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ABSTRACT

We explore the role that large fires played in the early developed of the fire insurance industry of pre-WWII Japan. To this end we construct a prefecture level data set spanning thirty years. Our econometric results show that large fires led to an increase in new policies and policy renewals, a result that is in line with historical narratives that insurance companies used these events to advertise their business. We also show that this subsequent surge in renewals and new policy holders led to more fraudulent behaviour by increasing the number of small fires due to arson, whereas there was no effect on unintentionally set small fires. While we are unable to identify whether this was due to adverse selection of new policy holders or moral hazard behaviour of existing ones, anecdotal evidence that is more likely to have been the latter.

Key words: Fire insurance, Disaster, Moral hazard, Adverse selection, Japan

JEL classification numbers: G22, G52, N25

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1. Introduction

Non-life insurance is a common device to cover property risks and thereby enhance incentives for investing in property. In this regard, fire insurance, one of the major sub-categories of non-life insurance, has its origin in late seventeenth century Britain. More specifically, the first private fire insurance company, the Fire Office, was created after the London Great Fire in 1666, a fire that started in a bakery and destroyed over 13,000 buildings living around 80 per cent of the City of London homeless. In the seventeenth and nineteenth centuries, the British fire insurance industry further expanded, insuring newly developed industrial factories, including textile, sugar refinery and brewery, as well as dwellings, and leading to faster growth than in any other sector or the macro economy (Raynes 1964; Pearson 2004). This impressive rise in the fire insurance industry can be explained by both demand side drivers, such as population growth and the development of industries with high fire risks, as well as supply side factors, like expansion of agency networks, improvement of risk assessment techniques, international reinsurance and the establishment of a cartel that stabilized fire insurance market (Raynes 1964; Cockwell and Green 1976; Pearson 2004; Gonzalez and Andersson 2018). Nevertheless, while the Great Fire of London in 1666 has been widely accepted as the starting point of fire insurance, the role that large fires have played in creating the need of insuring for fire risk and the possible implications of this, has, to the best of our knowledge, not yet been systematically examined. One likely reason for this may be the lack of data on both large fires as well as fire insurance during the early stages of the development of fire insurance in most countries. In this paper we intend to address this issue by exploiting such data for early twentieth century Japan.

The modern fire insurance industry started in Japan in 1888, when Tokyo Fire Insurance Co. was founded. Importantly for our analysis, data on large fires as well as on fire insurance are systematically available at the prefecture (regional) level just shortly after this, i.e., for the early 20th century. Moreover, since large fires at the time occurred not only because cities tended to be dense neighbourhoods with many wooden houses, but also because of unpredictable weather conditions, such as strong winds and earthquakes, they can arguably be viewed as exogenous events. In addition to exploring whether these large fires increased the take-up of fire insurance, we further examine whether in this early learning phase there was any impact on policy holder behaviour in terms of moral hazard and/or adverse selection. More specifically, based on the results of the fire insurance demand analyses and the condition that a large fire was exogenous, we instrument fire insurance by large fires to be able to identify the impact of fire insurance on the number of subsequent unintentional and arson caused small fires.

While our paper aims at contributing to understanding the historical process of fire insurance development and its implications, it is also related to a wider literature. Many recent studies have investigated how individual characteristics, such as time preference and risk attitude, are affected by the damage induced by large-scale natural disasters. For example, several studies observed that risk preference decreased after an event (Eckel et al., 2009), while some discover an increase in the taste for risk (Cameron and Shah, 2015; Hanaoka et al. 2018). In terms of time preference, Akesaka (2019) found that the Great East Japan Earthquake of

2011 increased present bias in spite of no significant impact on the time discount factor, whereas Callen (2015) shows an increased time preference after the Indian Ocean Earthquake of 2004. Furthermore, there is evidence that people in damaged areas sometimes display time inconsistent behaviours such as procrastination (O'Donoghue and Rabin, 1999). However, in spite of these significant impacts of large scale natural disasters on people's behaviours, risk attitudes, and time preference, the number of previous studies focusing on insurance and natural disasters is rather limited. In this regard, it has been shown that residents with high risk of natural disasters tend to be overoptimistic in insurance choice (Royal and Wall, 2019) and have remarkably low willingness to pay (Wagner, 2022) and the number of new insurance policies temporarily increased just after natural disasters (Trumbo et al., 2011; Asservatham et al., 2013, Atreya et al. 2015, Gallagher, 2014, Kamiya and Yanase, 2019).[1] Gallagher(2014), using US community level insurance data, found that the area damaged by floods, as well as the areas within the same TV network covering these floods, sharply increased new policies, but steadily declined to its baseline after only a few years. Atreya et al. (2015) found similar results on flood insurance on damaged area in Georgia in US, as did Kamiya and Yanase (2019), using new policies of earthquake insurance at the Japanese prefectural level in the 1990s to 2010s.

In examining the impact of natural disasters on insurance we focus on the historical period of 1910 to 1940 using the Japanese regional data. Exploiting this historical context has a number of advantages. First, people's access to information was limited, where during our time period the main sources in Japan were newspapers, with the radio, telephone, and telegram only emerging in the 1920s. In contrast, nowadays, mass-media (e.g., TV, radio, newspapers,

[1] Kamiya and Yanase (2019) found that the Kobe Earthquake of Japan in 1995 temporarily increased insurance take-up. This indicates that people tend to forget about the danger of natural disaster in a short period.

magazines), SNS, and personal information access (e.g., telecommunication, internet access) play an important role in affecting people's risk attitude and time preference in many ways, which might result in a possibly only temporary increase in insurance demand. Therefore, our sample period allows us to reduce potential biases such as information bias by mass media and more directly measure the impact of natural disasters on insurance purchases. Second, the 1910s to 1940s period saw many large scale disasters over Japan, including the Great Kanto Earthquake of 1923. At the same time this period was also characterized by an underdevelopment of government aid policies and anti-disaster infrastructure spending. For example, the nation-wide disaster-aid policies only started after the Ise Bay Typhoon of 1959 in Japan (Okubo and Strobl, 2021). As shown in Tesselaar et al. (2022), sufficient government aid policies made can bias risk attitude, and reduced insurance purchase in the high risk areas, due to what is commonly known as charity hazard.[2] In this sense, our historical data not only provides us with a set of arguably quasi-natural experiments, but also allows us to reduce biases from interventionist government's risk mitigation and management policies.

The results from our empirical analysis show that not only did large fires in Japan in the early part of the 20th Century increase insurance claims, as would be expected, but also induced a greater number of fire insurance policy holders. One consequence of this rise in policy uptake may have been a change in risk behaviour. To explore this we also investigate whether the impact on policies through large fires may have affected the number of small fires. Our results show that this was indeed the case in that the number of small fires due to arson

[2] Kousky and Michel-Kerjan (2015) studied the impact of federally managed National Flood Insurance Program from 1978 to 2012 on claims (e.g. frequency, values, and over-time change) in the United States.

increased as response, possibly indicative of moral hazard, whereas there was no impact on small unintentional fires.

The remainder of the paper is organized as follows. In the next section we outline the historical context of our study period in terms of the fire insurance and fires in early twentieth century Japan. We describe our data and provide summary statistics in Section 3. Section 4 provides the econometric analysis of large fires on fire insurance, while we examine the impact of fire insurance take up due to large fires on small fires in Section 5. Concluding remarks are provided in the final section.

2.Historical Background

2.1 Insurance System in Japan

The modern insurance system in Japan dates back to the late nineteenth century. When Tokugawa Shogunate abandoned the seclusion policy to open international trade under military pressure of the United States in 1859, foreign companies ran property insurance business at treaty ports, and after the Meiji Restoration in 1868, Tokyo Marine Insurance Co. was founded as the first Japanese modern insurance company in 1879. While Tokio Marine Insurance Co. was specialized in the marine insurance business, in 1881 Meiji Life Insurance Co. was established to offer life insurance. Then, in 1888, Tokyo Fire Insurance Co. was created to start the fire insurance industry (Innnan ed., 1966. p.227, 236, 266-267; Tokio Marine and Fire Insurance Co. 1979, pp.130-131; Kon and Kitazawa eds. 1944, p.1).

Figure 1 provides an overview of the development of the fire insurance industry in Japan. Following Tokyo Fire Insurance Co., many firms entered the fire insurance industry in the 1890s. Indeed, the number of fire insurance companies increased to be twenty in 1900, and the number and the value of fire insurance contracts in force multiplied over 57.1 times from 1890 to 1895 and 7.9 times from 1895 to 1900. The institutional background of this sharp increase in fire insurance companies is that there was no entry regulation for insurance business until the Insurance Business Law of 1900 introduced a licensing system and inspection by the government, while it prohibited that a company simultaneously could offer life insurance and property insurance (Innnan ed. 1966, pp.274-275; Tokio Marine and Fire Insurance Co., 1979. pp.161-162). After the enactment of the Insurance Business Law, the number of fire insurance companies stabilized, although the fire insurance business continued to grow, as indicated by the number and the value of fire insurance contracts in force.

Figure 1

Expansion of the fire insurance industry in the late nineteenth and early twentieth centuries reflected progress of industrialization in Japan in that modern industries and large companies considerably increased the demand for fire insurance. For example, Tokio Marine and Fire Insurance Co (1979) noted that cotton spinning firms, leading Japan's industrialization in its early stage, purchased fire insurance policies for their factories (p.144). Also, Kon and Kitazawa eds.(1944) stated that the rise of the silk weaving industry in Fukui Prefecture increased the demand for fire insurance (pp.17-18). During World War I Japan enjoyed a large economic boom because production capacity of major Western countries was mobilized for the war, and this boom boosted the development of the fire insurance industry in Japan. As shown in Figure 1, in the late 1910s the number of fire insurance companies more than doubled, and the growth of the number and value of fire insurance contracts in force accelerated. That is, the value of fire insurance contracts in force were around five times larger in 1920 compared to 1915.

In the 1920s the Japanese economy experienced a long stagnation because of the resumption of international competition with Western countries, large investment in equipment during WWI, and the appreciation of the Yen real exchange rate (Okazaki 1997). This affected the fire insurance industry by lowering its growth rate, although it still continued to grow, as reflected by the number and value of fire insurance contracts in force (Figure 1). Figure 2 depicts the number of buildings burnt down, estimated total damage by fires, and the fire insurance claims paid, excluding 1923, i.e., the year of the Great Kanto Earthquake, which importance is described in greater detail below. While the number of buildings burnt down tended to decrease from the late 1910s, the estimated total loss by fires increased substantially. At the same time, fire insurance claims paid increased as well, and became almost equal to the total estimated loss. This suggests that the fire insurance system developed enough to cover fire risk in Japan.

Figure 2

In the process of development of the fire insurance system in Japan, the impact of large fires is notable. As emphasized below, Japan experienced many large fires. A basic reason for this is that cities in Japan were crowded with numerous small wooden houses that easily caught fire and hence, under the right circumstances, could spread to become larger fires. When they did occur, large fires contributed to the expansion of the fire insurance system both from the demand and the supply side. The impact from the demand side can be illustrated by the case of a large fire in Kanda Ward of Tokyo City in 1892, where 4,252 buildings were burnt down. Concerning the loss by this large fire, Meiji Fire Insurance Co., paid insurance claims according to the contracts, and "as a result, recognition on fire insurance and reputation of Meiji Fire Insurance Co. were improved, which in turn increased fire insurance contracts of Meiji Fire Insurance Co. rapidly after the large fire" (Tokio Marine and Fire Insurance Co. 1979, p.143, the authors' translation). Moreover, large fires took place in Toyama City in 1899 and Takaoka City in 1900, where more than 5,300 and 3,500 buildings were burnt down, respectively. Kon and Kitazawa eds. (1944) notes that "due to frequent large fires, recognition on insurance diffused and insurance demand increased" (pp.17-18, the authors' translation)[3].

Many fire insurance companies also tended to utilize the events of large fires for good advertisement purposes. For instance, after the large fire in Kanda Ward in 1892, Meiji Fire Insurance Co. put the following advertisement in a major newspaper (*Yomiuri Shinbun*, November 16, 1892):

> A person would experience various unfortunes and disasters in his life. If he is not usually careful, he cannot avoid losing his assets and house. Above all the fire in Sarugaku-cho, Kanda Ward on April 10, has made clear that a fire is most terrible disaster. As fires are more frequent in winter, you should not hesitate to buy insurance even for a day (authors' translation)

[3] More generally, an article in a major journal on banking and insurance (*Ginko Hoken Jiho, Journal of Banking and Insurance*) wrote "human minds are so strange that people make a rope after looking at a thief. Like this, every year many people tend to purchase fire insurance policies in months with many fires". (p. 5, October 15, 1904).

The impact of large fires on the fire insurance system from the supply side was arguably large because the payment of insurance claims motivated fire insurance companies to sell more insurance policies (Innan ed. 1966, p.274). Tokio Marine and Fire Insurance Co. (1979) stated that a number of large fires in the late 1900s and the early 1910s had caused serious losses to fire insurance companies, and "consequently competition to acquire insurance contracts became harsh and they aggressively lowered insurance rates" (p.270, the authors' translation).

Finally, in the history of the fire insurance industry in Japan, the Great Kanto Earthquake in 1923 was an episode that cannot be overlooked. The Great Kanto Earthquake caused serious human and physical damage, especially in Tokyo and Yokohama Cities, where the estimated physical damage amounted to around 35.5% of Japan's GNP in 1922 (Imaizumi, et al. 2016). It is notable that most of the damage was because of the fire caused by the earthquake (Tokyo City Office 1925b, p. 1). More precisely, as a result of the earthquake fires almost simultaneously broke out at 69 places or more in Tokyo City, due to inflammable materials, ovens, braziers, etc., and these fires expanded rapidly to neighborhoods crowded with wooden houses. Furthermore, damage to the water supply infrastructure due to the earthquake weakened the capacity of fire extinction (ibid, pp.1-9) .

The loss of physical assets of policy holders of fire insurance policy holders of Japanese companies due to the 1923 Kanto Earthquake has been valued at 2,230 million yen, which was around 10 times larger than their capital (Innan ed., 1966, pp.313-314). Although the existing fire insurance contracts clearly granted exemption from paying claims for losses caused directly or indirectly by an earthquake, because of the pressure from the public and the government, fire insurance companies nevertheless agreed to pay 10% of the insurance amount in the name of "solatium", financed by long-term and low interest loans from the government (ibid, pp.315-316). Importantly, the extent of the fire after the Great Kanto Earthquake newly impressed the need for a fire insurance system to the Japanese public (ibid., 332).

2.2 Large fires: Case of Hakodate Large Fire of 1934

A lot of large fires other than the 1923 Kanto Earthquake, where hundreds of buildings were burnt down, happened in prewar Japan. These large fires were generally caused by natural disasters and/or weather conditions within the context of neighborhoods dense with wooden, easily flammable houses. In this regard, the large fire caused by the Great Kanto Earthquake, 1923 was the largest in the history of Japan, where more than 381 thousand buildings were burnt down (Tokyo City Office 1925, p.161). This was a typical large fire due to a natural disaster.

The second largest fire in twentieth pre-war Japan, Hakodate Large Fire, 1934, where 23 thousand buildings were burnt down, was a fire caused by a storm. Hakodate City is one of the early opening port cities in Japan and has a center of foreign trade, fishery, and commerce, and is located in Hokkaido, Northern island, and faces the Tsugaru Strait. It has longer winters and more snow and gusty winds than average Japan. Hakodate experienced several large fires until the 1930s. Among these, the large fire of 1934 was the most serious. More precisely, on March 21st, 1934 a spring storm hit Hakodate, where a low pressure zone approached and air pressure at Hakodate drastically decreased by more than 20 hPa. Then strong winds browed, reaching a maximum speed of 39m/s, resulting in the collapse of some wooden buildings. At

6:53 pm, a fireplace at a downtown wooden house collapsed due to the strong wind, causing fire. Strong winds spread this fire almost immediately, resulting in more than 20 neighbouring wooden building areas burning down and creating flying sparks to further spread the fire. In the end, 30% of the total city area was burnt down. (Hakodate City, 1997. pp728-730).

As illustrated by the case of Hakodate Large Fire, 1934, large fires in twentieth century pre-war Japan tended to be originally small fires, but rapidly spread as a consequence of adverse weather condition, e.g., strong wind, dry air, etc., as well as by the structure of a city with numerous crowded wooden buildings. The fact that exogenous natural conditions were a necessary condition for a large fire is essential to the identification strategy of this paper.

2.3 Moral Hazard and Adverse Selection Behaviour

. Usually moral hazard by fire insurance is a phenomenon that an insured person tends to draw less care of fire, causing more unintentional fire. There may be the case of such usual moral hazard, but we find anecdotal evidence of more aggressive moral hazard. That is, a major trade magazine of the insurance and banking industries, *Hoken Ginko Jiho,* reported a number of cases that insured persons set fire on their own houses intending to get insurance money. For example, an article in that magazine on August 21, 1905 reported:

> Tokyo Metropolitan Police Department told that arson cases or suspected cases of arson have increased in Tokyo recently, and that these cases were supposed to be caused by that fire insurance companies competed each other to have larger amount of contracts and hence they made contracts that insured value larger than the real value of the object (authors' translation).

It is noted that this kind of aggressive moral hazard was observed even in the 1930s. The editorial article of *Hoken Ginko Jiho* on November 27, 1931, stated:

> Arson cases in the territory in charge of the Tokyo Public Prosecutors' Office have increased almost twice this year, and will be 300 cases by the end of the year. 80% of these arson cases aim at fire insurance imposture (authors' translation).

Second, as shown in Table 3, new and renewed policies after the big fires increases small fires, but only those identified as arson. This implies high risk persons tend to join the insurance after the large fires. Large amount of paid claims after the big fires attract riskier persons to fire insurance. Such risk takers purchased insurance, causing more small fires to get large claims. This result is interpreted as adverse selection.

3. Data & Summary Statistics

3.1 Data

Our insurance data are taken from Hoken Nenkan (Yearbook on Insurance), which was published annually and provides information on fire insurance at the prefectural level from 1910 to 1940. More specifically, for each prefecture yearly information on the number of active policies, the number of claims, and the number of new and renewed policies is recorded. The data constitutes a balanced panel except that information is missing for 1923 because of the Great Kanto Earthquake.

The information on large fires is taken from the database of Yomiuri Shinbun Newspaper, one of the largest nation-wide newspapers in Japan. To identify large fires we searched articles for the keyword, "Taika" (a large fire in English), and identified the year and location (prefecture) of large fires where 300 or more buildings were burnt down. The data on small fires are taken from *Statistical Yearbooks of the Japanese Empire (Dai Nihon Teikoku Tokei Nenkan)* and S*tatistical Report of the Home Ministry (Naimusho Tokei Houkoku)* published by Ministry of Internal Affairs, which provide information on the number of small fires (unintentional fires and arsons) at the prefectural level for each year.

Finally, we also generate prefecture level population figures from the Population Census (Ministry of Internal Affairs). While from 1920 onwards these are available annually from the Population Census, prior to this year these figures are only available in 1890, 1913, and 1918. For this earlier period we thus linearly interpolate the numbers to obtain annual equivalents. Given that a large part of the data is only interpolated, and thus is unlikely to reflect any year to year variations in population, we only use these for summary statistics rather than for our econometric analysis.

3.2 Summary statistics in large fires and fire insurance policy variables

Summary Statistics for all our variables are provided in Table 1. One should note that while since we allow for lagged effects of large fires in our econometric analysis, these summary statistics are for the entire period from 1903 until 1938, for all other variables these are defined for the common sample period of 1909 until 1938, excluding 1923 (when no data are available). In terms of the average number of large fires the mean value is 0.08, suggesting an annual average 8 per cent chance of a large fire occurring within a prefecture. However, the standard deviation is multiple times its mean, indicating that this probability varies widely. This is also apparent from Figure 1, where we depict the regional variation of the number of large fires. Accordingly, Hokkaido (1), Tokyo (13), Niigata (15), Shizuoka (22), Ishikawa (17), Aomori

(2), Akita (5), and Miyagi (4) are the group of high probabilities. In Hokkaido (1), Hakodate City of Hokkaido, often suffered large fires in our sample period, where, for example, 8977 , 1532, 1763, 2141 buildings were burnt own in the large fires of 1907, 1913, 1916, 1921, and 1934, respectively. In particular, as mentioned above, the large fire of 1934 in Hakodate city burnt down 33% of the city, where 2,166 died. Shizuoka prefecture (22) also had some city-wide fires. For instance, in 1913, Numazu city had a big fire with 9 dead and 168 injured and 1,468 burnt buildings, while in 1940, Shizuoka city had a big fire. 5,229 buildings were burnt down with one dead and 788 injured. Tokyo City (13), characterized by the largest population and the highest population density, had many big fires since the Edo period (17^{th} to 19^{th} century). In our sample period, Asakusa Ward of Tokyo City had a big fire in 1921. 1,277 buildings were burnt down. Subsequently, when the Great Kanto Earthquake of 1923 hit Tokyo, 100% of Nihonbashi Ward and more than 90% of areas in Asakusa, Honjo, and Kanda Wards of Tokyo City were burnt down.

For our fire insurance variables, in order to roughly take account of potential differences in prefecture level demand, we have normalized these by the interpolated prefecture level population numbers to show their summary statistics in Table 1. In terms of the number of claims made by fire insurance policy holders there are on average 1.2 per every 1,000 inhabitants in a prefecture. Again, however, the number of claims varies widely as its standard deviation is more than double the mean. Examining the number of new policies and policy renewals it is noteworthy that these are large relative to the number of active policies, and thus indicate that policies tend to be short-lived (e.g., less than 1 year), but likely renewed and/or that there is a lot of turnover in policy holders.[4] More precisely, there are about 137 per thousand population policy renewals and new policies per year at the prefecture level.

Figure 5 depicts the trends in the prefecture annual average number of active policies, claims, and new and renewed policies, each normalized by thousands of population (trend lines), along with the average number of large fires (red bars). As is apparent, from 1918 onwards there was a continuous increase in the number of policies relative to the population size (green line of Panel (a)) until about 1925, where a plateau persisted until the end of the 1935, after which the per capita policy take up began to rise again. Claims (blue line of Panel (b)) started rising in a similar manner around 1918, but then experienced a stark rise a year after the 1923 Kanto earthquake for several years. While somewhat volatile, this increase continued until 1930, after which it more or less flattened. The prefecture level number of new and renewed policies (orange line of Panel (c)) display a similar pattern as that of policies in force, except for a short period between 1930 and 1934, where the former appears to be slightly more volatile.

The average number of large fires, displayed as red bars in Figures 5, has no trend emerging over time. Rather, during the period prior to 1915, prefectures appear to have on average experienced more large fires than thereafter. The highest average number of large fires occurred in 1932 and 1919, with some periods experiencing close to none. In terms of seeking to identify any correlations between the large fire time series and the insurance variables there appears to be some visual coinciding increases in the insurance series and peaks in large fire numbers, although only weakly so.

[4] Unfortunately the information provided in Hoken Nenkan does not allow us to distinguish between these two categories.

4. Impact of Large Fires on Insurance

4.1 Econometric Specification

In order to estimate the impact of large fires on the fire insurance industry we specify the following:

$$\boldsymbol{INS}_{it} = \beta_0 + \sum_{j=0}^{5} \beta_{FIRE_{t-j}} FIRE_{it-j} + \beta_{POP} POP_{it} + \beta_{TREND} TREND_{it} + \gamma_t + \mu_i + \varepsilon_{it} \quad (1)$$

where *i* and *t* indicate subscripts for prefecture and year, respectively. ***INS*** is a vector consisting of the number of claims, the number of active policies, and the number of new and renewal policies. *FIRE* is the number of incidences of large fires in a prefecture, where we allow for it to have both a contemporaneous impact (*j=0*) as well as lagged impacts up to 5 years after the events (*j=1, …, 5*). Additionally we control for year specific fixed effects *(γ)*, prefecture fixed effects (μ), and prefecture specific time trends (*TREND*). In all specification we cluster standard errors at the prefecture level.

Given the count nature of the dependent variables included in ***INS*** we estimate Equation (1) using a Poisson fixed effects estimator with robust standard errors, which has the advantage of being suitable to a number of different common count data features, including under-dispersion, over-dispersion, and a large number of zeros (Woolridge, 1999). Since spatial dependence, if time varying, is a possible threat to the estimation of the correct standard errors in a fixed effects Poisson estimation, we investigate the possible existence of such spatial correlation for each count model using the test developed by Bertanha and Moser (2016). One should finally note that the coefficients generated from a fixed effects Poisson estimator are interpreted as semi-elasticities.

4.2 Econometric Results

We first tested whether there was time varying spatial correlation present in estimating Equation (1) for our three fire insurance policy variables. However, the resultant test statistics did not indicate such and we thus proceeded using the fixed effects Poisson estimator with robust standard errors.[5] The results of estimating (1) for all properties for the number claims, active policies, and new and renewed polices are shown in terms of the estimated coefficients and 95 per cent confidence band on *FIRE* and its lags in Figure 6. Accordingly, there is a relatively large and significant positive impact on the number of claims in the year of the fires, and then a much smaller one at *t-2*. Taking these coefficients at face value suggests that in the year of its occurrence a large fire increases the number of claims in a prefecture by 24.2 per cent, while the largest observed number of large fires in any year in our sample period would have increased the number of claims by over 120 per cent. Moreover, two years after a large fire, claims further increase by a little over 10 per cent. There is also a relatively small fall in claims 5 years after the event(s), suggesting that claims fall by a little over 5 per cent.[6]

Examining the number of active policies one finds that large fires have a persistent positive impact until 4 years after their occurrence. This impact is relatively small, however, ranging from between 2.4 (t-1) to 5.4 (t-3) per cent for a large fire. The effect on new policies and renewals also persists until t-4, although the estimated coefficient is only significant at the ten

[5] The resultant test statistics was 9.77, 10.58, and 9.24 for the number of claims, the number of active policies, and the number of new and renewed policies, respectively, and hence we were in all cases unable to reject the null hypothesis of no time varying spatial correlation.

[6] One should note that we also experimented with including further (up to 8) lags of the number of large fires. Even with the subsequent loss in sample size, the results remained essentially the same as with our base specification. Moreover, further lags were never significant for any of the fire insurance variables.

per cent level at t-3. Importantly, the estimated impact, except for at t-4, is always larger compared to active policies. The largest observed impact on new and renewed policies is one year after a large fire, standing at 12 per cent for a single event.

5. Impact of Fire Insurance on Small Fires

5.1 Small fires

The summary statistics in Table 1 indicate that on average there are about 375 small fires annually in a prefecture.[7] However, as with large fires, there is a large variation in these measures across prefectures and time. Decomposing the number of small fires into those identified as caused by acts of arson and others, shows that a majority (over 93 per cent) of small fires were deemed to have been due to non-arson reasons. In Figure 8, we show the evolution of these variables (normalized by prefecture level population). As can be seen, on average the number of small fires (blue line of Panel (a)) has fallen since 1912, reaching a trough in 1917, to increase with some volatilities until 1926. After 1926 the number of small fires, however, appears to have started a declining trend. Unsurprisingly, given their dominance in the total figures, the number of non-arson caused small fires follows an essentially identical pattern (purple line of Panel (b)). In contrast, arson induced small fires appear to have been on a falling trend until 1924 after which they have increased relatively sharply (green line of Panel (c)). In the last years of our sample period, however, they have been again in decline.

[7] Tsubo is the traditional measure of area in Japan and is equal to 39,600 m^2.

5.2 *Econometric Specification*

In order to take into account of the potential endogeneity of new and renewed policies (*NEW*) in causing small fires, we instrument these with the occurrence of large fires. More specifically, we undertake an instrumental variables (IV) strategy where in the first stage fire insurance are instrumented with the occurrence of the number of large fires. Since our earlier analysis showed that the impact of the latter was up to four years after the event our first stage consists of re-estimating Equation (1) using a fixed effects Poisson estimator but only including lags of *FIRE* up to t-4:

$$NEW_{it} = \beta_0 + \sum_{j=0}^{4} \beta_{FIRE_{t-j}} FIRE_{it-j} + \beta_{POP} POP_{it} + \beta_{TREND} TREND_{it} + \gamma_t + \mu_i + \rho_{it} \quad (2)$$

In the second stage we then include the linear prediction of Equation (3):

$$SMALLFIRE_{it} = \beta_{\widehat{NEW}} \widehat{NEW}_{it} + \beta_{POP} POP_{it} + \beta_{TREND} TREND_{it} + \gamma_t + \mu_i + \pi_{it} \quad (3)$$

where $\widehat{NEW}$ is the predicted value of new policies and *SMALLFIRE* is the number of small fires as the dependent variable in the second stage. We also split small fires into those caused unintentionally and those due to arson. Given that the count nature of these proxies again require the use of a fixed effects Poisson estimator in the second stage a standard IV approach of including predicted values in (4) is no longer appropriate. Instead we use the control function approach as the 2nd stage (Woolridge, 2005):

$$SMALLFIRE_{it} = \beta_{NEW} NEW_{it} + \beta_{POP} POP_{it} + \beta_{TREND} TREND_{it} + \beta_{\hat{\rho}} \hat{\rho}_{it} + \gamma_t + \mu_i + \pi_{it} \quad (4)$$

where $\hat{\rho}$ is the non-linear prediction of the error term in Equation (2).

One should note that the identifying assumption underlying our IV approach is that large fires only affect small fires through new and renewed polices and that there are no other omitted factors that are correlated with both large and small fires, or that large fires have a direct effect on the number of small fires other than through new and renewed insurance policies. In this regard, large fires in our data are arguably exogenous events, involving a large number of casualties and a large amount of physical damage that have become large fires because of exogenous weather conditions and/or earthquakes. In contrast, small fires in our data are defined as fires of buildings (residential houses and shops) by unintentional causes and by arson. The small fires tend to be extinguished in a short time and completely or partially burn down the buildings of fire origin as well as sometimes neighbouring buildings, but did not spread further. Therefore, large fires and small fires can be assumed to be uncorrelated in our context.

5.3 Econometric Results

The results of estimating Equations (2) through (4) are depicted in Table 2. As can be seen, the first stage F-statistic on the excluded instruments is 166.77 and thus highly significant, indicating the relevance of our instruments, as would have already been suggested in Section 4.2. Examining the impact on the total number of small fires arising from such policies there is no apparent response. [8] However, once one divides these into those due to unintentional and arson causes, one discovers that it is the former that is not affected. In contrast, there is a positive and significant impact on small fires where their cause was identified as arson. More

[8] Note that the null hypothesis of no time varying spatial correlation could not be rejected for all regressions the number of small fires, the number of non-arson small fires, the number of arson small fires., and the number of new buildings. Detailed results are available from the authors upon request.

specifically, the implied semi-elasticity indicates that for the average number of new and renewed policies the number of arson related small fires increases by 8.3 per cent.

6. Conclusion

In this paper we investigated the role of large fires in the early development of the Japanese fire insurance industry. To this end we constructed a thirty year time varying prefecture level data set of large fires, as identified in newspaper sources, and fire insurance level data for pre-WWII Japan. Our empirical analysis shows not only, as would be expected, that fire insurance claims increased after large fires, but that this led to significant increases in new contracts and policy renewals. These results are in line with narrative accounts at the time where fire insurance companies used the incidence of large fires to advertise their business and the need to insure against fires.

We also investigated whether the new policies and policy renewals may have attracted riskier customers or induced existing policy holders to become greater risk takers by exploring the impact on small fires started unintentionally compared to those identified as being due to arson. We found that the increase in new policies and policy renewals due to large fires increased the number of fires due to arson but not those unintentionally set. While our data did not allow us to identify whether the increase in arsons was because of the adverse selection of fraudulent policy holders into the insurance market or the attempted exploitation of fire insurance by existing policy holders, anecdotal suggests that moral hazard may have been more likely driving force.

REFERENCES

Angrist, J., & Kolesar, M., (2023). “One Instrument to Rule Them All: The Bias and Coverage of just-ID IV”, *Journal of Econometrics*, forthcoming.

Atreya, A., Ferreira, S., & Michel-Kerjan, E. (2015). What drives households to buy flood insurance? New evidence from Georgia. *Ecological Economics*, *117*, 153-161.

Bellemare, M. F., & Wichman, C. J. (2020). Elasticities and the inverse hyperbolic sine transformation. *Oxford Bulletin of Economics and Statistics*, 82(1), 50-61.

Bertanha, M. and Moser, P. (2016). Spatial Errors in Count Data Regressions, Journal of Econometric Methods, 5, pp. 49-69.

Cameron, L., & Shah, M. (2015). Risk-taking behavior in the wake of natural disasters. *Journal of human resources*, *50*(2), 484-515.

Callen, M. (2015). Catastrophes and time preference: Evidence from the Indian Ocean Earthquake. *Journal of Economic Behavior & Organization*, *118*, 199-214.

Cockerell, H.A.L. and E. Green (1976), *The British Insurance Business 1547-1970: An Introduction and Guide to Historical Records in the United Kingdom*, Heinemann Educational Books Ltd.: London

Eckel, C. C., El-Gamal, M. A., & Wilson, R. K. (2009). Risk loving after the storm: A Bayesian-Network study of Hurricane Katrina evacuees. *Journal of Economic Behavior & Organization*, *69*(2), 110-124.

Field, J. F. (2017). London, Londoners and the Great Fire of 1666: disaster and recovery. Routledge.

Gallagher, J. (2014). Learning about an infrequent event: Evidence from flood insurance take-up in the United States. *American Economic Journal: Applied Economics*, 206-233.

Gonzalez, P. G. and L. Andersson (2018) Managing financial constraints: undercapitalization and underwriting capacity in Spanish fire insurance" *Economic History Review* 71(2): 567-592

Hanaoka, C., Shigeoka, H., Watanabe, Y., 2018. Do risk preferences change? Evidence from the Great East Japan Earthquake. Am. Econ. J. Appl. Econ. 10 (2), 298–330

Imaizumi, A., Ito, K., and Okazaki, T. (2016). Impact of natural disasters on industrial agglomeration: The case of the Great Kantō Earthquake in 1923. *Explorations in Economic History*, *60*, 52-68.

Kamiya, S., & Yanase, N. (2019). Learning from extreme catastrophes. *Journal of Risk and Uncertainty*, *59*, 85-124.

Kon, K. and Y. Kitazawa eds. (1944) *Nihon ni okeru Kasai Hoken Ryouritsu Kyotei Enkakushi (History of the Fire Insurance Rate Cartel in Japan)* vol.1, Tokyo: Nihon ni okeru Kasai Hoken Ryouritsu Kyotei Enkakushi Kankokai (in Japanese)

Kousky, C., & Michel - Kerjan, E. (2017). Examining flood insurance claims in the United States: Six key findings. *Journal of Risk and Insurance*, *84*(3), 819-850.

O'Donoghue, T., & Rabin, M. (1999). Doing it now or later. *American economic review*, *89*(1), 103-124.

Okazaki, Tetsuji., Okubo, Toshihiro., & Strobl, Eric. (2019) "Creative Destruction of Industries: Yokohama City in the Great Kanto Earthquake," *Journal of Economic History* 79(1): 1-31.

Okazaki, T., Okubo, T., & Strobl, E. (2023). The Bright and Dark Sides of a Central Bank's Financial Support to Local Banks after a Natural Disaster: Evidence from the Great Kanto Earthquake, 1923 Japan. *Journal of Money, Credit and Banking*.

Okubo, T., & Strobl, E. (2021). Natural disasters, firm survival, and growth: Evidence from the Ise Bay Typhoon, Japan. *Journal of Regional Science*.

Pearson, P. (2004) *Insuring the Industrial Revolution: Fire Insurance in Great Britain, 1700-1850*, Hampshire: Ashgate Publishing Limited

Raynes, H.E. (1964) *A History of British Insurance*, 2nd ed., London: Sir Issac Pitman & Sons

Royal, A., & Walls, M. (2019). Flood risk perceptions and insurance choice: Do decisions in the floodplain reflect overoptimism?. *Risk Analysis*, *39*(5), 1088-1104.

Tamura, Y (2004) "Kanto Daishinsai to Hokenkin Sodo" (Fire Insurance Troubles after the Great Earthquake of Kantoh), *Journal of the University of Marketing and Distribution Sciences. Humanities, arts & sciences*, *16*(3), 15-29.

Takitani, Z. (1930) "Kasai Hokenryo Kyotei no Hattatsu 1" (The development of agreements on fire insurance fee 1) Kokumin Keizai Zasshi 50 (4), pp. 105-130

Takitani, Z. (1931) "Kasai Hokenryo Kyotei no Hattatsu 2" (The development of agreements on fire insurance fee 2) Kokumin Keizai Zasshi 50 (6), pp. 249-303

Tesselaar, M., Botzen, W. W., Robinson, P. J., Aerts, J. C., & Zhou, F. (2022). Charity hazard and the flood insurance protection gap: An EU scale assessment under climate change. *Ecological Economics*, *193*, 107289.

Tokyo City Office (1925a) *Shinsai niyoru Nihon no Sonshitsu (Damage to Japan by the Great Kantō Earthquake)*, Tokyo: Isseisha (in Japanese)

Tokyo City Office (1925b) *Tokyo Taisho Sinsai-shi (Record on the Earthquake in Tokyo in Taisho Era)*, Tokyo: Tokyo City Office (in Japanese)

Toyo Keizai Shinpo-sha (1927) *Meiji Taisho Kokusei Soran (Statistical Handbook of Meiji and Taisho Eras)*, Tokyo: Toyo Keizai Shinpo-sha (in Japanese).

Trumbo, C., Lueck, M., Marlatt, H., & Peek, L. (2011). The effect of proximity to Hurricanes Katrina and Rita on subsequent hurricane outlook and optimistic bias. *Risk Analysis: An International Journal*, *31*(12), 1907-1918.

Wagner, Katherine RH. "Adaptation and adverse selection in markets for natural disaster insurance." *American Economic Journal: Economic Policy* 14.3 (2022): 380-421.

Woolridge, J. (1999). Distribution –free estimation of some nonlinear panel data models, Journal of Econometrics, 90, pp. 77-97

Woolridge, J. (2005). Control Function Methods in Applied Econometrics, Journal of Econometrics, 50, pp. 420-445.

Appendix: Tables and Figures

Table 1: Summary Statistics (Prefecture Level)

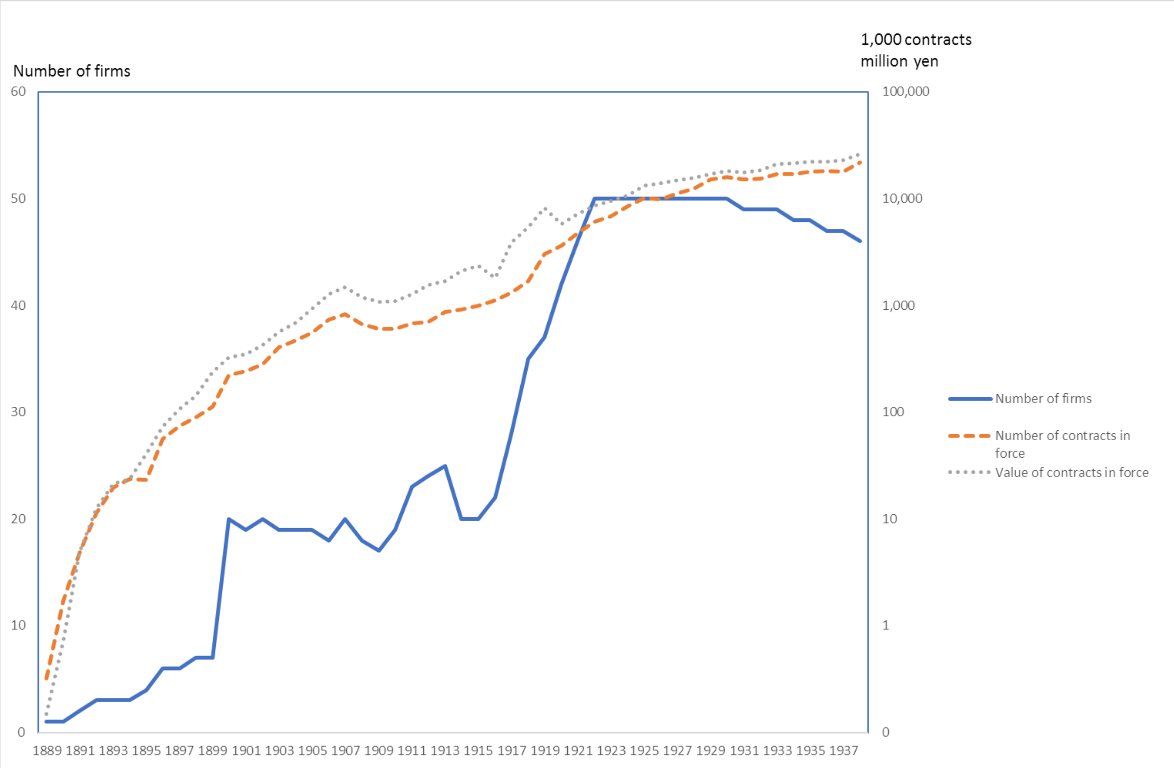
	MEAN	SD	MIN	MAX
Large Fires #	0.08	0.33	0	5
Active Policies on All Properties (# per '000s)	116.6	305.9	0.9	3868.3
Claims Made on All Properties (# per '000s)	1.2	3.4	0	38.4
New Policies on All Properties (# per '000s)	137.2	3.4	0.9	4280.9
All Small Fires (# per mill.)	375.1	277.1	71	1978
Non-Arson Small fires (# per mill.)	349.6	261.6	54	1870
Arson Small Fires (# mill.)	25.7	25.0	1	321

Table 2: Impact of New and Renewed Policies on Small Fires and New Buildings

	(1)	**(2)**	**(3)**	**(4)**
2nd St.:				
$\widehat{\boldsymbol{New} \& \boldsymbol{Ren}.\boldsymbol{Pol}.}$	5.69e-08	-5.62e-09	6.08e-07*	4.00e-07**
	(8.03e-08)	(7.58e-08)	(2.82e-07)	(1.20e-07)
1st St. F-Stat.:	*166.77***	*166.77***	*166.77***	*166.77***
Dep. Var.(2nd St.)	*All Fires*	*Non-Arson Fires*	*Arson Fires*	*New Bldgs*
Dep. Var (2nd St.) Unit	*Nr.*	*Nr.*	*Nr.*	*Nr.*

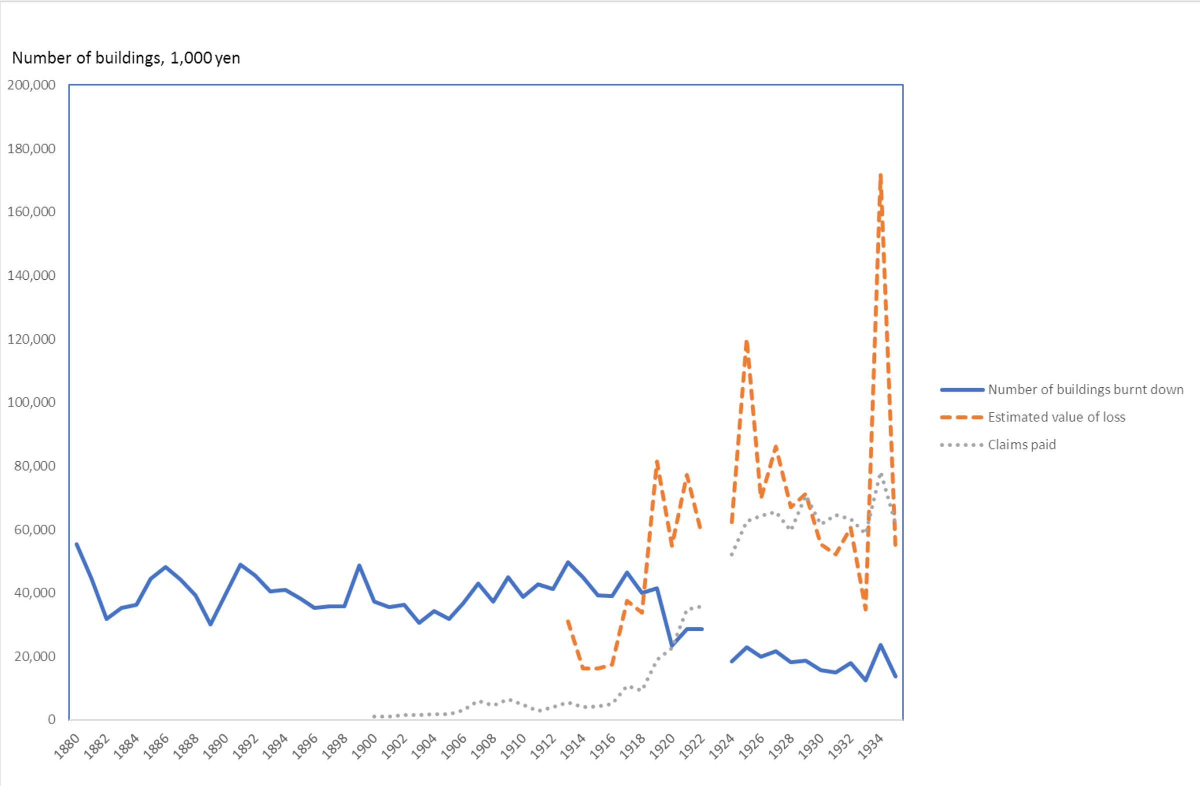
Notes: (a)** and * are 1, 5, and per cent significance levels, respectively. (b) Standard errors in the 2nd stage are bootstrapped using 500 random samples; (c) All regressions include prefecture level population, prefecture specific time trends; and year dummies; (d) The sample size is 1,126 and covers all prefectures over the years from 1909 to 1938.

Figure 1:



Source: Toyo Keizai Shinpo-sha (1928); Statistics Bureau of the Cabinet, *Nihon Teikoku Tokei Nenkan (Statistical Yearbook of Japan Empire)*, various issues.

Figure 2:



Source: Toyo Keizai Shinpo-sha (1928); Statistics Bureau of the Cabinet, *Nihon Teikoku Tokei Nenkan (Statistical Yearbook of Japan Empire)*, various issues.

Figure 3: # of Large Fires (Annual Avg.)

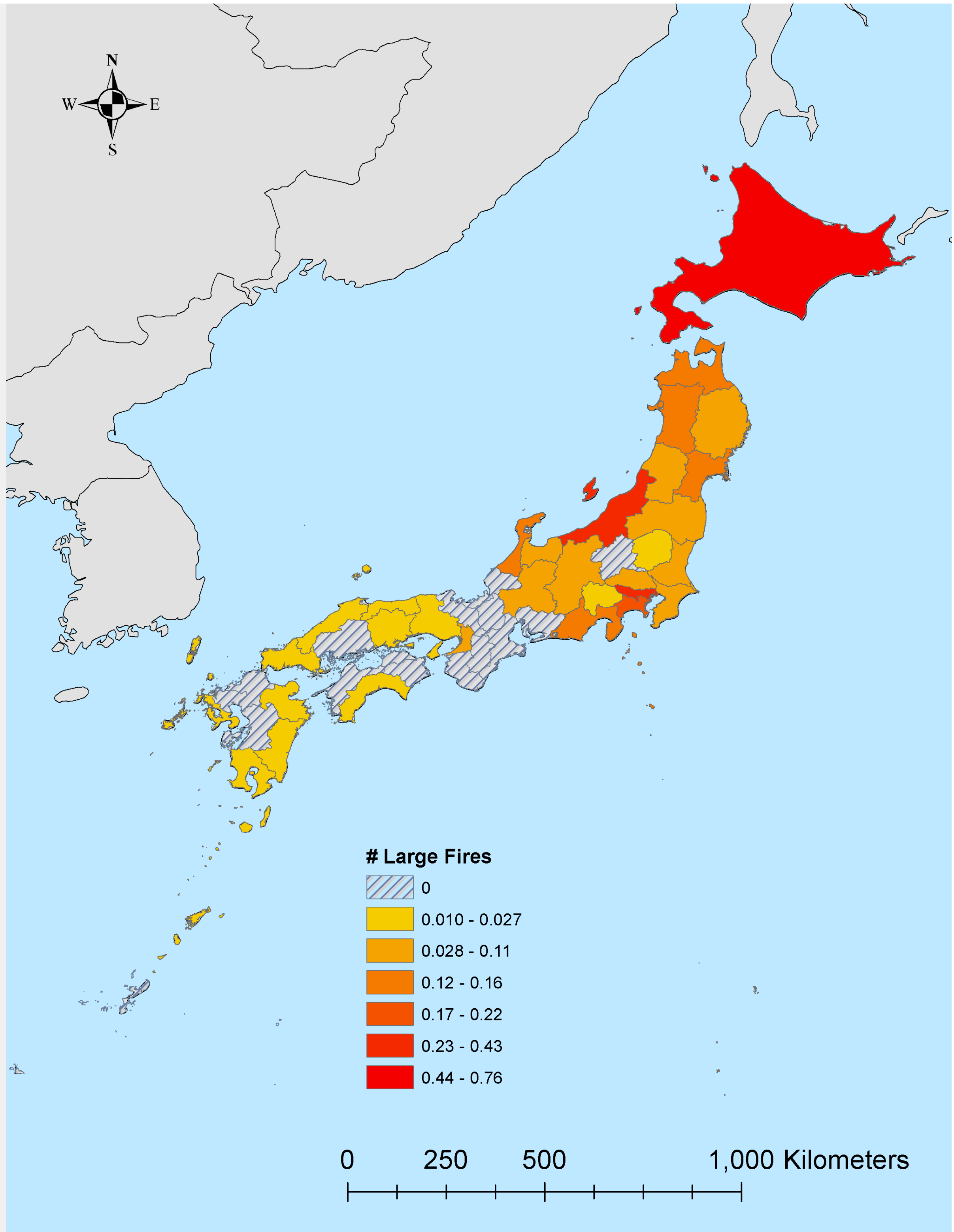


Figure 4: # Active Fire Policies for All Properties per Population ('000s)

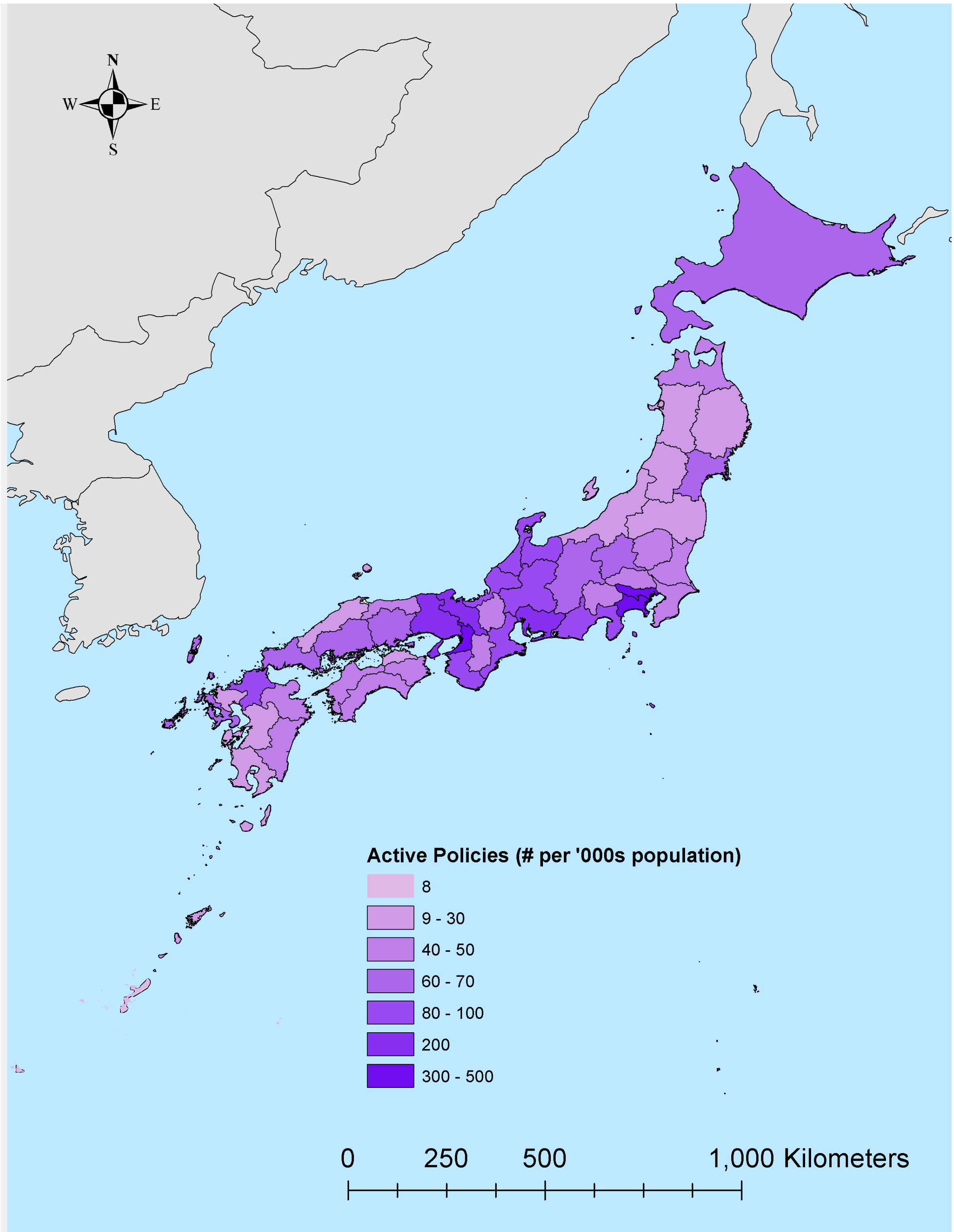


Figure 5: Evolution of Average Number Policies and Large Fires per Prefecture

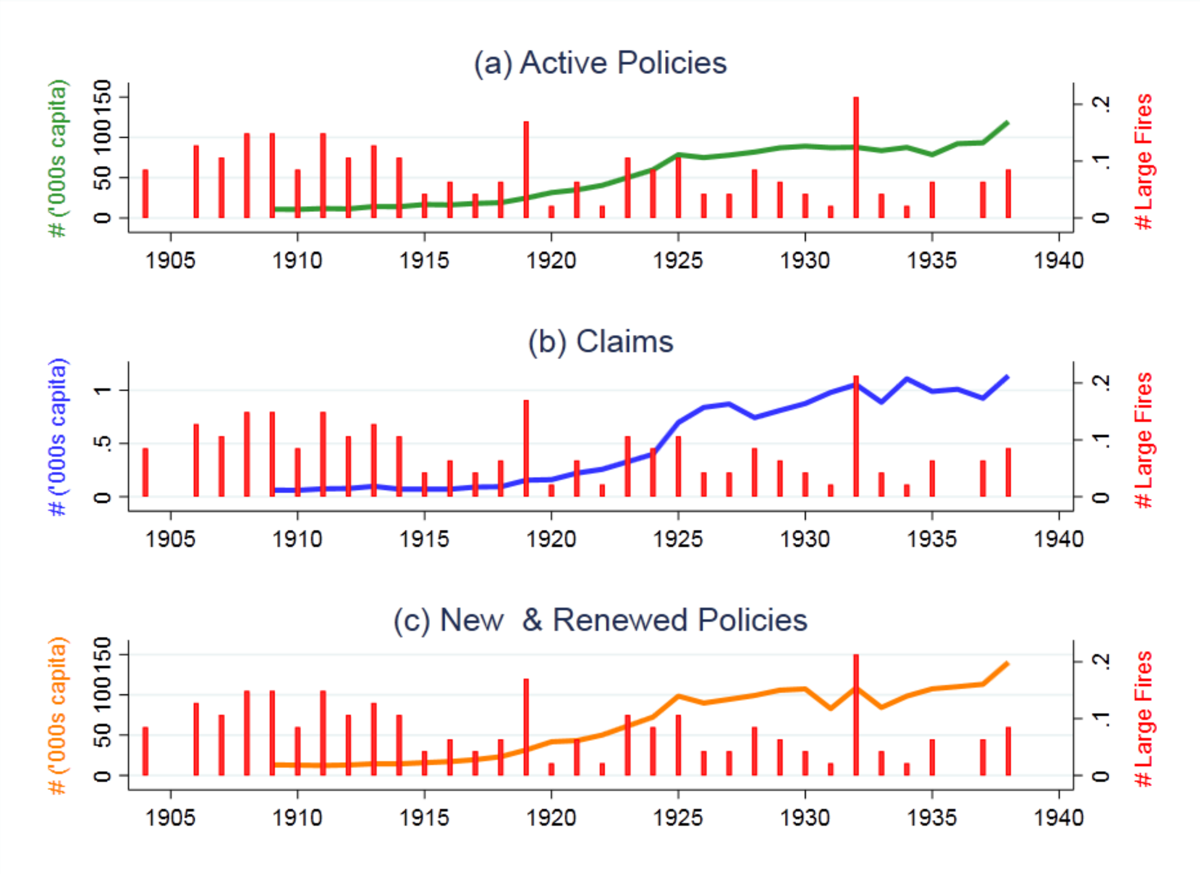
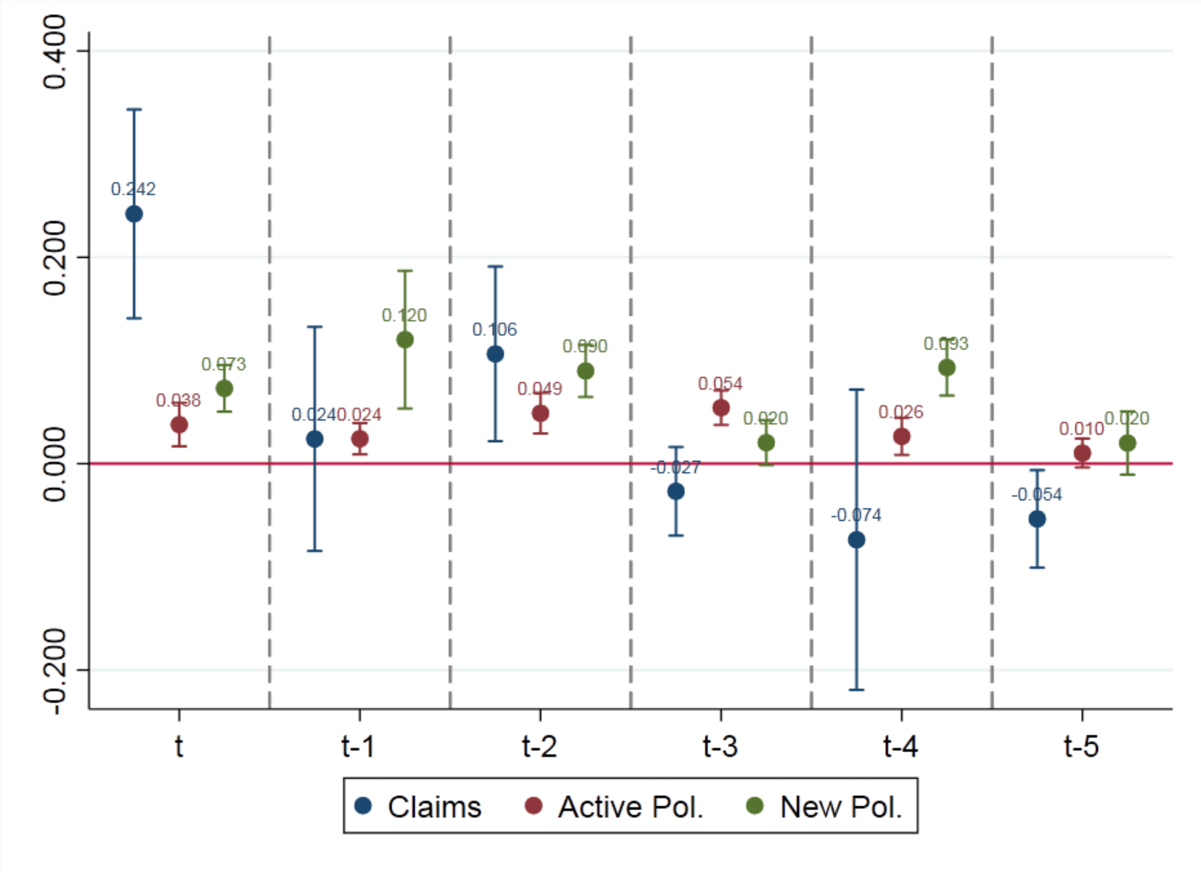


Figure 6: Contemporaneous and Lagged Large Fire #'s on Fire Insurance for All Properties



Notes: (a) t indicates time of impact; (b) Numerical values above dots are coefficient estimates; (c) Line bars indicate 95 per cent confidence bands and constructed from standard errors clustered at the prefecture level; (d) Estimations are run for each insurance aspect (Claims, Active Policies, New Policies, Premium Payments, Other Payments) separately;

Figure 7: Evolution of Average Number and Area of Small Fires per Prefecture