Local Economic Impacts of Wildfires*

Margaret Walls[†], Matthew Wibbenmeyer[‡]

December 30, 2021

PRELIMINARY DRAFT — DO NOT DISTRIBUTE OR CITE. COMMENTS WELCOME.

As large and damaging wildfires have increased in frequency in the western US, the consequences of these events for local economies remain largely unknown. Previous studies of the effects of natural disasters on local economic growth have yielded mixed results, and few studies have examined wildfires—especially large and damaging wildfires. In this study, we investigate the local economic impacts of wildfires in the western US using two empirical approaches, which make use of public county-level economic data and administrative establishment-level data, respectively. Results indicate that large wildfires that affect populated areas have positive short-run effects on county-level employment growth, especially within the construction sector, but zero effects beyond a year and a half after the fire. Preliminary results with establishment-level data show that establishments near (within 10 km of) selected large and damaging wildfires were less likely to have survived two years after the fire than establishments located farther away.

Classification: Social Sciences; **Keywords:** Natural Disasters; Wildfire; Economic Impacts

*We thank Isabelle Rabideau for research assistance on this project. This research was supported by the USDA National Institute of Food and Agriculture (NIFA) Agriculture and Food Research Initiative Award No. 2020-67023-33258.

[†]Resources for the Future, Washington, DC. Email: walls@rff.org.
[‡]Resources for the Future, Washington, DC. Email: wibbenmeyer@rff.org.

1 Introduction

Wildfires have increased in frequency and severity in the western United States over the past four decades. While most fires occur on forests or other wildlands away from where large numbers of people live and work, recent large wildfires have increasingly spread into populated areas and resulted in heavy damages. Of the top ten fires in insured losses, eight have occurred since 2017. In 2018, the Camp Fire, the most destructive fire in U.S. history, destroyed 18,804 structures and killed 85 people in Paradise, California. Sixty-two percent of the structures lost between 2005 and 2020 occurred in 2017, 2018, and 2020 (Headwaters Economics 2020). As population in the wildland-urban interface (WUI) continues to grow—some evidence suggests it's the fastest growing land use type in the U.S. (Radeloff et al., 2018)—these trends are likely to continue.

Wildfires, like other natural hazards, have uncertain impacts on local economies. Not all wildfires are disaster events. Fires that result in little damage may be net positives for local communities due to their ecological benefits (through, for example, fuel reduction), and the resulting influx of federal suppression spending (Nielsen-Pincus, Moseley, & Gebert, 2014). Even in the case of damaging wildfires, though, local economic impacts are ambiguous. Property and local infrastructure damage may lead to temporary business disruptions due to power outages, road closures, and direct damage to buildings and other business infrastructure. This can reduce sales, employment, and wages in these businesses, which may cause multiplier effects throughout the local economy. Some establishments may go out of business or move if damage is substantial. The disaster may spur out-migration, which reduces labor supply in the affected area, and puts upward pressure on local wages. Insurance payouts, disaster aid, and other government assistance can mitigate negative impacts, however, and increase income. And construction for rebuilding generally provides a local economic boost. Over the long run, many outcomes are possible, including "creative destruction" or "build back better" scenarios in which economic growth is higher than it would have been in the absence of the disaster (Hsiang & Jina, 2014).

In this study, we investigate the local economic impacts of wildfires in the western United States using two empirical approaches. First, using county-level quarterly data from 1990 through 2020 across the entire continental western U.S., we estimate the dynamic effects of wildfires on year-over-year growth rates in employment, earnings, and establishments. Our measure of wildfire activity is the population-weighted percentage area burned in a county and quarter. We construct this variable by mapping spatial fire perimeter data on Census block populatons to calculate the share of the county population that overlaps the fire perimeter. Our fire variable thus captures the relative potential of fires to create structure damage within each county. Unlike Nielsen-Pincus, Moseley, & Gebert (2014), whose analysis focused on fires that generated large local suppression spending, our measure of wildfire activity is designed to identify wildfires that may have resulted in significant property damages, which have become more common in recent years. However, we also compare the results to those from a specification that uses raw percentage area burned, irrespective of where fires occurred in relation to populated areas.

County-level data may obscure effects that occur at finer spatial resolutions, especially closer to the fire perimeter. Additionally, net employment and establishment data mask important gross effects on business and job creation and destruction. Thus in our second empirical approach, we use administrative micro-data on individual establishments to analyze the effects of specific wildfire events on the probability of establishment survival after a fire. In these regressions, we compare survival probabilities for establishments located within the fire perimeter and within a 10-kilometer buffer around the fire perimeter with establishments located farther away (between 10 and 50 km from the perimeter). We analyze two major fires in Colorado and three fires in California. Future work will extend this analysis to additional fires and utilize panel data methods to better isolate fire impacts.

Studies of the impacts of natural disasters on local economic activity have found mixed results. Using county-level quarterly data, Belasen & Polachek (2009) find increases in earnings growth rates and drops in employment growth rates, over both the short and long runs, in Florida counties affected by hurricanes. Groen, Kutzbach, & Polivka (2020) use data on individual workers and study the effects of Hurricanes Katrina and Rita, which struck the Gulf Coast in 2005. They find that over the medium and longer term, workers affected by the storms had higher earnings than those not affected. Boustan et al. (2020) use decadal county-level disaster data dating back to the 1920s. Their study is mainly focused on migration, but they find that severe disasters—those that cause at least 25 deaths—cause a decline in the growth rate of income over the decade in counties affected by the disaster. Tran & Wilson (2021) use county-level monthly, quarterly, and annual data over a 30-year period and study several different economic outcomes, including employment, wages, population growth, and personal income. Overall, their findings suggest that disasters have long run positive impacts on local economies, consistent with a "build back better" scenario. Two studies have studied business survival rates. Basker & Miranda (2018) analyze the impact of Hurricane Katrina on retail, restaurant, and hotel businesses in coastal areas of Mississippi. They find that businesses in areas with severe damage from the hurricane were less likely to survive, but the effect is attenuated somewhat by firm size, productivity, and access to credit. Meltzer, Ellen, & Li (2021) analyze the effect of Hurricane Sandy on survival rates. They exploit the random variation in storm inundation across blocks in the city's pre-determined evacuation zone to identify the localized impact of storm-induced flooding. Similar to Basker and Miranda, they find evidence of higher rates of business closures among retail establishments in blocks that experienced high flood levels. They also find that these closures are concentrated among standalone establishments and are not offset by new business openings.

Only a handful of studies have looked at wildfires. Both Boustan et al. (2020) and Tran & Wilson (2021) include fires among the disasters they analyze, but fires make up only a small percentage of official declared disasters (2 percent in Tran and Wilson's data) and even fewer cause at least 25 deaths (the cutoff in the Boustan et al. study). In separate analyses of fires, Boustan et al. find that fires cause an increase in household income (in contrast to their results for disasters as a whole) and Tran & Wilson find no statistically significant effect of fire on income, employment, wages, and population growth rates. Nielsen-Pincus, Moseley, & Gebert (2014) and Prudencio et al. (2018) use data and empirical approaches similar to the first part of our analysis here. Nielsen-Pincus, Moseley, & Gebert use monthly county-level data from 2004 through 2008 and analyze the effects of 346 wildfires that had fire suppression costs in excess of 1 million dollars. They find that small communities experience positive overall effects on employment growth from wildfires in the first two months after the fire, then a return to pre-fire levels, followed by a negative impact six months after the fire. They attribute these impacts to suppression spending. They find no statistically significant effect, positive or negative, in large communities. Prudencio et al. use monthly county data from 2001 through 2015 in the 8-state Intermountain West region and MTBS wildfire data and focus on fires greater than 400 hectares in size.

Our results at the county-level show no statistically significant effect of wildfires on employment or earnings growth rates in the first year and a half following a fire, but positive effects on growth in the number of establishments in this period. These results hold for population-weighted percentage area burned and simple percent area burned, though increases in weighted percentage area burned result in substantially larger increases in establishment growth rates. Estimating regressions separately by industry reveals large effects of wildfires on employment and establishment growth within the construction industry, likely due to increased rebuilding following damaging fires. We estimate that when weighted percentage area burned increases by approximately one percentage point, average construction-sector employment growth rates increases by approximately 30 percentage points six quarters later. In contrast with Nielsen-Pincus, Moseley, & Gebert and Prudencio et al., we find that effects on growth are strongest in urban areas. This discrepancy may be driven by the fact that our continuous percentage burned measures better capture the extent of fire impacts than do the binary measures used in previous studies.

In the establishment survival probability regressions, we estimate the probability an establishment that is in operation the year of the fire survives two or three years after the fire. The five fires in our sample were major fires that struck near developed areas and caused significant damage. They include two 2012 fires in Colorado: Waldo Canyon, which affected part of Colorado Springs, and High Park, which struck near Fort Collins. In California, we analyze the 2003 Cedar Fire, near San Diego, and the 2015 Butte and Valley Fires, which occurred in north central California and the Sierra Nevada Mountains southeast of Sacramento, respectively. We estimate a pooled regression model, which shows average effects across all five fires, and then each fire individually. Results reveal that being in the fire perimeter, or within 10 km of a fire perimeter, negatively affects an establishment's probability of surviving two or three years after the fire occurs. The effects vary with establishment size and age, however. And when we analyze the fires separately, we find some heterogeneous effects. We will explore this heterogeneity in more detail in future research.

The combination of a West-wide county-level panel regression model of net employment, establishment, and wage income growth rates with a highly localized, establishment-level analysis of business survival rates sheds new light on the economic impacts of wildfires. As with the literature on hurricanes and flooding, our preliminary work here shows highly localized negative impacts in areas with the greatest direct fire damage but positive or zero net impacts on a broader scale. We consider our localized negative impacts on survival rates to be preliminary as they are estimated on cross-section data for five fires. Future work will extend this analysis to additional fires and better control for unobservables that may be correlated with establishment proximity to fire perimeters using panel data methods. In addition, we may explore additional outcome variables beyond survival rates, such as establishment and job births and deaths (see, for example, Asquith et al. (2019); Walls, Lee, & Ashenfarb (2020)).

2 Data

2.1 County-level approach

To identify areas and establishments affected by wildfires we use data from the USGS Monitoring Trends in Burn Severity (MTBS) project. The MTBS project uses data collected by Landsat satellites to map perimeters of large fires dating back to 1984. In the western US, MTBS maps wildfires larger than 1,000 acres in the western US (Eidenshink et al., 2007), accounting for approximately 95 percent of total area burned in the region (`https://www.mtbs.gov/faqs`).

We use the MTBS data to construct two measures of the extent of county-level wildfire impacts. First, we measure the percent of total area burned in each county in each quarter (denoted A_{ct}). We assign area burned to a specific quarter in each year using fires' reported date of ignition. Second, we construct a weighted county-by-quarter measure of percentage area burned that accounts for the portion of a county's population that is affected by wildfire. Let A_i denote the area of Census block i within county c, and let A_{ikt} denote the total area within block i that is burned by fire k in time t. Let P_{it} represent the population of block i in time t, measured using US Census data. We define weighted percentage area burned as:

$$\tilde{A}_{ct} = \frac{100}{\sum_{i \in B_c} P_{it}} \sum_{i \in B_c} \sum_{k \in F_{ct}} \frac{A_{ikt}}{A_i} P_{it} \tag{1}$$

where B_c denotes the set of blocks in county c and F_{ct} denotes the set of fires that burned in county c during period t. This measure counts the percentage of each county's population that live within areas burned by large fires in each period, under the assumption that populations are distributed uniformly within Census blocks. Previous studies have typically used binary indicators to measure county-level wildfire impacts; however, fires frequently burn in remote areas, and those that burn large portions of a county or directly impact populated areas may have very different effects than fires that burn in remote areas. Our measure therefore allow us to effectively identify those fires we expect to have greatest county-level economic impacts, similar to the municipality-specific measure used by Liao & Kousky (2021).

Table 1 shows mean annual percentage of county area burned and weighted mean annual percentage of county area burned, as well the number of county-years in which the percentage and weighted percentage area burned was greater than one, across western states. Percentages of area burned tend to be small. Weighted percentages of area burned are smaller still, on average, since wildfires most frequently occur in sparsely populated parts of counties. In part, mean percentage area burned is small because large wildfires are rare events in most counties. Table 2 provides descriptive statistics for the top county-years in the sample with respect to weighted percentage burned. Weighted percentage area burned exceeded five percent in only twelve county-years (out of 12,784 county-years). Figure 1 shows that percentage area burned is not strongly predictive of weighted percentage area burned, suggesting potential importance of measuring the degree to which fires impacted populated areas.

We merge our county-level measures of percent area burned with quarterly data on economic activity within counties from the Bureau of Labor Statistics (BLS) Quarterly Census of Employment and Wages. The QCEW tabulates quarterly data on the number of establishments and average wages in US counties by ownership and industry using QCEW industry codes based on NAICS-coded data.[1]

We analyze data on employment, number of establishments, and wages in all privately-owned establishments, and privately-owned establishments in three specific industries: construction, natural resources and mining, and leisure and hospitality. Construction is of interest since areas impacted by a damaging wildfire may be expected to experience a surge in construction in its aftermath. Natural resources and mining includes both agriculture and forestry and logging, which may be affected either positively (due to increases in salvage logging) or negatively (due to damage to forest inventory) by fires. The leisure and hospitality sector could be negatively affected because it serves local demand, including tourism, compared to other sectors (e.g. manufacturing) which meet demand outside the fire-affected region. For each economic variable and sector, we calculate year-on-year growth in county c according to:

$$\Delta Y_{ct}^{s} = \left(\frac{Y_{ct}^{s} - Y_{c,t-4}^{s}}{Y_{c,t-4}^{s}} \right) \tag{2}$$

where Y_{ct}^{s} represents private employment, number of establishments, or average wages within sector s during quarter t. This year-on-year growth measure accounts for differences in seasonal economic activity. We use ΔY_{ct}^{s} defined for various sectors and outcomes measures as the dependent variable within event study regressions of the effects of wildfires on growth.

Finally, we consider effects of wildfires within urban western counties separately from effects in

[1] `https://www.bls.gov/cew/classifications/industry/industry-titles.htm`

rural counties. We classify counties as rural or urban based on 2013 USDA Economic Research Service Rural-Urban Continuum Codes (RUCC),[2] which assign US counties to one of nine categories based on rurality, population, and adjacency to metropolitan areas. We classify counties as urban if they include metropolitan areas (RUCC codes 1,2, and 3; 136 western counties) and as rural otherwise (278 western counties).

Figure 2 shows year-on-year growth in employment, the number of establishments, and wages, in Butte County, Lake County, and Napa and Sonoma counties, California. Dotted lines indicate the quarter in which the Camp Fire, Valley Fire, and Wine country fires (including the Tubbs and Nuns fires), respectively, occurred. Panels (a) – (c) show growth trends for all sectors, while panels (d) – (f) show growth trends for the construction sector.

Following the Valley and Wine country fires, growth in employment, the number of establishments, and wages remained relatively steady in Lake County and Napa and Sonoma counties (though wage growth was highly volatile across all counties between 2015 and 2018). In contrast, Butte County entered a period of negative employment and establishment growth in the year following the Camp Fire. Wage growth increased over this period, consistent with previous findings on the effects of natural disasters on labor markets (e.g. Belasen & Polachek, 2009).

Focusing on the construction sector (panels (d) – (f)), Lake County and Napa and Sonoma counties experienced employment and establishment growth in the one to two years following the Valley and Wine country fires, though only Lake County experienced a concurrent increase in construction sector wages. These trends are consistent with an increase in demand for construction following these fires. Growth in employment, the number of establishments, and wages in Butte County each decreased in 2019, consistent with decreased demand in the case of the highly destructive Camp Fire.

2.2 Establishment-level data

In our second empirical approach, we use individual establishment data from the 2019 edition of the National Establishment Times Series (NETS) Database, a 30-year panel of every individual establishment in the United States. The NETS Database includes employment, detailed industry code (8-digit SIC/6-digit NAICS), street address and latitude/longitude, as well as a variety of other information for approximately 71 million establishments nationwide between 1990 and 2019. The NETS Database is privately produced from Dun and Bradstreet archival data and is similar

[2] https://www.ers.usda.gov/data-products/rural-urban-continuum-codes.aspx

to the U.S. Census Bureau's Longitudinal Business Database (LBD), restricted-use longitudinal establishment-level microdata constructed from the Census Bureau's Business Register. A key difference between NETS and LBD is that the LBD covers only private non-farm businesses, whereas NETS includes all establishments, private and public, and covers the agricultural sector. In comparisons with the public government datasets from the Census Bureau and BLS, studies have shown that the NETS Database includes coverage of more small establishments, especially those with a single employee, which are excluded in the government data (Neumark, Zhang, & Wall, 2007). For our purposes, in the rural areas where wildfires typically occur, we consider the comprehensive nature of NETS and the inclusion of small businesses to be important.

We create geographic buffers around the MTBS fire perimeters and tally the number of establishments in each buffer in the year of the fire. Table 3 shows this information for the five fires we analyze. Our treatment variables are indicators for whether an establishment is located within the mapped perimeter of the fire and whether it is within 10 km of the fire perimeter. We limit the sample to establishments located within 50 km of the perimeter, thus our control group consists of establishments between 10 and 50 km of the fire perimeter. We use this geographic cut-off to ensure that control establishments are (i) from similar local economies as treated establishments and (ii) are not treated by other wildfires that may occur in the same year.

Table 4 shows summary statistics for establishment size and age for each of the fires and the pooled sample as a whole. The distribution of establishment size, measured by the number of employees, is left-skewed in all regions because of the preponderance of small establishments. The median number of employees per establishment is 2, while the mean ranges between 6 and 9. Establishment age is similarly distributed, though the means are larger. The median ranges between 4 and 8 years and the mean between 6 and 14. Establishments near the Butte and Valley fires, which were in more rural areas than the other three fires, have been in existence relatively longer, on average. This is consistent with some findings in the literature that businesses tend to survive longer in rural areas than in urban areas (Deller & Conroy, 2016; Renski, 2008).

We selected these five fires because they fall within the 1990-2019 sample period of our data and are some of the most damaging fires during this time period. Both the High Park and Waldo Canyon fires affected populated areas – the former Fort Collins and the latter Colorado Springs – and at the time, were two of the most destructive fires in Colorado history. The Cedar Fire struck near the city of San Diego in 2003 and as of 2020, was the 11th most costly fire in U.S. history, with estimated damages of $1.4 billion (in 2020 dollars) (Insurance Information Institute, 2020).

It destroyed more than 3,000 structures. According to CalFire statistics through 2021, Cedar was the fourth most destructive fire in California history, and Valley and Butte the sixth and twentieth most destructive, respectively (CalFire, 2021).

Figure 3 shows maps of each fire with the perimeter, the 10 km buffer, and the 10-50 km buffer. The colors of the grids correspond to numbers of establishments in each grid. The maps highlight that some of the fires – especially Cedar and Waldo Canyon – are quite close to highly developed areas, while others are near only smaller cities or towns. None of the five fires are in entirely remote rural areas, however.

3 County-level empirical approach

Figure 2 presents mixed evidence on the effects of wildfires on growth. To understand the effects of wildfires on county-level growth measures on average over the entire period 1990 to 2019 (we omit 2020 due to concerns over confounding effects of the Covid-19 pandemic), we estimate event study regressions according to the following the specification:

$$\Delta Y_{ct}^{s} = \alpha_c + \delta_t + \sum_{l=-8}^{12} \beta^l \tilde{A}_{ct} + \varepsilon_{ct}. \tag{3}$$

Here, α_c and δ_t are county and quarter level fixed effects, respectively. We estimate equation 3 for growth in employment, wages, and the number of establishments across all industries, and within the construction, natural resources and mining, and leisure and hospitality industries. For each outcome variable, we estimate versions of the model using weighted percentage area burned ($\tilde{A}_{ct}$) and percentage area burned (replacing $\tilde{A}_{ct}$ with A_{ct}). Results are presented in Figure 4.

For all sectors, we find that wildfires have no discernible effect, on average, on county-level employment growth (panel (a)) in either urban or rural counties. Wildfires may result in some negative earnings growth more than one and a half years later, though estimates differ across rural and urban areas, and depending on the percentage area burned measure used. Panel (b) indicates that wildfires lead to modest increases in growth in the number of establishments, especially when they occur in urban counties. The magnitude of estimated effects is substantially larger when we use weighted percentage area burned in place of percentage area burned (as indicated by the difference in y-axes across the upper and lower plots). When weighted percentage area burned increases by one percentage point, the establishment growth rate increases by approximately 2 percentage points, on average, in the years following a fire; however, when percentage area burned increases by one percent, establishment growth rate increases by only approximately 0.25 percentage points in the years following a fire. That the effect is an order of magnitude smaller when using percentage area burned suggests the significance of our weighted percentage area burned measure, which better identifies damaging wildfires.

Within the construction sector, we observe significant temporary increases in employment growth between four and six quarters following wildfires that occur in urban counties. The effects are large, with a one percentage point increase in weighted percentage area burned corresponding to an approximately 30 percentage point increase in employment growth six quarters after a fire. Since large wildfires typically occur between June and October, these increases are consistent with increases in construction activity during the spring and summer of the following year due to rebuilding following wildfires. In rural counties, percentage area burned is predictive of small increases in employment growth, whereas weighted percentage area burned is not. As previously, estimates of the average effects of percentage area burned are substantially smaller than effects of weighted percentage area burned. By 10 to 12 quarters after a wildfire, effects of wildfires on employment growth rates are negative, likely reflecting a ”bounce-back” to typical county-levels following post-fire spikes in employment.

Following wildfires, growth in the number of establishments increases in both urban and rural counties. Effects on the establishment growth rate persist somewhat longer than effects on the employment growth rate, though they are somewhat smaller in magnitude, with a one-percentage point increase in weighted percentage area burned corresponding to only an approximately 8 percentage point increase in the establishment growth rate one-year after a fire. Effects of wildfires on wages are less clear; however, they may lead to increased wage growth three to six quarters after a fire, based on regressions measuring fire activity using percentage area burned. In the appendix, we also include figures that consider effects of wildfires on the natural resources and mining-sector and the leisure and hospitality-sector.

Overall, county-level data reveal small impacts of damaging wildfires on local economic growth, except within the construction-sector, where effects of fires that affect populated areas on growth-measures are large, presumably due to demand for rebuilding. In contrast to Nielsen-Pincus, Moseley, & Gebert (2014) and Prudencio et al. (2018), who measure county-level fire impacts using binary indicator variables, we find the strongest effects of fires in urban counties. This discrepancy may be to due to the fact that in urban counties, local economic impacts of wildfires are more likely to be washed out by economic activity in unaffected urban areas. We are better able to identify fire impacts on urban counties since our continuous percentage burned measures better identify wildfires which we might expect to cause substantial county-level impacts within urban counties.

Discerning local economic impacts of destructive wildfires using county-level data may be difficult for several reasons. As suggested by Table 2, there were relatively few highly destructive wildfires within the western US over the period 1990-2019. Only one of these, the Camp Fire, burned more than five percent of the populated area within an affected county. Even among several of the fires than burned the greatest portions of affected counties, Figure 2 reveals heterogeneous effects. While effects on overall county-level growth are not apparent in the case of the Valley Fire and Wine country fires, employment growth and growth in the number of establishments across all industries declined in Butte County following the Camp Fire, while wage growth increased. It may be difficult to observe effects at the county-level in part because effects of fires are highly heterogeneous within affected counties; negative effects may be concentrated in affected areas, and in some cases may be mitigated by economic activity that is displaced to other parts of the county. Last, county-level data on employment and number of establishments is net of all job losses and job creation, and establishment births and deaths, and therefore may mask more complex dynamics as a result of wildfires. Establishment-level data from the National Establishment Time Series provides an opportunity to address some of these short-comings of county-level data.

4 Establishment-level empirical approach

County-level data may mask important localized economic impacts that occur at finer spatial scales. Basker & Miranda (2018) and Meltzer, Ellen, & Li (2021), for example, find negative impacts on businesses and employment in areas that suffered severe damage and flooding from hurricanes. Yet several studies find hurricanes to have positive or null effects at a county level. It is possible that the same patterns may be seen for wildfires. Moreover, net employment and establishment growth conceals underlying changes in gross establishment and job flows. Studies have shown that total job reallocation – gross job creation plus gross job destruction – is orders of magnitude greater than net employment change (Asquith et al., 2019; Fort, Pierce, & Schott, 2018). To fully assess the impacts of a shock such as a wildfire, or other natural hazard, it is important to analyze business and job "births" and "deaths." In this paper, we take the first step in this analysis by analyzing wildfire impacts on establishment survival rates. Specifically, we estimate a linear survival probability model as follows:

$$survive_i = \mathbf{x}_i'\beta + \mathbf{z}_i'\gamma + (\mathbf{x}_i \times \mathbf{z}_i)'\delta + \alpha_{c(i)} + \eta_{sic(i)} + \phi_{f(i)} + \varepsilon_i \tag{4}$$

where $survive_i$ is an indicator equal to 1 if establishment i survives either 2 or 3 after the fire, $\mathbf{x}_i$ is a vector containing indicators for whether establishment i is located within the fire perimeter or within 10 km of the fire perimeter, $\mathbf{z}_i$ is a vector containing controls for the number of years the establishment has been in business as of the year of the fire, and the number of employees, and $(\mathbf{x}_i \times \mathbf{z}_i)$ represents a vector containing interactions between all pairs of elements in $\mathbf{x}_i$ and $\mathbf{z}_i$. We include county fixed effects ($\alpha_{c(i)}$), two-digit SIC code fixed effects ($\eta_{sic(i)}$), and—in the pooled model—fire fixed effects ($\phi_{f(i)}$), which also account for differences in macroeconomic conditions across years in which fires took place (because the pooled model combines fires from different years). The regression sample includes all establishments in existence in the year of the fire and located within 50 km of the fire, thus we are designating establishments located between 10 and 50 km from the fire perimeter as in the control group, and estimating effects of being inside or within 10 km from the fire perimeter.

The identifying assumption in this cross-sectional regression is that, after controlling for two-digit SIC industry, establishment size and age, and fire (in the pooled model), there are not unobserved differences in survival rates that are unrelated to wildfire impacts but correlated with distance to wildfire perimeters. In any given wildfire, we expect that such unobserved differences may exist. For example, because the Cedar Fire (2003) occurred so close to San Diego, the 10 km buffer includes a high proportion of establishments in relatively dense areas, whereas the the 50 km buffer includes a higher proportion of lower density areas. If density is related to establishment survival, then estimates of the effects of the Cedar Fire based on proximity to its perimeter will be biased in regressions using only data from the Cedar Fire. The pooled regression model ameliorates these concerns somewhat, since unobserved factors may be correlated with proximity to the fire differently for different fires.

Table 4 shows the results of the pooled regression model. Being within 10 km of a fire reduces an establishment's probability of survival by approximately 4 percentage points, all else equal. Not many establishments are located inside the actual perimeter of a fire (see Table 3). For those that are, the probability of surviving two years after the fire is the same as the 10 km effect, a reduction of 4 percentage points. (Because an establishment located in the perimeter is also within 10 km, we need to add the coefficients on the 10 km buffer and in fire perimeter variables to get the effect of being in the perimeter.) The probability of surviving three years after the fire is higher for establishments in the perimeter, however, by 1 percentage point.

Both the age and size of establishments affect the probability of survival. Older and larger establishments have higher survival rates, all else equal. Older establishments located near a fire are also more likely than younger establishments to survive the fire. This effect holds for both the two-year and three-year survival rates and for establishments in the perimeter and within 10 km. Each additional year an establishment within 10 km of a fire has been in business lowers the negative effect the fire has on survival by between 0.35 and 0.4 percentage points. Establishment size, measured by the number of employees, has different effects on survival depending on whether an establishment is located in the perimeter of the fire or within 10 km. For establishments in the fire perimeter, having more employees lowers the probability of survival, but for establishments located within 10 km, having more employees increases the probability of survival. These effects hold for both two- and three-year survival rates.

These pooled regression results show average estimated impacts of wildfires on survival rates. Table 5 shows results of estimating the two-year survival probability regressions for each of the fires individually. Being in the fire perimeter negatively affects the probability of survival for the Butte, High Park, and Waldo Canyon Fires by 16, 2.5 and 10 percentage points, respectively. The Cedar Fire impacts are markedly different: being in the fire perimeter increases the probability of survival by 5.4 percentage points. The Valley Fire had no statistically significant effect on survival probabilities. For establishments located slightly farther away, 10 km from the perimeter, the effects vary across fires: they are more likely to survive in the case of Butte and Waldo Canyon, less likely for High park, and not significantly affected by the Cedar or Valley Fires.

The longer an establishment has been in business, the smaller the negative impact on survival for establishments in the perimeters of the Butte and Waldo Canyon Fires. For the High Park Fire, more years in business reinforces the negative effect of the fire but only in a minor way (i.e., the sum of the coefficients on the two interaction terms, Years in bus. x in fire and Year in bus. x 10 km, is near zero). The number of employees has no effect except for establishments in the perimeter of the Cedar Fire, where the greater the number of employees, the less likely the establishment is to survive.

Taken together, the results in Tables 4 and 5 indicate that wildfires negatively impact the probability of survival for establishments located either within the area burned by the fire or within 10 km of the fire perimeter. There are differences across fires, especially for the 10 km distance, and establishment age and size appear to matter for survival in complicated ways. Moreover, the Cedar Fire appears to be a bit of an outlier.

The cross-sectional nature of our data makes it difficult to control for some of the establishment unobservables that may be correlated with proximity to the fires. This is especially problematic in the individual fire regressions in Table 5. In future work, we will explore the use of additional fixed effects in the pooled model (e.g., establishment size and age categories interacted with 2-digit SIC codes); alternative definitions of treatment and control areas; and estimation of a panel data model using the full set of major fires that occurred in a limited geographic region (or single state) over the 30-year period of our data.

5 Future Work

In this paper, we find that wildfires have minimal impacts on county employment, establishment, and wage growth rates – even those fires that strike populated areas of a county. Short term boosts in some sectors are identified – namely, the construction sector – but longer run effects beyond 18 months after a fire are close to zero. Using establishment micro data and analyzing impacts of fires on business survival rates reveals some possible negative effects of fires on businesses located close to, or within, a fire perimeter. These results are preliminary, however, as they are based on analysis of five fires and may confound other establishment characteristics with proximity to fires. In future work, we plan to explore strategies for taking advantage of the panel nature of the data set. Since we anticipate an approximately 30-year panel of all western US establishments would present data processing, management, and analysis challenges, one strategy is to estimate fire impacts on business survival using a panel data set identifying all fires that have impacted establishments within a more limited study area (e.g. a sub-state region or set of counties). As well we may examine outcomes beyond survival rates, such as establishment births and deaths, and an intensive margin effect—changes in employment per establishment.

References

Asquith, B., Goswami, S., Neumark, D., & Rodriguez-Lopez, A. (2019). Us job flows and the china shock. Journal of International Economics, 118, 123–137.

Basker, E. & Miranda, J. (2018). Taken by storm: business financing and survival in the aftermath of hurricane katrina. Journal of Economic Geography, 18, 1285–1313.

Belasen, A. R. & Polachek, S. W. (2009). How disasters affect local labor markets the effects of hurricanes in florida. Journal of Human Resources, 44, 251–276.

Boustan, L. P., Kahn, M. E., Rhode, P. W., & Yanguas, M. L. (2020). The effect of natural disasters on economic activity in us counties: A century of data. Journal of Urban Economics, 118, 103257.

CalFire (2021). Top 20 most destructive california wildfires. Available online: `https://www.fire.ca.gov/media/t1rdhizr/top20_destruction.pdf` [last accessed: December 21, 2021].

Deller, S. & Conroy, T. (2016). Survival rates of rural businesses: What the evidence tells us. Choices, 31.

Eidenshink, J., Schwind, B., Brewer, K., Zhu, Z.-L., Quayle, B., & Howard, S. (2007). A project for monitoring trends in burn severity. Fire ecology, 3, 3–21.

Fort, T. C., Pierce, J. R., & Schott, P. K. (2018). New perspectives on the decline of us manufacturing employment. Journal of Economic Perspectives, 32, 47–72.

Groen, J. A., Kutzbach, M. J., & Polivka, A. E. (2020). Storms and jobs: The effect of hurricanes on individuals' employment and earnings over the long term. Journal of Labor Economics, 38, 653–685.

Hsiang, S. M. & Jina, A. S. (2014). The causal effect of environmental catastrophe on long-run economic growth: Evidence from 6,700 cyclones. Technical report, National Bureau of Economic Research.

Insurance Information Institute (2020). Top 10 costliest wildland fires in the united states. Available online: `https://www.iii.org/table-archive/21424` [last accessed: December 21, 2021].

Liao, Y. & Kousky, C. (2021). The fiscal impacts of wildfires on california municipalities. Available at SSRN 3612311.

Meltzer, R., Ellen, I. G., & Li, X. (2021). Localized commercial effects from natural disasters: The case of hurricane sandy and new york city. Regional Science and Urban Economics, 86, 103608.

Neumark, D., Zhang, J., & Wall, B. (2007). Employment dynamics and business relocation: New evidence from the National Establishment Time Series. Emerald Group Publishing Limited.

Nielsen-Pincus, M., Moseley, C., & Gebert, K. (2014). Job growth and loss across sectors and time in the western us: The impact of large wildfires. Forest Policy and Economics, 38, 199–206.

Prudencio, L., Choi, R., Esplin, E., Ge, M., Gillard, N., Haight, J., Belmont, P., & Flint, C. (2018). The impacts of wildfire characteristics and employment on the adaptive management strategies in the intermountain west. Fire, 1, 46.

Radeloff, V. C., Helmers, D. P., Kramer, H. A., Mockrin, M. H., Alexandre, P. M., Bar-Massada, A., Butsic, V., Hawbaker, T. J., Martinuzzi, S., Syphard, A. D., et al. (2018). Rapid growth of the us wildland-urban interface raises wildfire risk. Proceedings of the National Academy of Sciences, 115, 3314–3319.

Renski, H. (2008). New firm entry, survival, and growth in the united states: A comparison of urban, suburban, and rural areas. Journal of the American Planning Association, 75, 60–77.

Tran, B. R. & Wilson, D. J. (2021). The local economic impact of natural disasters. Federal Reserve Bank of San Francisco.

Walls, M., Lee, P., & Ashenfarb, M. (2020). National monuments and economic growth in the american west. Science advances, 6, eaay8523.

Table 1: Summary statistics for annual share of county area burned, by state.

State	Mean share burned	Mean weighted share burned	No. of county-years share burned > 0.01	No. of county-years weighted share burned > 0.01
Arizona	0.33209	0.02073	40	3
California	0.47477	0.07627	176	29
Colorado	0.09349	0.01401	45	7
Idaho	0.68410	0.04249	205	15
Montana	0.21989	0.04415	92	15
Nevada	0.44500	0.04451	58	7
New Mexico	0.27547	0.03307	61	6
Oregon	0.41633	0.05024	112	13
Utah	0.23706	0.01562	60	3
Washington	0.28280	0.03867	83	7
Wyoming	0.14812	0.01223	23	0

Table 2: Summary statistics for the top twenty county-years in terms of weighted percentage burned, 1990-2018

County	Year	County population	Area burned (acres)	Percentage burned	Weighted percentage burned	Fire names
Butte County, California	2018	220,000	153,374	14	16	Camp
Los Alamos County, New Mexico	2000	17,950	35,263	50	11	Cerro Grande
Lake County, California	2015	64,665	144,622	17	9.1	Valley, Rocky
Musselshell County, Montana	2012	4,538	66,655	5.6	7.2	Dahl, Wilson, Hawk Creek, Delphia, Bascomb Road
Sierra County, California	1994	3,240	55,234	9	7.2	Crystal, Cottonwood
Rosebud County, Montana	2012	9,233	225,443	7	7.2	Eagle Creek, Ash Creek, Chalky, Emile, Powerline, Beaver, Juniper, Sweeney, Bascomb Road, Little Breed
Mariposa County, California	2017	18,251	100,000	11	6.5	Railroad, South Fork, Detwiler, Empire
Idaho County, Idaho	2015	16,267	312,524	5.7	6.3	See note
Calaveras County, California	2015	45,578	69,198	10	6	Butte
Okanogan County, Washington	2015	41,120	532,757	16	5.9	Black Canyon, North Star, Twisp River, Tunk Block, Limebelt, 9 Mile, Newby Lake
Garfield County, Montana	2017	1,206	263,168	8.5	5.8	Cohagen, Lelig, Bridge Coulee, Edwards, Crying, South Breaks, Curry
Columbia County, Washington	2006	4,078	110,400	20	5.5	Columbia Complex
Okanogan County, Washington	2014	41,120	290,621	8.5	4.4	Carlton Complex, Little Bridge Creek, Upper Falls
Jefferson County, Oregon	2015	21,720	44,357	3.9	4.1	Ceremonial Pit, County Line 2
Sonoma County, California	2017	483,878	89,613	7.9	4	Thirty Seven, Nuns, Tubbs, Pocket
Powder River County, Montana	2012	1,743	249,773	12	4	Dutch, Taylor Creek, Stag, Ash Creek, Border
Crowley County, Colorado	2008	5,823	5,339	1	3.8	Ordway Crowley Co
Sherman County, Oregon	2018	1,765	52,974	10	3.7	Jack Knife 0440 Rn, Stubblefield 1008 Rn, Long Hollow 0806 Rn, Substation 0730 Rn, 1241 Rn
Lewis County, Idaho	2015	3,821	24,386	7.9	3.3	Lawyer 2, Kamiah Gulch, Fisher
Jefferson County, Oregon	1996	21,720	25,913	2.3	3.3	Little Cabin, Jefferson, Kuckup, Simnasho

Note: County populations come from the 2010 US Census. Twenty one large fires burned in Idaho County, Idaho in August 2015. These were the Tepee Springs, Campbells, Dillinger, Rattlesnake, Noble, Little Green, Baldy, Wash, Slide, Fire Creek, Woodrat, Flea Ridge, Lawyer 2, Kamiah Gulch, Fourbit Creek, Barren, Army Mule, Sponge, Pete Forks, Snowy Summit, and Jay Pt fires.

Table 3: Summary statistics for QCEW economic growth measures (1990-2020) within selected sectors, by county rural/urban designation.

Industry	Growth measure	Overall	Urban	Rural
Total (private, all industries)	Employment growth	0.016	0.022	0.014
	Establishment growth	0.018	0.026	0.014
	Wage growth	0.036	0.036	0.035
Construction (private)	Employment growth	0.047	0.041	0.051
	Establishment growth	0.023	0.024	0.022
	Wage growth	0.041	0.038	0.044
Natural Resource (private)	Employment growth	0.025	0.02	0.027
	Establishment growth	0.017	0.0086	0.021
	Wage growth	0.042	0.043	0.041
Leisure and hospitality (private)	Employment growth	0.02	0.025	0.017
	Establishment growth	0.015	0.023	0.012
	Wage growth	0.039	0.038	0.04

Table 4: Number of establishments near selected fires.

	In fire perimeter	Within 10 km	Within 50 km
California			
Cedar	1,159	77,187	171,628
Butte	103	2,798	22,570
Valley	322	1,539	51,657
Colorado			
High Park	194	10,564	67,853
Waldo Canyon	329	31,581	76,770
All Fires	2,107	123,667	390,455

Table 5: Employment and years in business for establishments within 50 km of selected fires.

	Employment			Years in business		
	Mean	Median	Max	Mean	Median	Max
California						
Cedar	9.1	2	32,689	9.9	6	374
Butte	6.2	2	1,200	14	8	215
Valley	6.8	2	2,500	14	8	215
Colorado						
High Park	5.6	2	4,000	8.5	4	212
Waldo Canyon	6.1	2	6,900	7.9	4	203
All Fires	7.4	2	32,689	10	6	374

Table 6: Effects of proximity to fire on business survival rates, pooled model.

	(1) 2-year survival rate	(2) 3-year survival rate
In fire perimeter	.035*	.065**
	[.014]	[.014]
10 km buffer	-.041**	-.043**
	[.0024]	[.0024]
Years in business	.011**	.016**
	[.000068]	[.000068]
Ln(employment)	.039**	.04**
	[.00093]	[.00094]
Years in bus. × in fire	-.0017*	-.0033**
	[.00074]	[.00075]
Years in bus. × 10 km	.0035**	.0041**
	[.00012]	[.00013]
Ln(employment) × in fire	-.022*	-.027*
	[.011]	[.011]
Ln(employment) × 10 km	.009**	.0084**
	[.0015]	[.0015]
County FE	Yes	Yes
Fire FE	Yes	Yes
2-digit SIC FE	Yes	Yes
Number of obs.	390,464	390,464
Mean survival rate	.696	.59

Table 7: Effects of proximity to fire on two-year business survival rates, by fire.

	(1) Cedar	(2) Butte	(3) Valley	(4) High Park	(5) Waldo Canyon
In fire perimeter	.054**	-.19**	-.03	.014	-.12**
	[.018]	[.063]	[.038]	[.056]	[.042]
10 km buffer	-.0048	.031*	.0071	-.025**	.02**
	[.0031]	[.015]	[.02]	[.0072]	[.005]
Years in business	.018**	.0062**	.0062**	.0098**	.013**
	[.00012]	[.00019]	[.00011]	[.00016]	[.00022]
Ln(employment)	.044**	.0092**	.015**	.046**	.04**
	[.0013]	[.0032]	[.002]	[.0024]	[.0027]
Years in bus × in fire	.0012	.0016	-.0012	-.0022	.012**
	[.0011]	[.0028]	[.0013]	[.0031]	[.0032]
Years in bus × 10 km	.00075**	-.0013**	-.00038	.0013**	-.0028**
	[.00018]	[.00048]	[.00069]	[.00041]	[.00031]
Ln(employment) × in fire	-.047**	.054	.03	.032	-.000074
	[.013]	[.047]	[.023]	[.059]	[.041]
Ln(employment) × 10 km	.0021	.0037	-.0021	.0055	.0048
	[.0019]	[.0078]	[.011]	[.0054]	[.0037]
County FE	Yes	Yes	Yes	Yes	Yes
2-digit SIC FE	Yes	Yes	Yes	Yes	Yes
Number of obs.	171,618	22,567	51,651	67,848	76,765
Mean survival rate	.644	.813	.816	.706	.685

Figure 1: Relationship between fraction burned and weighted fraction burned

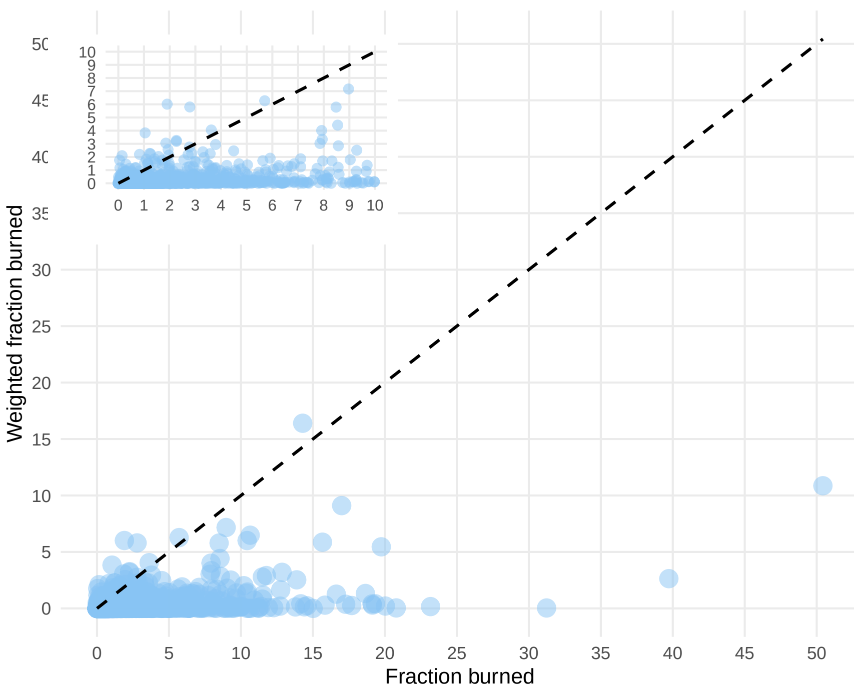
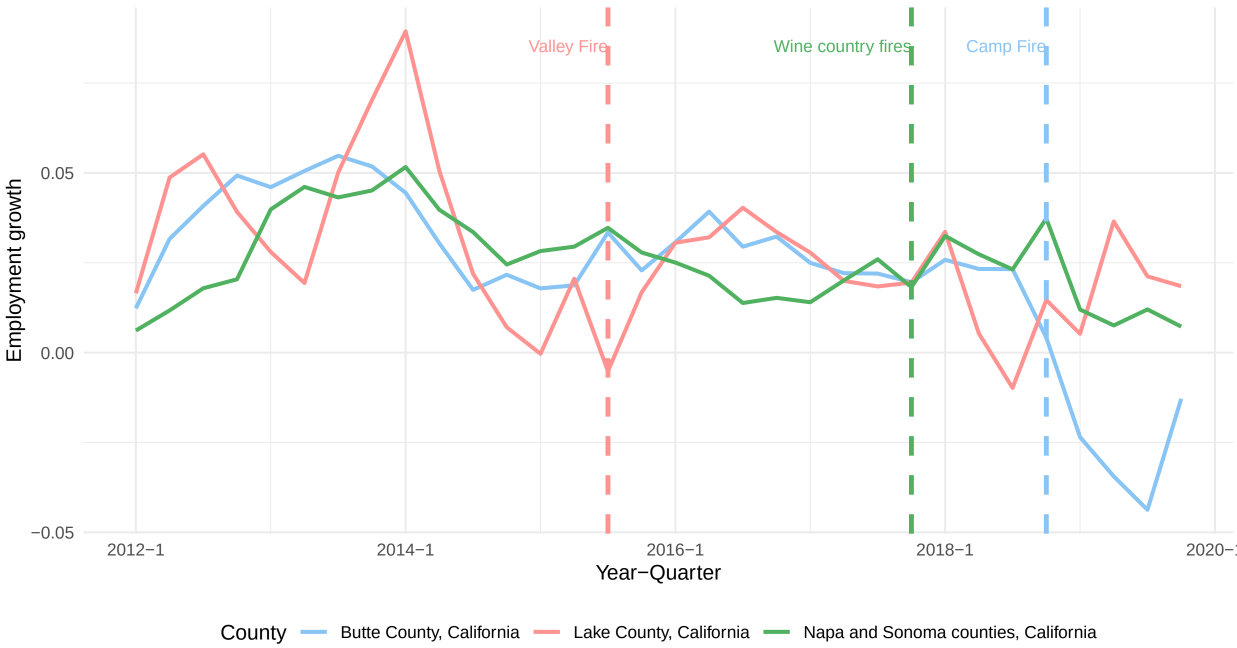
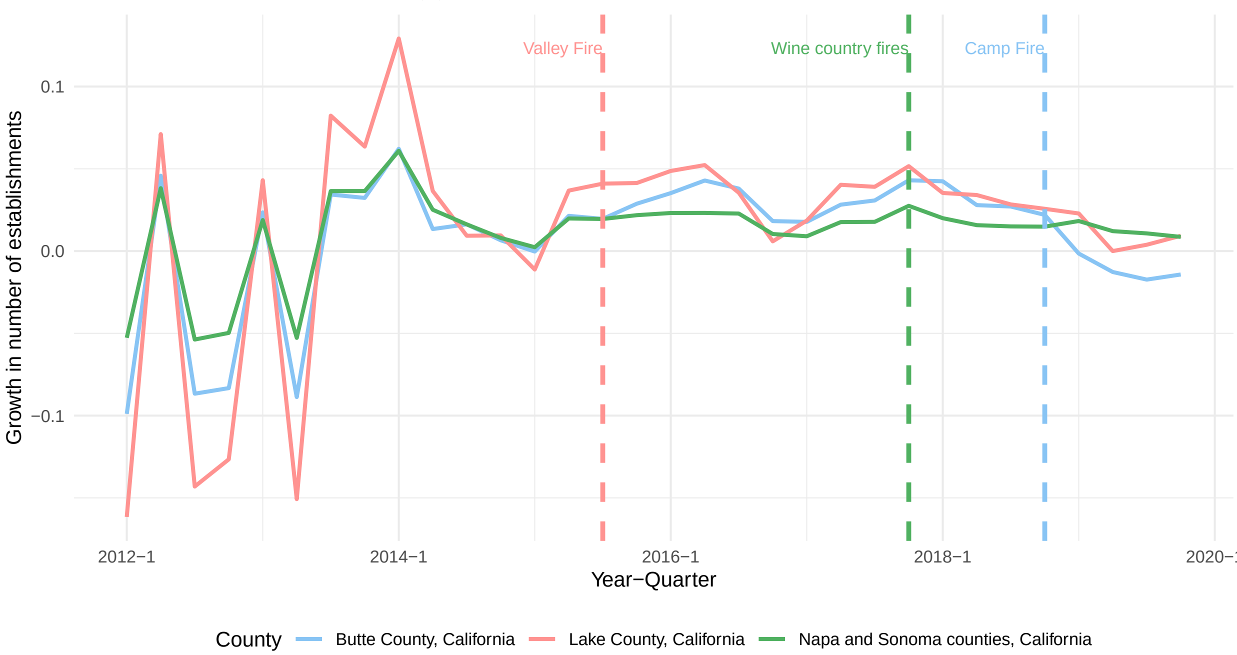


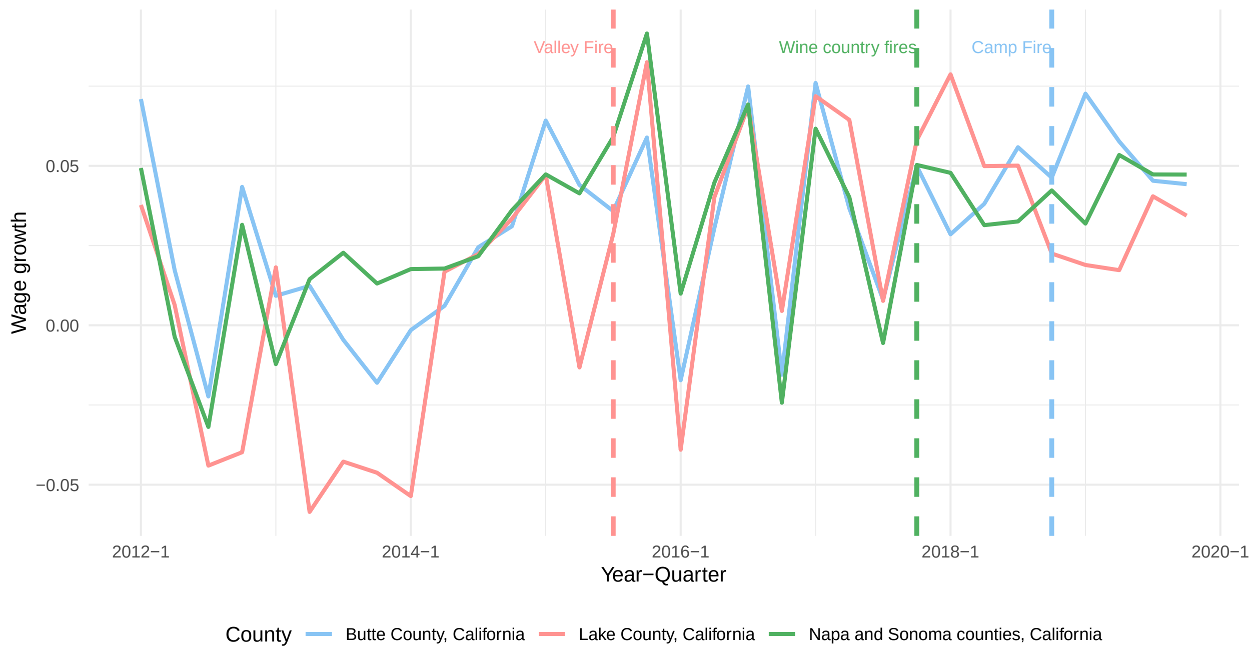
Figure 2: Trends in employment, establishment, and wage growth before and after selected fires



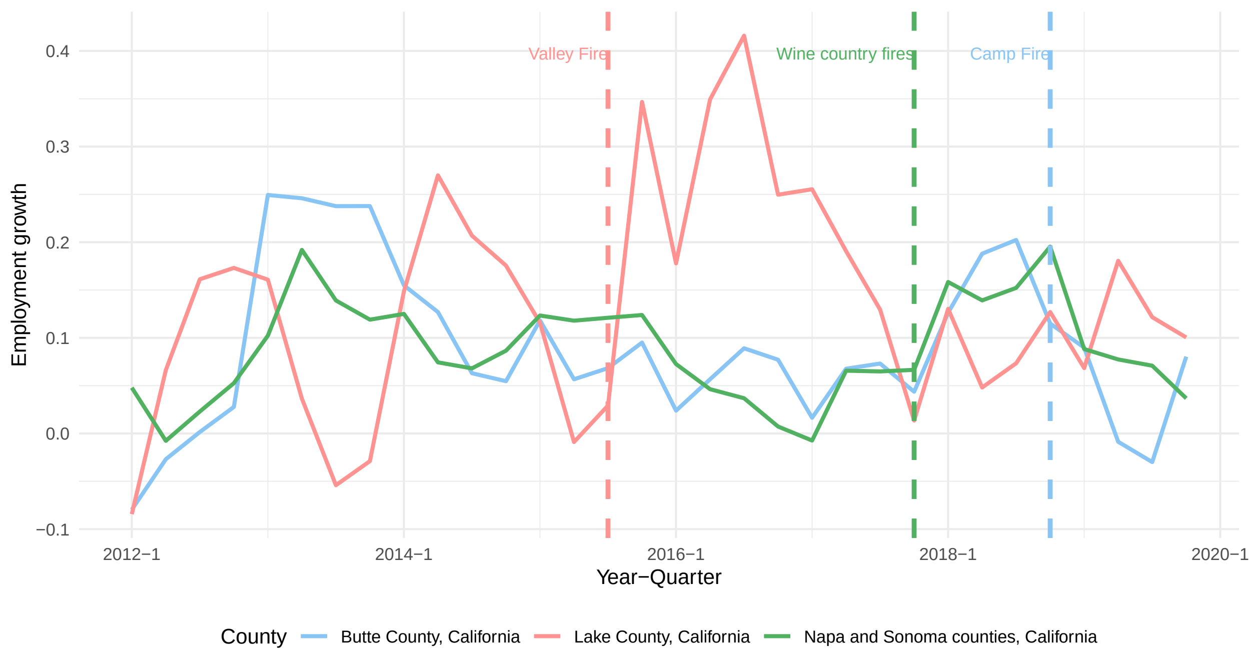
(a) Employment growth, all sectors



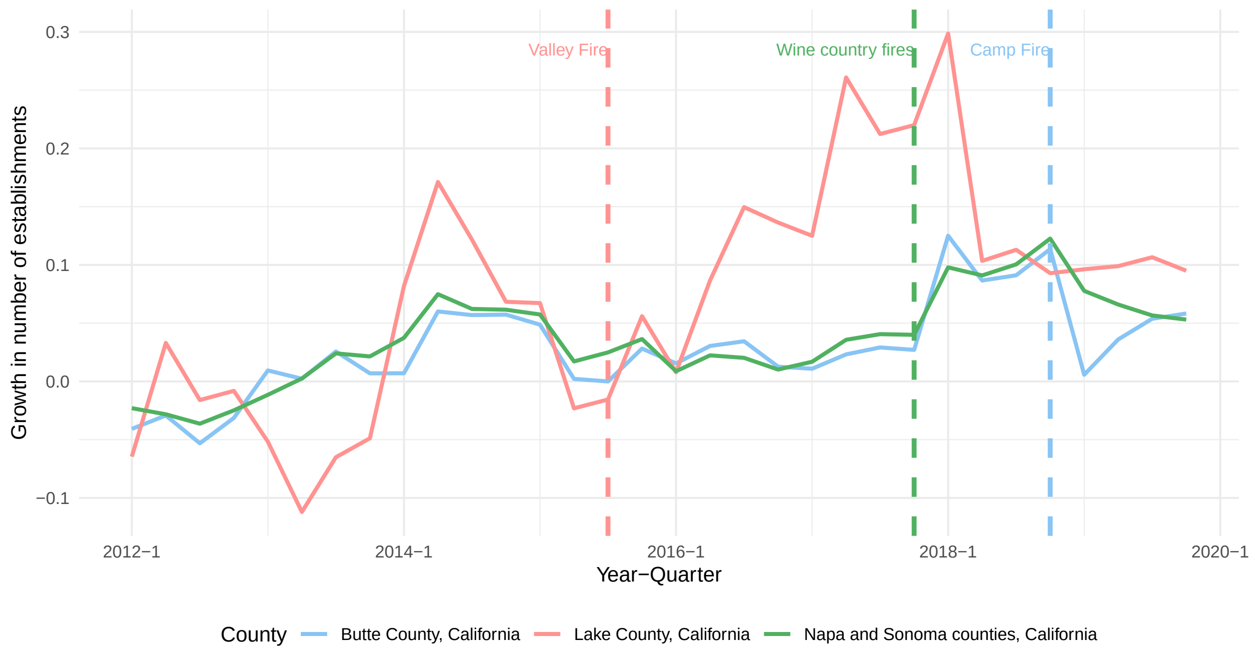
(b) Growth in the number of establishments , all sectors



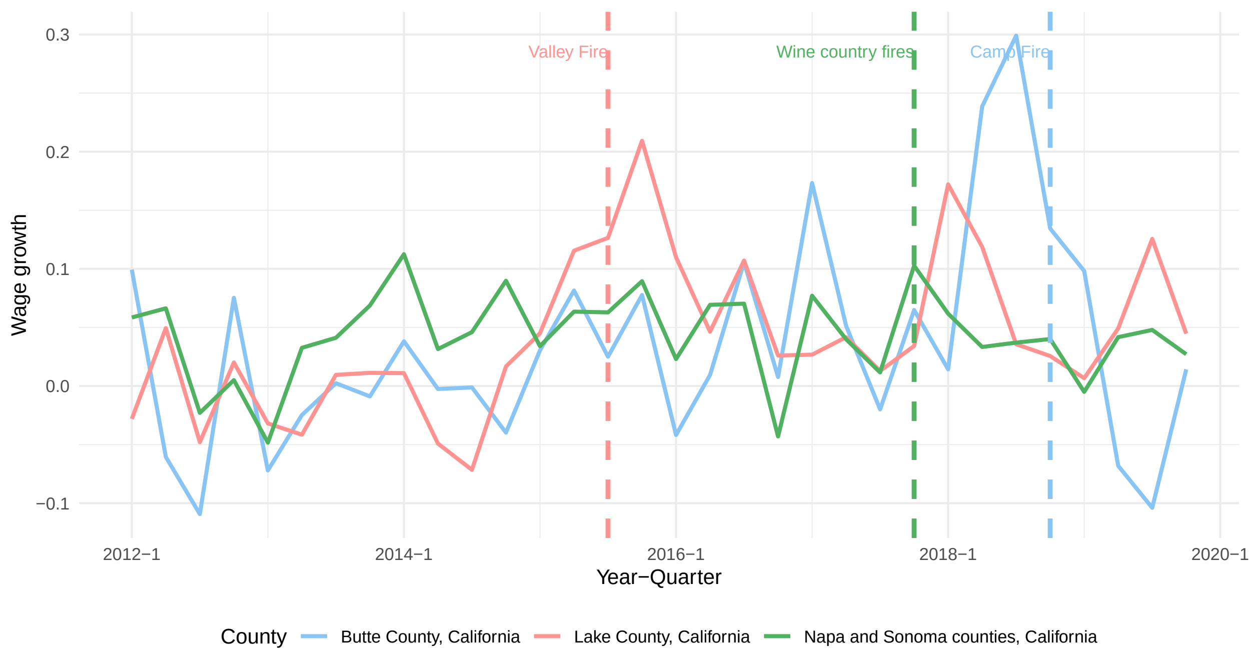
(c) Wage growth, all sectors



(d) Employment growth, construction

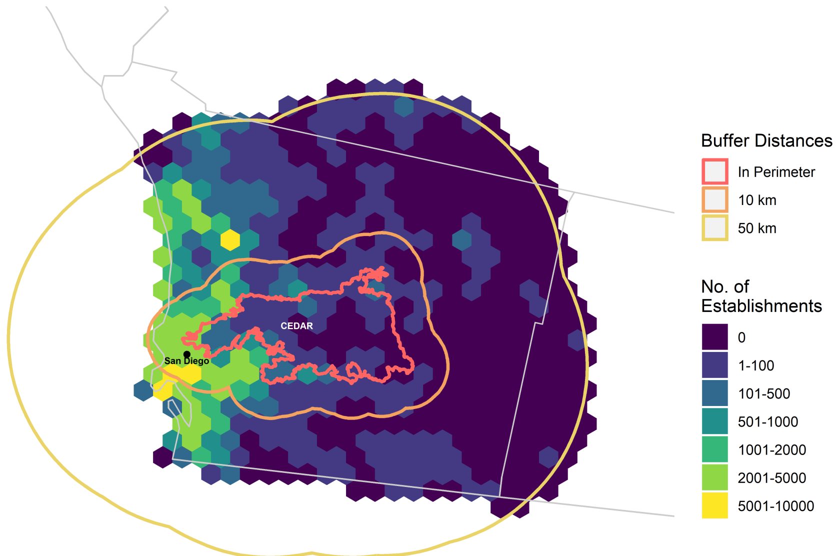


(e) Growth in the number of establishments , construction

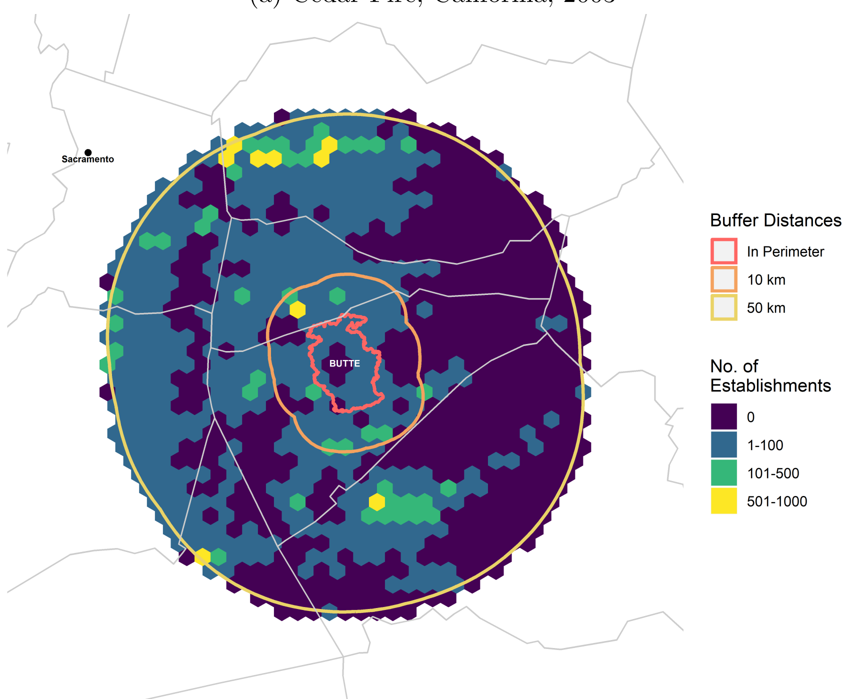


(f) Wage growth, construction

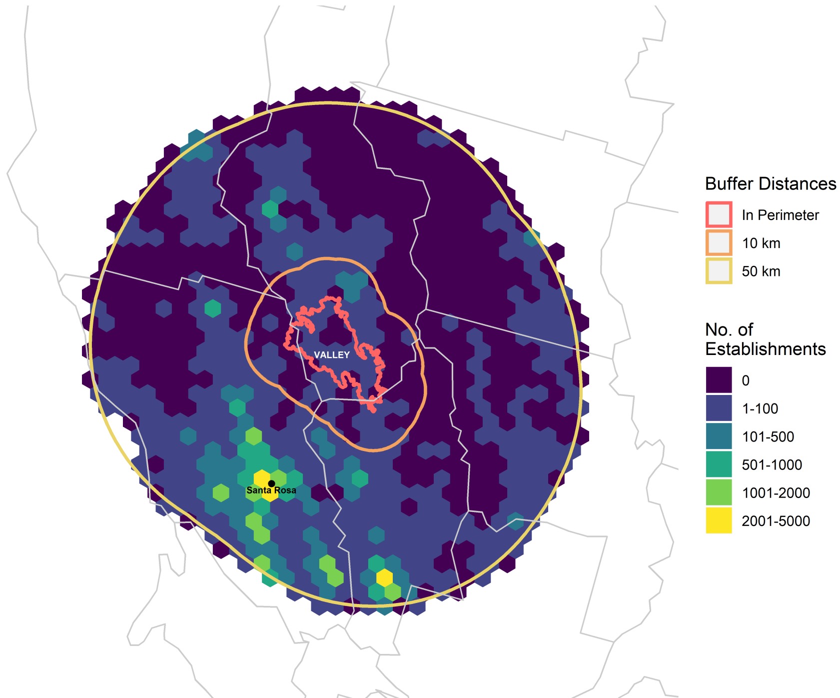
Figure 3: Maps of buffers and establishment density around selected fires



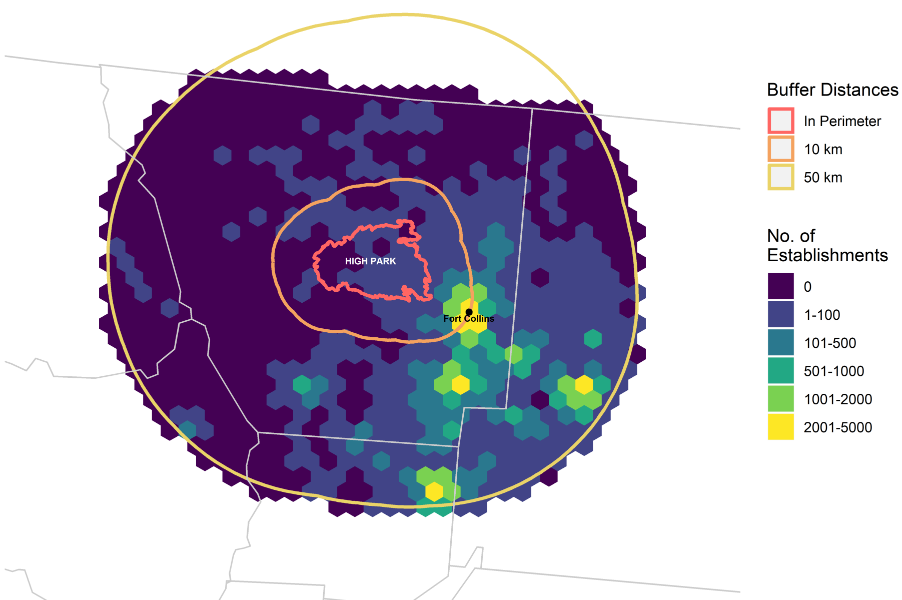
(a) Cedar Fire, California, 2003



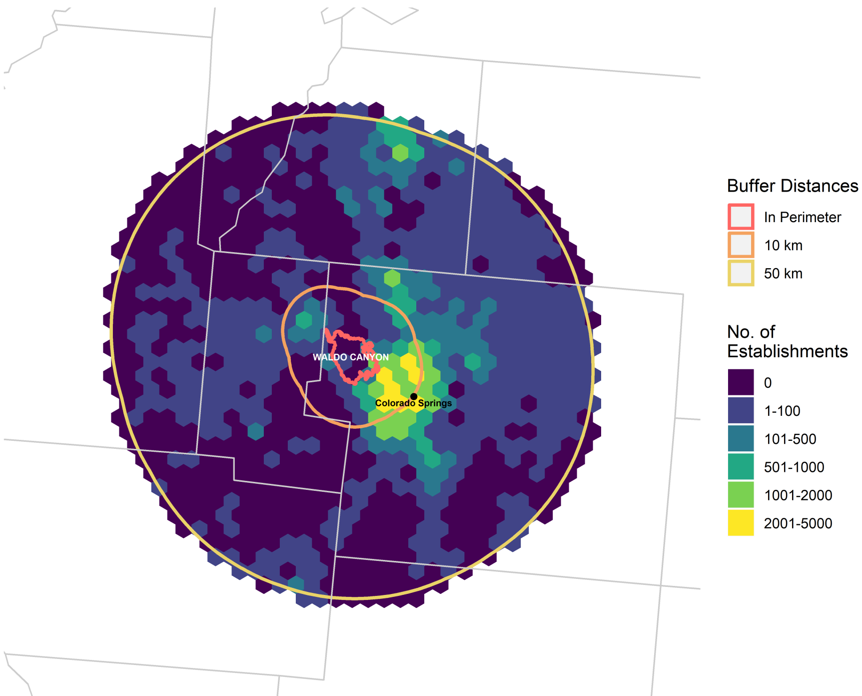
(b) Butte Fire, California, 2015



(c) Valley Fire, Colorado, 2015

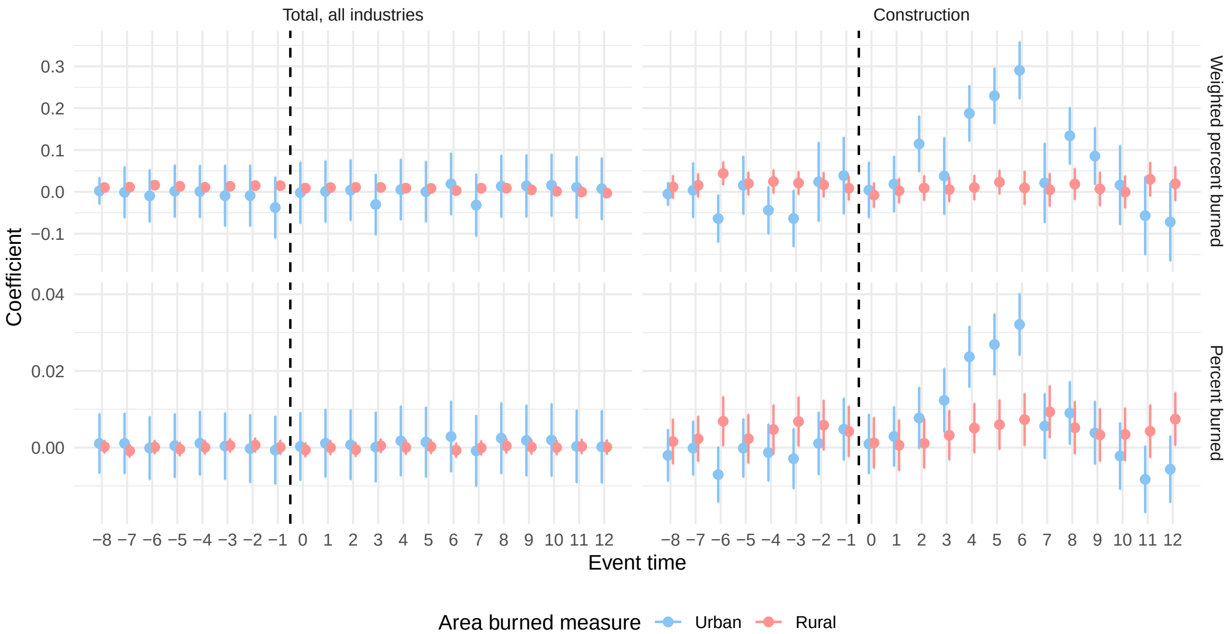


(d) High Park Fire, Colorado, 2012

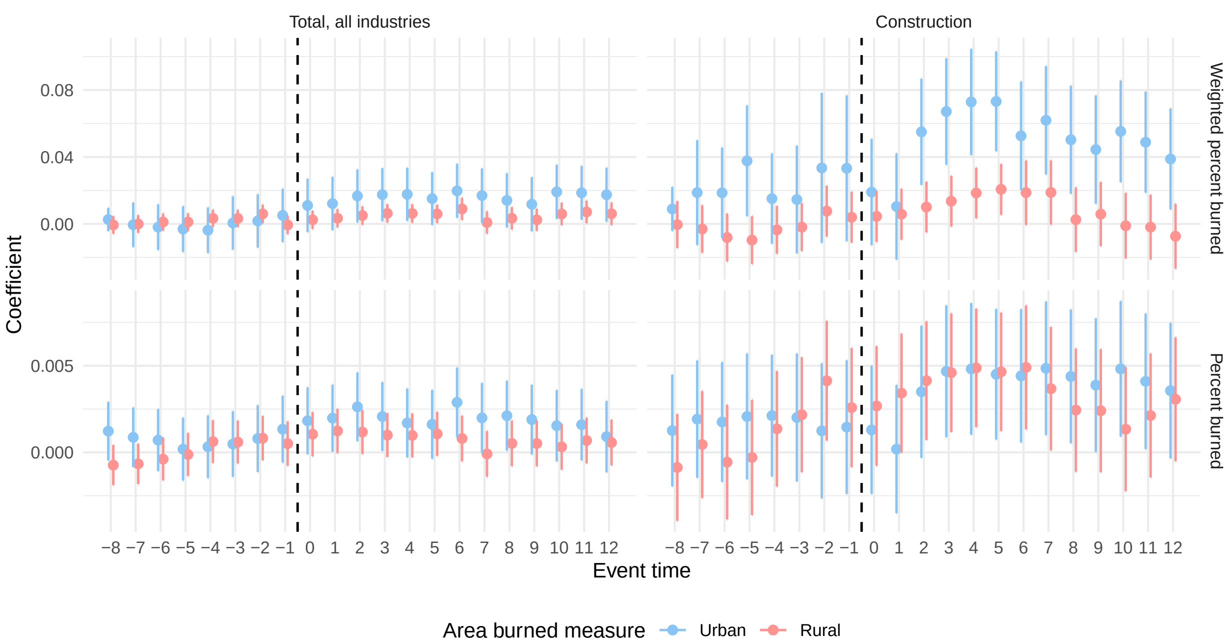


(e) Waldo Canyon Fire, Colorado, 2012

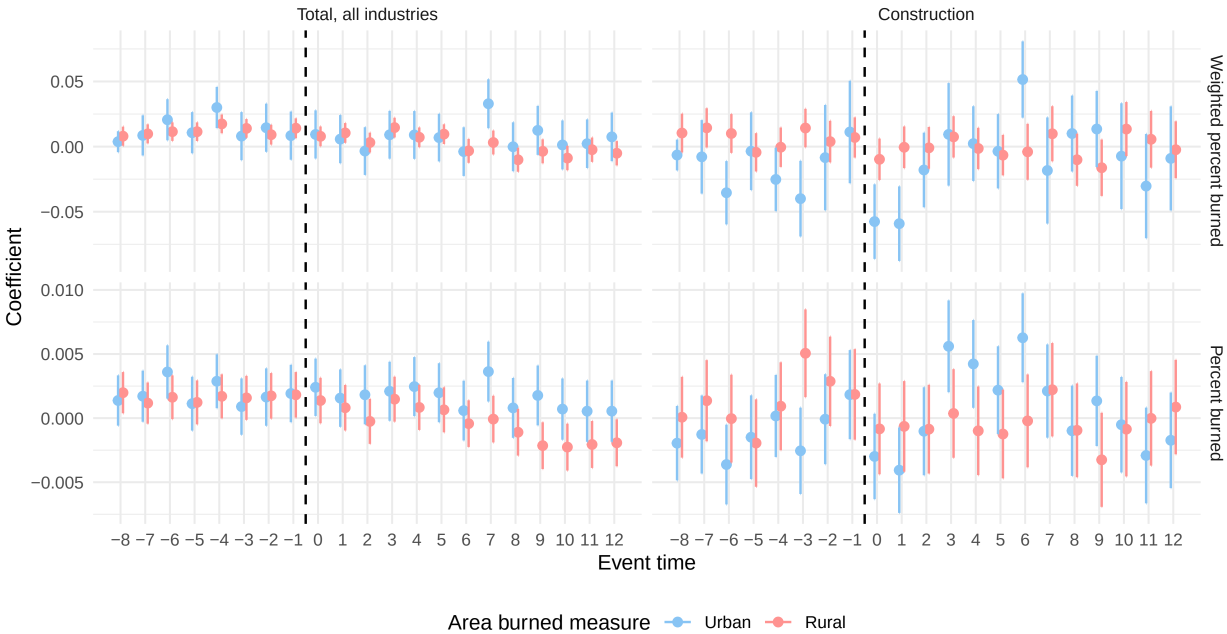
Figure 4: Wildfire effects on county employment, establishment, and wage growth



(a) Employment growth

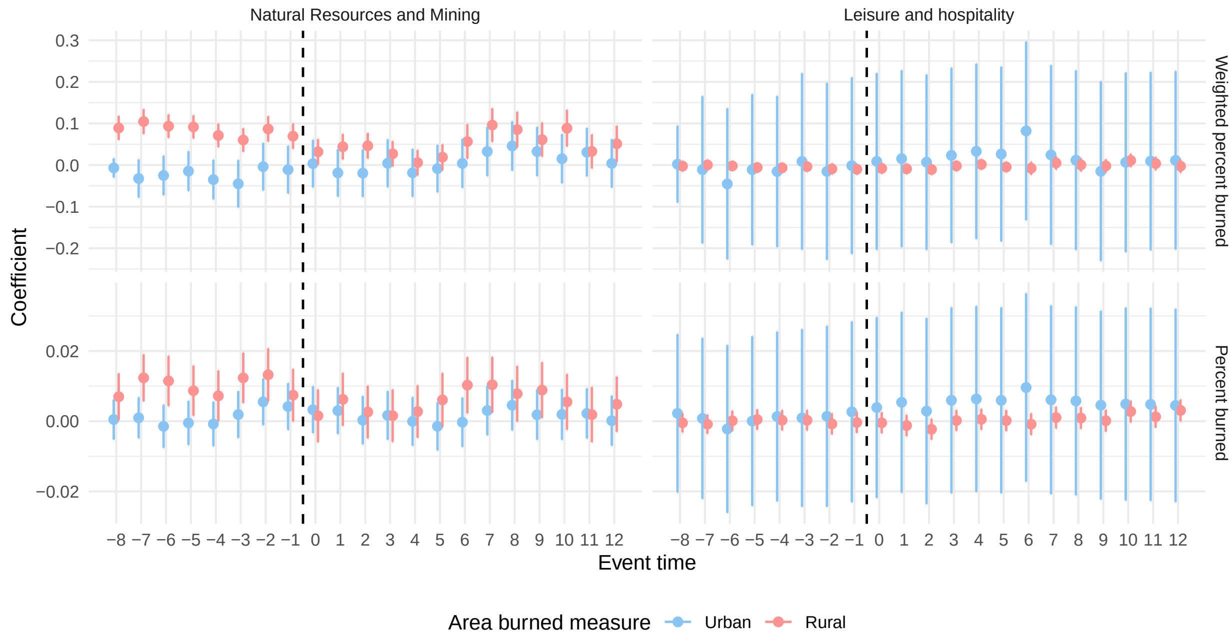


(b) Growth in the number of establishments

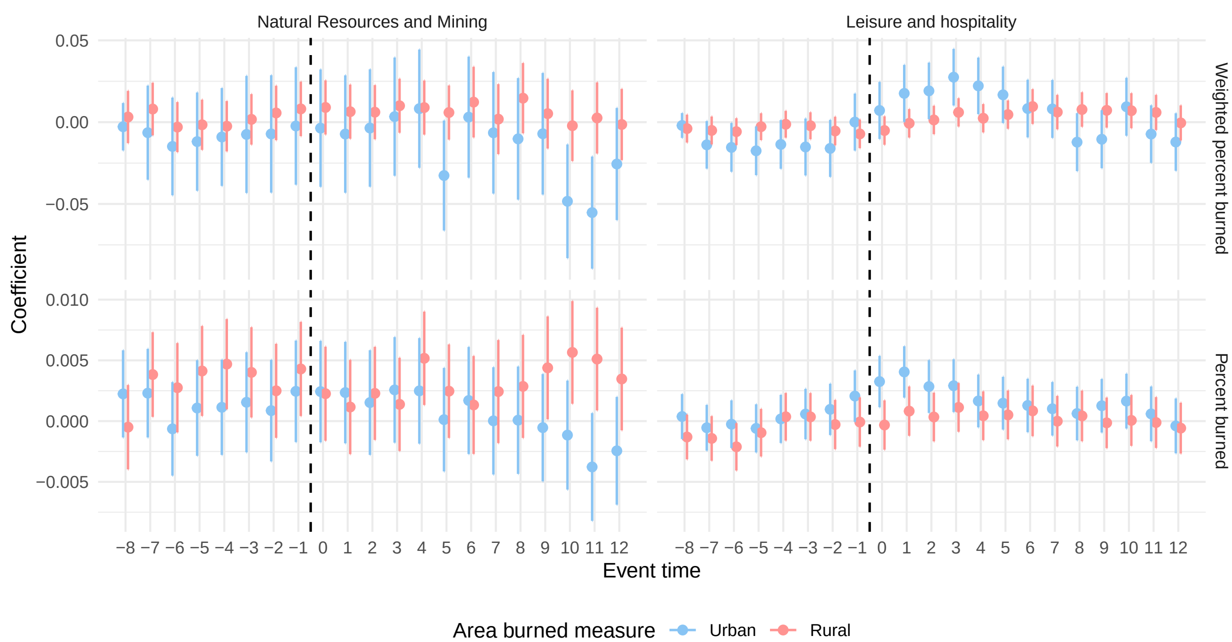


(c) Wage growth

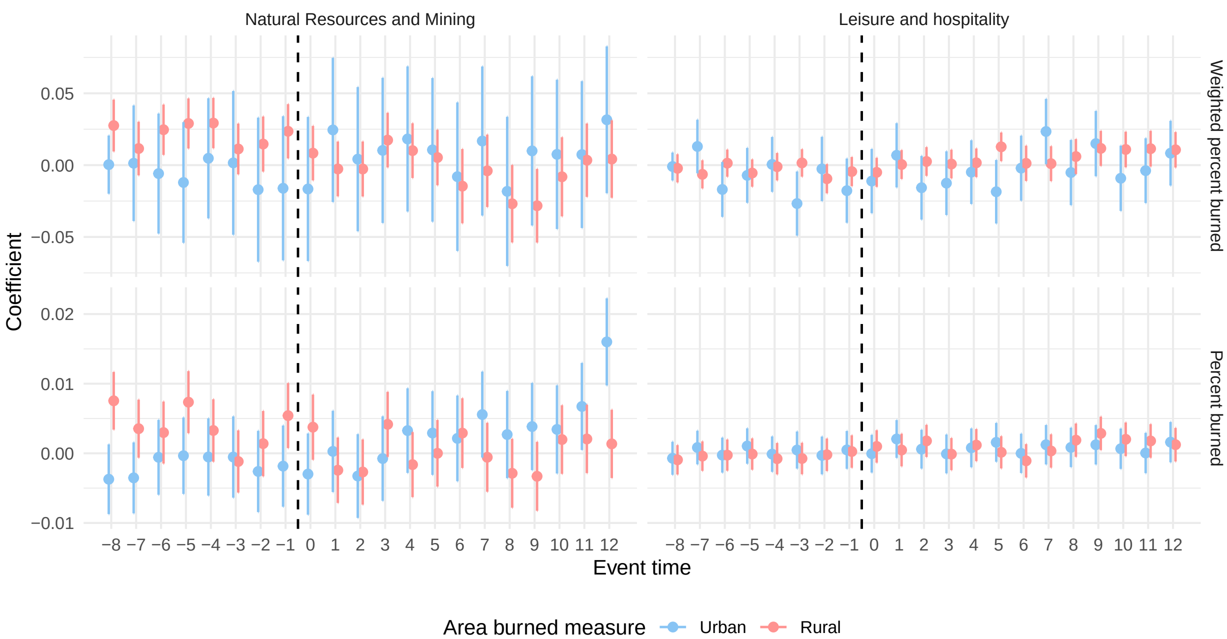
Figure 5: Wildfire effects on county employment, establishment, and wage growth



(a) Employment growth



(b) Growth in the number of establishments



(c) Wage growth