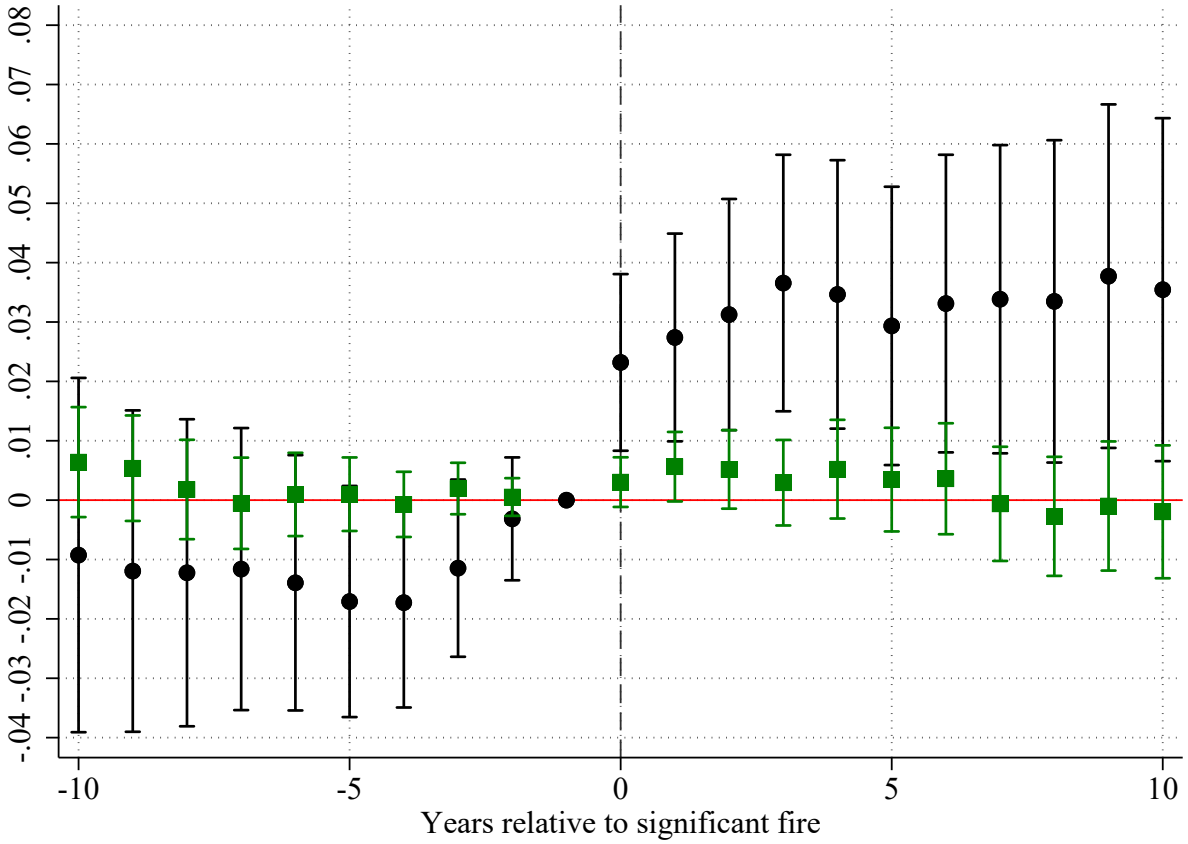


Figure D.1: Effect of Significant Fire on Probability of Having a Fire Brigade with Interaction Terms for Existence of Club

Notes: Figure plots regression coefficients $\beta_h^{\overline{club}}$ in green and β_h^{club} in black of Equation D.1. Estimates are obtained from 20 individual regressions for each $-10 \leq h \leq 10$, $h \neq -1$, restricting the sample according to Equation 7 with $L = 4$. Error bands indicate 95% confidence intervals with standard errors clustered at the municipality level.

E Frequency, Size, and Causes of Fires

In this appendix, we provide additional details on the frequency, size, and causes of fires. Remember that our main data source of fires are lists published by the state fire insurance institution in the government law gazette. These lists specify for each year which municipalities were assigned to insurance classes 2, 3, and 4. Municipalities were assigned to these insurance classes if the total amount of insurance compensation received in this year was more than 0.1, 0.5, or 1.5% of the municipality's total property value, respectively. If fires in a municipality had caused compensation claims of less than 0.1% of its property value, it was assigned to the default insurance class 1. In this case, the municipality is not included in the list. Besides the assignment of municipalities across fire insurance classes 2, 3, and 4, the lists provide the total amount of fire compensation as well as the municipality's overall property value.

In our analysis, we say that a municipality experienced a *significant fire* if it was assigned to insurance class 2, 3, or 4 in that year. In essence, this gives us a *relative* measure of fire activity because it means that fires have destroyed more than 0.1% of the property value in the respective year.[37] Although we cannot tell whether this was due to a single fire or several fires, below we provide evidence which suggests that in most years, the damage must have been caused by just one or two fires.

As another data source of fires, there exists a second type of lists published by the state fire insurance institution in the government law gazette. These lists are at the individual level rather than the municipality level. More specifically, the lists include all citizens who are entitled to receive a compensation together with their name, place of residence, and the exact amount of compensation. Hence, these lists allow us to compute a municipality-level measure of the annual fire compensation. Importantly, this measure includes *all* fires, even those that were small relative to the municipality's total property value. Unfortunately, the individual-level lists are available only for the years 1852 until 1870. Moreover, they do not mention the municipality's total property value, so they only provide an absolute rather than a relative measure of fire activity. This is why we focus on data from the municipality-level lists in the main body of our paper. Nevertheless, the individual-level lists provide interesting insights into how the subset of significant fires differs from the full set of fires.

[37] In fact, the actual property value destroyed is higher because the state fire insurance only covered 80% of the damaged incurred.

Table E.1: Frequency of Fires

	Significant fires				All fires	
	1852-1889		1852-1870		1852-1870	
Fires	Frequency	Cum. %	Frequency	Cum. %	Frequency	Cum. %
0	161	10.2	494	31.3	291	18.5
1	251	26.1	484	62.0	362	41.4
2	261	42.7	303	81.2	304	60.7
3	231	57.3	165	91.7	227	75.1
4	174	68.4	68	96.0	143	84.2
5	140	77.2	37	98.4	90	89.9
6	119	84.8	13	99.2	59	93.6
7	79	89.8	10	99.8	30	95.5
8	60	93.6	1	99.9	16	96.5
9	28	95.4	1	99.9	17	97.6
10	33	97.5	0	99.9	15	98.5
11	10	98.1	1	100.0	6	98.9
12	11	98.8	0	100.0	5	99.2
13	8	99.3	0	100.0	2	99.4
14	4	99.6	0	100.0	0	99.4
15	3	99.8	0	100.0	3	99.6
16	2	99.9	0	100.0	1	99.6
17	1	99.9	0	100.0	3	99.8
18	0	99.9	0	100.0	2	99.9
19	1	100.0	0	100.0	1	100.0
Total	1,577		1,577		1,577	

Notes: Absolute frequency and cumulative percentage share of fires. Columns 2 to 5 are limited to significant fires. In these columns, the absolute frequency gives the number of municipalities that were assigned to fire insurance class 2, 3, or 4 the corresponding number of years over the respective observation period. Columns 6 and 7 consider all fires. In these columns, the absolute frequency refers to the number of municipalities which received any fire compensation in the corresponding number of years over the observation period 1852–1870. Data on columns 2 to 5 are taken from the municipality-level lists published by the state fire insurance agency in the government law gazette. Data on columns 6 and 7 are taken from the individual-level lists published by the state fire insurance agency in the same place.

Table E.1 considers the frequency of fires. Columns 2 and 3 show that three quarters of municipalities experienced at most five significant fires over our observation period. Only 10% did not experience any significant fire. The last two columns consider all fires (i.e., fires of any size). Here, a municipality is classified as having experienced a fire if at least one citizen of that municipality appears in the individual-level list of insurance claimants in that year. Due to the limited availability of these lists, the observation period is restricted

to 1852–1870. For comparison, columns 4 and 5 provide the frequency of significant fires for the same observation period. Given that significant fires are a subset of all fires, years with any fire are more frequent than years with significant fire. Overall, we conclude from Table E.1 that fires were an infrequent event, occurring roughly once per decade. At the same time, the vast majority of municipalities experienced at least one significant fire during our observation period, though.

Table E.2: Size of Fires

	Mean	SD	Min	Median	Max	N
Panel A: Significant fires (1852-1889)						
Compensation (Gulden)	2,934.7	5,787.0	40	1,524	150,635	5,706
Compensation (% of property value)	1.09	2.36	0.1	0.51	70	5,706
Fire insurance class	2.69	0.76	2	3	4	5,706
Panel B: All fires (1852-1870)						
Significant fire	0.56	0.50	0	1	1	3,987
Compensation (Gulden)	1,383.0	3,924.5	0.8	440	98,901	3,987
Fire insurance class	1.94	1.01	1	2	4	3,987
Number of compensation recipients	2.57	4.28	1	1	81	3,987
Panel C: Significant fires (1852-1870)						
Compensation (Gulden)	2,302.1	5,028.9	40	1,120	98,901	2,218
Compensation (% of property value)	1.09	2.20	0.1	0.5	47	2,218
Fire insurance class	2.68	0.77	2	2	4	2,218
Number of compensation recipients	3.29	5.32	1	2	81	2,218

Notes: Table provides descriptive statistics on the size of fires. Panel A considers municipality-year observations in which the municipality experienced a significant fire, that is, was assigned to insurance class 2, 3, or 4. Panel B considers municipality-year observations in which the municipality experienced at least one fire of any size. As Panel B is limited to 1852–1870, Panel C provides statistics on significant fires for the same observation period. Compensation is the total value of insurance compensations caused in that year. It is provided in Gulden and, if data on total property value is available, as a share of total property value. Monetary values after the currency reform in 1875 are transformed back to Gulden. Fire insurance class is the insurance class to which the municipality was assigned in that year. The number of compensation recipients gives the number of citizens for whom an insurance claim arose in that year.

Table E.2 provides descriptive statistics on the size of fires. Panel A considers municipality-year observations in which the municipality was assigned to insurance class 2, 3, or 4. The distribution of the monetary value of insurance compensations is strongly right-skewed, which is reflected in the median being much lower than the mean. Panel B considers municipality-years in which the municipality experienced at least one fire of any size. In a little more than half of these years, the compensation is high enough for the year to be classified as a year with significant fire. For comparison, Panel C provides summary statistics for municipality-year

observations with significant fire over the same observation period (1852–1870). As shown in Panel B, the median number of compensation recipients is just one. This implies that if a municipality experiences a fire, it is usually just one per year. Given that significant fires are relatively larger, the median number of compensation recipients is two. Although a little higher, this shows that even in a year in which a municipality is assigned to insurance class 2, 3, or 4, this usually is due to just one or two fires.

Further evidence that a municipality is usually hit by at maximum one or two fires per year can be obtained from the Statistical Yearbook for the Grand Duchy of Baden. The Yearbook lists the number of fires and the number of affected municipalities for each district. Between 1868 and 1877, the district median for the number of fires divided by the number of affected municipalities is just 1.2.

Table E.3: Causes of Fires

Cause of fire	Share	Share of fires with known cause
Arson	6.0%	10.6%
Negligence	17.2%	30.4%
of which by children	6.2%	10.9%
Defective or faulty firing systems	16.3%	28.9%
Fire-hazardous business operations	2.5%	4.4%
Explosion	0.8%	1.5%
Coincidence or self-ignition	2.9%	5.1%
Lightning strike	10.8%	19.2%
Unknown	43.6%	
Number of fires	10,465	5,906

Notes: Table shows the relative frequency of the causes of all fires that occurred between 1868 and 1889. Data is taken from the Statistical Yearbook for the Grand Duchy of Baden (Statistisches Bureau Baden 1869–1891).

Table E.3 deals with the causes of fires. Data is taken from the Statistical Yearbook for the Grand Duchy of Baden (Statistisches Bureau Baden 1869–1891). As this Yearbook was published only from 1868 onward, Table E.3 is limited to the causes of fires that happened after that year. In total, there were 10,465 fires between 1868 and 1889. For a little more than half of the cases, a cause for the fire was noted. The most frequently cited cause is negligence, which in turn is attributed to children in a third of cases. Of similar relevance as a cause of fire are defective or faulty firing systems. Another fifth of the fires with know cause was attributed to a lightning strike.

One may wonder whether steam boilers have played a role as cause of fires. The major

hazard with steam boilers, however, was explosions rather than fires. Although such explosions did occur, their number was low. Data on steam boilers and explosions are available from the Statistical Yearbook for the Grand Duchy of Baden but only from 1875 onward. According to this source, there were 1,120 steam boilers in Baden in 1875. The number of steam boilers increased to 2,475 in 1889, of which roughly a third were located in the districts of Karlsruhe and Mannheim alone. Most importantly, over the period 1875 until 1889 there was only a single explosion in Baden. Steam boilers hence most likely did not represent a major source of fire during our observation period.

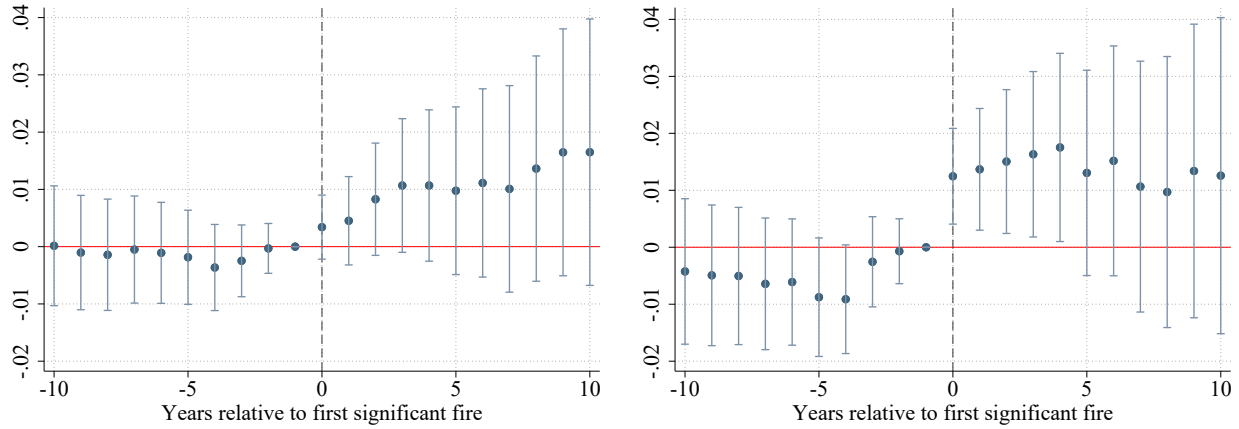
Cathiau (1876) is another interesting source that offers insights into the causes of fires. He presents a table of all the 100 fires in which the volunteer fire brigade of the city of Karlsruhe was involved from its foundation in 1847 until 1876. According to this table, there were 26 major fires (including attic fires), 39 medium-sized and small fires (especially chimney fires), 7 basement fires, and one forest fire. In addition, the volunteer fire brigade responded to 27 fires in neighboring municipalities. Most of the fires occurred in residential buildings or in the workshops of craftsmen. Although Karlsruhe was the second largest city of Baden (after Mannheim) and one of the most industrialized centers, only 10 fires took place in factories.

F Effect of First Fire

In this appendix, we estimate the effect of the first significant fire after the start of the observation period on the probability of having a fire brigade. In the first step, we continue to estimate the LP-DiD specification of Equation 6, with the treatment dummy $D_{i,t}$ re-defined to be one if municipality i experiences the first significant fire after the start of the observation period in year t and zero otherwise. Following Dube et al. (2023), we adjust the clean control condition in the following way:

$$\begin{cases} \text{treated} & D_{i,t} = 1 \text{ and } (D_{i,t-j} = 0 \text{ for } j \geq 1) \text{ and } FB_{i,t-10} = 0, \\ \text{clean controls} & (D_{i,t-j} = 0 \text{ for } j \geq -h) \text{ and } FB_{i,t-10} = 0. \end{cases} \tag{D.2}$$

Importantly, we no longer impose an effect stabilization assumption. Restricting the sample according to Equation D.2 yields the estimation results presented in Figure F.1.



(A) Effect of first significant fire after 1852 (B) Effect of first significant fire after 1860

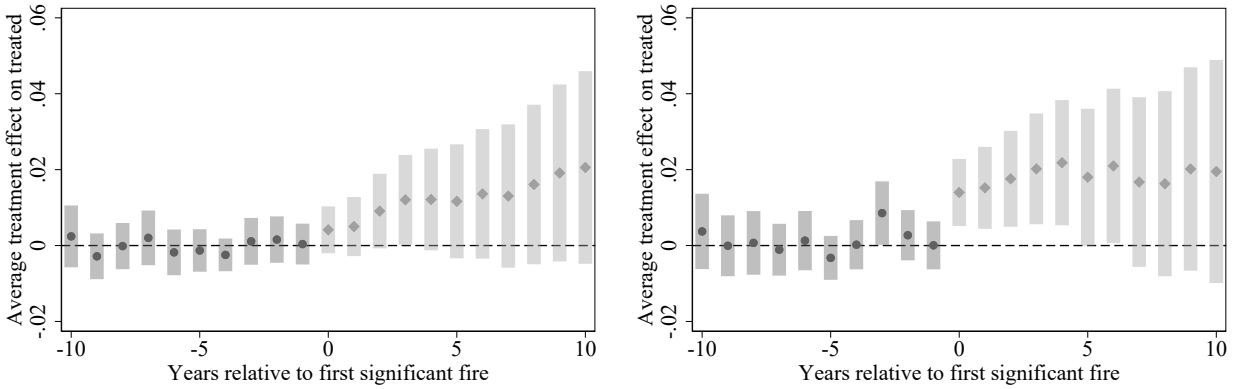
Figure F.1: Effect of First Fire on Probability of Having a Fire Brigade (LP-DiD)

Notes: Figure plots regression coefficients β_h of Equation 6 when $D_{i,t}$ is a dummy that is one if municipality i experiences the first significant fire after the start of the observation period in year t and zero otherwise. Panel A considers the effect of the first significant fire since 1852, while Panel B considers the effect of the first significant fire since 1860. Estimates are obtained from 20 individual regressions for each $-10 \leq h \leq 10$, $h \neq -1$, restricting the sample according to Equation D.2. Error bands indicate 95% confidence intervals with standard errors clustered at the municipality level.

In Panel A, which looks at the effect of the first fire in the full observation period, coefficients in the post-treatment period are estimated to be positive but insignificant. This

likely is due to the fact that few fire brigades were established in the 1850s so that few of the fires considered in this sample had an effect. In the 19th century, clubs generally could be established only after obtaining consent from the government. After the failed German revolution of 1848-1849, the political climate was rather restrictive in this regard. Only after a more liberal political phase began in Baden in 1860, the so-called New Era (*Neue Ära*), the founding of new associations was subject to virtually no restrictions anymore (Becht, 2009). Panel B therefore considers the effect of the first fire since 1860. Here, the medium-term effect of the fire on the probability to have a fire brigade is estimated to be large in size and statistically significant. In fact, the immediate effect in the year of the fire is even larger than the effect we found in applying our main empirical strategy in Figure 7.

As additional robustness check, we study the effect of the first fire using the heterogeneity-robust difference-in-differences estimator proposed by Callaway and Sant'Anna (2021). We implement their estimator using the Stata package *csdid*. As in our LP-DiD specification, we control for the log of population and drop from the sample all municipalities that already had established a fire brigade at the beginning of the observation period. We use both not yet treated as well as never treated observations as control group. Figure F.2 presents the results, again separately for the effect of the first fire since 1852 (Panel A) and the first fire since 1860 (Panel B). Essentially, the results are the same as those obtained applying the LP-DiD approach. The first fire is estimated to increase the probability of having established a fire brigade but significantly so only when considering the period since 1860.



(A) Effect of first significant fire after 1852 (B) Effect of first significant fire after 1860

Figure F.2: Effect of First Fire on Probability of Having a Fire Brigade (Callaway and Sant'Anna, 2021)

Notes: Average treatment effect of first fire since 1852 (Panel A) or since 1860 (Panel B) using the estimator by Callaway and Sant'Anna (2021). Control group consists of municipalities never treated or not yet treated. The estimation includes the log of population as control variable.