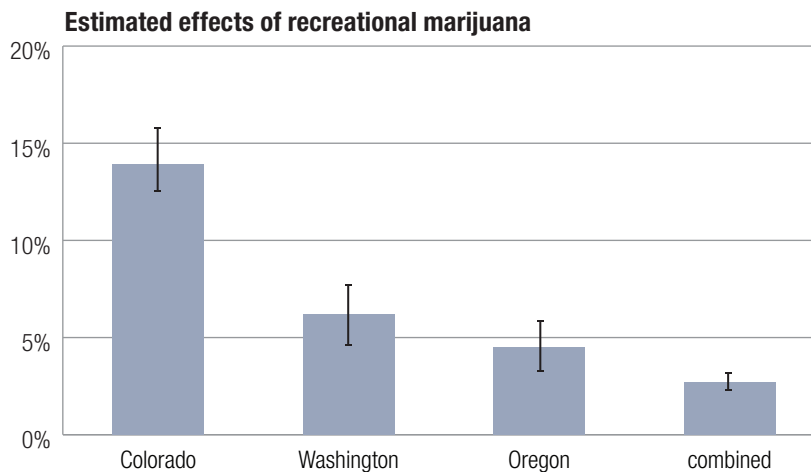# Recreational marijuana and collision claim frequencies

▶ **Summary**

Colorado was the first state to legalize recreational marijuana for adults 21 and older in the United States. Voters approved the measure in November 2012 and sales began in January 2014. Washington voters also approved recreational marijuana in November 2012 and sales began in July 2014. Oregon followed suit two years later legalizing marijuana in November 2014 with sales starting in October 2015. The Highway Loss Data Institute (HLDI) has been monitoring changes in collision claim frequencies in each of these states since the inception of legal recreational use.

Collision claim frequencies in each of the three states with legal recreational use were separately analyzed relative to nearby states. Each analysis controlled for differences in the rated driver populations, insured vehicle fleet, the mix of urban versus rural exposure, unemployment, weather, and seasonality. In every analysis, the advent of the legal retail sale of marijuana is correlated with increases in collision claim frequency. Claim frequencies in Colorado were 13.9 percent higher than in Nebraska, Utah and Wyoming (see figure below). Claim frequencies in Washington state were 6.2 percent higher than in Montana and Idaho. In Oregon claim frequencies were 4.5 percent higher than in Idaho, Montana and Nevada.

A single analysis that combined each of the three states with legal recreational use was also conducted. In this analysis, the study states were compared to other western states whose monthly collision claim frequencies prior to legalization were highly correlated with the frequencies for each of the study states. Using this approach, the legalization of retail sales was associated with a 2.7 percent increase in collision claim frequencies.

**Estimated effects of recreational marijuana**

# ▶ Introduction

Colorado was the first state to legalize recreational marijuana for adults 21 and older in the United States. Voters approved the measure in November 2012 and sales began in January 2014. Washington voters also approved recreational marijuana in November 2012 and sales began in July 2014. Oregon followed suit two years later legalizing marijuana in November 2014 with sales starting in October 2015. Collision claim frequencies are examined in this report for each individual state, comparing their losses to nearby control states without such laws. A second analysis is conducted that combines all three states into one model to evaluate the combined effect of legalizing recreational marijuana.

# ▶ Methods

## Vehicles

The vehicles in this study were 1981-2017 models. The 33 most recent model years available for each calendar year were used (e.g., data from calendar year 2014 included 1985-2015 models). Loss data is included from January 2012 through October 2016. **Table 1** summarizes the exposure and claims for the study and control states used in both the single state and combined analyses.

| Table 1: Data summary by coverage type | | |
|---|---|---|
| | Exposure | Claims |
| **Single state analysis** | | |
| Colorado | 21,538,921 | 1,117,764 |
| Oregon | 17,509,251 | 836,019 |
| Washington | 18,276,655 | 900,403 |
| **Combined analysis** | 49,225,462 | 2,494,668 |

## Insurance data

Automobile insurance covers damages to vehicles and property as well as injuries to people involved in crashes. Different insurance coverages pay for vehicle damage versus injuries, and different coverages may apply depending on who is at fault.

This study is based on collision coverage data. This coverage insures against physical damage to a driver's vehicle sustained in a crash with an object or other vehicle, generally when the driver is at fault. Such claims are the most frequent for insurers, and, hence they provide the greatest power in looking at changes in crash frequency. In addition, because they represent the crashes of culpable drivers, they should be sensitive to changes in driving ability; although, they do not necessarily account for all crashes that might be attributable to marijuana use. For example, a driver under the influence of marijuana might crash into another vehicle that violates their right of way; the other person is at fault, but absent marijuana influence, the crash might not have occurred.

## Rated drivers

HLDI collects a limited number of factors about rated drivers including age, gender, marital status, and garaging location. The rated driver is the one considered to represent the greatest loss potential for an insured vehicle. In a household with multiple vehicles and/or drivers, the assignment of drivers to vehicles can vary from insurance company to company and from state to state, but typically it reflects the driver most likely to operate the vehicle. Information on the actual driver at the time of a loss is not available in the HLDI database. In the present study, the data were stratified by rated driver age group (<25, 25-65, 66+, or unknown), gender (male, female, or unknown), marital status (married, single, or unknown), and registered vehicle density of garaging location (<50, 50-99, 100-249, 250-499, 500-99, ≥1,000 registered vehicles per square mile).

### External data

**Unemployment**: State monthly unemployment data were obtained from the Bureau of Labor Statistics. Unadjusted unemployment percentages were used.

**Monthly mean temperature**: State monthly mean temperatures, measured in degrees Fahrenheit, were obtained from the National Oceanic and Atmospheric Administration (NOAA) for January 2012 through October 2016 and were linked to HLDI loss data. Daily mean temperatures for states were unknown. Mean monthly temperatures were divided into two ranges: below freezing (<32 °F), and above freezing (32+ °F).

NOAA state monthly precipitation, measured in inches, for January 2012 through October 2016 were also linked to HLDI loss data. The type of precipitation and number of days in a given month with measurable precipitation were not available. Temperature and precipitation were further used to create a proxy for the amount of snowfall – amount of precipitation during months with average temperature below freezing.

### Study states

The 3 studied states with legal recreational marijuana sales are Colorado, Washington, and Oregon. Relevant law dates are summarized in **Table 2**.

| Table 2: Key effective marijuana law dates | | | |
|---|---|---|---|
| | **Colorado** | **Washington** | **Oregon** |
| **Vote** | November 2012 | November 2012 | November 2014 |
| **Retail sales** | January 2014 | July 2014 | October 2015 |

### Single state analysis

Two separate analyses were conducted for the states of Colorado, Washington, and Oregon. In these analyses the individual study state was compared to its controls. Control states were selected based on proximity to the study state as well as on the similarity of seasonal crash patterns prior to 2014. For each potential control state, monthly frequencies were obtained for the 24 months of 2012-13. Further, the Pearson correlation coefficient was calculated between the frequencies in the study state and each potential control state. For Colorado, the states of Nebraska (correlation of 0.85), Wyoming (0.79), and Utah (0.60) were selected as controls. For Washington, the states of Montana (0.67) and Idaho (0.63) were selected as controls. For Oregon, the states of Idaho (0.67), Montana (0.83) and Nevada (0.70) were used.

Regression analysis was used to quantify the effect of marijuana legislation on collision claim frequency while controlling for other factors. The dataset was stratified by vehicle model year and vehicle type, rated driver age group, gender, marital status, garaging state, vehicle density, and calendar year and month. For example, a unit of observation was May 2012 collision exposure and claim count for 2007 model luxury SUVs, with young married males as rated drivers and vehicles garaged in an area of Idaho with a vehicle density of 50-99 vehicles per square mile. Claim frequency (claims per year of exposure) was modeled using Poisson regression with a logarithmic link function. Collision claim frequency was defined as the number of collision claims divided by the number of insured vehicle years. Independent variables corresponding to vehicle model year, vehicle type, driver age group, gender, marital status, and vehicle density were included in the model to control for any frequency fluctuations affected by changes in the demographic composition over time. A categorical month variable (i.e. January, February, etc.) was used in the model to further control for seasonality. To control for economic factors, unemployment was used as an independent variable. In an attempt to control for weather related changes to claim frequency that might occur independently of seasonality, temperature range and precipitation below freezing were used as independent variables. For space reasons, illustrative full regression results on Colorado collision claim frequency are shown in the **Appendix**.

In addition, the following variables were used:

- **Month index**: continuous, sequential variable to identify each month in the time series

- **State type**: categorical variable used to identify a state as a study state or part of the control states

- **Legislation status**: categorical variable used to identify the status of legal marijuana for each month; 0 value was used to identify months during the period before the legalization, and the value of 1 was used to identify months during the period after the legalization.

Two interactions were used in the model. The first, month index and state type, estimated trend lines for both a study state and its control states. The estimate for the month index variable represents the trend for the control states, while the estimate for the month index and state type interaction is the difference between trends for a study state and its control states. The second more critical interaction, state type and legislation status, similarly quantified the difference in collision claim frequency between states with and without legal marijuana. A p-value less than 0.05 for this interaction indicates the legislation had a statistically meaningful effect on collision claim frequency.

### Combined analysis

In this analysis Colorado, Washington and Oregon were included in the same dataset with selected control states. The control states included Idaho, Montana, Nevada, Utah and Wyoming. Control states were selected among the states identified as the West region by the U.S. Census Bureau. The five control states had statistically significant correlations of monthly claim frequencies with each of the three study states. The Poisson regression model from the single state analysis was used with the following changes:

- Discrete state values were used instead of the binary state type variable.

- A single legislation variable was used to estimate the main effect instead of the interaction. This variable was based on both the month and the state, and equaled 1 only in the study states after the legislation took effect in that state.
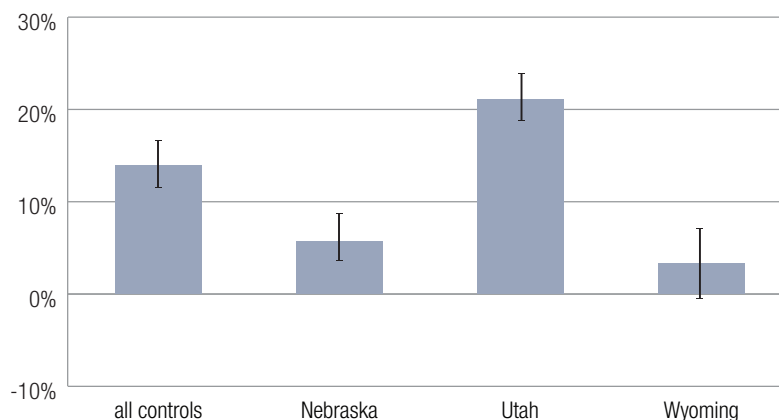
## ▶ Results

### Single state analysis

The following figures (1-3) illustrate the estimated changes in collision claim frequency that are estimated to be associated with legalized recreational marijuana sales. A summary table (**Table 3**) at the end of the results section contains the model estimates and regression details.

### Colorado

**Figure 1** shows the estimated effects of marijuana sales in Colorado, which began in January 2014. A significant 13.9 percent increase in collision claim frequency was estimated in Colorado compared to the three control states combined. Results vary when each individual control state is examined independently with effects ranging from a 3.3 percent increase in Colorado compared to Wyoming to a 21.1 percent increase when compared to Utah. With the exception of the Wyoming comparison, all of the claim frequency increases were significant.
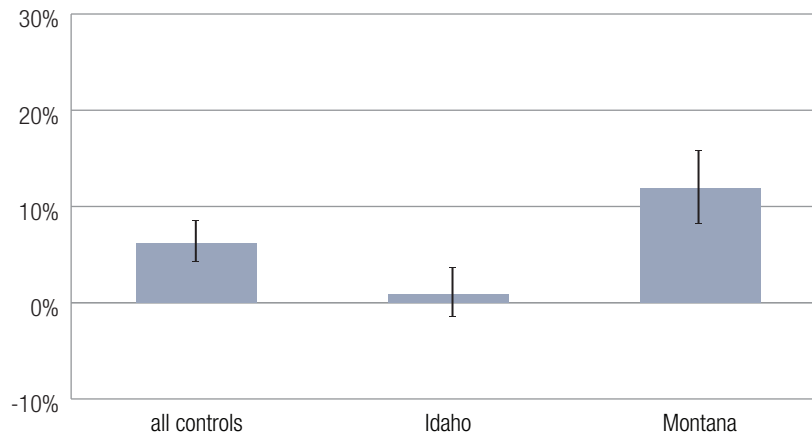
**Figure 1: Estimated effect of marijuana sales in Colorado**

## Washington

**Figure 2** shows the estimated effects of marijuana sales in Washington, which began 6 months after Colorado. A significant 6.2 percent increase in collision claim frequency was estimated in Washington after retail sales began in July 2014 compared to the control states combined. When compared to Idaho and Montana individually, claim frequencies were also up. Compared to Idaho, collision claim frequencies were up 0.9 percent but not significantly. This compares to the significant claim frequency increase of nearly 12 percent when Washington is compared to Montana.
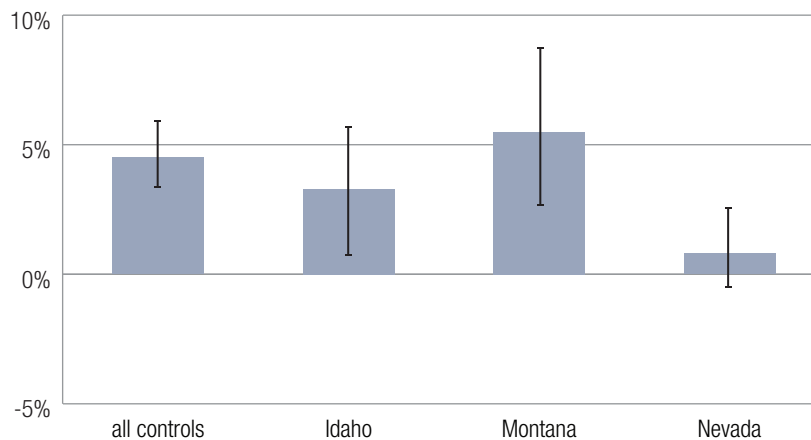
**Figure 2: Estimated effect of marijuana sales in Washington**



## Oregon

Oregon began retail sales of marijuana to the public in October 2015. **Figure 3** shows the estimated effects of legalizing marijuana sales in the state compared to three control states. As with Colorado and Washington, collision claim frequencies are higher than before the legalization of marijuana. Collision claim frequencies are 4.5 percent higher and the result is significant. Effects vary when compared to each control state individually but range from a 0.8 percent increase compared to Nevada to a 5.5 percent increase compared to Montana. The increases are significant when Oregon is compared to Idaho and Montana.

**Figure 3: Estimated effect of marijuana sales in Oregon**



## Combined analysis

A final analysis was completed that combined the loss results for the three study states and five highly correlated control states (correlation ≥0.6) in the west that included Idaho, Utah, Montana, Nevada and Wyoming. This analysis yielded a significant 2.7 percent increase in collision claim frequency for states that are currently legally selling recreational marijuana.

| Table 3: Detailed results of regression analysis of collision claim frequencies | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Study | Control | Estimate | Effect | Standard error | Wald 95% confidence limits | | Chi-square | P-value |
| Colorado | Nebraska | 0.0554 | 5.7% | 0.0108 | 0.0342 | 0.0766 | 26.25 | <0.0001 |
| | Utah | 0.1917 | 21.1% | 0.0093 | 0.1734 | 0.2100 | 421.37 | <0.0001 |
| | Wyoming | 0.0327 | 3.3% | 0.0175 | -0.0016 | 0.0670 | 3.50 | 0.0615 |
| | Nebraska, Utah, Wyoming | 0.1300 | 13.9% | 0.0075 | 0.1153 | 0.1447 | 299.50 | <0.0001 |
| Washington | Idaho | 0.0089 | 0.9% | 0.0127 | -0.0161 | 0.0338 | 0.48 | 0.4862 |
| | Montana | 0.1126 | 11.9% | 0.0155 | 0.0822 | 0.1429 | 52.91 | <0.0001 |
| | Idaho and Montana | 0.0601 | 6.2% | 0.0104 | 0.0398 | 0.0804 | 33.57 | <0.0001 |
| Oregon | Idaho | 0.0322 | 3.3% | 0.0117 | 0.0093 | 0.0551 | 7.62 | 0.0058 |
| | Nevada | 0.0080 | 0.8% | 0.0088 | -0.0092 | 0.0251 | 0.83 | 0.3619 |
| | Montana | 0.0534 | 5.5% | 0.0142 | 0.0255 | 0.0812 | 14.14 | 0.0002 |
| | Idaho, Nevada, Montana | 0.0437 | 4.5% | 0.0075 | 0.029 | 0.0584 | 33.93 | <0.0001 |
| Colorado, Washington, Oregon | Idaho, Nevada, Montana, Utah, Wyoming | 0.0267 | 2.7% | 0.0022 | 0.0224 | 0.0311 | 143.3 | <0.0001 |

▶ **Discussion**

In January 2014 Colorado became the first state in the U.S. to legalize retail sales of marijuana for recreational purposes. Washington and Oregon have followed with sales starting in July 2014 and October 2015, respectively. While HLDI has been monitoring changes in collision claim frequencies in these states since 2014, this is the first publication from HLDI on recreational marijuana sales and insurance losses. Results from single state analyses as well as the combination of the three states indicate that collision claim frequencies increased significantly when retail sales commenced. When states are examined individually, the frequency of collision claims increases between 4.5 and 13.9 percent. A single analysis that combined the three states with legal recreational use found a smaller yet significant increase of 2.7 percent.

| Appendix: Detailed results of linear regression analysis of Colorado collision claim frequency | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Parameter | | Degrees of freedom | Estimate | Effect | Standard error | Wald 95% confidence limits | | Chi-square | P-value |
| Intercept | | 1 | -8.8083 | | 0.0594 | -8.9247 | -8.6919 | 21986.70 | <0.0001 |
| Model year | 1981 | 1 | -1.4705 | -77.0% | 0.2566 | -1.9735 | -0.9675 | 32.83 | <0.0001 |
| | 1982 | 1 | -1.5434 | -78.6% | 0.1916 | -1.9189 | -1.1679 | 64.90 | <0.0001 |
| | 1983 | 1 | -1.5380 | -78.5% | 0.1491 | -1.8303 | -1.2457 | 106.37 | <0.0001 |
| | 1984 | 1 | -1.4345 | -76.2% | 0.1041 | -1.6385 | -1.2304 | 189.86 | <0.0001 |
| | 1985 | 1 | -1.5358 | -78.5% | 0.0975 | -1.7269 | -1.3447 | 248.05 | <0.0001 |
| | 1986 | 1 | -1.3341 | -73.7% | 0.0864 | -1.5035 | -1.1647 | 238.18 | <0.0001 |
| | 1987 | 1 | -1.2785 | -72.2% | 0.0824 | -1.4400 | -1.1170 | 240.83 | <0.0001 |
| | 1988 | 1 | -1.1739 | -69.1% | 0.0768 | -1.3244 | -1.0234 | 233.57 | <0.0001 |
| | 1989 | 1 | -1.1734 | -69.1% | 0.0725 | -1.3154 | -1.0314 | 262.22 | <0.0001 |
| | 1990 | 1 | -1.0758 | -65.9% | 0.0683 | -1.2098 | -0.9419 | 247.75 | <0.0001 |
| | 1991 | 1 | -0.9688 | -62.0% | 0.0656 | -1.0973 | -0.8403 | 218.34 | <0.0001 |
| | 1992 | 1 | -0.8687 | -58.1% | 0.0637 | -0.9935 | -0.7439 | 186.12 | <0.0001 |
| | 1993 | 1 | -0.8370 | -56.7% | 0.0620 | -0.9586 | -0.7154 | 182.06 | <0.0001 |
| | 1994 | 1 | -0.8065 | -55.4% | 0.0608 | -0.9257 | -0.6873 | 175.96 | <0.0001 |
| | 1995 | 1 | -0.7552 | -53.0% | 0.0599 | -0.8726 | -0.6379 | 159.13 | <0.0001 |
| | 1996 | 1 | -0.6420 | -47.4% | 0.0594 | -0.7584 | -0.5256 | 116.78 | <0.0001 |
| | 1997 | 1 | -0.6174 | -46.1% | 0.0589 | -0.7329 | -0.5019 | 109.83 | <0.0001 |
| | 1998 | 1 | -0.5440 | -42.0% | 0.0587 | -0.6590 | -0.4290 | 85.90 | <0.0001 |
| | 1999 | 1 | -0.5157 | -40.3% | 0.0585 | -0.6303 | -0.4011 | 77.73 | <0.0001 |
| | 2000 | 1 | -0.4476 | -36.1% | 0.0584 | -0.5620 | -0.3331 | 58.78 | <0.0001 |
| | 2001 | 1 | -0.4980 | -39.2% | 0.0583 | -0.6123 | -0.3837 | 72.94 | <0.0001 |
| | 2002 | 1 | -0.4205 | -34.3% | 0.0583 | -0.5347 | -0.3063 | 52.09 | <0.0001 |
| | 2003 | 1 | -0.3612 | -30.3% | 0.0582 | -0.4754 | -0.2471 | 38.47 | <0.0001 |
| | 2004 | 1 | -0.3027 | -26.1% | 0.0582 | -0.4167 | -0.1886 | 27.04 | <0.0001 |
| | 2005 | 1 | -0.2377 | -21.2% | 0.0582 | -0.3517 | -0.1236 | 16.69 | <0.0001 |
| | 2006 | 1 | -0.1743 | -16.0% | 0.0582 | -0.2883 | -0.0603 | 8.98 | 0.0027 |
| | 2007 | 1 | -0.1355 | -12.7% | 0.0582 | -0.2495 | -0.0215 | 5.42 | 0.0199 |
| | 2008 | 1 | -0.1104 | -10.5% | 0.0582 | -0.2245 | 0.0036 | 3.60 | 0.0576 |
| | 2009 | 1 | -0.0980 | -9.3% | 0.0582 | -0.2121 | 0.0161 | 2.83 | 0.0923 |
| | 2010 | 1 | -0.0451 | -4.4% | 0.0582 | -0.1591 | 0.0690 | 0.60 | 0.4388 |
| | 2011 | 1 | -0.0090 | -0.9% | 0.0582 | -0.1231 | 0.1050 | 0.02 | 0.8769 |
| | 2012 | 1 | 0.0242 | 2.4% | 0.0582 | -0.0898 | 0.1382 | 0.17 | 0.6777 |
| | 2013 | 1 | 0.0531 | 5.5% | 0.0582 | -0.0609 | 0.1672 | 0.83 | 0.3613 |
| | 2014 | 1 | 0.0821 | 8.6% | 0.0582 | -0.0321 | 0.1962 | 1.99 | 0.1587 |
| | 2015 | 1 | 0.1083 | 11.4% | 0.0583 | -0.0060 | 0.2226 | 3.45 | 0.0632 |
| | 2016 | 1 | 0.0955 | 10.0% | 0.0589 | -0.0200 | 0.2110 | 2.63 | 0.1052 |
| | 2017 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| Rated driver age group | <25 | 1 | 0.3128 | 36.7% | 0.0040 | 0.3049 | 0.3207 | 6048.48 | <0.0001 |
| | 25-65 | 1 | -0.0023 | -0.2% | 0.0027 | -0.0076 | 0.0030 | 0.70 | 0.4024 |
| | 66+ | 0 | 0 | 0 | 0 | 0 | 0 | | |
| Rated driver gender | Female | 1 | 0.2870 | 33.2% | 0.0061 | 0.2750 | 0.2990 | 2205.88 | <0.0001 |
| | Male | 1 | 0.2578 | 29.4% | 0.0062 | 0.2457 | 0.2698 | 1751.96 | <0.0001 |
| | Unknown | 0 | 0 | 0 | 0 | 0 | 0 | | |

| Parameter | | Degrees of freedom | Estimate | Effect | Standard error | Wald 95% confidence limits | | Chi-square | P-value |
|---|---|---|---|---|---|---|---|---|---|
| **Appendix: Detailed results of linear regression analysis of Colorado collision claim frequency** | | | | | | | | | |
| Rated driver marital status | Married | 1 | -0.1666 | -15.3% | 0.0058 | -0.178 | -0.1552 | 819.33 | <0.0001 |
| | Single | 1 | 0.0689 | 7.1% | 0.0059 | 0.0574 | 0.0804 | 137.44 | <0.0001 |
| | Unknown | 0 | 0 | 0 | 0 | 0 | 0 | | |
| Registered vehicle density | 0-50 | 1 | -0.2792 | -24.4% | 0.0031 | -0.2852 | -0.2732 | 8366.78 | <0.0001 |
| | 51-100 | 1 | -0.2504 | -22.2% | 0.0036 | -0.2575 | -0.2434 | 4840.31 | <0.0001 |
| | 101-250 | 1 | -0.0414 | -4.1% | 0.0034 | -0.0480 | -0.0347 | 147.99 | <0.0001 |
| | 251-500 | 1 | -0.1675 | -15.4% | 0.0032 | -0.1738 | -0.1613 | 2770.98 | <0.0001 |
| | 501-1,000 | 1 | -0.1047 | -9.9% | 0.0030 | -0.1106 | -0.0987 | 1194.29 | <0.0001 |
| | >1,000 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| Vehicle type | luxury cars | 1 | 0.4419 | 55.6% | 0.0046 | 0.4328 | 0.4509 | 9247.36 | <0.0001 |
| | luxury SUVs | **1** | **0.2546** | **29.0%** | **0.0052** | **0.2443** | **0.2648** | **2376.06** | **<0.0001** |
| | nonluxury cars | 1 | 0.3167 | 37.3% | 0.0030 | 0.3108 | 0.3226 | 11205.90 | <0.0001 |
| | nonluxury SUVs | 1 | 0.0916 | 9.6% | 0.0032 | 0.0853 | 0.0979 | 806.89 | <0.0001 |
| | pickups | 0 | 0 | 0 | 0 | 0 | 0 | | |
| Unemployment | | 1 | -0.0128 | -1.3% | 0.0023 | -0.0174 | -0.0083 | 30.41 | <0.0001 |
| Temperature range | 00-31 | 1 | 0.0546 | 5.6% | 0.0086 | 0.0378 | 0.0714 | 40.60 | <0.0001 |
| | 32+ | 0 | 0 | 0 | 0 | 0 | 0 | | |
| Precipitation | | 1 | 0.0431 | 4.4% | 0.0065 | 0.0304 | 0.0558 | 44.08 | <0.0001 |
| Month index | | 1 | -0.0019 | -0.2% | 0.0002 | -0.0023 | -0.0016 | 121.17 | <0.0001 |
| State type | | 1 | 0.0978 | 10.3% | 0.0061 | 0.0859 | 0.1098 | 257.14 | <0.0001 |
| Legislation status | | 1 | -0.0461 | -4.5% | 0.0059 | -0.0578 | -0.0345 | 60.18 | <0.0001 |
| Month index x state type | | 1 | -0.0032 | -0.3% | 0.0003 | -0.0037 | -0.0027 | 149.90 | <0.0001 |
| Month | January | 1 | -0.0818 | -7.9% | 0.0058 | -0.0931 | -0.0705 | 202.28 | <0.0001 |
| | February | 1 | -0.0390 | -3.8% | 0.0059 | -0.0507 | -0.0274 | 43.13 | <0.0001 |
| | March | 1 | -0.1319 | -12.4% | 0.0081 | -0.1478 | -0.1160 | 264.95 | <0.0001 |
| | April | 1 | -0.1800 | -16.5% | 0.0079 | -0.1954 | -0.1646 | 524.69 | <0.0001 |
| | May | 1 | -0.1772 | -16.2% | 0.0078 | -0.1925 | -0.1619 | 515.83 | <0.0001 |
| | June | 1 | -0.1290 | -12.1% | 0.0081 | -0.1448 | -0.1132 | 255.54 | <0.0001 |
| | July | 1 | -0.1759 | -16.1% | 0.0079 | -0.1914 | -0.1604 | 495.40 | <0.0001 |
| | August | 1 | -0.1651 | -15.2% | 0.0077 | -0.1802 | -0.1500 | 457.37 | <0.0001 |
| | September | 1 | -0.1703 | -15.7% | 0.0076 | -0.1852 | -0.1555 | 505.51 | <0.0001 |
| | October | 1 | -0.1844 | -16.8% | 0.0076 | -0.1992 | -0.1695 | 594.58 | <0.0001 |
| | November | 1 | -0.0550 | -5.4% | 0.0075 | -0.0697 | -0.0402 | 53.35 | <0.0001 |
| | December | 0 | 0 | 0 | 0 | 0 | 0 | | |
| State type x legislation status | | 1 | 0.130 | 13.9% | 0.0075 | 0.1153 | 0.1447 | 299.50 | <0.0001 |