Assignment 2
Code of Collab file:
https://colab.research.google.com/drive/101hJTV5y9JzstUJRSTPUk7Z9j-INqZ8v?usp=sharing

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Q1. Conduct an event study analysis to study the change of trend in petrol prices after the Indian government introduced day-to-day changes in fuel prices on 16th June 2017. [15 marks]

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                   rate   R-squared:                       0.588
Model:                            OLS   Adj. R-squared:                  0.588
Method:                 Least Squares   F-statistic:                     2398.
Date:                Tue, 03 Sep 2024   Prob (F-statistic):               0.00
Time:                        14:48:29   Log-Likelihood:                -15514.
No. Observations:                5048   AIC:                         3.104e+04
Df Residuals:                    5044   BIC:                         3.106e+04
Df Model:                           3
Covariance Type:            nonrobust
===============================================================================
                  coef    std err          t      P>|t|      [0.025      0.975]
-------------------------------------------------------------------------------
const          38.2716      0.575     66.579      0.000      37.145      39.399
time            0.0069      0.000     48.484      0.000       0.007       0.007
policy         -4.0357      1.350     -2.990      0.003      -6.682      -1.389
interaction     0.0002      0.000      1.007      0.314      -0.000       0.001
==============================================================================
Omnibus:                       86.790   Durbin-Watson:                   0.029
Prob(Omnibus):                  0.000   Jarque-Bera (JB):               90.272
Skew:                           0.321   Prob(JB):                     2.50e-20
Kurtosis:                       2.866   Cond. No.                     1.52e+05
==============================================================================

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.
[2] The condition number is large, 1.52e+05. This might indicate that there are
strong multicollinearity or other numerical problems.
```

a. What is the regression equation for your model?
Ans: Petrol Price=38.27+0.0069×Time−4.0357×Policy+0.0002×(Time×Policy)

b. What is the relationship of time with petrol prices?
Ans:

- **Time (`time`)**: The coefficient for `time` is 0.0069, which is statistically significant (p-value = 0.000). This indicates that, on average, the petrol price increased by approximately 0.0069 units each day before the policy implementation. This shows a clear upward trend in petrol prices over time.
- **Policy (`policy`)**: The coefficient for `policy` is -4.0357, which is also statistically significant (p-value = 0.003). This suggests that the implementation of the policy caused an immediate decrease in petrol prices by approximately 4.0357 units.
- **Interaction (`interaction`)**: The coefficient for the interaction term is 0.0002, but it is not statistically significant (p-value = 0.314). This suggests that the policy did not

significantly alter the trend of petrol prices after its implementation. The trend of petrol prices (as represented by the `time` variable) remained mostly unchanged post-policy.

c. What is your conclusion about the policy implemented from 16th June 2017?
Ans:
The policy implemented on June 16, 2017, appears to have immediately reduced petrol prices, as indicated by the negative and significant `policy` coefficient. However, the insignificant interaction term suggests that this policy did not change the existing trend of petrol prices over time. The long-term trend in petrol prices continued to rise at a similar rate as before the policy implementation.

Q2. For the event study model above, include the state as one of the covariates. [25 marks]

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                   rate   R-squared:                       0.660
Model:                            OLS   Adj. R-squared:                  0.659
Method:                 Least Squares   F-statistic:                     1395.
Date:                Tue, 03 Sep 2024   Prob (F-statistic):               0.00
Time:                        15:14:05   Log-Likelihood:                -15032.
No. Observations:                5048   AIC:                         3.008e+04
Df Residuals:                    5040   BIC:                         3.013e+04
Df Model:                           7
Covariance Type:            nonrobust
================================================================================================
                                   coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------------------------
Intercept                       35.0689      0.537     65.355      0.000      34.017      36.121
C(state)[T.Karnataka]            2.5023      0.213     11.732      0.000       2.084       2.920
C(state)[T.Maharashtra]          6.5624      0.209     31.337      0.000       6.152       6.973
C(state)[T.Tamil Nadu]           2.7976      0.210     13.347      0.000       2.387       3.209
C(state)[T.Telangana]            4.2894      0.213     20.127      0.000       3.872       4.707
time                             0.0069      0.000     52.957      0.000       0.007       0.007
policy                          -4.0758      1.229     -3.317      0.001      -6.485      -1.667
interaction                      0.0003      0.000      1.157      0.248      -0.000       0.001
==============================================================================
Omnibus:                      105.973   Durbin-Watson:                   0.036
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              112.135
Skew:                           0.362   Prob(JB):                     4.47e-25
Kurtosis:                       2.905   Cond. No.                     1.52e+05
==============================================================================

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.
[2] The condition number is large, 1.52e+05. This might indicate that there are
strong multicollinearity or other numerical problems.
```

a. What is the regression equation for your model?
Ans:
The regression equation with the state variable included is:

Petrol Price = 35.0689 + 0.0069 x Time - 4.0758 x Policy + 0.0003 x (Time x Policy) + 2.5023 x Karnataka + 6.5624 x Maharashtra + 2.7976 x Tamil Nadu + 4.2894 x Telangana

Here:
- Time: Number of days since the start of the observation period.
- Policy: A binary indicator (0 before the policy, 1 after the policy).
- Interaction: The interaction term between Time and Policy.
- Karnataka, Maharashtra, Tamil Nadu, Telangana: These are the dummy variables representing different states. **Dummy variables for the states relative to the baseline state (Delhi).**

b. What is the relationship of time with petrol prices? Did the relationship change from the first model to the second model?
Ans:
Time: The coefficient for time remains 0.0069, similar to the first model. This means that, on average, petrol prices increased by 0.0069 units per day before the policy implementation. The relationship between time and petrol prices has not changed from the first model to the second model.

Policy: The coefficient for policy is -4.0758, which is slightly more negative than in the first model (-4.0357). This indicates that after including the state variable, the policy's impact on reducing petrol prices is slightly stronger.

Interaction: The interaction term's coefficient is 0.0003, which remains statistically insignificant (p-value = 0.248). This suggests that the policy did not significantly alter the trend in petrol prices after implementation, even when accounting for state differences.

c. What can you say about the relationship between states and petrol prices? Is the relationship causal – why or why not?

State Relationships:
- Karnataka: Petrol prices are 2.5023 units higher compared to the baseline state (Delhi).
- Maharashtra: Petrol prices are 6.5624 units higher.
- Tamil Nadu: Petrol prices are 2.7976 units higher.
- Telangana: Petrol prices are 4.2894 units higher.

These coefficients show that petrol prices are higher in these states compared to Delhi, holding other factors constant.

Causality:
- The relationship between states and petrol prices as captured by this model is **correlational, not causal**. The coefficients show average differences in petrol prices across states, but they do not account for potential confounding factors that could influence these differences (e.g., local taxes, distribution costs, or demand variations.

- To establish causality, you would need to control for or randomize these confounders or use methods designed to infer causal relationships, such as instrumental variables or difference-in-differences.

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                   rate   R-squared:                       0.370
Model:                            OLS   Adj. R-squared:                  0.369
Method:                 Least Squares   F-statistic:                     423.0
Date:                Tue, 03 Sep 2024   Prob (F-statistic):               0.00
Time:                        16:24:57   Log-Likelihood:                -16585.
No. Observations:                5048   AIC:                         3.319e+04
Df Residuals:                    5040   BIC:                         3.324e+04
Df Model:                           7
Covariance Type:            nonrobust
================================================================================================
                                   coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------------------------
Intercept                       58.0939      0.546    106.484      0.000      57.024      59.163
C(state)[T.Karnataka]     -8.056e+12   9.13e+12     -0.883      0.377   -2.59e+13    9.84e+12
C(state)[T.Maharashtra]   -8.056e+12   9.13e+12     -0.883      0.377   -2.59e+13    9.84e+12
C(state)[T.Tamil Nadu]    -8.056e+12   9.13e+12     -0.883      0.377   -2.59e+13    9.84e+12
C(state)[T.Telangana]     -8.056e+12   9.13e+12     -0.883      0.377   -2.59e+13    9.84e+12
post_policy                   16.3286      0.583     28.001      0.000      15.185      17.472
treated                    8.056e+12   9.13e+12      0.883      0.377   -9.84e+12    2.59e+13
DiD_interaction               -3.8720      0.663     -5.839      0.000      -5.172      -2.572
==============================================================================
Omnibus:                     1043.259   Durbin-Watson:                   0.047
Prob(Omnibus):                  0.000   Jarque-Bera (JB):             4074.110
Skew:                          -0.980   Prob(JB):                         0.00
Kurtosis:                       6.940   Cond. No.                     4.06e+14
==============================================================================

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.
[2] The smallest eigenvalue is 1.01e-25. This might indicate that there are
strong multicollinearity problems or that the design matrix is singular.
```

The above are DID method results

Using the Difference-in-Differences (DiD) results to address causality:

Causality Analysis Using DiD Results:

DiD Model Output:
- Post_policy: Coefficient = 16.3286 (significant, p-value < 0.001)
- Treated: Coefficient = 8.056e+12 (not significant, p-value = 0.377)
- DiD_interaction: Coefficient = -3.8720 (significant, p-value < 0.001)

Interpreting Causality:

1. Effect of Policy (Post_policy):
   - The coefficient for `post_policy` is 16.3286, indicating that, on average, petrol prices increased by 16.3286 units after the policy was implemented. This suggests a substantial effect of the policy on petrol prices.

2. Effect of Treatment (Treated):

- The coefficient for `treated` is 8.056e+12, but it is not statistically significant (p-value = 0.377). This means that there is no significant difference in petrol prices between treated and non-treated states before the policy was implemented, holding other factors constant.

3. Interaction Term (DiD_interaction):
- The coefficient for `DiD_interaction` is -3.8720, which is statistically significant (p-value < 0.001). This suggests that the policy had a significant impact on reducing petrol prices in the treated states relative to the baseline state after the policy was implemented.

- Limitations:
- While the DiD model provides evidence of a causal effect of the policy on petrol prices in the treated states, it is important to note that causality can still be affected by other factors not accounted for in the model, such as external economic conditions, changes in local regulations, or other concurrent policy changes.

- Robustness Checks:
- To strengthen the causal inference, further robustness checks could be conducted, such as testing different time windows, adding additional control variables, or using alternative identification strategies like instrumental variables.

Q3. Fit two event studies model – one for Karnataka and one for Maharashtra. [20 marks]

For Karnataka

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                   rate   R-squared:                       0.451
Model:                            OLS   Adj. R-squared:                  0.449
Method:                 Least Squares   F-statistic:                     265.6
Date:                Tue, 03 Sep 2024   Prob (F-statistic):          7.84e-126
Time:                        17:01:51   Log-Likelihood:                -2750.8
No. Observations:                 975   AIC:                             5510.
Df Residuals:                     971   BIC:                             5529.
Df Model:                           3
Covariance Type:            nonrobust
================================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
--------------------------------------------------------------------------------
Intercept     97.3174      3.526     27.598      0.000      90.398     104.237
time          -0.0057      0.001     -7.328      0.000      -0.007      -0.004
policy       -73.8731      4.123    -17.919      0.000     -81.964     -65.783
interaction    0.0144      0.001     16.904      0.000       0.013       0.016
==============================================================================
Omnibus:                       30.174   Durbin-Watson:                   0.036
Prob(Omnibus):                  0.000   Jarque-Bera (JB):               19.002
Skew:                           0.202   Prob(JB):                     7.48e-05
Kurtosis:                       2.448   Cond. No.                     3.32e+05
==============================================================================

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.
[2] The condition number is large, 3.32e+05. This might indicate that there are
strong multicollinearity or other numerical problems.
```

For Maharashtra

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                   rate   R-squared:                       0.730
Model:                            OLS   Adj. R-squared:                  0.729
Method:                 Least Squares   F-statistic:                     928.5
Date:                Tue, 03 Sep 2024   Prob (F-statistic):          2.09e-292
Time:                        17:11:12   Log-Likelihood:                -3101.2
No. Observations:                1035   AIC:                             6210.
Df Residuals:                    1031   BIC:                             6230.
Df Model:                           3
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
Intercept     38.1138      0.906     42.053      0.000      36.335      39.892
time           0.0075      0.000     31.640      0.000       0.007       0.008
policy        10.2567      2.686      3.819      0.000       4.986      15.527
interaction   -0.0021      0.000     -4.480      0.000      -0.003      -0.001
==============================================================================
Omnibus:                       59.665   Durbin-Watson:                   0.035
Prob(Omnibus):                  0.000   Jarque-Bera (JB):               34.322
Skew:                           0.296   Prob(JB):                     3.52e-08
Kurtosis:                       2.332   Cond. No.                     1.45e+05
==============================================================================

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.
[2] The condition number is large, 1.45e+05. This might indicate that there are
strong multicollinearity or other numerical problems.
```

a. Write the regression equations of the model for both the states.

Ans:

For Karnataka:

Petrol Price Karnataka = 97.3174 − 0.0057 × Time − 73.8731 × Policy + 0.0144 × (Time×Policy)

For Maharashtra:

Petrol Price Maharashtra = 38.1138 + 0.0075 × Time + 10.2567 × Policy − 0.0021 × (Time×Policy)

b. Compare and interpret the causal relationship of policy implementation for the two states.

Ans:

Karnataka:

- **Policy Coefficient:** −73.8731(significant, p-value < 0.001)
    - This suggests a large reduction in petrol prices after policy implementation in Karnataka.
- **Interaction Term Coefficient:** 0.01440(significant, p-value < 0.001)

    - The positive interaction term implies that the reduction in petrol prices due to the policy was moderated over time. The effect of the policy became less severe as time passed.

Maharashtra:

- **Policy Coefficient:** 10.2567 (significant, p-value < 0.001)
    - This suggests an increase in petrol prices after policy implementation in Maharashtra.
- **Interaction Term Coefficient:** −0.0021(significant, p-value < 0.001)
    - The negative interaction term implies that the impact of the policy on increasing petrol prices became less pronounced over time.

Comparison and Interpretation:

- **Magnitude of Policy Effect:** The policy had a strong negative impact on petrol prices in Karnataka, reducing prices significantly. In contrast, the policy led to an increase in petrol prices in Maharashtra. This indicates that the policy's effect on petrol prices was opposite in these two states.
- **Time Dynamics:** The interaction term in Karnataka is positive, indicating that while the policy initially reduced petrol prices, the effect moderated over time. Conversely, in Maharashtra, the interaction term is negative, showing that while the policy initially increased prices, the effect diminished over time.
- **Overall Causality:** The differing directions of policy impact between Karnataka and Maharashtra suggest that local factors, such as market conditions or state-specific regulations, may have influenced the effectiveness of the policy differently. This analysis reflects correlation and provides insight into how the policy might have been implemented differently or had varying local effects. To better establish causality, additional factors such as local economic conditions, distribution costs, or other regulatory changes should be considered