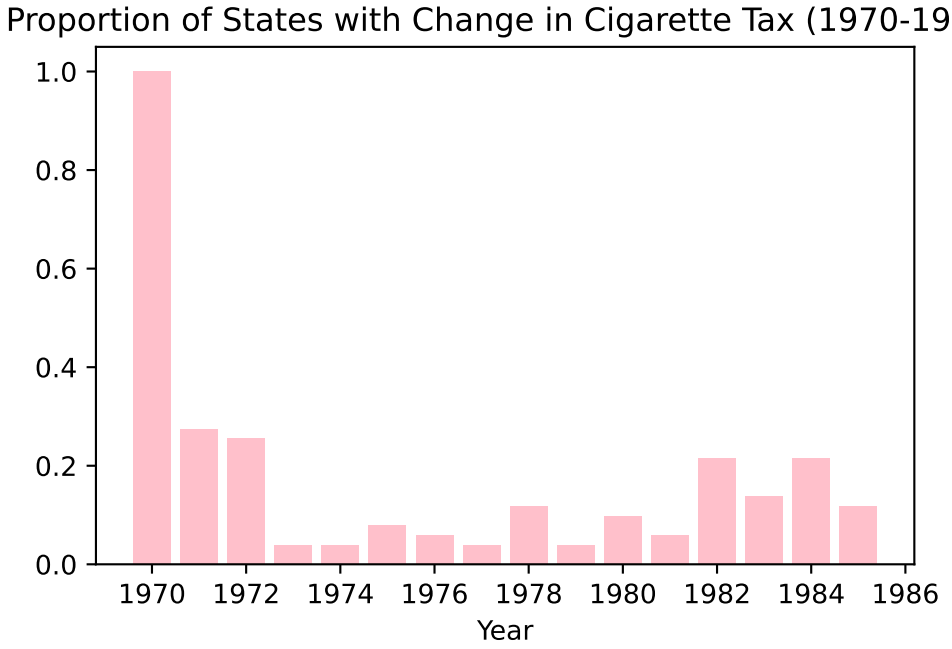
ECON 470 Homework 3

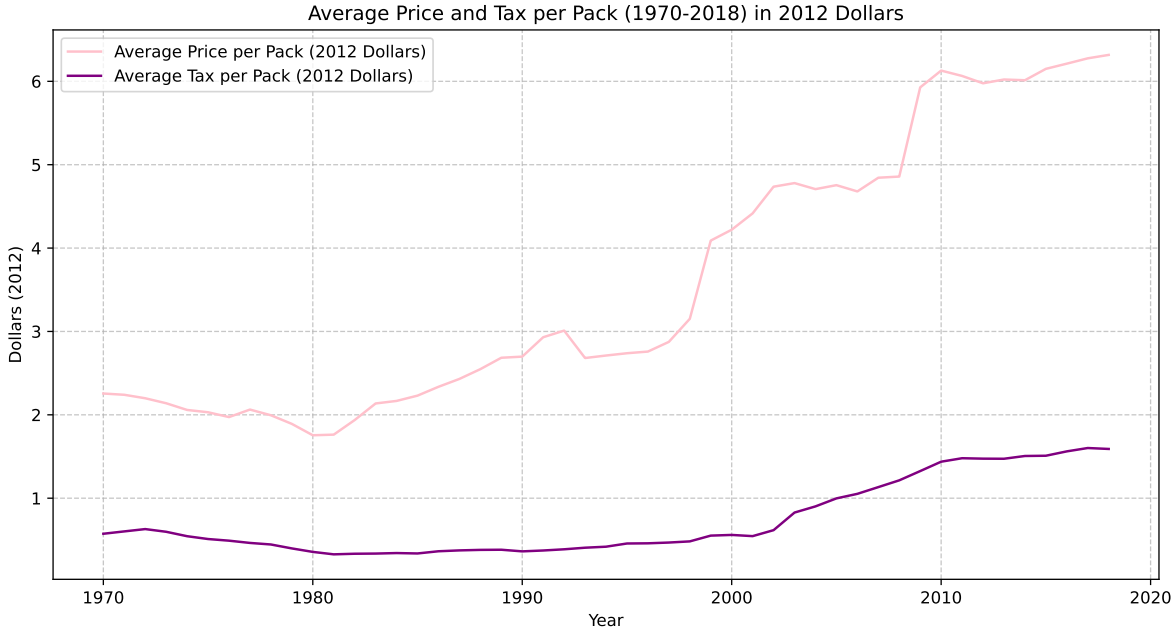
Ellen Wu

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

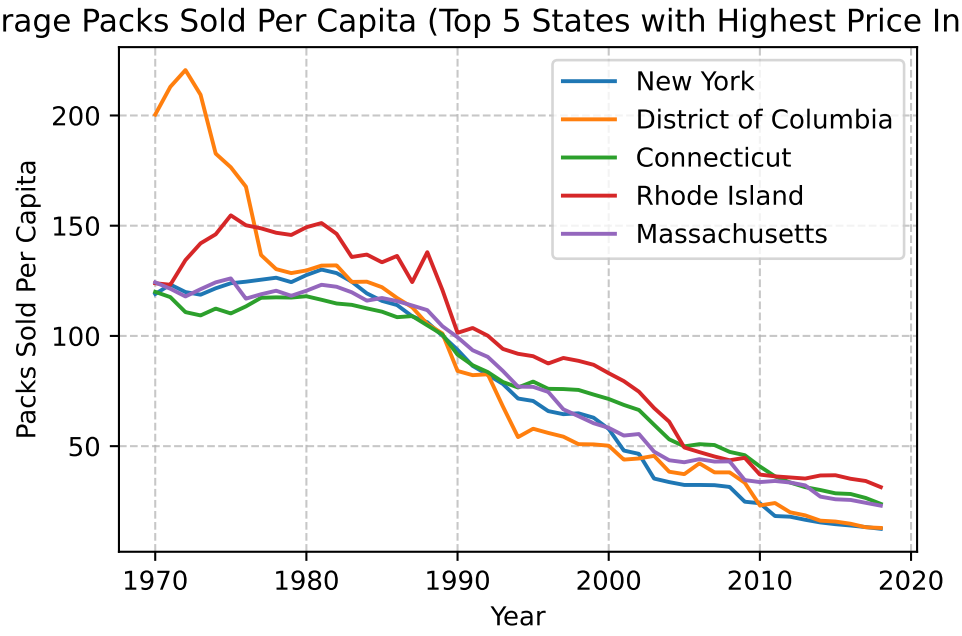
1. Present a bar graph showing the proportion of states with a change in their cigarette tax in each year from 1970 to 1985.



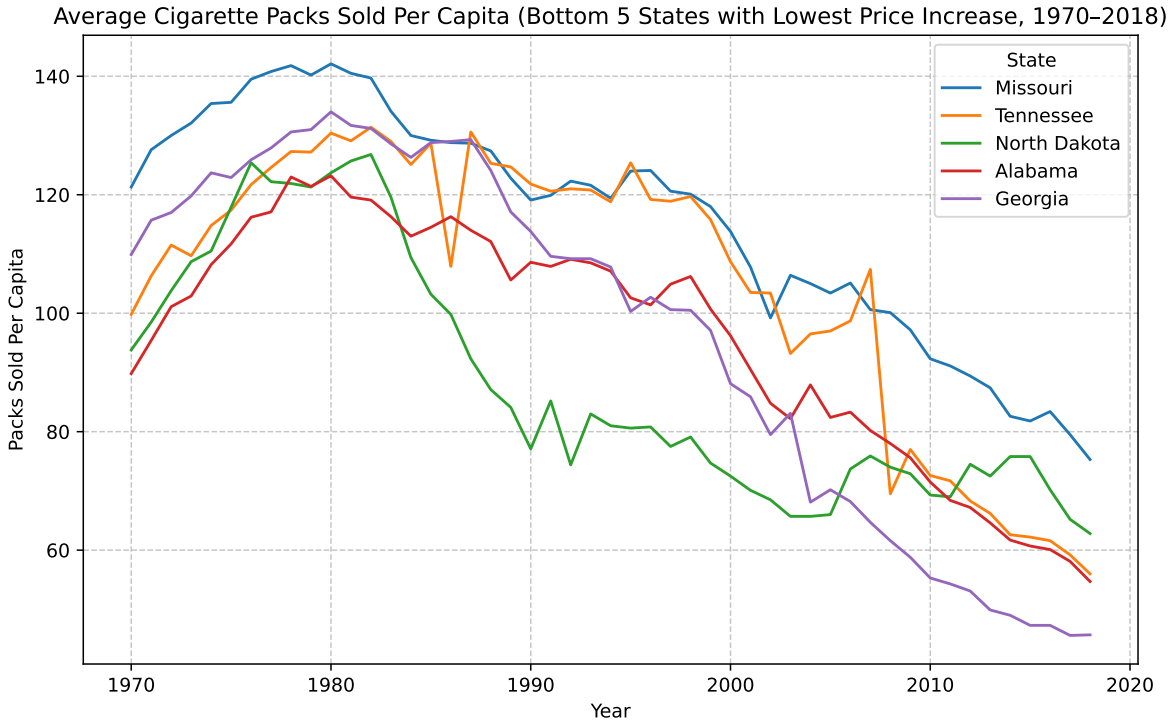
2. Plot on a single graph the average tax (in 2012 dollars) on cigarettes and the average price of a pack of cigarettes from 1970 to 2018.



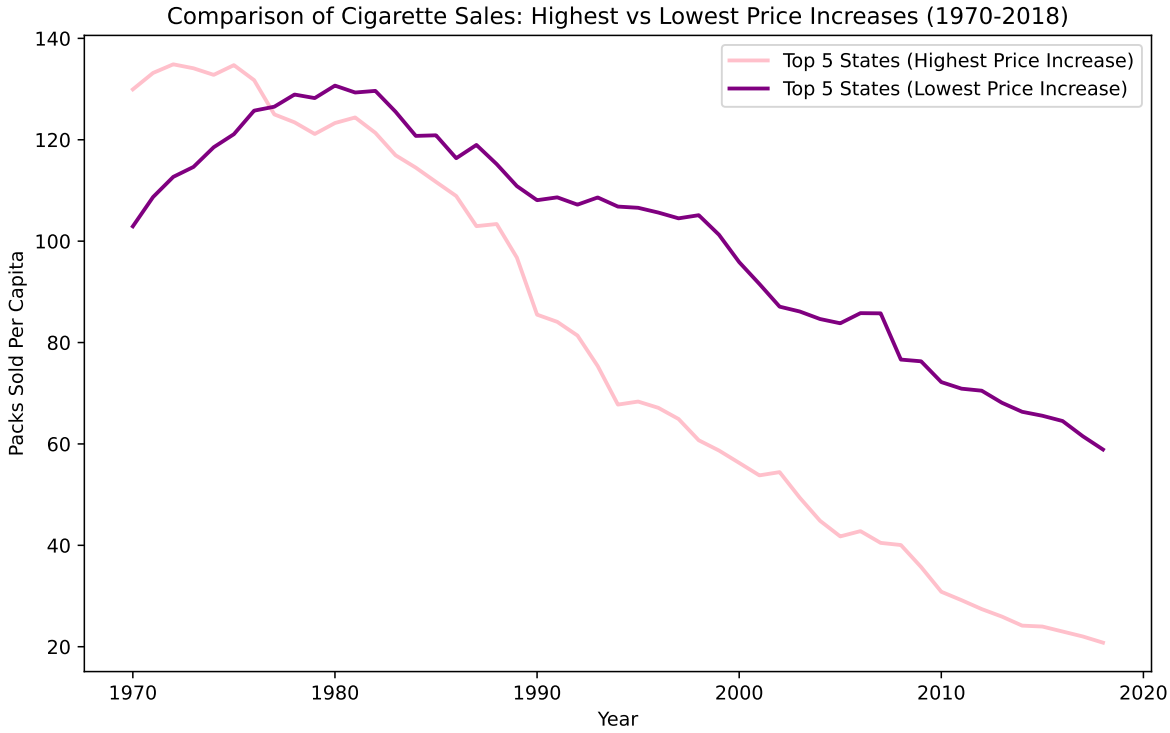
3. Identify the 5 states with the highest increases in cigarette prices (in dollars) over the time period. Plot the average number of packs sold per capita for those states from 1970 to 2018.



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. 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   R-squared:                       0.294
Model:                            OLS   Adj. R-squared:                  0.293
Method:                 Least Squares   F-statistic:                     445.1
Date:                Thu, 20 Mar 2025   Prob (F-statistic):           6.98e-83
Time:                        15:54:02   Log-Likelihood:                 263.40
No. Observations:                1071   AIC:                            -522.8
Df Residuals:                    1069   BIC:                            -512.8
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const          5.3854      0.028    193.692      0.000       5.331       5.440
log_price     -0.8094      0.038    -21.098      0.000      -0.885      -0.734
==============================================================================
Omnibus:                       89.160   Durbin-Watson:                   0.183
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              466.536
Skew:                           0.128   Prob(JB):                    4.93e-102
Kurtosis:                       6.223   Cond. No.                         10.0
==============================================================================

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

The coefficient on log_price is -0.8094, meaning that a 1% increase in price is associated with a 0.81% decrease in cigarette sales. This suggests that demand for cigarettes is inelastic, but somewhat responsive to price changes. The p-value for log_price is 0.000, which is highly significant, indicating strong evidence that price affects cigarette sales.

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?

First-Stage Regression Results:

OLS Regression Results

Dep. Variable:	log_price	R-squared:	0.617
Model:	OLS	Adj. R-squared:	0.617
Method:	Least Squares	F-statistic:	1725.
Date:	Thu, 20 Mar 2025	Prob (F-statistic):	2.80e-225
Time:	15:54:02	Log-Likelihood:	1020.7
No. Observations:	1071	AIC:	-2037.
Df Residuals:	1069	BIC:	-2027.
Df Model:	1		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	1.1819	0.012	100.663	0.000	1.159	1.205
log_tax	0.3328	0.008	41.537	0.000	0.317	0.349

Omnibus:	6.850	Durbin-Watson:	0.303
Prob(Omnibus):	0.033	Jarque-Bera (JB):	5.505
Skew:	0.081	Prob(JB):	0.0638
Kurtosis:	2.689	Cond. No.	8.72

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

Second-Stage (IV) Regression Results:

OLS Regression Results

Dep. Variable:	log_sales	R-squared:	0.236
Model:	OLS	Adj. R-squared:	0.235
Method:	Least Squares	F-statistic:	330.3
Date:	Thu, 20 Mar 2025	Prob (F-statistic):	1.56e-64
Time:	15:54:02	Log-Likelihood:	221.17
No. Observations:	1071	AIC:	-438.3
Df Residuals:	1069	BIC:	-428.4
Df Model:	1		

```
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const          5.4660      0.037    149.749      0.000       5.394       5.538
log_price_hat -0.9231      0.051    -18.175      0.000      -1.023      -0.823
==============================================================================
Omnibus:                       83.338   Durbin-Watson:                   0.157
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              430.014
Skew:                           0.023   Prob(JB):                     4.20e-94
Kurtosis:                       6.104   Cond. No.                         12.7
==============================================================================

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

IV-Estimated Price Elasticity of Demand: -0.923

OLS-Estimated Price Elasticity: -0.809
Difference between OLS and IV Estimates: 0.114
```

Based on the results, when using the total cigarette tax as an instrument for log prices, the IV-estimated price elasticity of demand is -0.923, compared to -0.809 from the OLS regression without an instrument. The IV estimate is slightly more negative, suggesting that the OLS approach may have been biased toward a smaller (less negative) elasticity, potentially due to endogeneity in the relationship between price and sales. The first-stage regression confirms that log tax is a strong instrument for log price, as indicated by the high F-statistic (1725) and the significant relationship between log tax and log price (coefficient = 0.3328, $p < 0.001$). This suggests that IV is addressing potential simultaneity bias, making the IV estimate more reliable in capturing the causal effect of price on cigarette demand.

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:	Thu, 20 Mar 2025	Prob (F-statistic):	1.52e-277
Time:	15:54:02	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

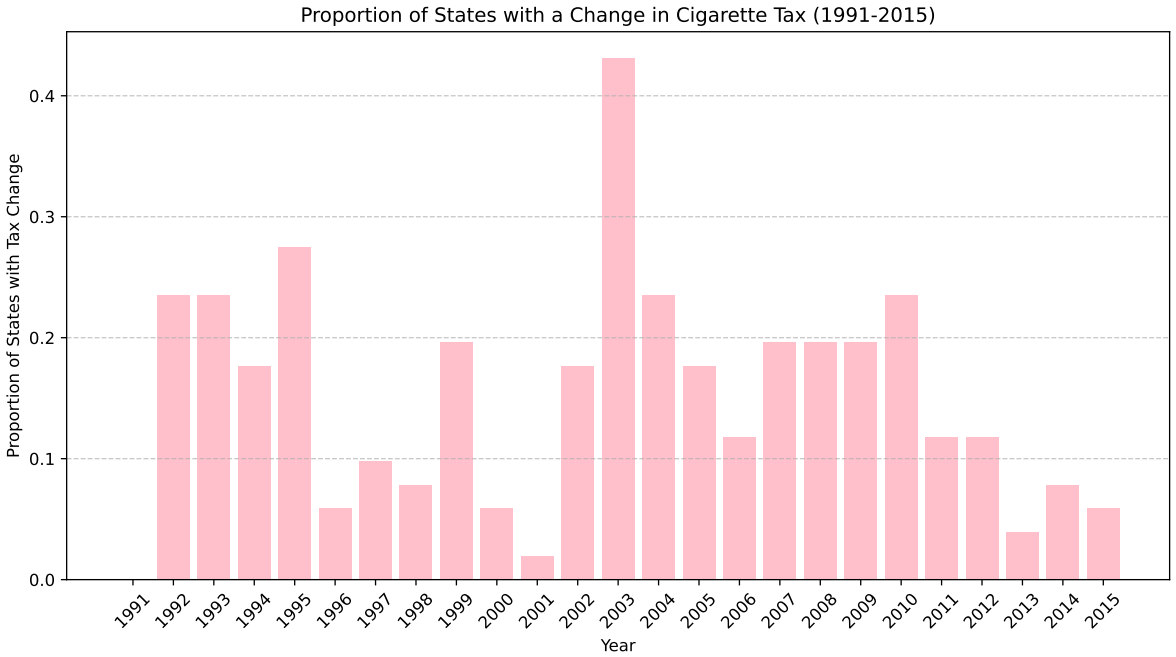
Dep. Variable:	log_sales_per_capita	R-squared:	0.217
Model:	OLS	Adj. R-squared:	0.216
Method:	Least Squares	F-statistic:	296.2
Date:	Thu, 20 Mar 2025	Prob (F-statistic):	8.91e-59
Time:	15:54:02	Log-Likelihood:	207.94
No. Observations:	1071	AIC:	-411.9
Df Residuals:	1069	BIC:	-401.9
Df Model:	1		
Covariance Type:	nonrobust		

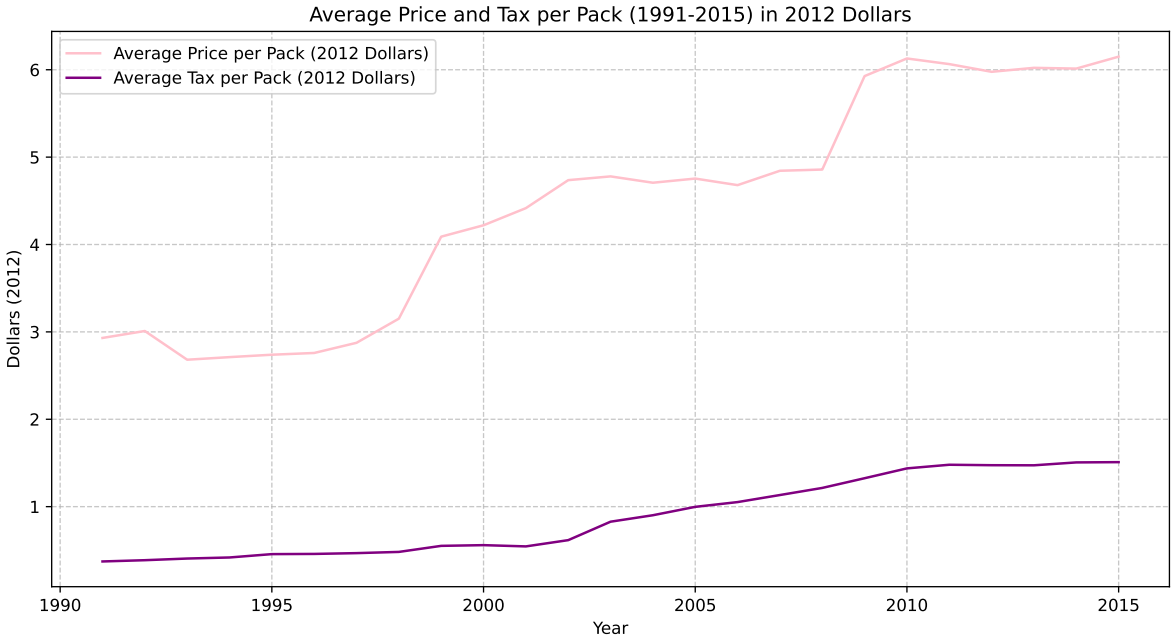
	coef	std err	t	P>|t|	[0.025	0.975]
const	5.1013	0.018	284.988	0.000	5.066	5.136
tax_dollar	-1.1267	0.065	-17.209	0.000	-1.255	-0.998

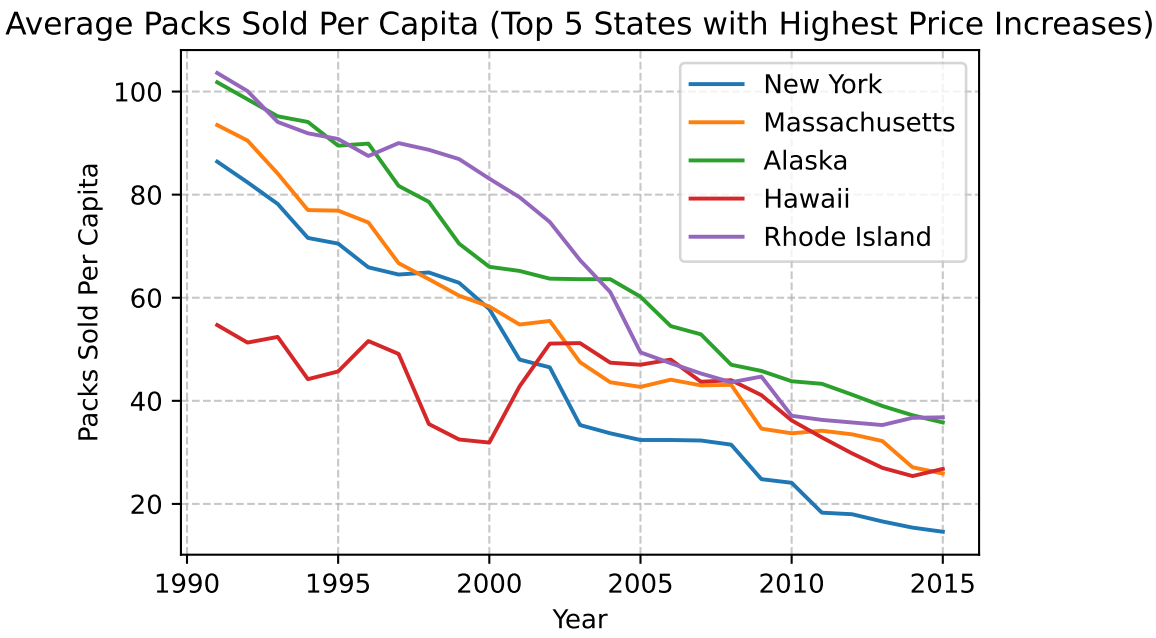
Omnibus:	77.756	Durbin-Watson:	0.157
Prob(Omnibus):	0.000	Jarque-Bera (JB):	352.076
Skew:	0.115	Prob(JB):	3.53e-77
Kurtosis:	5.799	Cond. No.	11.5

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?

```
=== Price Elasticity Estimate for 1970-1990 ===
                            OLS Regression Results
==============================================================================
Dep. Variable:              log_sales   R-squared:                       0.294
Model:                            OLS   Adj. R-squared:                  0.293
Method:                 Least Squares   F-statistic:                     445.1
Date:                Thu, 20 Mar 2025   Prob (F-statistic):           6.98e-83
Time:                        15:54:02   Log-Likelihood:                 263.40
No. Observations:                1071   AIC:                            -522.8
Df Residuals:                    1069   BIC:                            -512.8
Df Model:                           1
Covariance Type:            nonrobust
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                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const          5.3854      0.028    193.692      0.000       5.331       5.440
log_price     -0.8094      0.038    -21.098      0.000      -0.885      -0.734
==============================================================================
Omnibus:                       89.160   Durbin-Watson:                   0.183
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              466.536
Skew:                           0.128   Prob(JB):                    4.93e-102
Kurtosis:                       6.223   Cond. No.                         10.0
==============================================================================

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.
Estimated Price Elasticity: -0.809

=== Price Elasticity Estimate for 1991-2015 ===
                            OLS Regression Results
==============================================================================
Dep. Variable:              log_sales   R-squared:                       0.561
Model:                            OLS   Adj. R-squared:                  0.561
Method:                 Least Squares   F-statistic:                     1630.
Date:                Thu, 20 Mar 2025   Prob (F-statistic):          4.20e-230
Time:                        15:54:02   Log-Likelihood:                -256.00
No. Observations:                1275   AIC:                             516.0
Df Residuals:                    1273   BIC:                             526.3
```

```
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const          5.6083      0.035    159.600      0.000       5.539       5.677
log_price     -0.9968      0.025    -40.370      0.000      -1.045      -0.948
==============================================================================
Omnibus:                       23.003   Durbin-Watson:                   0.208
Prob(Omnibus):                  0.000   Jarque-Bera (JB):               43.688
Skew:                           0.011   Prob(JB):                     3.26e-10
Kurtosis:                       3.907   Cond. No.                         8.90
==============================================================================

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.
Estimated Price Elasticity: -0.997

=== Elasticity Comparison ===
Elasticity (1970-1990): -0.809
Elasticity (1991-2015): -0.997
Difference: 0.187
```

Compared to my elasticity estimate for 1970-1990, the estimated price elasticity of demand for 1991-2015 was -0.997, indicating that demand became more elastic during this period. This suggests that consumers became more sensitive to price changes, although demand remained inelastic (since the absolute value is still less than 1). While price had a greater influence on purchasing decisions, factors such as addiction or brand loyalty likely continued to play a significant role.