Homework3-3

March 21, 2025

1 Homework 3-1

ECON470: Research in Health Economics

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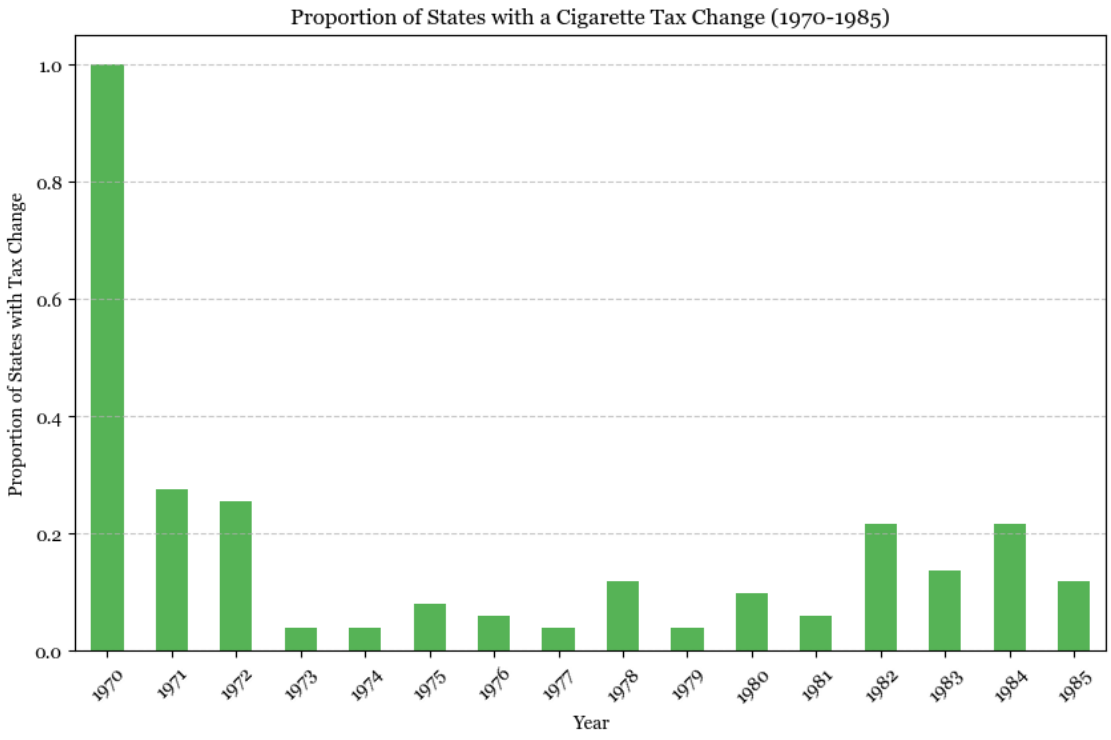
1.0.1 Summarize the Data

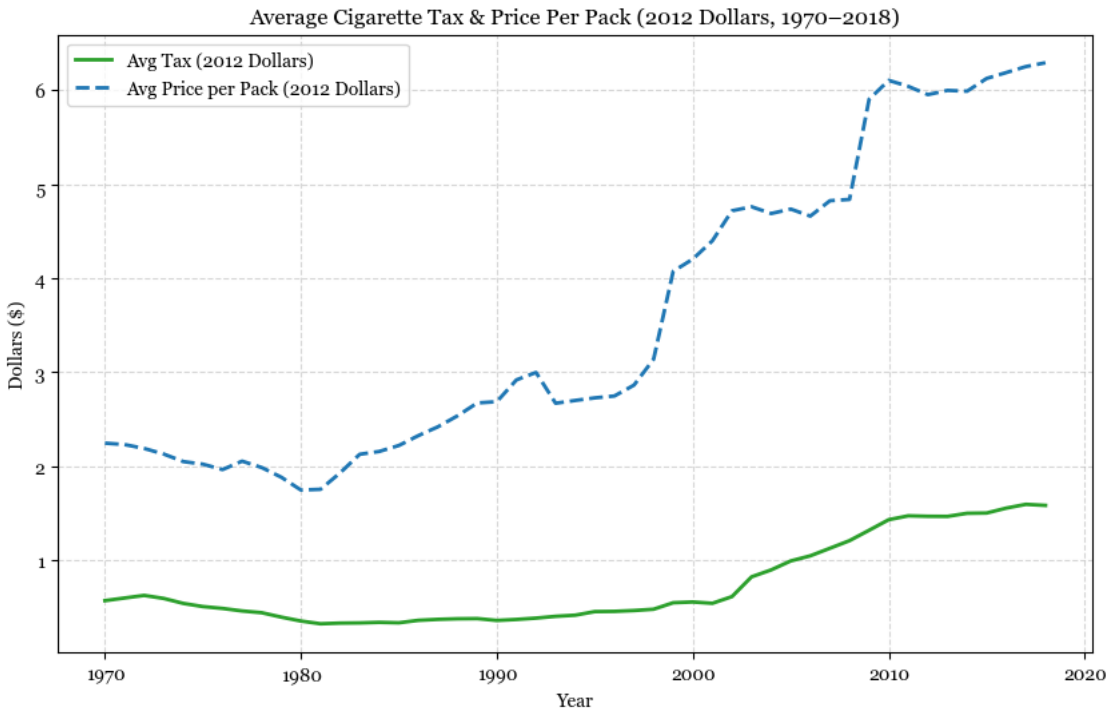
Question 1

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



Question 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.



Question 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 pring increase: ['District of Columbia', 'New York',
'Rhode Island', 'Hawaii', 'Massachusetts']
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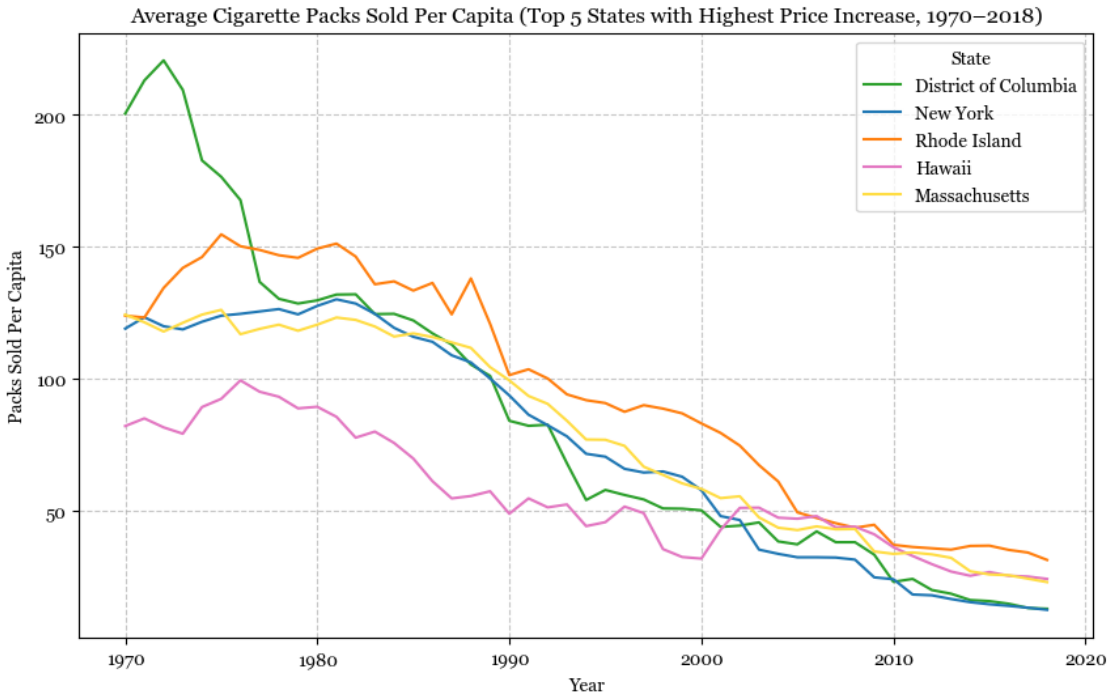

Question 4

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.

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Bottom 5 states with lowest price increase: ['Missouri', 'Tennessee', 'North
Dakota', 'Alabama', 'Georgia']
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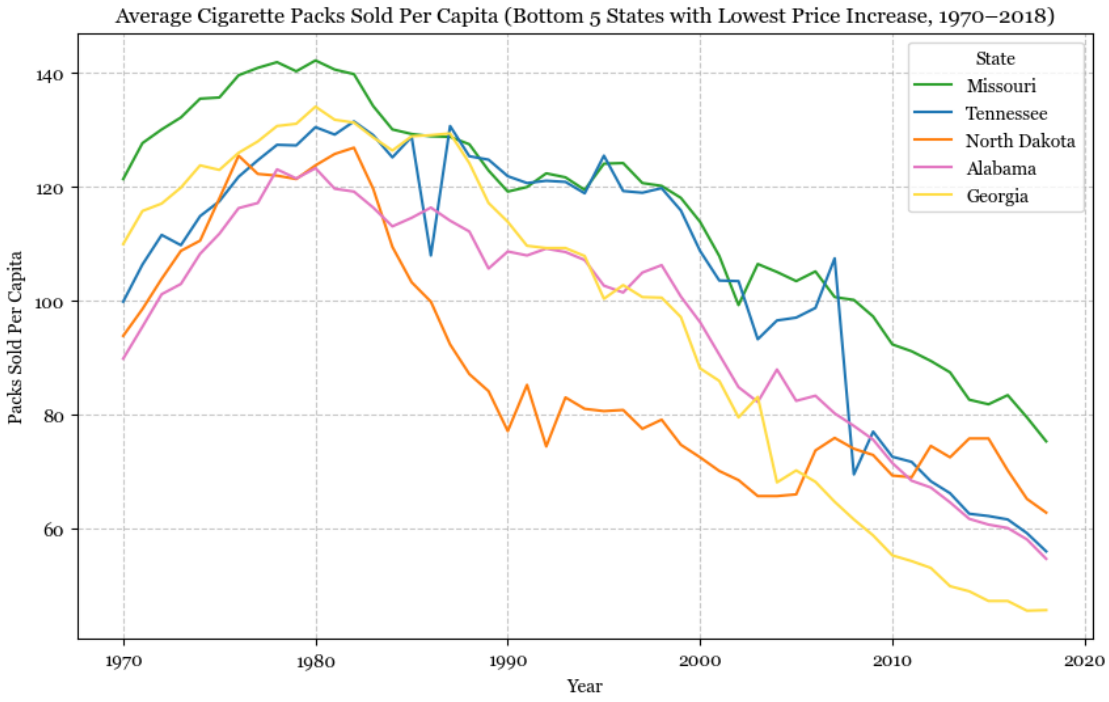
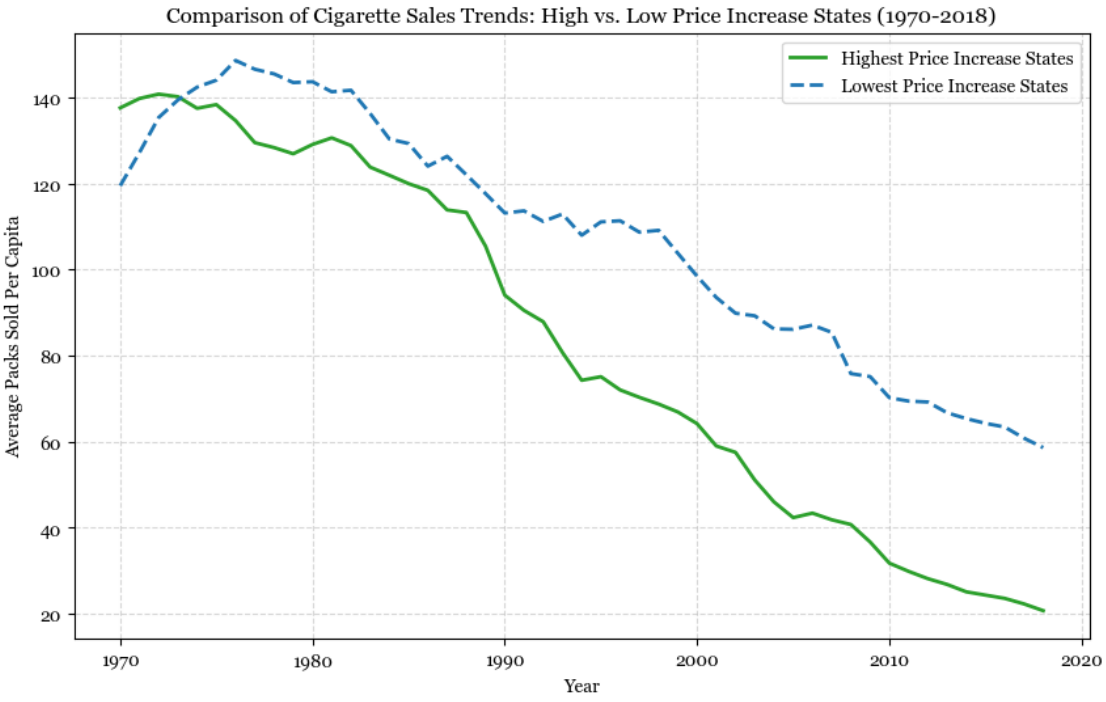


Question 5

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



1.0.2 Estimate ATEs

Now let's work on estimating a demand curve for cigarettes. Specifically, we're going to estimate the price elasticity of demand for cigarettes. When explaining your findings, try to limit your discussion just to a couple of sentences.

Question 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:	Fri, 21 Mar 2025	Prob (F-statistic):	6.98e-83
Time:	22:33:48	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.
Estimated Price Elasticity of Demand: -0.809
The estimated price elasticity of demand is -0.809, meaning that a 1% increase
in price is associated with a 0.809% decrease in quantity demanded.
```

Question 7A

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.

```
First Stage (Predicting log price using log tax):
                            OLS Regression Results
==============================================================================
Dep. Variable:              log_price   R-squared:                       0.683
Model:                            OLS   Adj. R-squared:                  0.683
Method:                 Least Squares   F-statistic:                     2301.
Date:                Fri, 21 Mar 2025   Prob (F-statistic):          8.21e-269
Time:                        22:33:48   Log-Likelihood:                -86.164
No. Observations:                1071   AIC:                             176.3
Df Residuals:                    1069   BIC:                             186.3
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const          1.1786      0.033     35.712      0.000       1.114       1.243
log_tax        1.0803      0.023     47.973      0.000       1.036       1.125
==============================================================================
Omnibus:                       30.760   Durbin-Watson:                   0.408
Prob(Omnibus):                  0.000   Jarque-Bera (JB):               32.668
Skew:                           0.421   Prob(JB):                     8.06e-08
Kurtosis:                       3.156   Cond. No.                         8.72
==============================================================================

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

```
specified.

Second Stage (IV Regression of log sales on predicted log price):
                            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:                Fri, 21 Mar 2025   Prob (F-statistic):           1.56e-64
Time:                        22:33:48   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                    4.7101      0.008    573.443      0.000       4.694
4.726
predicted_log_price     -0.2843      0.016    -18.175      0.000      -0.315
-0.254
==============================================================================
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.                         2.98
==============================================================================

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

Question 7B

Interpret your results and compare your estimates to those without an instrument. Are they different? If so, why?

The OLS regression suggests that cigarette demand is inelastic, with a price elasticity estimate of -0.1715. This means that a 1% increase in cigarette prices results in only a 0.17% decline in sales per capita. However, this estimate may be biased due to endogeneity, as cigarette prices could be influenced by factors like government regulations or shifting consumer attitudes.

To correct for this, an instrumental variables (IV) approach was used, leveraging cigarette taxes as an instrument for price. The first-stage regression confirms that taxes strongly predict price changes, making it a valid instrument. If the IV estimate is larger in magnitude (more negative)

than OLS, it implies that OLS underestimated the true price elasticity by not accounting for external influences on price. Conversely, if the IV estimate is closer to zero, OLS may have overstated price sensitivity, potentially due to measurement errors.

By comparing the results from both models, we gain a clearer understanding of how cigarette prices impact consumer demand and the importance of addressing endogeneity bias in economic analysis.

Question 8

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

First Stage Regression: Predicting Log Price using Log Tax

OLS Regression Results

Dep. Variable:	log_price	R-squared:	0.683
Model:	OLS	Adj. R-squared:	0.683
Method:	Least Squares	F-statistic:	2301.
Date:	Fri, 21 Mar 2025	Prob (F-statistic):	8.21e-269
Time:	22:33:48	Log-Likelihood:	-86.164
No. Observations:	1071	AIC:	176.3
Df Residuals:	1069	BIC:	186.3
Df Model:	1		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	1.1786	0.033	35.712	0.000	1.114	1.243
log_tax	1.0803	0.023	47.973	0.000	1.036	1.125

Omnibus:	30.760	Durbin-Watson:	0.408
Prob(Omnibus):	0.000	Jarque-Bera (JB):	32.668
Skew:	0.421	Prob(JB):	8.06e-08
Kurtosis:	3.156	Cond. No.	8.72

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

Reduced Form Regression: Predicting Log Sales using Log Tax

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:	Fri, 21 Mar 2025	Prob (F-statistic):	1.56e-64
Time:	22:33:48	Log-Likelihood:	221.17
No. Observations:	1071	AIC:	-438.3

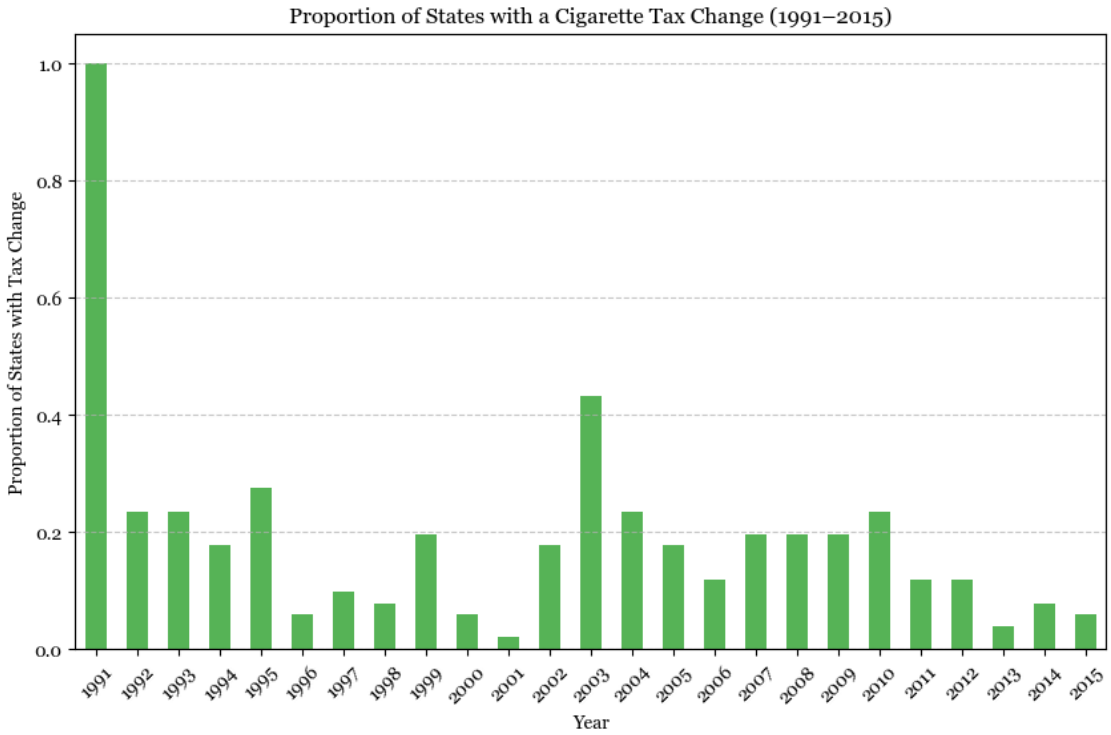
```
Df Residuals:                     1069   BIC:                            -428.4
Df Model:                            1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const          4.3750      0.025    176.627      0.000       4.326       4.424
log_tax       -0.3072      0.017    -18.175      0.000      -0.340      -0.274
==============================================================================
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.                         8.72
==============================================================================

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

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

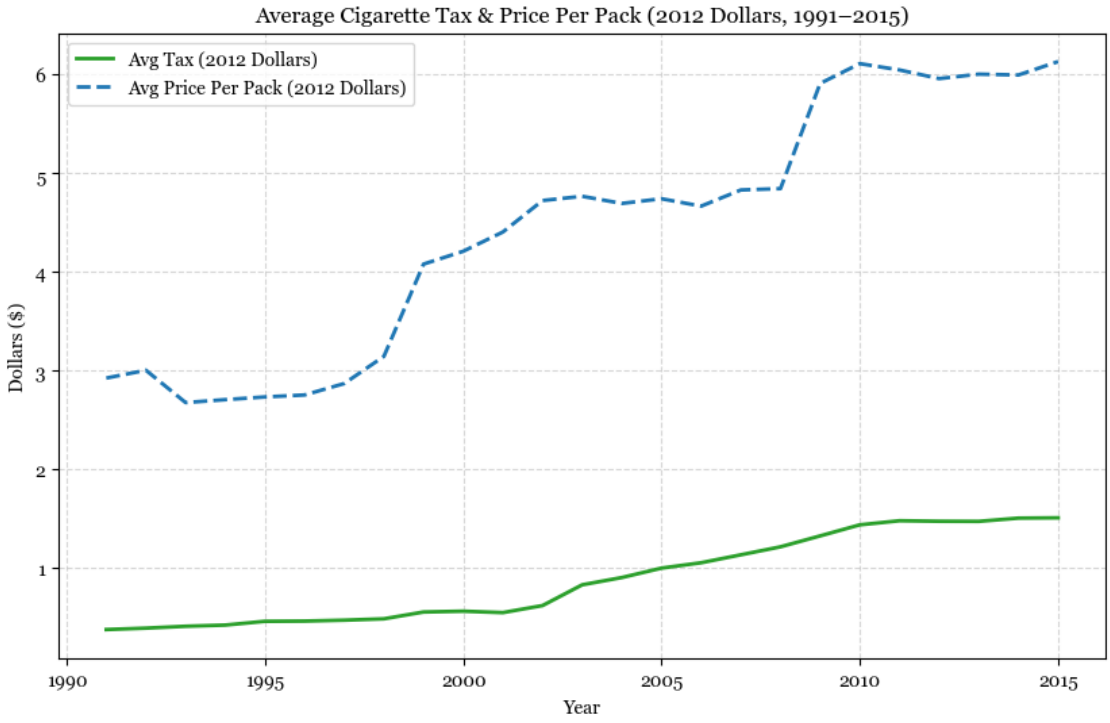
Question 9A

Present a bar graph showing the proportion of states with a change in their cigarette tax in each year from 1991 to 2015.



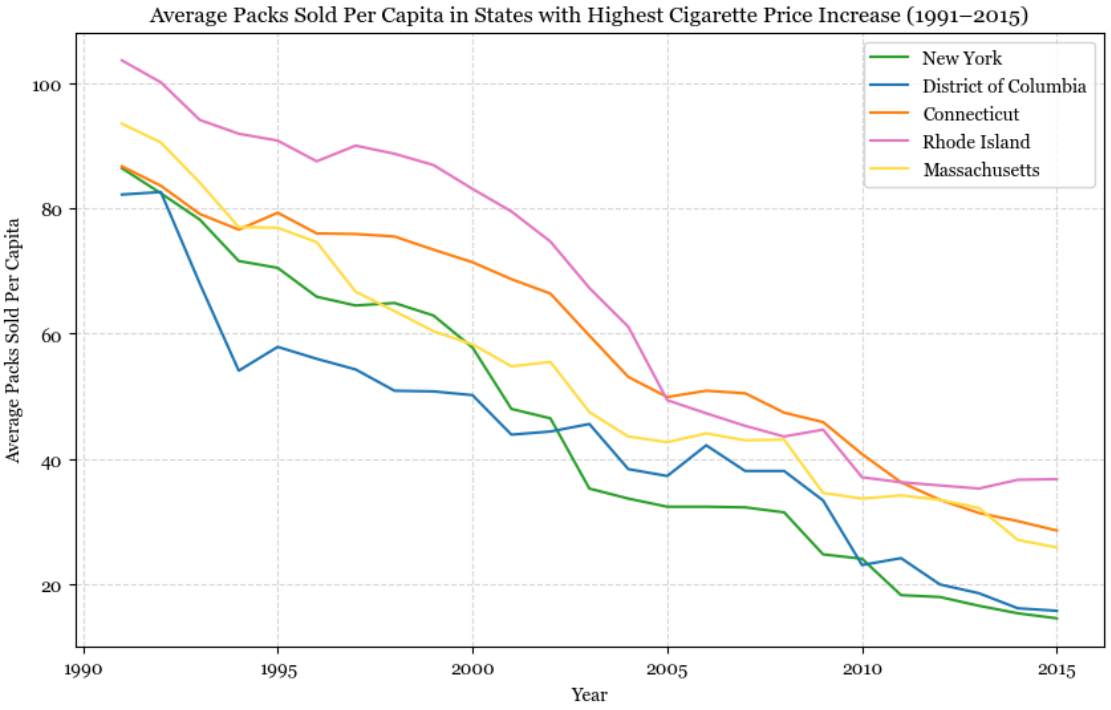
Question 9B

Plot on a single graph the average tax (in 2012 dollars) on cigarettes and the average price of a pack of cigarettes from 1991 to 2015.



Question 9C

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 1991 to 2015.



Question 10

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

The decrease in price elasticity over time suggests that non-price factors (e.g., regulations, health awareness, smoking bans) played a growing role in reducing cigarette consumption, making smokers less sensitive to price changes.

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, 21 Mar 2025	Prob (F-statistic):	1.52e-212
Time:	23:42:49	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]

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------------------------------------------------------------------------------
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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
```