California's Heat Standard Did Not Harm Construction and Agriculture

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Abstract

In previous research, we found that California's 2005 heat standard was associated with a 33-51% reduction in heat-related deaths among outdoor workers. With roughly 3,000 such deaths in the United States in 2024, extending California's heat protections across the country could prevent roughly 1,000 to 1,500 worker deaths per year. Opponents of heat standards claim that such regulations will negatively impact outdoor industries. Using the same methodological approach as our previous study, we examined the economic consequences of California's heat standard in construction and agriculture from 1999 through 2020. We found no evidence that California's heat standard negatively affected the state's construction or agriculture sectors.

Introduction

In 2005, California passed the nation's first state-level outdoor heat standard. The policy requires employers to provide outdoor workers with low-cost protections including rest, water, and shade on hot days. Although the initial policy was criticized for weak enforcement and regulatory loopholes, Cal/OSHA increased enforcement in 2010 and the California legislature passed a strengthened law in 2015. In prior research with Jamie McCallum, we found that the effectiveness of California's heat standard increased substantially over time. We found no decrease associated with the policy during the initial implementation period (2005–09), but point estimates suggested a 33 percent decrease in heat-related deaths among outdoor workers after increased enforcement (2010–14) and a 51 percent decrease after California's heat standard revisions went into effect (2015–20).[1]

In 2024, there were 2,892 heat-related deaths among outdoor workers. Extending California's heat protections to the entire United States could prevent roughly 1,000 to 1,500 worker deaths per year. Yet efforts to implement new outdoor heat standards at the state and federal level have met strong opposition from employers, especially in outdoor industries like agriculture and construction. According to these critics, heat standards are "a rigid, one-size-fits-all approach" to protecting workers that will increase labor costs and decrease economic output. In the face of such employer opposition, many policymakers wonder if the health benefits of protecting workers are outweighed by the potential economic costs of heat standards.

To begin to answer this question, we examined the relationship between California's outdoor heat standard and the economic wellbeing of the state's agriculture and construction industries from 1999 through 2020. For construction, we estimated the association between California's heat standard and county-level employment, wages, and number of establishments.

[1] The estimated effects of California's heat standard for 2010-2014 (33% reduction) and 2015-2020 (51%) were jointly statistically significant. This means that at least one of the two periods is associated with a statistically significant reduction. Therefore, a 33% reduction represents a "conservative" estimate of the association between California's heat standard and heat-related deaths among outdoor workers, while a 51% reduction represents an "optimistic" estimate. See Dean and McCallum, "California's Heat Standard and Heat-Related Deaths among Outdoor Workers."

For agriculture, we estimated the association between California's heat standard and county-level farm cash receipts, total production expenses, and hired farm labor expenses. We chose these six outcomes because they correspond directly to the claims made by industry opponents of heat standards, namely that such regulations will destroy jobs, force firms to close, reduce workers' earnings, raise labor costs, and reduce economic output in outdoor industries.

To increase comparability with our *Health Affairs* study of California's heat standard and heat-related deaths among outdoor workers, we analyzed agricultural and construction outcomes using the same study cohort, study period, and methodology. That study's central finding was that the standard's benefits grew as the policy became more demanding. If compliance imposed economic burdens on employers, we would expect those consequences to follow the same trajectory, appearing smallest under the original, weakly enforced standard and largest after the 2015 revisions. We therefore evaluated the association between the heat standard and each economic outcome in every policy period, and whether any economic burdens grew as the standard was strengthened.

Study Data and Method

We estimated the association between California's outdoor heat standard and construction and agriculture outcomes during the period 1999-2020. We evaluated the consequences of California's 2005 heat standard, as well as how they varied with increased enforcement efforts that began in 2010 and a 2015 revision that closed loopholes to improve compliance. Our study sample included all 126 counties in Arizona, California, Nevada, and Oregon during 1999–2020, or 2,772 county-years. Construction models are estimated on 2,546 of these, because the Bureau of Labor Statistics does not disclose data on construction for 226 county-years, most of them in Nevada; agricultural models are estimated on 2,706, excluding Alpine and San Francisco counties in California and Storey County in Nevada, which report no farm cash receipts in any year.

For construction, the primary outcomes were employment, average weekly wages, and the number of establishments at the county-year level. These data are available from the Bureau of Labor Statistics' Quarterly Census of Employment and Wages (QCEW). We log transformed average weekly wages to address their non-normal distribution and to reduce the influence of outliers. We gathered county-year level data on population, which we used as an exposure term in our negative binomial models of construction employment and number of establishments. We also gathered county-year data on total private employment, which we used as an alternative exposure as a sensitivity analysis.

For agriculture, the primary outcomes were farm cash receipts, total farm production expenses, and hired farm labor expenses, all at the county-year level. These data are available from the Bureau of Economic Analysis (BEA). Cash receipts measure the scale of the agricultural economy and enable us to analyze whether heat standards are associated with a reduction in the agricultural sector. Production expenses measure the total cost of production, enabling us to analyze whether heat standards create regulations that increase production costs. Hired labor expenses specifically focuses on labor costs and enables us to test whether heat standards are associated with higher labor costs. All three agricultural outcomes were log transformed to address their non-normal distributions and to reduce the influence of outliers.

We also gathered county-year data on average high temperature from May through September from the National Centers for Environmental Information, which we use to characterize the study counties in exhibit 1.

Statistical Analysis

We first estimated descriptive statistics for all outcomes and covariates separately for counties with and without heat standards. We then explored how construction and agricultural outcomes varied with state-level heat standards during our study period. We began by plotting annual county means for each outcome in California, which adopted a heat standard in 2005, and in the neighboring states of Arizona, Nevada, and Oregon, which did not.

To estimate the association between an outdoor heat standard and construction employment and establishments, we estimated a time-series cross-sectional, multivariable negative binomial regression model, using population as an exposure term. Because population enters as an exposure, the resulting coefficient is an estimate of the effect on construction employment per capita. To estimate the association with construction wages and the three agricultural outcomes, we estimated time-series cross-sectional, multivariable ordinary least squares regression models on the log of each outcome. All models included county and year fixed effects to adjust for time-invariant differences across counties and for common shocks or trends affecting all counties in a given year.

Our main models included three dummy variables representing key policy phases in California: the initial 2005 standard (2005–09), increased enforcement efforts (2010–14), and legislative revisions that closed loopholes (2015–20). This approach compared changes in agricultural and construction outcomes in California with contemporaneous changes in Arizona, Nevada, and Oregon, which never adopted a heat standard.

We report 95% confidence intervals based on wild cluster bootstrapped standard errors to account for potential correlation in errors within states over time, with Webb weights to improve finite-sample properties. We also used these standard errors to conduct a Wald test for the joint significance of the 2010–14 and 2015–20 policy periods. All analyses were conducted using Stata, version 15.

Sensitivity Tests

We assessed the robustness of the results from our negative binomial regression models to using county-level total private employment, rather than county-level population, as an exposure term.

Limitations

This study had several limitations. First, even with the inclusion of county and year fixed effects, the observational study design precluded causal interpretations. Second, the scarcity of state-level heat standards nationwide limited our analysis to four states, reducing statistical power. Third, the 2015-2020 period coincided with two other California policies that may have raised farm labor costs; a 2016 bill that phased out agriculture's exemption from the state's overtime law and legislation that increased the state's minimum wage. We therefore cannot separate our estimates for the 2015-2020 period from the effects of these other policy changes. Fourth, farm cash receipts are the product of prices and quantities, and California's crop mix differs from that of neighboring states; although year fixed effects adjust for price shocks common to all counties, we were unable to adjust for commodity-specific shocks that may affect counties or states differentially. Fifth, the construction estimates cannot fully separate the effect of the heat standard from the housing boom and bust that dominated the sector during this period. That cycle differed across the four states in both timing and magnitude. Year fixed effects absorb shocks common to all counties in a given year, but a cycle that arrived at different times and with different force is not a common shock, and a state-by-period indicator cannot distinguish it from a policy effect.

Study Results

Descriptive Statistics

We obtained data for all 126 counties in Arizona, California, Nevada, and Oregon for the period 1999–2020. All fifty-eight counties in California were covered by a heat standard starting in 2005, whereas none of the sixty-eight counties in the neighboring states was covered by a heat standard during the study period. We compared counties in California with counties in the neighboring states and found that California counties were larger, hotter, and had larger agriculture and construction sectors (exhibit 1).

Plots of unadjusted outcomes (exhibits 2 and 3) showed that California and its neighboring states followed closely parallel trajectories through the study period, with no visible trend breaks at California's adoption of a heat standard in 2005, its increase in enforcement in 2010, or its heat standard revision in 2015.

Construction employment rose through the housing boom in both groups, peaking in 2006 in California and 2007 in the neighboring states, fell sharply through the collapse, and returned to growth after 2011 and 2012 respectively. Construction establishments followed a similar path but declined longer, bottoming in 2013 and 2014, and ended the period close to where they began. Construction wages rose steadily in both groups. In agriculture, cash receipts rose in both groups through a peak in 2014 and then declined through 2020; production expenses grew at nearly the same rate in both groups over the full period; and hired farm labor expenses rose in both groups.

Main Regression Results

Construction

Our negative binomial regression analysis found that California's heat standard was not associated with a change in construction employment (exhibit 4). During the initial period (2005–09), the heat standard was associated with an estimated 6.5 percent decrease ($p = 0.427$) in employment. Following California's increased enforcement efforts in 2010, the standard was associated with an estimated 7.6 percent decrease ($p = 0.535$), and following the 2015 revisions, with an estimated 3.1 percent decrease ($p = 0.720$). A Wald test found that the combined effect of the 2010–14 and 2015–20 periods was not statistically significant ($p = 0.603$).

Our negative binomial regression analysis found that California's heat standard was not associated with a change in the number of construction establishments (exhibit 4). During the initial period (2005–09), the heat standard was associated with an estimated 5.3 percent decrease ($p = 0.054$). Following increased enforcement in 2010, the standard was associated with an estimated 0.8 percent decrease ($p = 0.860$), and following the 2015 revisions, with an estimated 10.2 percent increase ($p = 0.337$). A Wald test found that the combined effect of the 2010–14 and 2015–20 periods was not statistically significant ($p = 0.301$).

Our ordinary least squares regression analysis found that California’s heat standard was not associated with a change in construction wages (exhibit 4). During the initial period (2005–09), the heat standard was associated with an estimated 3.2 percent increase ($p = 0.676$) in average weekly wages. Following increased enforcement in 2010, the standard was associated with an estimated 3.1 percent increase ($p = 0.741$), and following the 2015 revisions, with an estimated 3.8 percent increase ($p = 0.607$). A Wald test found that the combined effect of the 2010–14 and 2015–20 periods was not statistically significant ($p = 0.448$). Because average weekly wages are total wages divided by employment, they reflect both hourly rates and hours worked, and these data cannot distinguish between the two.

Agriculture

Our ordinary least squares regression analysis found that California's heat standard was not associated with a change in hired farm labor expenses (exhibit 5). During the initial period (2005–09), the heat standard was associated with an estimated 8.2 percent decrease ($p = 0.330$) in hired farm labor expense. Following increased enforcement in 2010, the standard was associated with an estimated 6.8 percent decrease ($p = 0.361$), and following the 2015 revisions, with an estimated 17.5 percent increase ($p = 0.196$). A Wald test found that the combined effect of the 2010–14 and 2015–20 periods was not statistically significant ($p = 0.233$).

Our ordinary least squares regression analysis found no evidence that California's heat standard reduced farm cash receipts (exhibit 5). During the initial period (2005–09), the heat standard was associated with an estimated 0.2 percent increase ($p = 0.864$). Following increased enforcement in 2010, the standard was associated with an estimated 12.6 percent increase ($p = 0.165$), and following the 2015 revisions, with an estimated 14.8 percent increase ($p = 0.066$). A Wald test of the combined effect of the 2010–14 and 2015–20 periods returned $p = 0.069$. Every estimate for this outcome is positive, pointing toward higher agricultural receipts in California, not lower.

Our ordinary least squares regression analysis found no evidence that California’s heat standard increased total farm production expenses (exhibit 5). During the initial period (2005–09), the heat standard was associated with an estimated 7.8 percent decrease ($p = 0.381$) in production expenses. Following increased enforcement in 2010, the standard was associated with an estimated 10.0 percent decrease ($p = 0.446$), and following the 2015 revisions, with an estimated 2.0 percent decrease ($p = 0.824$). A Wald test found that the combined effect of the 2010–14 and 2015–20 periods was not statistically significant ($p = 0.370$).

Sensitivity Analyses

Our negative binomial results for construction employment and establishments were similar when we used county-level total private employment, rather than county-level population, as an exposure term (exhibit 6).

Discussion

Our previous research found that California's heat standard was associated with a 33-51% reduction in heat-related deaths among outdoor workers. In 2024, there were roughly 3,000 heat-related deaths among outdoor workers across the United States. If the whole country were covered by these simple measures, it could save between 1,000 and 1,500 lives each year.

While heat standards may reduce heat-related deaths for outdoor workers, many employers and industry associations argue that heat standards will cause serious economic harm in industries such as agriculture and construction. Our results provide no support for those claims. Across six outcomes spanning employment, establishment counts, wages, revenue, total costs, and labor costs, not one estimate indicates a statistically significant decline associated with any of California's three heat standard policy phases, and none of the six joint Wald tests is significant at conventional levels.

These null results contradict the claims frequently made by agriculture and construction industry representatives about the economic costs of heat standards. The National Grain and Feed Association, for example, opposed a federal heat standard on the grounds that it would "place an undue regulatory burden on grain-handling facilities" through added employee time, equipment costs, and paperwork, and warned against "a one-size-fits-all standard that lacks the necessary flexibility for employers to determine and implement appropriate controls to protect their employees." Similarly, The American Farm Bureau Federation, for example, recently lobbied against a federal heat standard arguing that such regulations will impose "onerous burdens on farmers and ranchers that will lead to economic losses." In contrast, our results suggest that California's heat standard had no effect on farm receipts, production expenses, and hired labor expenses.

The Construction Industry Safety Coalition (CISC), a group of 29 construction trade associations, argues that OSHA's proposed heat standard would lower workers' wages. According to CISC, the heat standard's acclimatization rules would frequently prohibit workers from working an entire day, thus reducing their incomes. In contrast, our results suggest that California's heat standard had no effect on construction workers' average weekly wages.

In a 2026 letter to Secretary of Labor Chavez-DeRemer, Senator Bill Cassidy and fifteen other Republican Senators argued that OSHA's proposed heat standard was a "one-size-fits-all" rule that could reduce employment. According to the letter, the proposed heat standard would create burdensome regulations that could "encourage some businesses to forgo creating a new job." Associated General Contractors of America CEO Jeffrey D. Shoaf made a similar argument in 2024, urging OSHA that regulation would "do more to hamstring firms than to protect workers." In contrast, our results suggest that California's heat standard had no effect on construction employment.

CISC similarly argued that "OSHA's proposed acclimatization schedule is administratively burdensome and economically infeasible, particularly for the small businesses." In contrast, our results suggest that California's heat standard had no effect on the number of construction establishments; heat standards do not appear to create infeasible economic burdens that lead to construction firm closures.

Although the 2005–09 estimate for construction establishments approaches statistical significance, this is the period when California's heat standard was newly adopted, largely unenforced, and not associated with a reduction in heat-related deaths (Dean and McCallum 2025). The estimates for the periods when the standard was actively enforced (2010–14) and then strengthened (2015–20) are both indistinguishable from zero, and the latter is positive in sign. If compliance with the heat standard reduced the number of construction establishments, we would expect the opposite pattern, with the associated decrease growing as the standard became more demanding.

Beyond the absence of measurable harm in our data, there are practical reasons why heat standards barely impose any burden on employers. The core protections required under California state law are not expensive or logistically complex: free drinking water, paid rest breaks, and access to shade. Many employers already provide these accommodations as a matter of ordinary safety practice, so a heat standard mainly formalizes and enforces what many workplaces are already doing. Rather than functioning as an unfunded mandate, the evidence suggests heat standards mostly ask employers to do what already protects their own workforce and bottom line. These heat protections cost little to provide relative to the price of a heat-related death, a workers' compensation claim, lost productivity from heat-impaired workers, or the legal and reputational exposure that can follow a high-profile and preventable workplace catastrophe.

Conclusion

California's 2005 heat standard was not associated with reduced farm receipts, construction employment, construction wages, or the number of construction establishments — including the periods of increased enforcement after 2010 and the state's revised standard after 2015. These null results held up not only for each individual policy period but also when we tested the combined effect of multiple periods jointly, thereby providing consistent evidence that California's heat standard did not meaningfully harm the state's agriculture or construction industries.

These findings stand in contrast to warnings from agriculture and construction industry lobbyists, who have argued that heat standards—in California and in pending state and federal proposals—will raise costs, cut wages, reduce employment, and/or force small businesses to close. Our results, together with our earlier finding that the California heat standard was associated with a 33 percent reduction in heat-related worker deaths after 2010 and a 51 percent reduction after 2015, suggest that commonsense heat protections—water, rest, and shade—can save workers' lives without the economic costs that opponents predict.

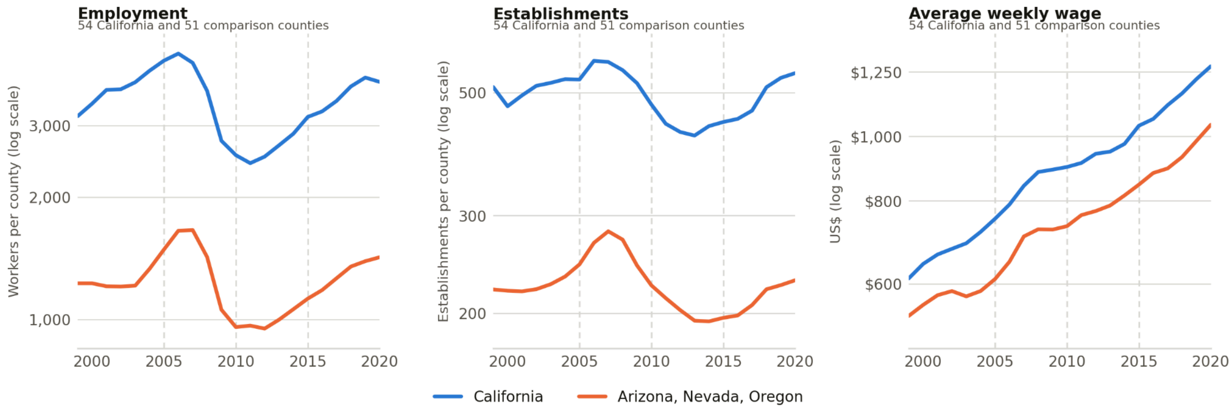
Policymakers weighing new heat standards at the state or federal level should not assume that protecting workers from extreme heat requires accepting economic harm to the industries most affected. Our findings from California instead point to a fairly rare policy opportunity – a substantial improvement in worker health and safety at little to no cost to the broader economy.

Exhibit 1: Characteristics of counties in California versus counties in neighboring states during the study period (1999–2020), as measured in the baseline year of 1999

	California (n = 58)		Arizona, Nevada, Oregon (n = 68)	
County-level variables	**Mean**	**SD**	**Mean**	**SD**
Population	577,572**	1,339,192	152,242	408,610
Max temperature, May–September (°F)	83.0**	6.7	80.3	7.8
Total private employment	217,995*	516,185	69,841	195,785
Construction employment	12,264	22,566	5,741	17,899
Construction establishments	1,302**	2,239	535	1,116
Construction average weekly wage (US$)	628**	134	540	128
Farm cash receipts (US$ millions)	433.9**	631.8	83.4	141.6
Total farm production expenses (US$ millions)	386.0**	550.1	82.8	120.7
Hired farm labor expense (US$ millions)	126.0**	179.6	21.3	36.7

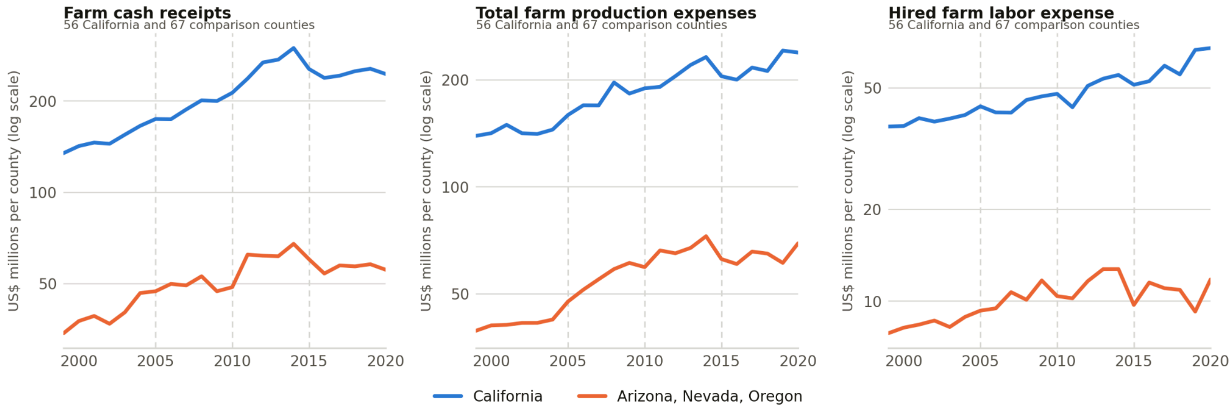
SOURCE Author's analysis of data from the Bureau of Labor Statistics Quarterly Census of Employment and Wages, the Bureau of Economic Analysis, the National Centers for Environmental Information, and the Census Bureau. **NOTE** Values for total private employment and the three construction measures are based on 55 California and 57 comparison-state counties; the Quarterly Census of Employment and Wages does not disclose these cells for the remaining counties in 1999. *p<0.10, **p < 0.05, two-sample t test allowing unequal variances.

Exhibit 2: Unadjusted construction outcomes in California and neighboring states, 1999–2020



SOURCE Author's analysis of data from the Bureau of Labor Statistics Quarterly Census of Employment and Wages. **NOTE** Series are geometric means across counties (the mean of the logged outcome, exponentiated), plotted on a logarithmic scale. Each panel is restricted to counties observed in every year of the study period, so the series are not disturbed by counties entering or leaving the average; panel subtitles report the number of counties. Dashed vertical lines mark the adoption of the standard in 2005, the expansion of enforcement in 2010, and the revisions that took effect in 2015. Average weekly wages are total quarterly wages divided by employment and are not adjusted for inflation.

Exhibit 3: Unadjusted agricultural outcomes in California and neighboring states, 1999–2020



SOURCE Author's analysis of data from the Bureau of Economic Analysis. **NOTE** Series are geometric means across counties (the mean of the logged outcome, exponentiated), plotted on a logarithmic scale. Each panel is restricted to counties observed in every year of the study period, so the series are not disturbed by counties entering or leaving the average; panel subtitles report the number of counties. Dashed vertical lines mark the adoption of the standard in 2005, the expansion of enforcement in 2010, and the revisions that took effect in 2015. Dollar values are current, not inflation-adjusted.

Exhibit 4: Association between California's outdoor heat standard and construction outcomes, 1999–2020

Outcome and policy period	Ratio	95% CI	p value
<u>Construction employment (N = 2,546)</u>			
Original standard (2005–09)	0.935	0.793, 1.103	0.427
Increased enforcement (2010–14)	0.924	0.719, 1.187	0.535
Revised standard (2015–20)	0.969	0.816, 1.151	0.720
Wald test, 2010–14 and 2015–20 jointly	—	—	0.603
<u>Construction establishments (N = 2,546)</u>			
Original standard (2005–09)	0.947	0.896, 1.001	0.054
Increased enforcement (2010–14)	0.992	0.903, 1.089	0.860
Revised standard (2015–20)	1.102	0.904, 1.342	0.337
Wald test, 2010–14 and 2015–20 jointly	—	—	0.301
<u>Construction average weekly wage (N = 2,546)</u>			
Original standard (2005–09)	1.032	0.890, 1.196	0.676
Increased enforcement (2010–14)	1.031	0.860, 1.235	0.741
Revised standard (2015–20)	1.038	0.901, 1.195	0.607
Wald test, 2010–14 and 2015–20 jointly	—	—	0.448

SOURCE Author's analysis of data from the Bureau of Labor Statistics Quarterly Census of Employment and Wages. **NOTE** Each row reports the ratio of the outcome in California relative to Arizona, Nevada and Oregon during the indicated policy period, from models with county and year fixed effects. Construction employment and establishments are estimated by negative binomial regression with county population as the exposure term, matching Dean and McCallum (2025); construction average weekly wages are estimated by ordinary least squares on the natural log of the outcome, with coefficients exponentiated for comparability with the incidence rate ratios reported for employment and establishments. The 95% confidence intervals and Wald test of joint significance were calculated using wild cluster bootstrapped standard errors with Webb weights, clustered at the state level.

Exhibit 5: Association between California's outdoor heat standard and agricultural outcomes, 1999–2020

Outcome and policy period	Ratio	95% CI	p value
Farm cash receipts (N = 2,706)			
Original standard (2005–09)	1.002	0.980, 1.024	0.864
Increased enforcement (2010–14)	1.126	0.952, 1.332	0.165
Revised standard (2015–20)	1.148	0.991, 1.329	0.066
Wald test, 2010–14 and 2015–20 jointly	—	—	0.069
Total farm production expenses (N = 2,706)			
Original standard (2005–09)	0.922	0.770, 1.105	0.381
Increased enforcement (2010–14)	0.900	0.686, 1.180	0.446
Revised standard (2015–20)	0.980	0.818, 1.174	0.824
Wald test, 2010–14 and 2015–20 jointly	—	—	0.370
Hired farm labor expense (N = 2,706)			
Original standard (2005–09)	0.918	0.773, 1.090	0.330
Increased enforcement (2010–14)	0.932	0.801, 1.084	0.361
Revised standard (2015–20)	1.175	0.920, 1.501	0.196
Wald test, 2010–14 and 2015–20 jointly	—	—	0.233

SOURCE Author's analysis of data from the Bureau of Economic Analysis. **NOTE** Each row reports the ratio of the outcome in California relative to Arizona, Nevada and Oregon during the indicated policy period, from models with county and year fixed effects. All outcomes are estimated by ordinary least squares on the natural log of the outcome, with coefficients exponentiated for comparability with the incidence rate ratios reported in Exhibit 4. The 95% confidence intervals and Wald test of joint significance were calculated using wild cluster bootstrapped standard errors with Webb weights, clustered at the state level.

Exhibit 6: Sensitivity of the construction count models to the exposure term

Outcome and policy period	Ratio	95% CI	p value
<u>Construction employment (N = 2,542)</u>			
Original standard (2005–09)	0.947	0.843, 1.063	0.357
Increased enforcement (2010–14)	0.932	0.778, 1.115	0.441
Revised standard (2015–20)	0.973	0.844, 1.122	0.709
Wald test, 2010–14 and 2015–20 jointly	—	—	0.548
<u>Construction establishments (N = 2,542)</u>			
Original standard (2005–09)	0.954	0.894, 1.019	0.159
Increased enforcement (2010–14)	0.976	0.914, 1.041	0.455
Revised standard (2015–20)	1.065	0.911, 1.245	0.431
Wald test, 2010–14 and 2015–20 jointly	—	—	0.212

SOURCE Author's analysis of data from the Bureau of Labor Statistics Quarterly Census of Employment and Wages. **NOTE** Identical to exhibit 4 except that total private employment replaces county population as the exposure term in the two count models — the robustness specification reported in Dean and McCallum (2025). The sample is four county-years smaller because total private employment is suppressed where county population is not.