Homework 3-1

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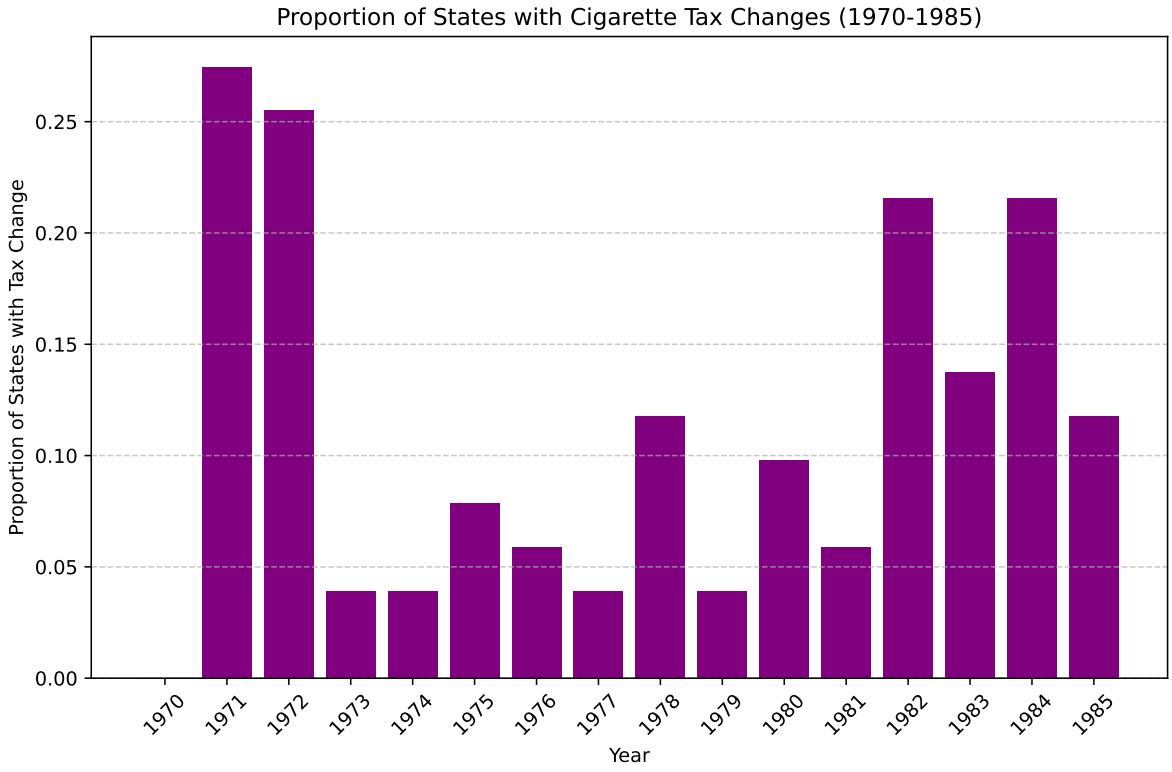
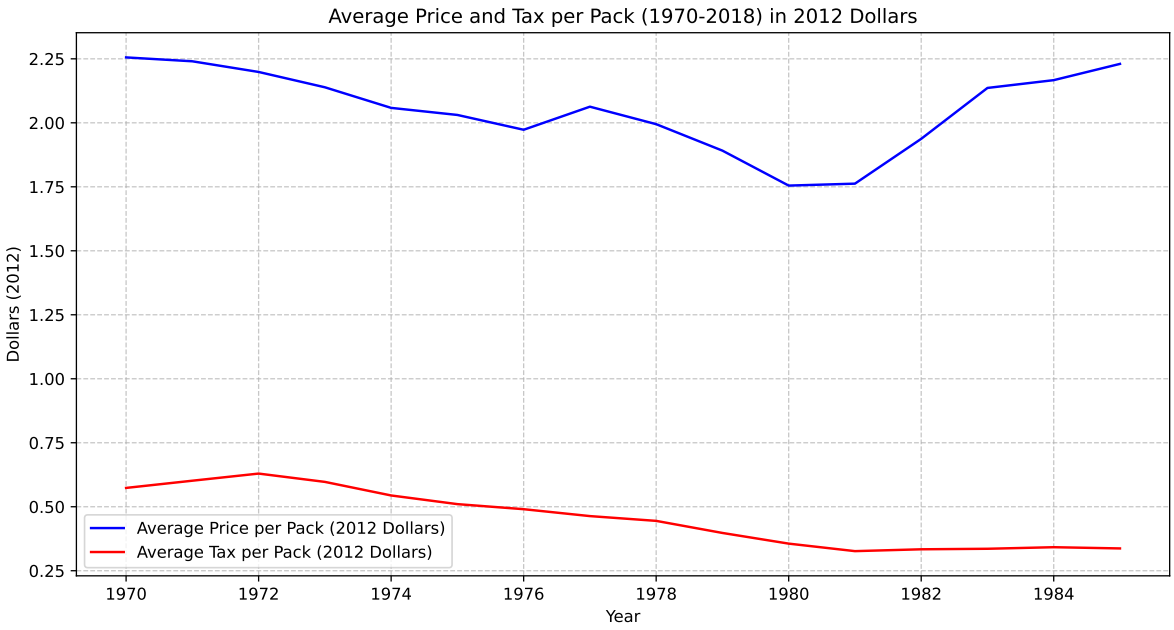
The link to my repository:
https://github.com/sarina-tan/HLTH470hw3

1. Present a bar graph showing the proportion of states with a change in their cigarette tax in each year from 1970 to 1985.

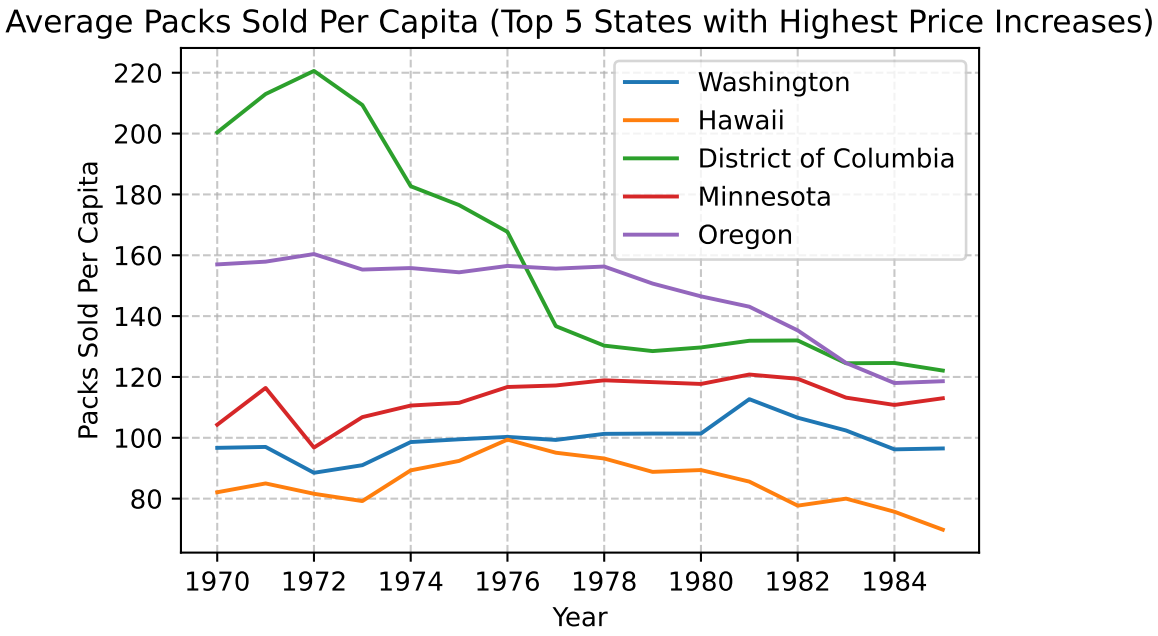


2. Plot on a single graph the average tax (in 2012 dollars) on cigarettes and the average price of a pack of cigarettes from 1970 to 2018.



3. Identify the 5 states with the highest increases in cigarette prices (in dollars) over the time period. Plot the average number of packs sold per capita for those states from 1970 to 2018.

```
Top 5 states with highest cigarette price increases in cigarette prices in dollars:
47              Washington
11                  Hawaii
8     District of Columbia
23               Minnesota
37                  Oregon
Name: state, dtype: object
```

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5 states with the lowest cigarette price increases:
['North Carolina', 'South Carolina', 'Kentucky', 'Tennessee', 'Maryland']
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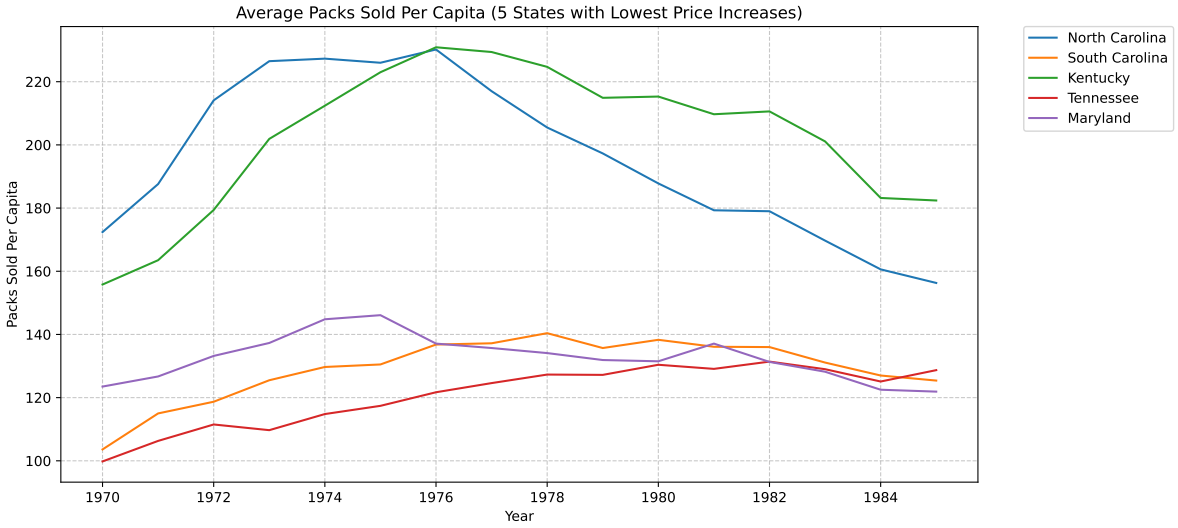
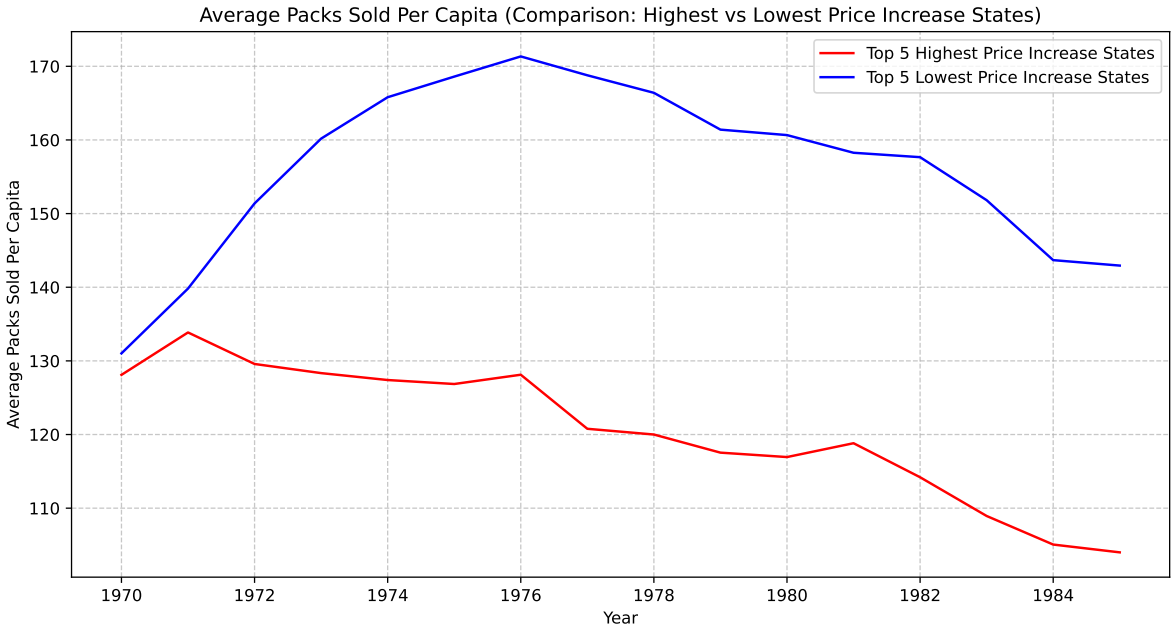

Average Packs Sold Per Capita (5 States with Lowest Price Increases)
Packs Sold Per Capita
Year
100
120
140
160
180
200
220
1970
1972
1974
1976
1978
1980
1982
1984
North Carolina
South Carolina
Kentucky
Tennessee
Maryland

5. Compare the trends in sales from the 5 states with the highest price increases to those with the lowest price increases.



The five states with the largest increases in cigarette prices saw a sharp decline in packs sold per capita from 1970 to 2018, indicating the influence of higher prices and likely stricter tobacco control policies. In contrast, the five states with the smallest price increases experienced more stable cigarette consumption over time, with only a gradual decline. This suggests that states with smaller price hikes, many of which have historical ties to tobacco production, were less proactive in using price-based policies to discourage smoking.

6. Focusing only on the time period from 1970 to 1990, regress log sales on log prices to estimate the price elasticity of demand over that period. Interpret your results.

OLS Regression Results

Dep. Variable:	log_sales_per_capita	R-squared:	0.023
Model:	OLS	Adj. R-squared:	0.021
Method:	Least Squares	F-statistic:	18.82
Date:	Fri, 07 Mar 2025	Prob (F-statistic):	1.62e-05
Time:	15:34:10	Log-Likelihood:	116.37
No. Observations:	816	AIC:	-228.7
Df Residuals:	814	BIC:	-219.3
Df Model:	1		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	4.8011	0.014	344.661	0.000	4.774	4.828
log_price_per_pack	-0.0929	0.021	-4.338	0.000	-0.135	-0.051

Omnibus:	88.176	Durbin-Watson:	0.150
Prob(Omnibus):	0.000	Jarque-Bera (JB):	241.716
Skew:	0.556	Prob(JB):	3.25e-53
Kurtosis:	5.424	Cond. No.	3.89

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.
Estimated Price Elasticity of Demand: -0.09

The estimated price elasticity of demand for cigarettes from 1970 to 1990 is about -0.093, meaning that a 10% rise in cigarette prices corresponds to a 0.93% decline in per capita cigarette sales. This indicates that demand was relatively inelastic during this period, suggesting consumers were not highly sensitive to price changes.

7. Again limiting to 1970 to 1990, regress log sales on log prices using the total (federal and state) cigarette tax (in dollars) as an instrument for log prices. Interpret your results and compare your estimates to those without an instrument. Are they different? If so, why?

IV-2SLS Estimation Summary

Dep. Variable:	log_sales_per_capita	R-squared:	-0.0501
Estimator:	IV-2SLS	Adj. R-squared:	-0.0514
No. Observations:	816	F-statistic:	79.982
Date:	Fri, Mar 07 2025	P-value (F-stat)	0.0000
Time:	15:34:10	Distribution:	chi2(1)
Cov. Estimator:	robust		

Parameter Estimates

	Parameter	Std. Err.	T-stat	P-value	Lower CI	Upper CI
const	4.7090	0.0149	315.62	0.0000	4.6798	4.7383
log_price_per_pack	-0.2596	0.0290	-8.9433	0.0000	-0.3165	-0.2027

Endogenous: log_price_per_pack
Instruments: tax_dollar
Robust Covariance (Heteroskedastic)
Debiased: False

Instrumented Price Elasticity of Demand: -0.26

Using cigarette taxes as an instrument for prices, the estimated price elasticity of demand for cigarettes between 1970 and 1990 is about -0.26. This implies that a 10% rise in cigarette prices leads to a 2.6% decline in per capita cigarette sales, confirming that demand remains relatively inelastic. Compared to the OLS estimate of -0.093, this IV estimate suggests a greater sensitivity to price changes. The difference indicates that the OLS regression likely underestimated the true elasticity, potentially due to endogeneity bias—where factors like state-level anti-smoking campaigns or cultural attitudes toward smoking may simultaneously impact both cigarette consumption and pricing. By leveraging taxes as an instrument, the IV approach isolates the effect of external price shifts driven by policy, offering a more accurate measure of consumer responsiveness to price changes.

8. Show the first stage and reduced-form results from the instrument.

```
First Stage Regression Results:
                            OLS Regression Results
==============================================================================
Dep. Variable:     log_price_per_pack   R-squared:                       0.583
Model:                            OLS   Adj. R-squared:                  0.582
Method:                 Least Squares   F-statistic:                     1138.
Date:                Fri, 07 Mar 2025   Prob (F-statistic):          1.00e-156
Time:                        15:34:10   Log-Likelihood:                 71.316
No. Observations:                 816   AIC:                            -138.6
Df Residuals:                     814   BIC:                            -129.2
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const         -1.4340      0.027    -52.581      0.000      -1.488      -1.380
tax_dollar     3.9366      0.117     33.728      0.000       3.708       4.166
==============================================================================
Omnibus:                       45.486   Durbin-Watson:                   0.445
Prob(Omnibus):                  0.000   Jarque-Bera (JB):               35.777
Skew:                           0.423   Prob(JB):                     1.70e-08
Kurtosis:                       2.420   Cond. No.                         15.8
==============================================================================

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.

Reduced Form Regression Results:
                            OLS Regression Results
==============================================================================
Dep. Variable:     log_sales_per_capita   R-squared:                       0.103
Model:                            OLS   Adj. R-squared:                  0.102
Method:                 Least Squares   F-statistic:                     93.27
Date:                Fri, 07 Mar 2025   Prob (F-statistic):           5.78e-21
Time:                        15:34:10   Log-Likelihood:                 151.30
No. Observations:                 816   AIC:                            -298.6
Df Residuals:                     814   BIC:                            -289.2
Df Model:                           1
Covariance Type:            nonrobust
```

```
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const          5.0813      0.025    205.508      0.000       5.033       5.130
tax_dollar    -1.0219      0.106     -9.657      0.000      -1.230      -0.814
==============================================================================
Omnibus:                       79.495   Durbin-Watson:                   0.187
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              317.645
Skew:                           0.367   Prob(JB):                     1.06e-69
Kurtosis:                       5.967   Cond. No.                         15.8
==============================================================================

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.
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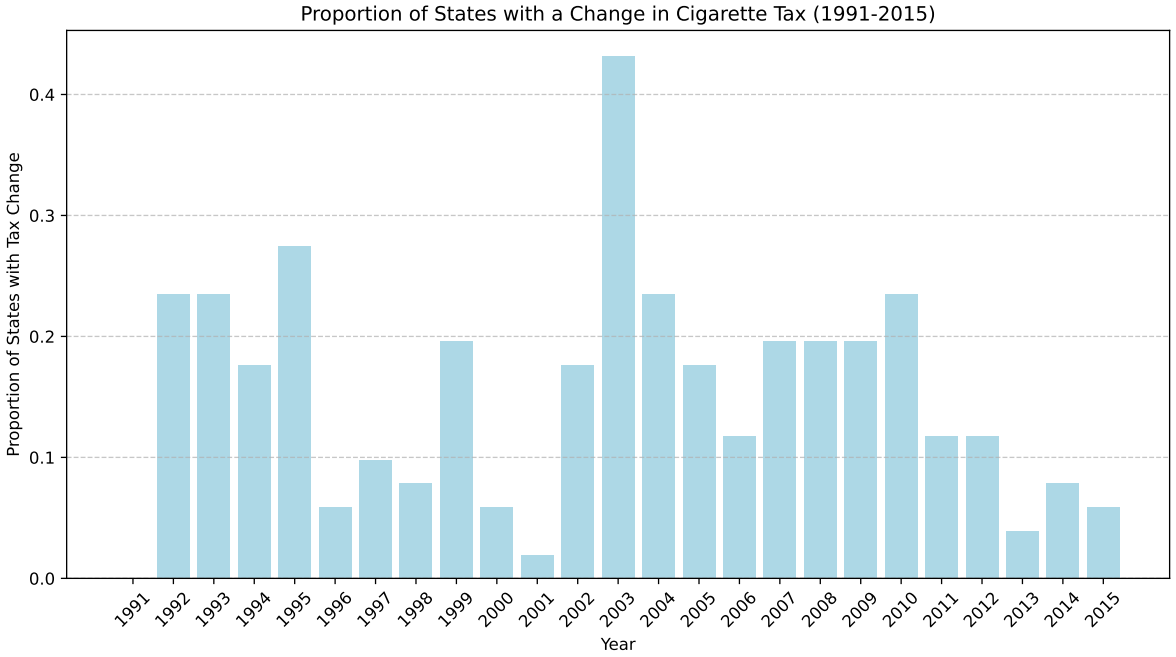
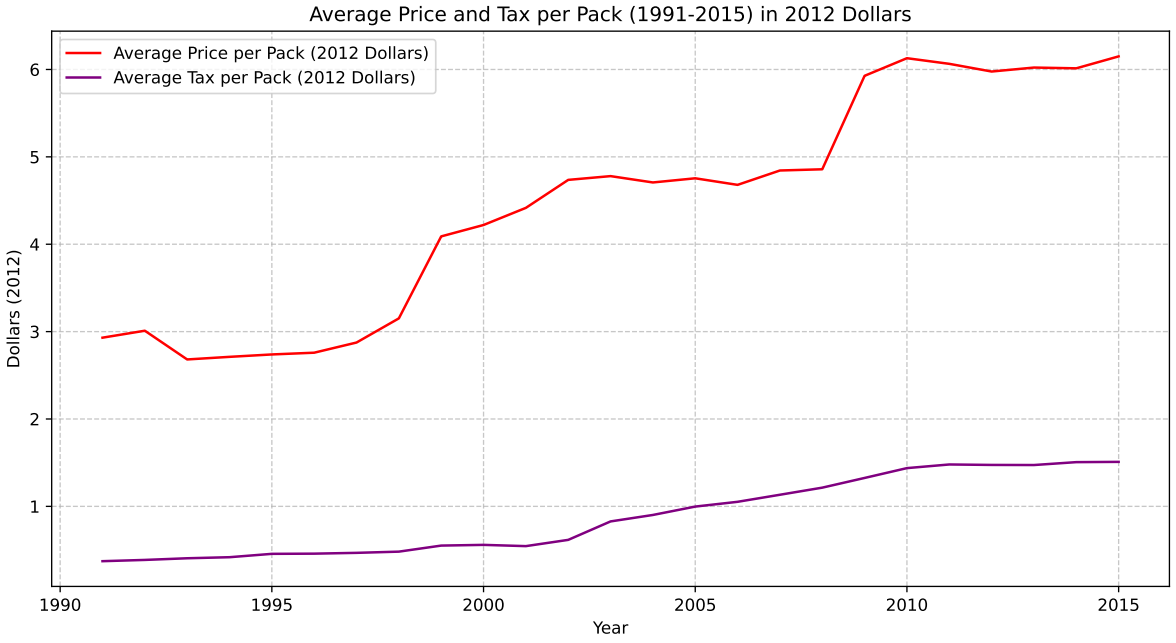
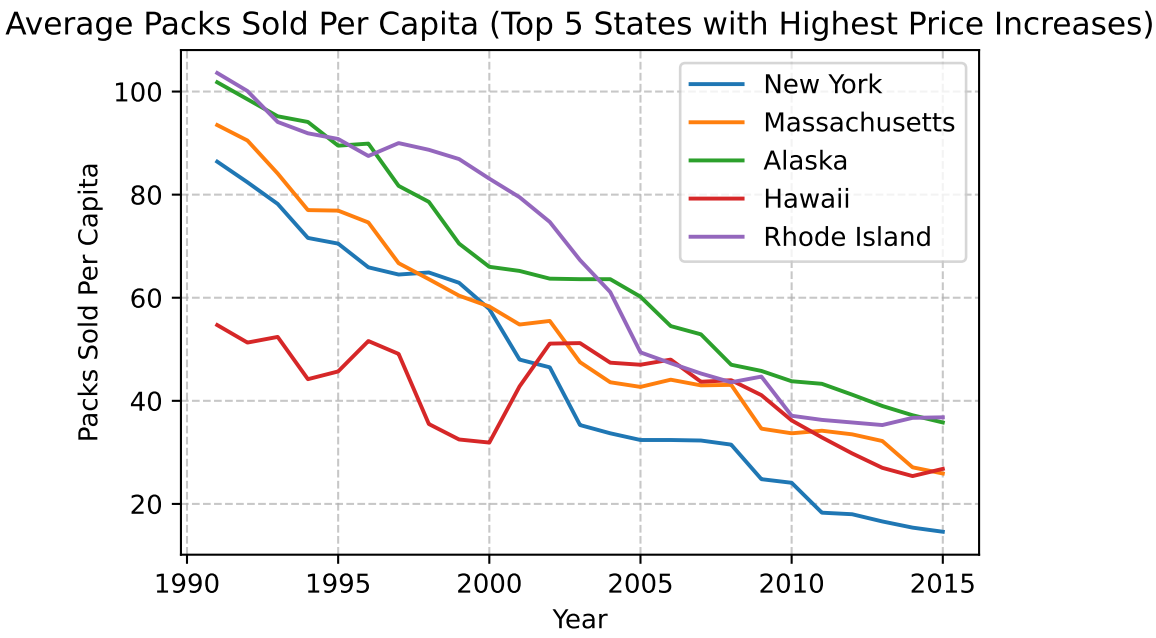
The first stage regression shows that cigarette taxes are strongly associated with a positive relationship with cigarette prices, with a statistically significant coefficient, confirming that taxes are a strong and relevant instrument for price.

9. Repeat questions 1-3 focusing on the period from 1991 to 2015.






Average Packs Sold Per Capita (Top 5 States with Highest Price Increases)
Packs Sold Per Capita
100
80
60
40
20
1990
1995
2000
2005
2010
2015
Year
New York
Massachusetts
Alaska
Hawaii
Rhode Island

10. Compare your elasticity estimates from 1970-1990 versus those from 1991-2015. Are they different? If so, why?

```
                            OLS Regression Results
==============================================================================
Dep. Variable:     log_sales_per_capita   R-squared:                       0.533
Model:                              OLS   Adj. R-squared:                  0.532
Method:                   Least Squares   F-statistic:                     1451.
Date:                  Fri, 07 Mar 2025   Prob (F-statistic):          1.52e-212
Time:                          15:34:11   Log-Likelihood:                -296.47
No. Observations:                  1275   AIC:                             596.9
Df Residuals:                      1273   BIC:                             607.2
Df Model:                             1
Covariance Type:              nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const          5.0395      0.023    219.934      0.000       4.995       5.084
log_price_per_pack    -0.6656      0.017    -38.094      0.000      -0.700      -0.631
==============================================================================
Omnibus:                       19.351   Durbin-Watson:                   0.158
Prob(Omnibus):                  0.000   Jarque-Bera (JB):               33.046
Skew:                           0.064   Prob(JB):                     6.67e-08
Kurtosis:                       3.778   Cond. No.                         5.37
==============================================================================

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.
Estimated Price Elasticity of Demand: -0.67
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Compared to my elasticity estimated for 1970-1990, my estimated price elasticity of demand was -0.67 for 1991-2015. This implies that a 10% rise in cigarette prices leads to a 6.7% decline in per capita cigarette sales, confirming that demand still remains inelastic, but less than 1970-1990. This suggests consumers are more price-sensitive, though demand is still inelastic (absolute value is less than 1). This could mean that while price matters more in purchasing decisions, other factors (like addiction or brand loyalty) still play a role.