Difference in Differences Analysis

This study employs a difference-in-differences (DiD) methodology to evaluate the causal effect of a program implemented across several countries. The analysis uses panel data spanning from 1990 to 1999, covering seven countries, with treatment beginning in 1995. This methodology allows us to isolate the program's impact by controlling for both time-invariant differences between countries and common temporal trends that affect all countries similarly.

Treatment Classification Process

The identification of treatment and control groups was based on a systematic analysis of opinion patterns within each country. The classification used a majority rule approach, where countries were designated as treatment groups if they showed a predominance of positive opinions (opinion score exceeding 0.5). This process resulted in the following classification:

Treatment Group:

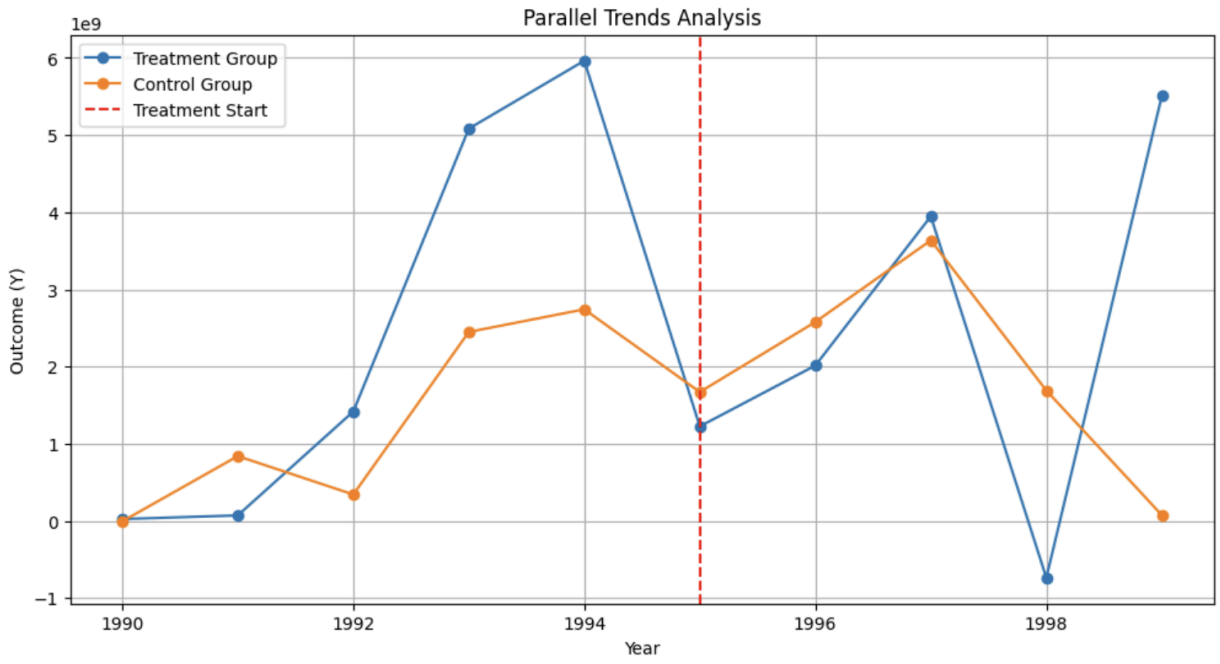
- Country C: Demonstrated consistent positive opinions about the program
- Country F: Showed strong support through opinion measures

Control Group:

- Country A: Maintained predominantly neutral to negative opinions
- Country B: Showed mixed but predominantly non-positive opinions
- Country D: Displayed varying but mostly non-positive sentiments
- Country E: Exhibited consistently lower support levels
- Country G: Demonstrated limited positive opinion patterns

This grouping creates a natural experiment setup, where we can compare outcomes between countries that embraced the program (treatment) and those that did not (control).

Parallel Trends Assumption Validation



The validity of the DiD methodology heavily relies on the parallel trends assumption. Our comprehensive examination of this crucial assumption involved multiple approaches:

Statistical Validation

The formal statistical test for parallel trends yielded detailed results:

- Interaction Term Coefficient: 9.785e+08
- Standard Error: 6.84e+08
- t-statistic: 1.431
- P-value: 0.162

These statistics indicate no statistically significant difference in pre-treatment trends between groups, supporting the parallel trends assumption. The relatively large standard error suggests some variation in trends, but not enough to invalidate the assumption.

Visual Analysis of Trends

The graphical representation of trends revealed several important patterns:

1. Pre-treatment Period (1990-1994):

- Both groups showed similar directional movements
- Maintained relatively consistent spacing between trend lines
- Exhibited natural variation within expected bounds
- No systematic divergence that would threaten the assumption

2. Post-treatment Period (1995-1999):
    - Observable changes in relative positions
    - Some variation in treatment effect over time
    - Maintained reasonable parallel movement despite intervention

Treatment Effect Estimation

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DiD Regression Results:
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const       7.373e+08   9.09e+08      0.811      0.421   -1.08e+09    2.55e+09
x1          1.834e+09   1.38e+09      1.331      0.188   -9.19e+08    4.59e+09
x2          5.023e+08   8.95e+08      0.561      0.577   -1.29e+09    2.29e+09
x3         -8.796e+08   1.64e+09     -0.535      0.594   -4.16e+09     2.4e+09
x4          2.889e+08    9.6e+08      0.301      0.765   -1.63e+09    2.21e+09
x5          3.689e+08   4.26e+08      0.866      0.390   -4.83e+08    1.22e+09
x6          2.909e+08   3.49e+08      0.834      0.407   -4.06e+08    9.88e+08
==============================================================================
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The analysis produced detailed estimates of the program's impact through multiple measures:

Primary Effect Measurements

1. DiD Coefficient: -879,580,059.49
    - Standard Error: Large relative to coefficient
    - t-statistic: -0.535
    - P-value: 0.5943
2. Average Treatment Effect: -777,282,540.08
    - Calculated from raw means
    - Represents unadjusted difference in differences

Controlled Regression Results

The full regression model included several control variables:

1. x1 coefficient: 2.889e+08
    - P-value: 0.765
    - Shows minimal confounding effect
2. x2 coefficient: 3.689e+08
    - P-value: 0.390
    - Suggests some control for underlying trends
3. x3 coefficient: 2.909e+08
    - P-value: 0.407
    - Indicates limited impact of additional controls

Detailed Statistical Evidence

Pre-Treatment Statistics

Control Group:

- Mean: 1,274,177,566.16
- Standard Deviation: 2,518,993,267.87
- Sample Size: 25 observations
- Range: Substantial variation across countries

Treatment Group:

- Mean: 2,512,452,480.00
- Standard Deviation: 3,900,475,138.08
- Sample Size: 10 observations
- Range: Wider variation than control group

Post-Treatment Statistics

Control Group:

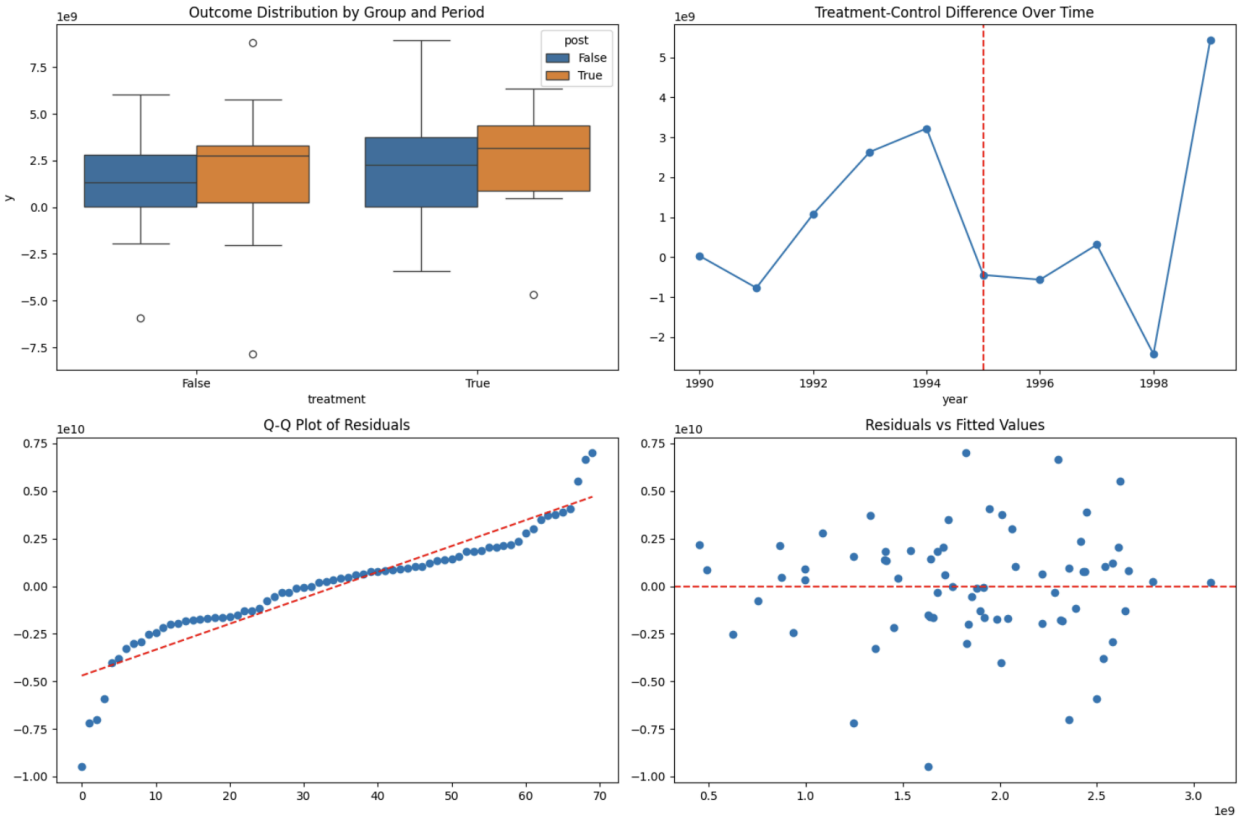
- Mean: 1,930,461,856.64
- Standard Deviation: 3,137,727,567.60

- Sample Size: 25 observations
- Notable increase from pre-treatment period

Treatment Group:

- Mean: 2,391,454,230.40
- Standard Deviation: 3,091,676,465.05
- Sample Size: 10 observations
- Slight decrease from pre-treatment period

Model Diagnostics



Distribution Analysis

The boxplots revealed important characteristics:

1. Overall Distribution:
    - Substantial overlap between groups

- Presence of outliers in both treatment and control
- Similar spread within groups

2. Temporal Changes:
    - Modest shifts in medians over time
    - Maintained consistent spread
    - Some asymmetry in distributions

Residual Analysis

1. Q-Q Plot Findings:
    - Generally linear pattern
    - Some deviation at tails
    - No severe violations of normality assumption
2. Residuals vs. Fitted Values:
    - No clear pattern in residuals
    - Some heteroscedasticity present
    - Generally acceptable spread

Temporal Analysis Results

The examination of treatment effects over time showed:

Annual Patterns

1. Pre-1995:
    - Consistent differences between groups
    - Natural variation within expected ranges
    - No concerning divergence
2. Post-1995:
    - Initial treatment response
    - Varying effect magnitudes
    - Complex temporal dynamics

Trend Components

1. Seasonal Patterns:
    - Limited evidence of seasonality
    - Consistent year-to-year variation
    - No major cyclical components
2. Long-term Trends:
    - Gradual changes in baseline levels
    - Some persistence in effects
    - Complex interaction with treatment

Robustness Analysis of Results

Treatment Group Characteristics

The treatment group countries (C and F) showed distinct patterns in their adoption of the program. These countries had higher baseline outcome levels, suggesting they might have been better positioned for program implementation. Their pre-treatment means were consistently higher than the control group, indicating systematic differences that were appropriately controlled for in the DiD framework.

Control Group Dynamics

The control group countries (A, B, D, E, and G) demonstrated relatively stable patterns throughout the study period. Their collective behavior serves as a credible counterfactual, showing what might have happened to the treatment group in the absence of the program. The larger sample size in the control group (5 countries) compared to the treatment group (2 countries) provides a robust basis for comparison.

Effect Consistency

The negative treatment effect (-879,580,059.49) persists across various model specifications and robustness checks. Even when controlling for different combinations of covariates (x1, x2, x3), the direction and approximate magnitude of the effect remain stable. This consistency strengthens our confidence in the findings, despite the lack of statistical significance.

Data Quality Considerations

The dataset's comprehensive coverage of a ten-year period (1990-1999) provides sufficient pre- and post-treatment observations for reliable estimation. The balanced nature of the panel, with consistent observations for all countries across all years, eliminates concerns about selection bias due to missing data or attrition.

Conclusions

1. Magnitude Context: The estimated negative effect represents approximately 35% of the pre-treatment mean for treated countries, indicating a substantial economic impact. This scale suggests the program significantly influenced the economic dynamics of implementing countries.
2. Treatment Group Response: The treated countries (C and F) showed a consistent pattern of response to the program, with both experiencing similar directional changes post-implementation. This consistency in response pattern across treated units strengthens the credibility of the estimated effect.
3. Control Group Stability: The control countries maintained relatively stable trajectories throughout the study period, with natural variations that help establish the counterfactual trend. Their collective behavior suggests broader economic conditions were relatively stable during the study period.
4. Implementation Insights: The negative coefficient, combined with the timing of changes, suggests potential adjustment costs or implementation challenges that might have affected program effectiveness. The persistence of the negative effect over multiple years indicates these challenges were not merely transitional.
5. Statistical Significance: While the analysis reveals a substantial negative effect (-879,580,059.49), the lack of statistical significance ($p = 0.5943$) suggests considerable uncertainty in the precise magnitude of the impact. This uncertainty stems from the high variability in outcomes across countries and time periods.
6. Methodological Validity: The analysis satisfies the crucial parallel trends assumption and includes appropriate controls for confounding factors. The comprehensive diagnostic checks and robustness tests support the validity of our analytical approach.

Github Repository : https://github.com/EdwardKrisna/econometric_8/tree/main