Empirical Replication Guide for Romer and Romer (2010)

A Replication Recipe for Theory, Plots, Tables, and Graphs

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1 Summary of the Theoretical Framework

The full theoretical derivation can be summarized in the following steps:

1. Start with the simple reduced-form relationship:

$$\Delta \ln Y_t = \alpha + \beta \, \Delta T_t + \varepsilon_t.$$

2. Decompose the error term into a sum of distinct shocks:

$$\varepsilon_t = \sum_{i=1}^{K} \varepsilon_t^i.$$

3. Model tax changes as driven by endogenous responses and exogenous motivations:

$$\Delta T_t = \sum_{i=1}^{K} b_t^i \, \varepsilon_t^i + \sum_{j=1}^{L} \omega_t^j.$$

4. Substitute the tax-change equation into the output equation and define:

$$\nu_t = \sum_{i=1}^{K} \left(1 + \beta \, b_t^i\right) \varepsilon_t^i.$$

   This yields:

$$\Delta \ln Y_t = \alpha + \beta \sum_{j=1}^{L} \omega_t^j + \nu_t.$$

5. Use narrative evidence to classify tax changes. Only those tax changes that are exogenous

(i.e., the ω_t^j components) are aggregated into the tax shock series:

$$\tau_t = \sum_{j=1}^{L} \omega_t^j.$$

6. Dynamic effects are captured by a distributed lag model:

$$\Delta \ln Y_t = \alpha + \sum_{i=0}^{M} \beta_i \, \Delta T_{t-i} + \varepsilon_t,$$

where the cumulative effect is $\sum_{i=0}^{M} \beta_i$.

7. Anticipation effects are incorporated by including a news variable:

$$\Delta \ln Y_t = a + \sum_{i=0}^{M} b_i \, \Delta T_{t-i} + \sum_{j=0}^{M} c_j \, \text{NEWS}_{t-j} + \sum_{k=1}^{N} d_k \, \Delta \ln Y_{t-k} + e_t.$$

2 Data Acquisition and Preparation

2.1 Data Sources

- **Replication Package:** First to Obtain the replication dataset from OpenICPSR or the AEA repository. We can visit:

  https://www.openicpsr.org/openicpsr/project/112357/version/V1/view

- **Macroeconomic Data:**
  - **GDP Data:** Download quarterly real and nominal GDP data from the Bureau of Economic Analysis (BEA) via https://www.bea.gov/data/gdp/gross-domestic-product.
  - **Additional Variables:** Obtain variables such as government spending, interest rates (e.g., the Federal funds rate from the Federal Reserve's H15 series), and oil prices (from the Bureau of Labor Statistics) if necessary.

2.2 Data Cleaning and Variable Construction

- **Align Time Series:**
- **Normalization:** Convert raw tax revenue changes into percentages by normalizing with nominal GDP.
- **Key Variables:**

- **Real GDP Growth:** Compute the logarithm of real GDP and its quarterly differences.
- **Exogenous Tax Shock Series:** Identify the tax changes classified as exogenous from the narrative coding and aggregate them by quarter. Normalize these by nominal GDP.
- **Alternative Tax Measures:** Construct series for all legislated tax changes and for cyclically adjusted revenue changes.

- **Lagged Variables:** Create lagged variables (e.g., up to 12 lags) for the exogenous tax shock series and for GDP growth to capture dynamic effects.

- **Anticipation Effects (Optional):** If available, construct a "news" variable that represents the present value of future tax changes (using, for example, a three-year Treasury rate as the discount rate).

3 Model Specification and Estimation Strategy

3.1 Distributed Lag Regressions

- **Baseline Model:** Specify a distributed lag regression of GDP growth on the contemporaneous and lagged values of the exogenous tax shock series:

$$\Delta \ln Y_t = \alpha + \sum_{i=0}^{M} \beta_i \, \Delta T_{t-i} + \varepsilon_t.$$

- **Cumulative Multiplier:** Compute the cumulative multiplier as the sum of the estimated coefficients, i.e., $\sum_{i=0}^{M} \beta_i$.

3.2 Extended Model with Controls

- **Incorporate Lagged GDP Growth:** Add several lags of GDP growth to control for the inherent dynamics of the economy:

$$\Delta \ln Y_t = \alpha + \sum_{i=0}^{M} \beta_i \, \Delta T_{t-i} + \sum_{j=1}^{N} \gamma_j \, \Delta \ln Y_{t-j} + \varepsilon_t.$$

- **Other Controls:** Optionally include additional variables (e.g., government spending, oil prices, interest rates) to test robustness.

3.3 Vector Autoregression (VAR)

- **VAR Specification:** Set up a VAR with the exogenous tax shock series and the level of log real GDP:

$$\begin{pmatrix} \tau_t \\ \ln Y_t \end{pmatrix} = A_0 + \sum_{k=1}^{p} A_k \begin{pmatrix} \tau_{t-k} \\ \ln Y_{t-k} \end{pmatrix} + u_t.$$

- **Impulse Response Functions (IRFs):** Compute IRFs to trace the dynamic response of GDP to a 1% tax shock.

3.4 Incorporating Anticipation Effects (Optional)

- **Extended Specification:** Include a "news" variable to capture anticipation effects:

$$\Delta \ln Y_t = a + \sum_{i=0}^{M} b_i \, \Delta T_{t-i} + \sum_{j=0}^{M} c_j \, \text{NEWS}_{t-j} + \sum_{k=1}^{N} d_k \, \Delta \ln Y_{t-k} + e_t.$$

- **Interpretation:** Compare the output response from the news variable versus the response when the tax change is implemented.

4 Replication of Figures, Tables, and Graphs

4.1 Regression Tables

- Create tables that report:
  - Coefficient estimates, robust standard errors, and t-statistics for the baseline model.
  - Results from the extended model with lagged GDP and additional controls.
  - Comparisons using alternative tax measures (exogenous, all legislated, and cyclically adjusted revenues).

4.2 Time Series and Comparative Plots

- Plot the time series of:
  - Exogenous tax shocks.
  - All legislated tax changes.
  - Cyclically adjusted revenue changes.
- Use clear legends and axis labels (e.g., "Percent of GDP").

4.3 Dynamic Multipliers

- Plot the cumulative impact (multiplier) over quarters by summing the coefficients from the distributed lag regression.
- Include confidence intervals or error bars to reflect estimation uncertainty.

4.4 Impulse Response Functions (IRFs)

- Generate IRF plots from the VAR model to visualize the dynamic response of log GDP to a tax shock.
- Compare these IRFs with those obtained from the distributed lag regressions.

4.5 Subsample and Robustness Plots

- Create additional plots for subsample analyses (e.g., pre-1980 versus post-1980).
- Plot comparisons showing the sensitivity of the results to different lag lengths or the inclusion of control variables.

5 Robustness Checks and Sensitivity Analysis

- **Lag Structure:** Estimate models with alternative lag lengths (e.g., 8, 12, 14 lags) to assess stability.
- **Sample Splitting:** Divide the data into different subperiods (e.g., pre-1980 and post-1980) and compare results.
- **Additional Controls:** Incorporate extra variables such as government spending, oil prices, and interest rates to check the robustness of the estimated multipliers.
- **Alternative Tax Measures:** Compare results using the exogenous tax shock series, the series for all legislated tax changes, and the cyclically adjusted revenue changes.
- **Anticipation Effects:** If a news variable is available, test models that incorporate anticipation effects to determine if the output response is driven by the timing of announcements versus implementation.