ECON 470 Homework 3

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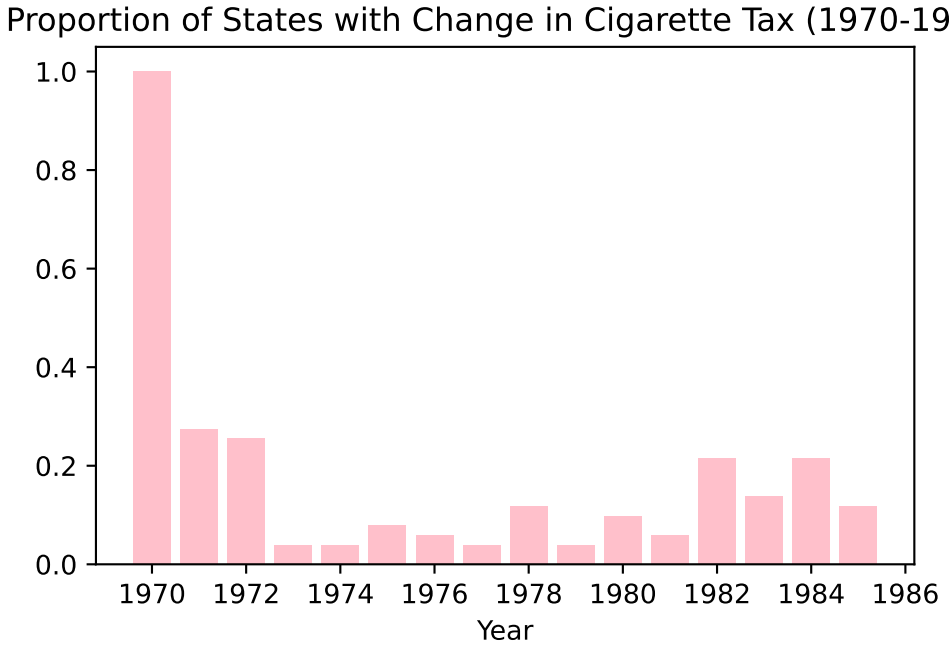
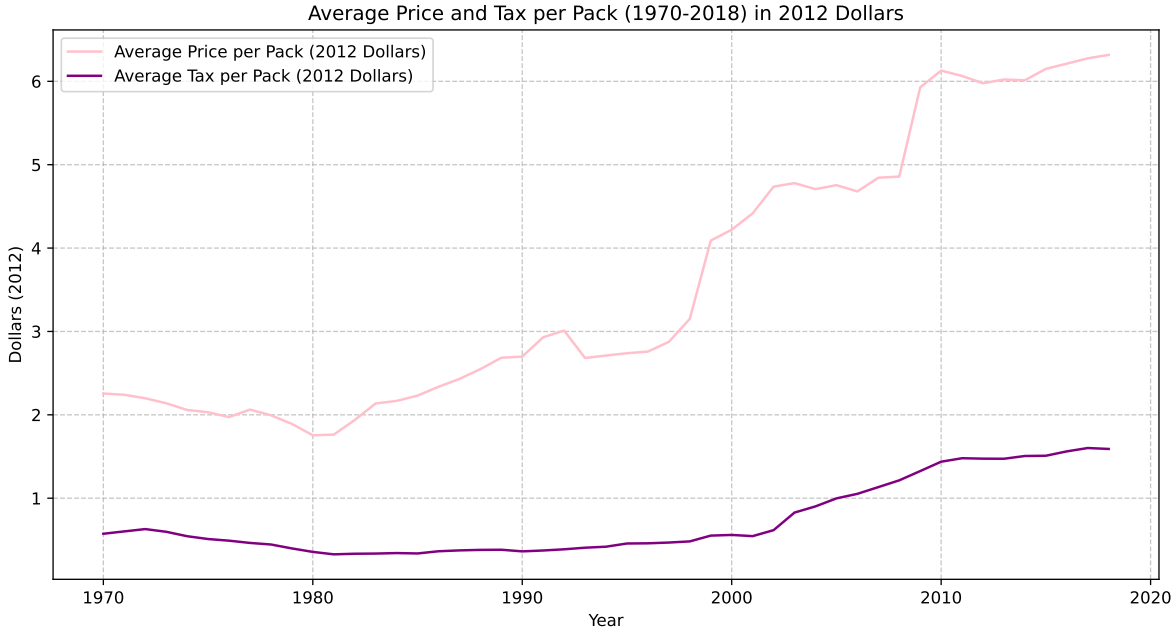
The link to my repository: https://github.com/ellenwu-git/homework3

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.

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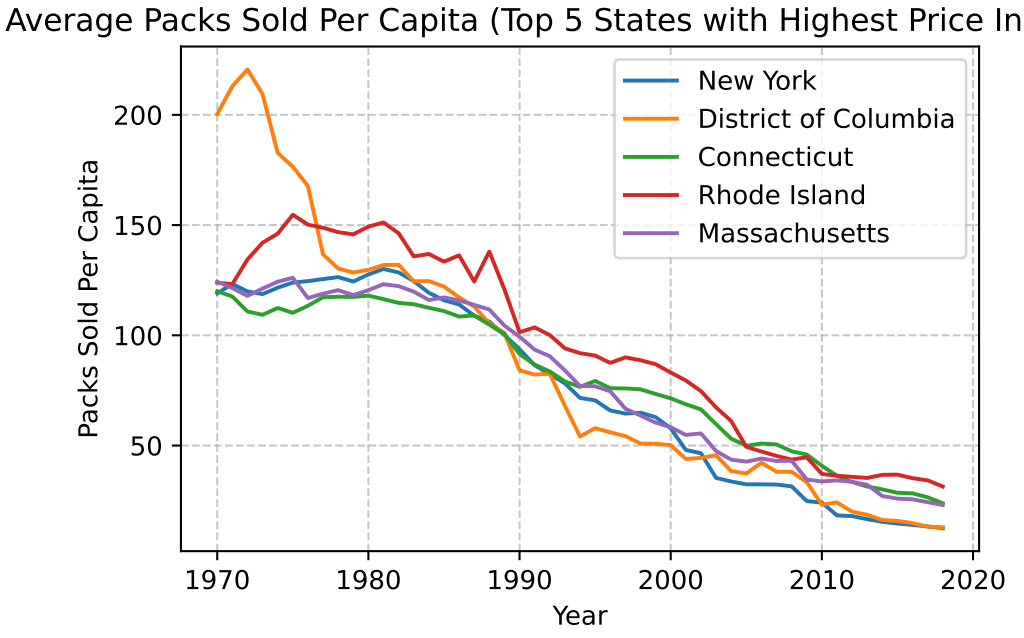
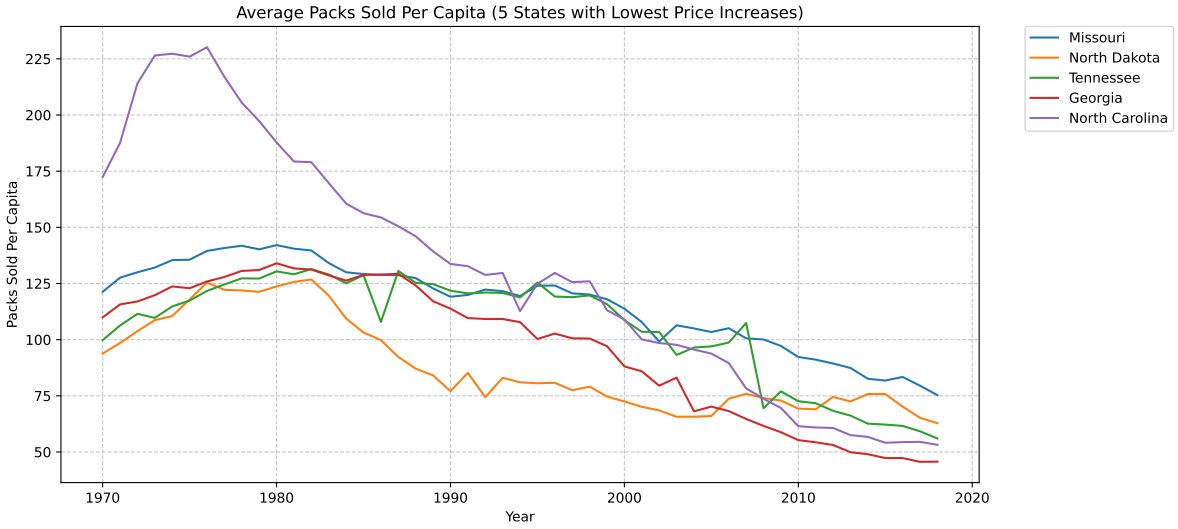
Top 5 states with highest cigarette price increases:
32                New York
8     District of Columbia
6               Connecticut
39             Rhode Island
21            Massachusetts
Name: state, dtype: object
```

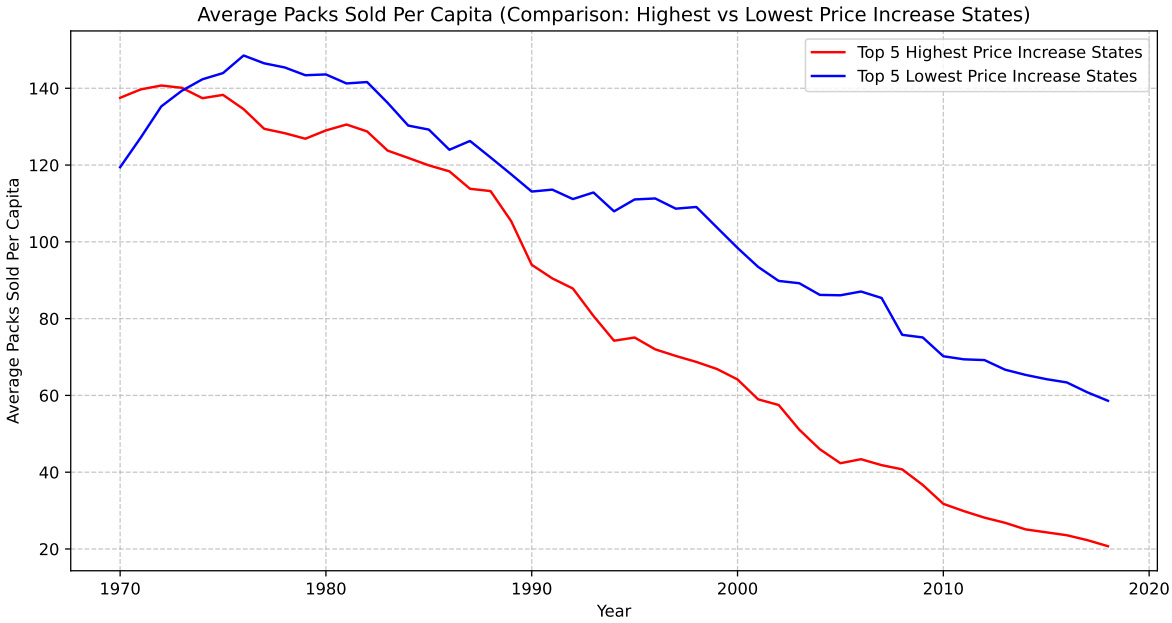


4. Identify the 5 states with the lowest increases in cigarette prices over the time period. Plot the average number of packs sold per capita for those states from 1970 to 2018.

```
5 states with the lowest cigarette price increases:
['Missouri', 'North Dakota', 'Tennessee', 'Georgia', 'North Carolina']
```



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



Based on the graph, states with the highest price increases experienced a steeper decline in average cigarette packs sold per capita over time compared to states with the lowest price increases. The states with the lowest price increases initially had higher per capita sales and, while they also saw a decline, the decline was more gradual. This suggests that higher cigarette prices are associated with sharper reductions in cigarette consumption, supporting the idea that cigarette demand is responsive to price increases.

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:                       0.126
Model:                              OLS   Adj. R-squared:                  0.125
Method:                   Least Squares   F-statistic:                     153.9
Date:                  Tue, 18 Mar 2025   Prob (F-statistic):           4.18e-33
Time:                          22:12:23   Log-Likelihood:                148.99
No. Observations:                  1071   AIC:                            -294.0
Df Residuals:                      1069   BIC:                            -284.0
Df Model:                             1
Covariance Type:              nonrobust
==============================================================================
                         coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const                  4.7504      0.008    585.321      0.000       4.734       4.766
log_price_per_pack    -0.1715      0.014    -12.404      0.000      -0.199      -0.144
==============================================================================
Omnibus:                       64.611   Durbin-Watson:                   0.139
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              224.414
Skew:                           0.173   Prob(JB):                     1.86e-49
Kurtosis:                       5.216   Cond. No.                         2.48
==============================================================================

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.
Estimated Price Elasticity of Demand: -0.17
```

The estimated price elasticity of demand for cigarettes from 1970 to 1990 is approximately -0.09. This means that a 1% increase in the price of cigarettes is associated with only a 0.09% decrease in cigarette sales per capita. The elasticity is small in magnitude, indicating that cigarette demand was relatively inelastic during this period — meaning consumers were not highly responsive to price changes. The coefficient is statistically significant (p-value < 0.001), so there is strong evidence that price is related to cigarette sales, though the effect is quite small.

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:	0.0841
Estimator:	IV-2SLS	Adj. R-squared:	0.0833
No. Observations:	1071	F-statistic:	220.14
Date:	Tue, Mar 18 2025	P-value (F-stat)	0.0000
Time:	22:12:23	Distribution:	chi2(1)
Cov. Estimator:	robust		

Parameter Estimates

	Parameter	Std. Err.	T-stat	P-value	Lower CI	Upper CI
const	4.7151	0.0081	583.37	0.0000	4.6993	4.7310
log_price_per_pack	-0.2703	0.0182	-14.837	0.0000	-0.3060	-0.2346

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

Instrumented Price Elasticity of Demand: -0.27

Using cigarette taxes as an instrument for prices, the estimated price elasticity of demand for cigarettes between 1970 and 1990 is approximately -0.26. This suggests that a 10% increase in cigarette prices is associated with a 2.6% decrease in cigarette sales per capita, indicating that demand for cigarettes is relatively inelastic. This IV estimate of -0.26 is more elastic than the OLS estimate of -0.093. This suggests that the OLS regression likely underestimated the true price elasticity, possibly due to endogeneity bias — factors like state-level health campaigns or smoking culture may simultaneously influence both cigarette prices and consumption. By using taxes as an instrument, the IV estimate isolates the effect of exogenous price changes caused by policy, giving a clearer picture of how consumers respond 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:                       0.695
Model:                            OLS   Adj. R-squared:                  0.694
Method:                 Least Squares   F-statistic:                     2431.
Date:                Tue, 18 Mar 2025   Prob (F-statistic):          1.52e-277
Time:                        22:12:23   Log-Likelihood:                -66.026
No. Observations:                1071   AIC:                             136.1
Df Residuals:                    1069   BIC:                             146.0
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const         -1.4288      0.023    -61.805      0.000      -1.474      -1.383
tax_dollar     4.1686      0.085     49.300      0.000       4.003       4.334
==============================================================================
Omnibus:                       48.404   Durbin-Watson:                   0.428
Prob(Omnibus):                  0.000   Jarque-Bera (JB):               54.366
Skew:                           0.551   Prob(JB):                     1.57e-12
Kurtosis:                       2.923   Cond. No.                         11.5
==============================================================================

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

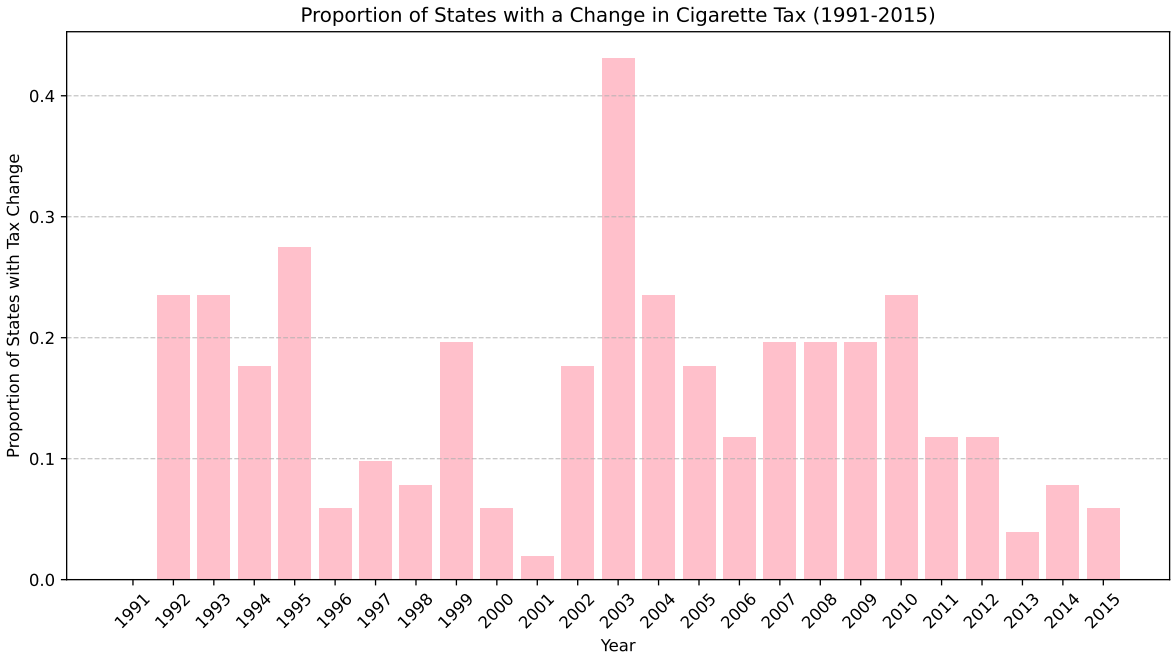
Reduced Form Regression Results:
                            OLS Regression Results
==============================================================================
Dep. Variable:     log_sales_per_capita   R-squared:                       0.217
Model:                            OLS   Adj. R-squared:                  0.216
Method:                 Least Squares   F-statistic:                     296.2
Date:                Tue, 18 Mar 2025   Prob (F-statistic):           8.91e-59
Time:                        22:12:23   Log-Likelihood:                 207.94
No. Observations:                1071   AIC:                            -411.9
Df Residuals:                    1069   BIC:                            -401.9
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
```

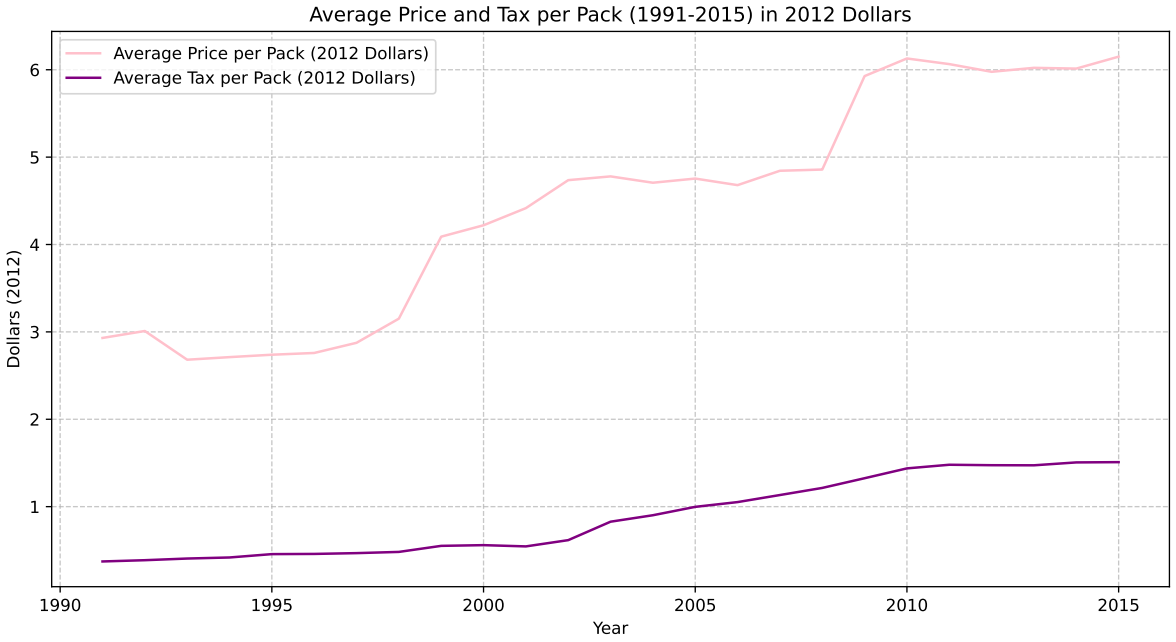
	coef	std err	t	P>|t|	[0.025	0.975]
const	5.1013	0.018	284.988	0.000	5.066	5.136
tax_dollar	-1.1267	0.065	-17.209	0.000	-1.255	-0.998

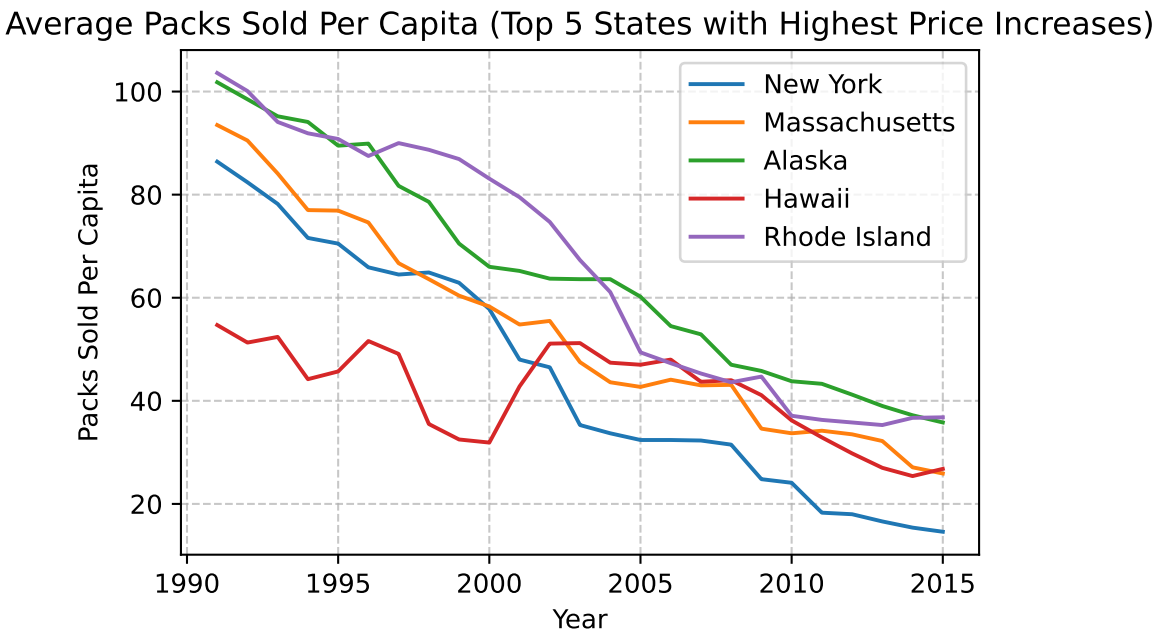
Omnibus:	77.756	Durbin-Watson:	0.157
Prob(Omnibus):	0.000	Jarque-Bera (JB):	352.076
Skew:	0.115	Prob(JB):	3.53e-77
Kurtosis:	5.799	Cond. No.	11.5

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

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:                  Tue, 18 Mar 2025   Prob (F-statistic):          1.52e-212
Time:                          22:12:23   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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The estimated price elasticity of demand for cigarettes was -0.09 for the 1970-1990 period and -0.67 for the 1991-2015 period. This indicates that cigarette demand became significantly more elastic over time, meaning that consumers became much more responsive to price changes in the later period. The increase in price elasticity from -0.09 to -0.67 suggests that cigarettes became much more price-sensitive in the later years, likely due to a combination of higher taxes, public health campaigns, and the availability of alternatives. This implies that tax increases may now be a much more effective tool in reducing smoking rates than they were in earlier decades.