Replication of the Theoretical Framework in Romer and Romer (2010)

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(Replicated and Derived by Behrooz Moosavi)

1 Introduction

This document derives the theoretical framework used by Romer and Romer (2010) to estimate the macroeconomic effects of tax changes on output. The key challenge in such analyses is that tax changes are often correlated with other economic factors, leading to biased estimates. Romer and Romer address this by using a narrative approach to isolate exogenous tax changes—those not driven by current or prospective economic conditions—and use these to estimate the causal effect of taxes on output.

2 The Baseline Reduced-Form Equation

We start with a simple model linking tax changes to output growth. Define:

- Y_t: the logarithm of real GDP at time t, so $\Delta \ln Y_t$ is the growth rate of real GDP.
- ΔT_t: the change in legislated tax liabilities (as a percentage of GDP) at time t.
- ε_t: a composite error term capturing all other factors affecting output growth.

The baseline model is:

$$\Delta \ln Y_t = \alpha + \beta \Delta T_t + \varepsilon_t, \tag{1}$$

where β is the short-run effect of a tax change on output growth. Estimating β directly using this equation is problematic because ΔT_t may be correlated with ε_t, leading to biased estimates.

3 Decomposition of the Error Term

The error term ε_t includes various shocks affecting output, such as government spending changes, monetary policy shifts, or external shocks (e.g., oil prices). We decompose it as:

$$\varepsilon_t = \sum_{i=1}^{K} \varepsilon_t^i, \tag{2}$$

where ε_t^i represents the i-th shock. These shocks may be correlated with each other, reflecting the interconnected nature of economic variables.

4 Modeling the Determinants of Tax Changes

Tax changes are not random; they result from policymakers' decisions, which can be driven by two types of factors:

A. Endogenous Responses

Policymakers often adjust taxes in response to economic conditions. For example, they might cut taxes during a recession to stimulate growth or raise taxes to fund increased government spending. Let b_t^i represent the responsiveness of tax changes to the shock ε_t^i. The endogenous component of tax changes is:

$$\sum_{i=1}^{K} b_t^i \varepsilon_t^i, \tag{3a}$$

where the time subscript on b_t^i reflects that policy responses vary across episodes (e.g., the response to a spending increase may differ depending on the economic context).

B. Exogenous Motivations

Some tax changes are motivated by factors unrelated to current or near-term economic conditions, such as reducing an inherited budget deficit or promoting long-run growth (e.g., the Kennedy-Johnson tax cut of 1964). These are denoted by ω_t^j for $j = 1, \ldots, L$, and their aggregate effect is:

$$\sum_{j=1}^{L} \omega_t^j. \tag{3b}$$

The key assumption is that these exogenous tax changes are uncorrelated with the shocks ε_t^i:

$$\mathrm{Cov}(\omega_t^j, \varepsilon_t^i) = 0 \quad \forall i, j.$$

The full model for tax changes combines both components:

$$\Delta T_t = \underbrace{\sum_{i=1}^{K} b_t^i \varepsilon_t^i}_{\text{Endogenous responses}} + \underbrace{\sum_{j=1}^{L} \omega_t^j}_{\text{Exogenous shocks}} . \tag{3}$$

5 Combining the Equations

Substitute Equation (3) into Equation (1):

$$\begin{aligned} \Delta \ln Y_t &= \alpha + \beta \left(\sum_{i=1}^{K} b_t^i \varepsilon_t^i + \sum_{j=1}^{L} \omega_t^j \right) + \varepsilon_t \\ &= \alpha + \beta \sum_{i=1}^{K} b_t^i \varepsilon_t^i + \beta \sum_{j=1}^{L} \omega_t^j + \varepsilon_t. \end{aligned} \tag{4}$$

Using Equation (2), $\varepsilon_t = \sum_{i=1}^{K} \varepsilon_t^i$, we combine the terms involving ε_t^i:

$$\begin{aligned} \beta \sum_{i=1}^{K} b_t^i \varepsilon_t^i + \varepsilon_t &= \beta \sum_{i=1}^{K} b_t^i \varepsilon_t^i + \sum_{i=1}^{K} \varepsilon_t^i \\ &= \sum_{i=1}^{K} \left(\beta b_t^i + 1 \right) \varepsilon_t^i. \end{aligned} \tag{5}$$

Define a new composite error term:

$$\nu_t = \sum_{i=1}^{K} \left(1 + \beta b_t^i \right) \varepsilon_t^i. \tag{6}$$

Substituting into Equation (4), we get:

$$\Delta \ln Y_t = \alpha + \beta \sum_{j=1}^{L} \omega_t^j + \nu_t. \tag{7}$$

Define the exogenous tax shock series as:

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

so Equation (7) becomes:

$$\Delta \ln Y_t = \alpha + \beta \tau_t + \nu_t. \tag{8}$$

6 Identification Strategy via Narrative Evidence

The problem with estimating Equation (1) directly is that ΔT_t includes the endogenous component $\sum_{i=1}^{K} b_t^i \varepsilon_t^i$, which is correlated with ε_t, causing bias in the estimate of β. Romer and Romer (2010) address this using a narrative approach:

1. **Identify Tax Changes:** Catalog all major postwar legislated tax changes (1945–2007) using historical records.

2. **Classify Motivations:** Use primary sources (e.g., presidential speeches, Congressional reports) to classify tax changes as:

   - *Endogenous*: Motivated by current or prospective economic conditions (e.g., countercyclical tax cuts during a recession) or to offset spending changes (e.g., tax increases to fund Medicare in 1965).

   - *Exogenous*: Motivated by factors unrelated to short-term economic conditions, such as addressing an inherited budget deficit (e.g., the 1993 Clinton tax increase) or promoting long-run growth (e.g., the 1964 Kennedy-Johnson tax cut).

3. **Construct Exogenous Tax Shocks:** Aggregate only the exogenous tax changes into the series $\tau_t = \sum_{j=1}^{L} \omega_t^j$.

Since τ_t is assumed to be uncorrelated with ν_t, regressing $\Delta \ln Y_t$ on τ_t provides an unbiased estimate of β. This approach avoids the bias from endogenous tax changes and nonpolicy factors (e.g., automatic revenue changes due to economic fluctuations) that plague broader measures like cyclically adjusted revenues.

7 Dynamic Effects: Distributed Lag Model

Tax changes affect output over time, not just immediately. To capture these dynamics, Romer and Romer (2010) use a distributed lag model:

$$\Delta \ln Y_t = \alpha + \sum_{i=0}^{M} \beta_i \tau_{t-i} + \sum_{k=1}^{N} \gamma_k \Delta \ln Y_{t-k} + u_t, \tag{9}$$

where:

- τ_{t-i} is the exogenous tax shock at lag i,
- β_i is the effect of a tax shock i periods ago on current output growth,
- $\Delta \ln Y_{t-k}$ are lagged output growth terms to control for serial correlation,
- u_t is an error term.

The cumulative effect over M periods is:

$$\text{Cumulative Multiplier} = \sum_{i=0}^{M} \beta_i. \tag{10}$$

Empirically, Romer and Romer find that a 1% of GDP exogenous tax increase reduces GDP by about 3% over three years, with the peak effect after 10 quarters.

8 Extending the Model to Include Anticipation Effects

Tax changes are often announced before they are implemented, and economic agents may adjust their behavior in anticipation. Romer and Romer (2010) explore this by including a "news" variable:

$$\Delta \ln Y_t = \alpha + \sum_{i=0}^{M} \beta_i \tau_{t-i} + \sum_{j=0}^{M} \delta_j \text{NEWS}_{t-j} + \sum_{k=1}^{N} \gamma_k \Delta \ln Y_{t-k} + u_t, \tag{11}$$

where:

- τ_{t-i} is the exogenous tax change at implementation,
- NEWS_{t-j} is the present value of future tax changes announced at time $t - j$,
- δ_j captures the effect of news on output growth.

They find that output responds more to the actual implementation of tax changes than to the announcement, suggesting that anticipation effects are limited.

9 Heterogeneity by Motivation

Exogenous tax changes are driven by two main motivations: addressing inherited budget deficits and promoting long-run growth. To explore differences, we can estimate:

$$\Delta \ln Y_t = \alpha + \beta^{\mathrm{DEF}} \tau_t^{\mathrm{DEF}} + \beta^{\mathrm{LR}} \tau_t^{\mathrm{LR}} + \nu_t, \tag{12}$$

where τ_t^{DEF} and τ_t^{LR} are exogenous tax changes motivated by deficit reduction and long-run growth, respectively. Romer and Romer (2010) find that deficit-driven tax increases have a smaller negative effect on output (sometimes even positive) compared to growth-driven tax changes.

10 Summary of the Theoretical Framework

The framework can be summarized as follows:

1. Start with a baseline model: $\Delta \ln Y_t = \alpha + \beta \Delta T_t + \varepsilon_t$.
2. Decompose the error term: $\varepsilon_t = \sum_{i=1}^{K} \varepsilon_t^i$.
3. Model tax changes: $\Delta T_t = \sum_{i=1}^{K} b_t^i \varepsilon_t^i + \sum_{j=1}^{L} \omega_t^j$.
4. Derive the estimating equation: $\Delta \ln Y_t = \alpha + \beta \tau_t + \nu_t$, where $\tau_t = \sum_{j=1}^{L} \omega_t^j$ and $\nu_t = \sum_{i=1}^{K} (1 + \beta b_t^i) \varepsilon_t^i$.
5. Use narrative evidence to construct τ_t by isolating exogenous tax changes.
6. Capture dynamic effects with a distributed lag model: $\Delta \ln Y_t = \alpha + \sum_{i=0}^{M} \beta_i \tau_{t-i} + \sum_{k=1}^{N} \gamma_k \Delta \ln Y_{t-k} + u_t$.
7. Incorporate anticipation effects: $\Delta \ln Y_t = \alpha + \sum_{i=0}^{M} \beta_i \tau_{t-i} + \sum_{j=0}^{M} \delta_j \mathrm{NEWS}_{t-j} + \sum_{k=1}^{N} \gamma_k \Delta \ln Y_{t-k} + u_t$.
8. Explore heterogeneity: $\Delta \ln Y_t = \alpha + \beta^{\mathrm{DEF}} \tau_t^{\mathrm{DEF}} + \beta^{\mathrm{LR}} \tau_t^{\mathrm{LR}} + \nu_t$.