Homework 3 by Avanth Pakanati

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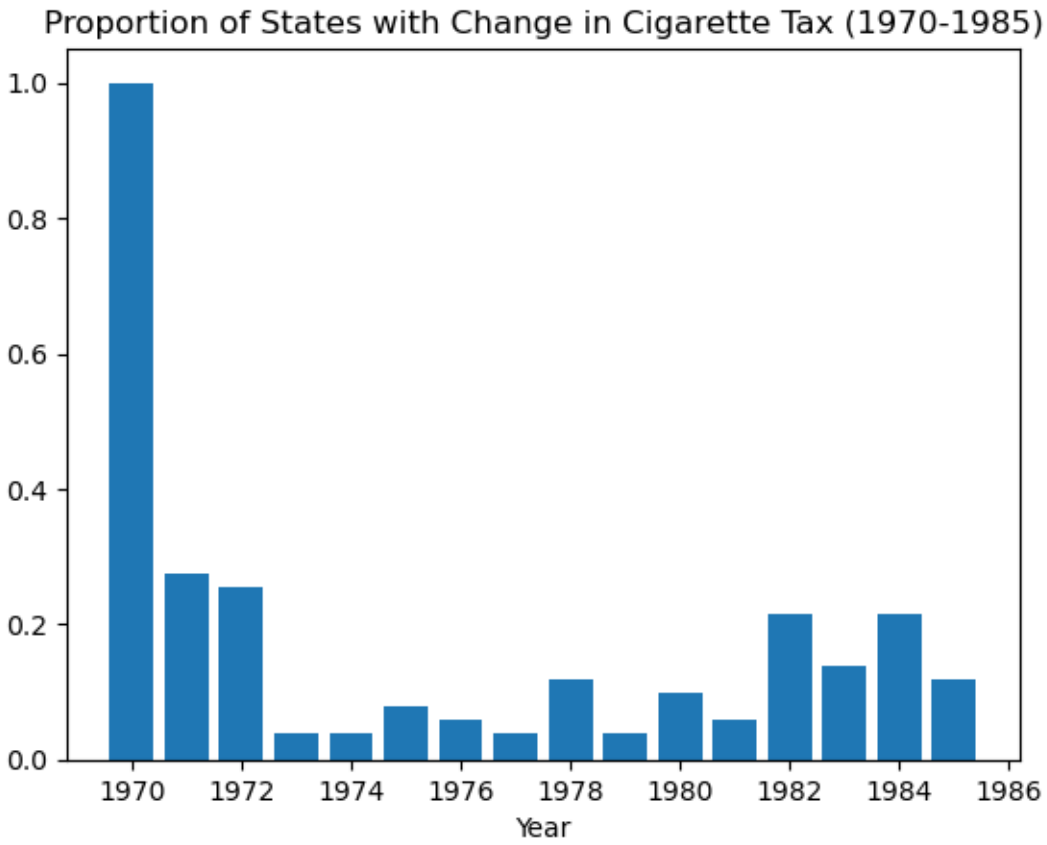
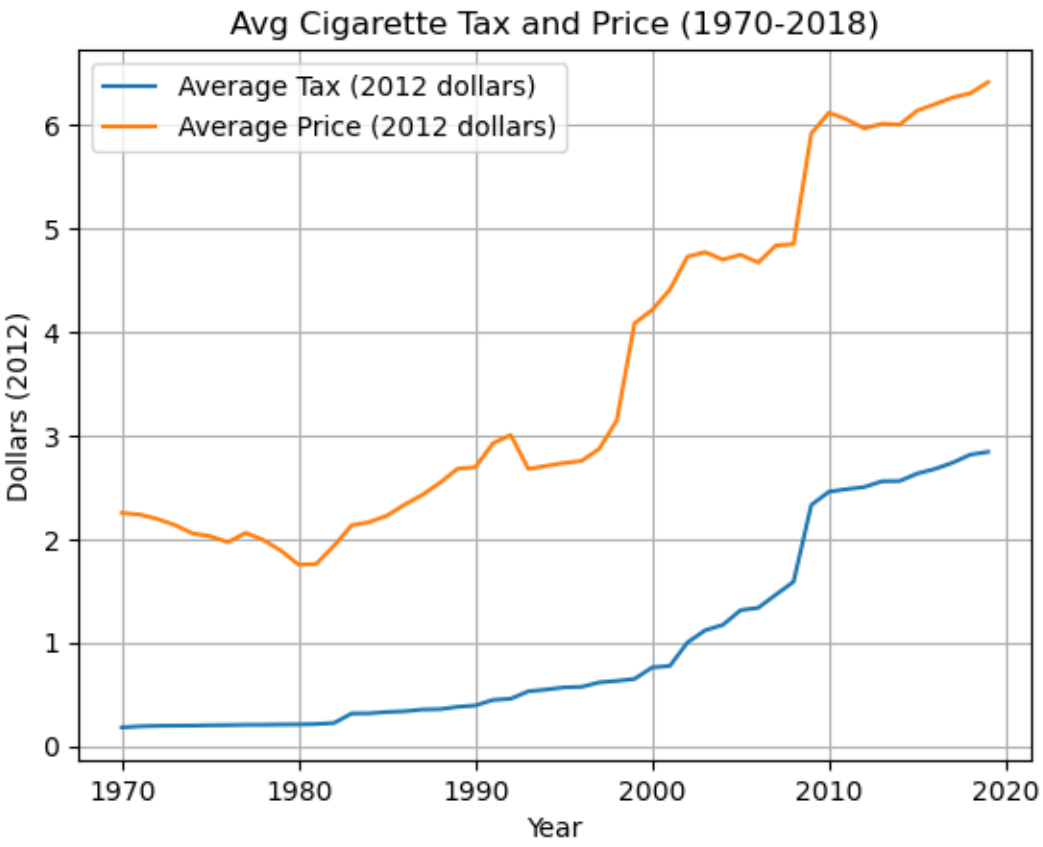
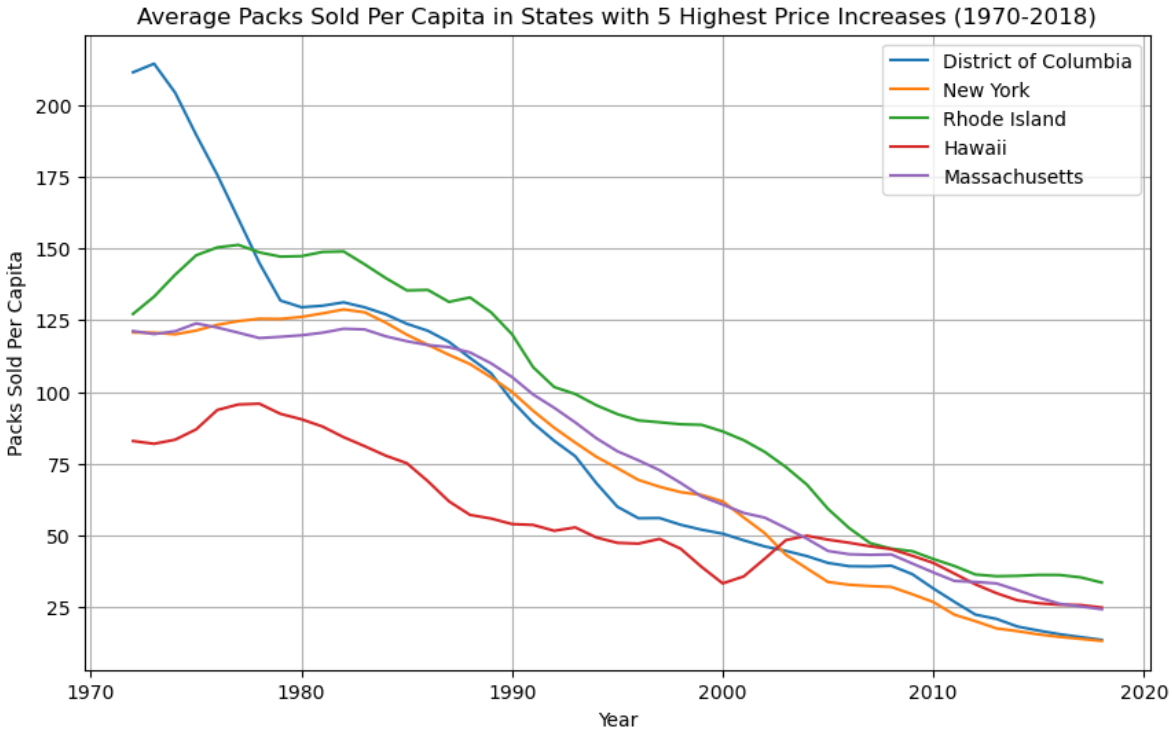
Question 1



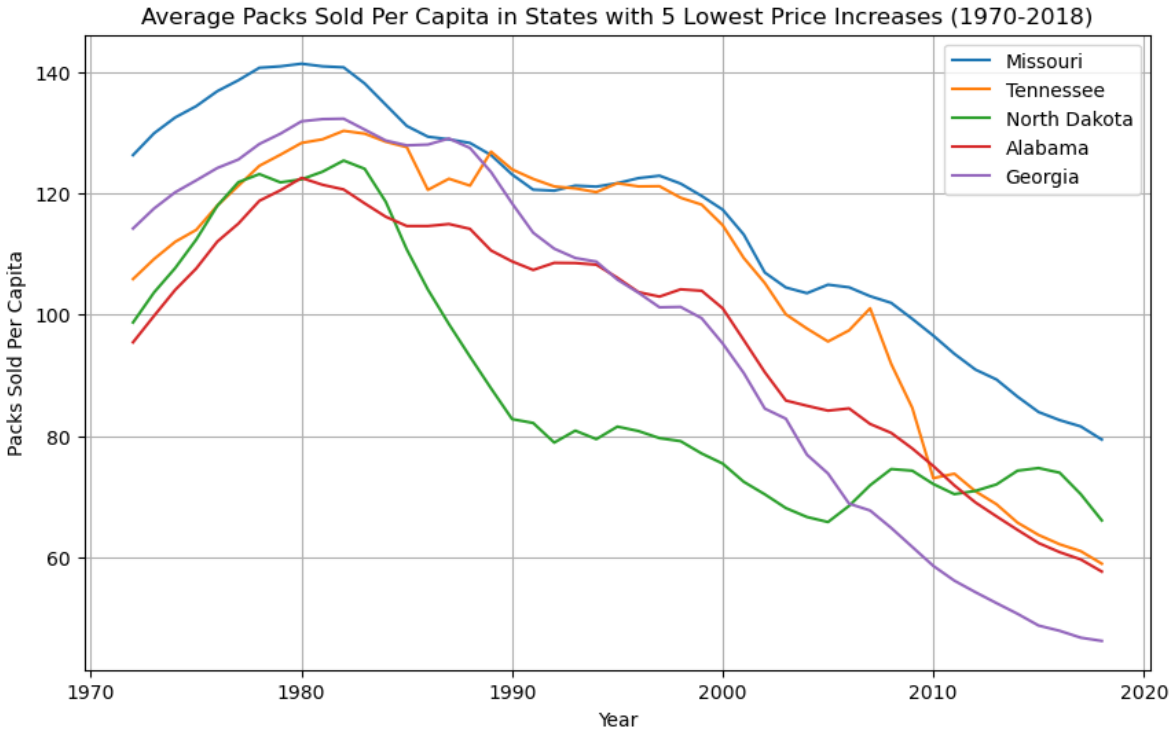
Question 2


Avg Cigarette Tax and Price (1970-2018)
Average Tax (2012 dollars)
Average Price (2012 dollars)
Dollars (2012)
0
1
2
3
4
5
6
1970
1980
1990
2000
2010
2020
Year

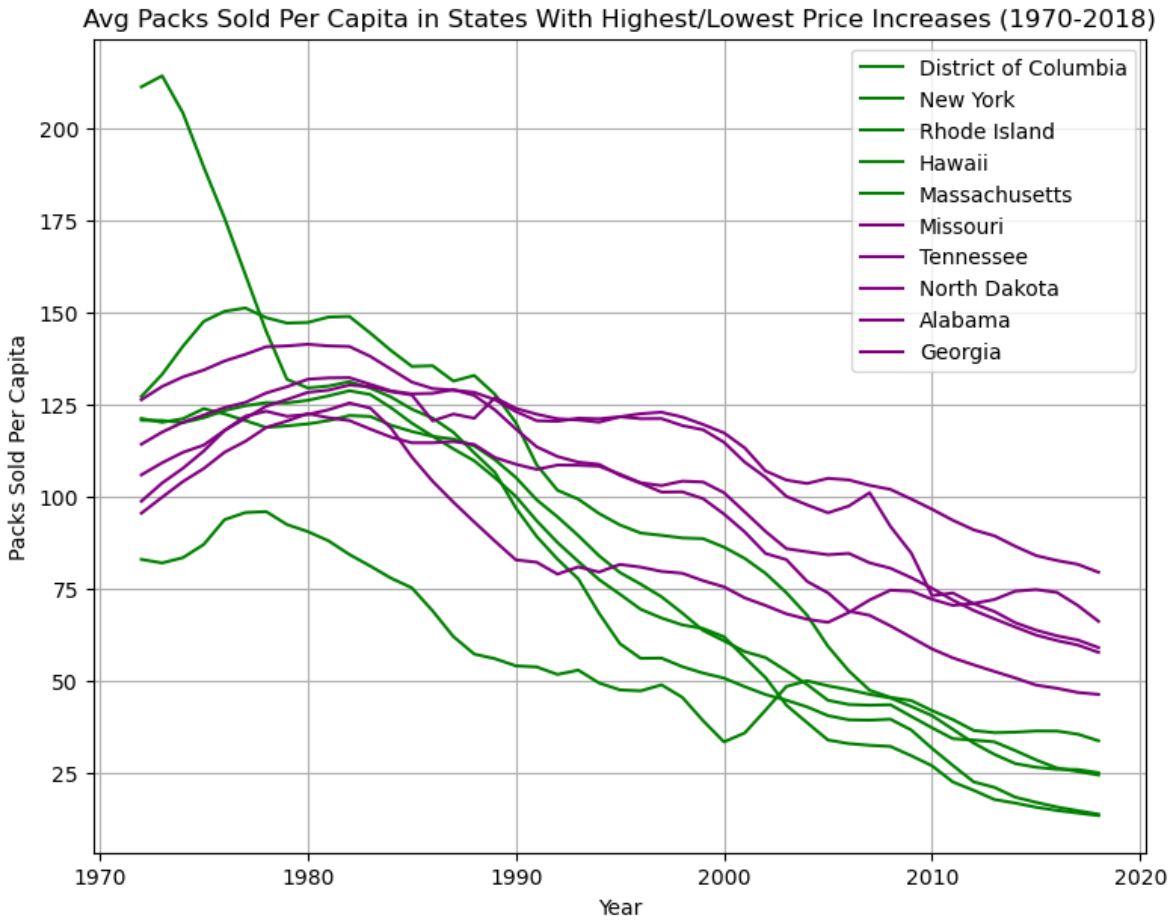
Question 3


Average Packs Sold Per Capita in States with 5 Highest Price Increases (1970-2018)
District of Columbia
New York
Rhode Island
Hawaii
Massachusetts
Packs Sold Per Capita
200
175
150
125
100
75
50
25
1970
1980
1990
2000
2010
2020
Year

Question 4


Average Packs Sold Per Capita in States with 5 Lowest Price Increases (1970-2018)
Missouri
Tennessee
North Dakota
Alabama
Georgia
Packs Sold Per Capita
140
120
100
80
60
1970
1980
1990
2000
2010
2020
Year

Question 5



The graph shows that sales of cigarettes per capita declined over time in every state, although the loss was significantly more in the states with the biggest price increases (green lines) than in the states with the lowest price increases (purple lines). Both groups of states initially had comparable sales levels, but as prices increased, cigarette use fell much more in the states with the biggest increases. This shows a consistent pattern across several states, potentially indicating that higher cigarette prices are associated with a bigger reduction in smoking rates.

Question 6

OLS Regression Results

Dep. Variable:	ln_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:                        14:02:27   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          5.4274      0.030    182.424      0.000       5.369       5.486
ln_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.                         10.5
==============================================================================

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

When this regression is ran, the estimated price elasticity is -0.8094, meaning that a 1% increase in price leads to a 0.81% decrease in cigarette sales.

Question 7 and 8

```
First stage (ln_price ~ ln_total_tax):

                            OLS Regression Results
==============================================================================
Dep. Variable:               ln_price   R-squared:                       0.290
Model:                           OLS   Adj. R-squared:                  0.289
Method:                 Least Squares   F-statistic:                     436.8
Date:                Fri, 21 Mar 2025   Prob (F-statistic):           1.32e-81
Time:                        14:02:27   Log-Likelihood:                 689.61
No. Observations:                1071   AIC:                            -1375.
Df Residuals:                    1069   BIC:                            -1365.
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
```

```
------------------------------------------------------------------------------
const            0.8396      0.005    154.879      0.000       0.829       0.850
ln_total_tax     0.2601      0.012     20.901      0.000       0.236       0.284
==============================================================================
Omnibus:                       78.233   Durbin-Watson:                   0.412
Prob(Omnibus):                  0.000   Jarque-Bera (JB):               93.984
Skew:                           0.719   Prob(JB):                     3.90e-21
Kurtosis:                       2.803   Cond. No.                         3.52
==============================================================================

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

Second stage Regression (ln_sales ~ pricehat):

```
                            OLS Regression Results
==============================================================================
Dep. Variable:               ln_sales   R-squared:                       0.082
Model:                            OLS   Adj. R-squared:                  0.082
Method:                 Least Squares   F-statistic:                     95.97
Date:                Fri, 21 Mar 2025   Prob (F-statistic):           9.31e-22
Time:                        14:02:27   Log-Likelihood:                 123.02
No. Observations:                1071   AIC:                            -242.0
Df Residuals:                    1069   BIC:                            -232.1
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const          5.4168      0.062     87.196      0.000       5.295       5.539
0             -0.7955      0.081     -9.796      0.000      -0.955      -0.636
==============================================================================
Omnibus:                       89.561   Durbin-Watson:                   0.196
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              464.515
Skew:                           0.141   Prob(JB):                    1.36e-101
Kurtosis:                       6.214   Cond. No.                         19.5
==============================================================================

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

When cigarette taxes are used as a price tool, the price elasticity is -0.7955, which is little

different from the -0.809 OLS estimate. This means that cigarette sales are decreased by roughly 0.80% (IV) or 0.81% (OLS) for every 1% price rise. The slight difference is due to endogeneity; states with high smoking rates may impose higher taxes, which would skew the OLS result. But since the results are so close the OLS bias is probably minimal.

```
Reduced Form Regression (ln_sales ~ ln_total_tax):

                            OLS Regression Results
==============================================================================
Dep. Variable:               ln_sales   R-squared:                       0.082
Model:                            OLS   Adj. R-squared:                  0.082
Method:                 Least Squares   F-statistic:                     95.97
Date:                Fri, 21 Mar 2025   Prob (F-statistic):           9.31e-22
Time:                        14:02:27   Log-Likelihood:                123.02
No. Observations:                1071   AIC:                            -242.0
Df Residuals:                    1069   BIC:                            -232.1
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const          4.7488      0.009    516.092      0.000       4.731       4.767
ln_total_tax  -0.2069      0.021     -9.796      0.000      -0.248      -0.165
==============================================================================
Omnibus:                       89.561   Durbin-Watson:                   0.196
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              464.515
Skew:                           0.141   Prob(JB):                    1.36e-101
Kurtosis:                       6.214   Cond. No.                         3.52
==============================================================================

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

Question 9

```
                            OLS Regression Results
==============================================================================
Dep. Variable:               ln_sales   R-squared:                       0.561
Model:                            OLS   Adj. R-squared:                  0.561
Method:                 Least Squares   F-statistic:                     1630.
Date:                Fri, 21 Mar 2025   Prob (F-statistic):          4.20e-230
Time:                        14:02:27   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	5.6600	0.036	155.560	0.000	5.589	5.731
ln_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.	9.34

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

First-stage (ln_price ~ ln_total_tax):

OLS Regression Results

Dep. Variable:	ln_price	R-squared:	0.812
Model:	OLS	Adj. R-squared:	0.812
Method:	Least Squares	F-statistic:	5504.
Date:	Fri, 21 Mar 2025	Prob (F-statistic):	0.00
Time:	14:02:27	Log-Likelihood:	648.41
No. Observations:	1275	AIC:	-1293.
Df Residuals:	1273	BIC:	-1283.
Df Model:	1		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	1.3151	0.004	299.842	0.000	1.306	1.324
ln_total_tax	0.5136	0.007	74.186	0.000	0.500	0.527

Omnibus:	1.638	Durbin-Watson:	0.349
Prob(Omnibus):	0.441	Jarque-Bera (JB):	1.708
Skew:	0.075	Prob(JB):	0.426
Kurtosis:	2.902	Cond. No.	1.83

```
==============================================================================

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

Second Stage Form Regression (ln_sales ~ pricehat):

```
                            OLS Regression Results
==============================================================================
Dep. Variable:               ln_sales   R-squared:                       0.607
Model:                           OLS   Adj. R-squared:                  0.607
Method:                Least Squares   F-statistic:                     1966.
Date:               Fri, 21 Mar 2025   Prob (F-statistic):          2.01e-260
Time:                       14:02:27   Log-Likelihood:                -186.12
No. Observations:               1275   AIC:                             376.2
Df Residuals:                   1273   BIC:                             386.5
Df Model:                          1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const          5.8799      0.038    154.597      0.000       5.805       5.954
0             -1.1501      0.026    -44.340      0.000      -1.201      -1.099
==============================================================================
Omnibus:                       37.095   Durbin-Watson:                   0.264
Prob(Omnibus):                  0.000   Jarque-Bera (JB):               88.126
Skew:                           0.040   Prob(JB):                     7.31e-20
Kurtosis:                       4.286   Cond. No.                         10.3
==============================================================================

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

Reduced Form Regression (ln_sales ~ ln_total_tax):

```
                            OLS Regression Results
==============================================================================
Dep. Variable:               ln_sales   R-squared:                       0.607
Model:                           OLS   Adj. R-squared:                  0.607
Method:                Least Squares   F-statistic:                     1966.
Date:               Fri, 21 Mar 2025   Prob (F-statistic):          2.01e-260
Time:                       14:02:27   Log-Likelihood:                -186.12
```

```
No. Observations:                1275   AIC:                             376.2
Df Residuals:                    1273   BIC:                             386.5
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const          4.3674      0.008    517.496      0.000       4.351       4.384
ln_total_tax  -0.5906      0.013    -44.340      0.000      -0.617      -0.564
==============================================================================
Omnibus:                       37.095   Durbin-Watson:                   0.264
Prob(Omnibus):                  0.000   Jarque-Bera (JB):               88.126
Skew:                           0.040   Prob(JB):                     7.31e-20
Kurtosis:                       4.286   Cond. No.                         1.83
==============================================================================

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

Question 10

Time Period	Model	ATE (Price Elasticity)	P-Value	Standard Error	R^2
1970-1990	OLS	-0.809438	6.981617e-83	0.038366	0.293983
1970-1990	IV (First Stage)	0.260060	1.317559e-81	0.012443	0.290101
1970-1990	IV (Second Stage)	-0.795524	9.310015e-22	0.081207	0.082378
1970-1990	Reduced Form	-0.206884	9.310015e-22	0.021119	0.082378
1991-2015	OLS	-0.996814	4.195667e-230	0.024692	0.561445
1991-2015	IV (First Stage)	0.513550	0.000000e+00	0.006922	0.812147
1991-2015	IV (Second Stage)	-1.150084	2.014365e-260	0.025938	0.606978
1991-2015	Reduced Form	-0.590626	2.014365e-260	0.013320	0.606978

The price elasticity is more negative in 1991-2015 (-1.15 IV, -0.996 OLS) than in 1970-1990 (-0.80 IV, -0.81 OLS), meaning demand became more responsive to price changes. Increased awareness of smoking risks, change in societal norms, and stricter anti-smoking laws could be possible causes of this. Before 1990, demand was more inelastic, and this could maybe be the result of more relaxed laws and more social acceptance surrounding smoking culture. In contrast, higher elasticity indicates that consumers were more likely to cut back on smoking in reaction to price increases after 1990.