Has Adult Smoking Been Decreasing Over The Years In The United States?

Cesar Corral

2025-08-13

Causal Analysis: Interrupted Time Series (ITS)

To assess whether a specific event — the **2009 federal tobacco tax increase** — had a causal impact on adult smoking rates, we applied an Interrupted Time Series (ITS) model. This method allows us to isolate both the **immediate level change** and **change in trend** following the policy.

We modeled per capita cigarette consumption (`Total_Per_Million`) using:

- `time`: continuous time since 2000
- `intervention`: binary variable marking years after 2009
- `post_time`: time since intervention began

```
smoking_data <- read.csv("~/cleaned_smoking_data.csv")
head(smoking_data,7)
```

```
##   Year Population                  Topic           Measure
## 1 2000  209786736 Noncombustible Tobacco Smokeless Tobacco
## 2 2000  209786736    Combustible Tobacco        Cigarettes
## 3 2000  209786736    Combustible Tobacco            Cigars
## 4 2000  209786736    Combustible Tobacco     Loose Tobacco
## 5 2000  209786736    Combustible Tobacco            Cigars
## 6 2000  209786736    Combustible Tobacco     Loose Tobacco
## 7 2000  209786736 Noncombustible Tobacco Smokeless Tobacco
##              Submeasure       Data.Value.Unit Domestic_Per_Million
## 1       Chewing Tobacco                Pounds             216897.2
## 2    Cigarette Removals            Cigarettes         2017526769.1
## 3          Small Cigars                Cigars           10692454.1
## 4 Roll-Your-Own Tobacco Cigarette Equivalents           26961236.4
## 5          Large Cigars                Cigars           16062656.5
## 6          Pipe Tobacco Cigarette Equivalents           12561170.8
## 7                 Snuff                Pounds             315247.0
##   Imports_Per_Million Total_Per_Million   Product_Type
## 1        4.383738e+02          217335.6 Noncombustible
## 2        5.872470e+07      2076251468.4    Combustible
## 3        1.718364e+05        10864290.5    Combustible
## 4        1.613494e+06        28574730.2    Combustible
## 5        2.441498e+06        18504155.0    Combustible
## 6        1.736297e+06        14297467.7    Combustible
## 7        8.450963e+01          315331.5 Noncombustible
```

```r
tail(smoking_data,7)
```

```
##     Year Population                  Topic           Measure
## 162 2023  262083034    Combustible Tobacco        Cigarettes
## 163 2023  262083034    Combustible Tobacco            Cigars
## 164 2023  262083034    Combustible Tobacco            Cigars
## 165 2023  262083034    Combustible Tobacco     Loose Tobacco
## 166 2023  262083034    Combustible Tobacco     Loose Tobacco
## 167 2023  262083034 Noncombustible Tobacco Smokeless Tobacco
## 168 2023  262083034 Noncombustible Tobacco Smokeless Tobacco
##                Submeasure       Data.Value.Unit Domestic_Per_Million
## 162    Cigarette Removals            Cigarettes         651797527.94
## 163          Large Cigars                Cigars          11541606.17
## 164          Small Cigars                Cigars            165920.23
## 165          Pipe Tobacco Cigarette Equivalents          41581519.19
## 166 Roll-Your-Own Tobacco Cigarette Equivalents           1737254.24
## 167       Chewing Tobacco                Pounds             44619.61
## 168                Snuff                Pounds            375305.28
##     Imports_Per_Million Total_Per_Million   Product_Type
## 162        26113334.753       677910862.7    Combustible
## 163        32081283.064        43622889.2    Combustible
## 164          368230.627          534150.9    Combustible
## 165         4270477.337        45851996.5    Combustible
## 166         2022374.802         3759629.0    Combustible
## 167           4992.097           49611.7 Noncombustible
## 168           5313.301          380618.6 Noncombustible
```

```r
library(ggplot2)
cigs <- subset(smoking_data, Submeasure == "Cigarette Removals")

#Create ITS Variables
cigs$time <- cigs$Year - min(cigs$Year)  # time since 2000
cigs$intervention <- ifelse(cigs$Year >= 2009, 1, 0)  # 2009 tax increase
cigs$post_time <- ifelse(cigs$Year >= 2009, cigs$time - (2009 - 2000), 0)  # years since intervention
```

Interrupted Time Series Model

```r
its_model <- lm(Total_Per_Million ~ time + intervention + post_time, data = cigs)
summary(its_model)
```

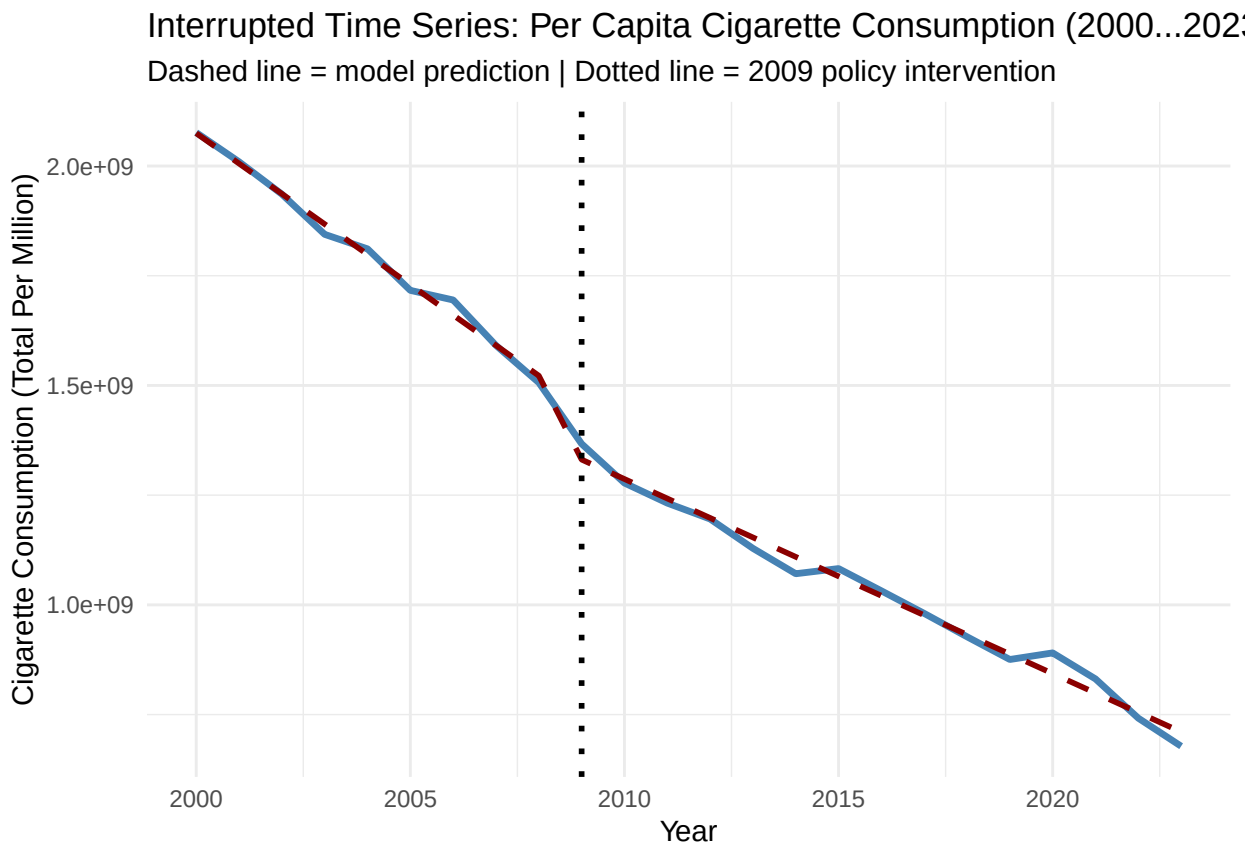
```
##
## Call:
## lm(formula = Total_Per_Million ~ time + intervention + post_time,
##     data = cigs)
##
## Residuals:
##       Min        1Q    Median        3Q       Max
## -38435131 -12826670  -1574972  11574565  47077070
##
## Coefficients:
```

```
##                Estimate Std. Error t value Pr(>|t|)
## (Intercept)  2074709616   14407128 144.006  < 2e-16 ***
## time          -69062950    3026102 -22.822 8.57e-16 ***
## intervention -122104447   20561172  -5.939 8.29e-06 ***
## post_time      24736888    3334602   7.418 3.67e-07 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 23440000 on 20 degrees of freedom
## Multiple R-squared:  0.9974, Adjusted R-squared:  0.997
## F-statistic:  2571 on 3 and 20 DF,  p-value: < 2.2e-16
```

Trend & ITS Model Visualization

```r
cigs$predicted <- predict(its_model)

ggplot(cigs, aes(x = Year, y = Total_Per_Million)) +
  geom_line(color = "steelblue", size = 1.2) +
  geom_line(aes(y = predicted), color = "darkred", linetype = "dashed", size = 1) +
  geom_vline(xintercept = 2009, linetype = "dotted", color = "black", size = 1) +
  labs(title = "Interrupted Time Series: Per Capita Cigarette Consumption (2000-2023)",
       subtitle = "Dashed line = model prediction | Dotted line = 2009 policy intervention",
       x = "Year",
       y = "Cigarette Consumption (Total Per Million)") +
  theme_minimal()
```



The results from the Interrupted Time Series model suggest a causal relationship between the 2009 federal tobacco tax increase and adult cigarette consumption in the United States.

- There was a strong declining trend in smoking from 2000 to 2008.
- In 2009, there was a significant and immediate drop in cigarette consumption — suggesting a policy effect.
- However, the post-policy trend slowed down slightly, indicating that while the tax caused an initial drop, the rate of decline wasn't as steep in the following years.
- Overall, the analysis supports the conclusion that the 2009 tax increase had a substantial immediate effect on reducing adult smoking, although long-term behavior change may have plateaued somewhat.

Conclusion and Next Steps

Using national-level data from 2000 to 2023, this study found a strong downward trend in per capita cigarette consumption, particularly around the time of the 2009 federal tobacco tax increase. The use of Interrupted Time Series (ITS) analysis allowed us to assess not just the long-term trend, but also the potential causal impact of this key policy intervention.

- From 2000 to 2008, there was a statistically significant decline in adult smoking.
- In 2009, a large and statistically significant drop occurred in per capita cigarette consumption, coinciding with the tax hike.

- Post-2009, the rate of decline in smoking slowed slightly, though the overall consumption continued to decrease.
- These results suggest that increasing tobacco taxes is an effective tool for reducing adult smoking.
- Future interventions may benefit from combining price increases with education and cessation support, especially to sustain long-term behavior change.