Macroeconomics I

Fiscal Policy

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Introduction

- Government is a relevant part of GDP:
  - In most countries, government expenditures are $>20\%$ of GDP.

$$Y_t = C_t + I_t + G_t$$

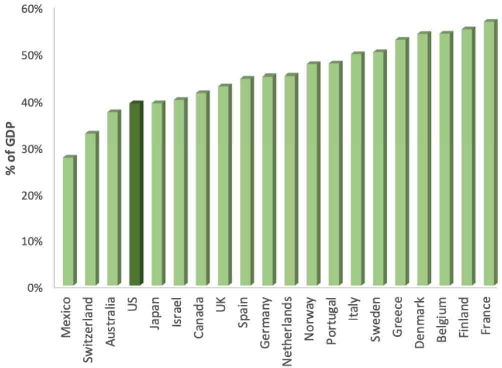
- These expenditures are financed via various taxes.

- The government can also accumulate debt, absorbing household savings.

- Let's think about how fiscal policy affects agents (households and firms) and various aggregates in the context of a neoclassical growth model and in the OLG model.

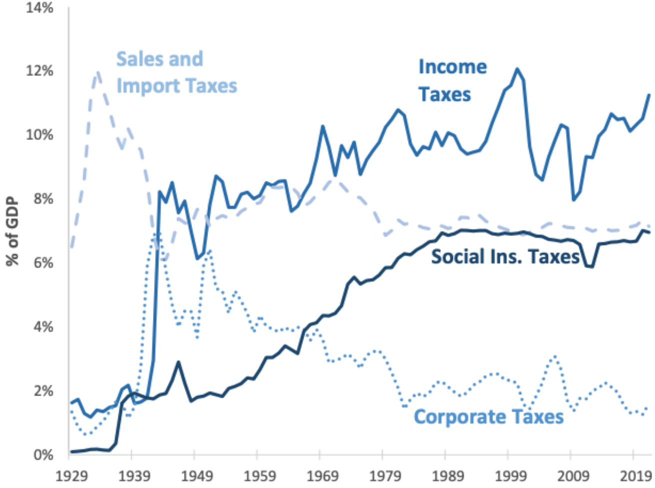
Government Expenditure

Figura: Government Spending across Countries (avg 2010-2019)



Source: PhD Macrobook: Government and Public Policy

Taxes in the U.S. Over Time



Source: PhD Macrobook: Government and Public Policy

What We Learn in This Chapter

- How to write the government's budget constraint in infinite periods.
- How to solve the competitive equilibrium in the neoclassical growth model with distortionary taxes.
- When Ricardian Equivalence holds.
- How to solve the transitional dynamics with distortionary taxes.

References

- PhD Macrobook Ch. 11.
- Ljungqvist and Sargent: fiscal policy chapters: "Ricardian Equivalence" and "Fiscal policies..."
- Dirk Krueger Ch. 8

Fiscal Policy in the Neoclassical Growth Model

Government Budget Constraint

- Suppose the **government budget constraint** for all periods t (B_0 given):

$$B_{t+1} = (1 + r_t)B_t + \underbrace{G_t - T_t}_{\text{primary deficit at } t \equiv D_t}$$

  - G_t is government spending on final goods.
  - T_t is total tax revenue.
  - B_t is the stock of public debt at time t.

- Suppose a *no-Ponzi* condition for the government: $\lim_{T\to\infty} \frac{B_{T+1}}{\prod_{s=0}^{T}(1+r_s)} = 0$

- Iterating the budget constraint and using the government's no-Ponzi game, we find the **government's intertemporal budget constraint**:

$$B_0 = \sum_{t=0}^{\infty} \left(\frac{T_t - G_t}{\prod_{s=0}^{t}(1 + r_s)} \right)$$

Digression: A Note on Debt Sustainability

- Sometimes it is useful to write the government budget constraint as a ratio of GDP (lower case letters):

$$\frac{B_{t+1}}{Y_{t+1}}\frac{Y_{t+1}}{Y_t} = (1 + r_t)\frac{B_t}{Y_t} + \frac{D_t}{Y_t}$$
$$b_{t+1}(1 + \gamma_t) = (1 + r_t)b_t + d_t$$

  where γ_t is the GDP growth of the economy.

- If primary deficit is zero, the debt to GDP increases if $\gamma_t < r_r$ and decreases if $\gamma_t > r_r$.
- In fact, given this equation, the government can even have sustainable deficits as long the growth rate of the economy is higher enough relative to the interest rate.

Government Budget Constraint

- We will assume that the sequence of government expenditures $\{G_t\}_{t=0}^{\infty}$ and the stock of debt $\{B_t\}_{t=0}^{\infty}$ are policy decisions and therefore exogenous from the perspective of households and firms.

- Tax revenue depends on exogenous and endogenous variables:

$$T_t = \tau_t^c c_t + \tau_t^k r_t a_t + \tau_t^\ell w_t \ell_t + \tau_t$$

  - τ_t^c is the consumption tax rate.
  - τ_t^k and τ_t^ℓ are tax rates on capital and labor income.
  - τ_t is the lump-sum tax.

- Given that $\{G_t\}_{t=0}^{\infty}$ is exogenous, the sequence $\{T_t\}_{t=0}^{\infty}$ must satisfy the government's intertemporal budget constraint. There are different sequences $\{\tau_t^c, \tau_t^k, \tau_t^\ell, \tau_t\}_{t=0}^{\infty}$ possible.
  - We will assume that $\{\tau_t^c, \tau_t^k, \tau_t^\ell\}_{t=0}^{\infty}$ are exogenous, and $\{\tau_t\}_{t=0}^{\infty}$ adjusts to satisfy the budget constraint.

Households and Firms

- There is a representative household with mass one that discounts consumption utility by $\beta \in (0,1)$: $U = \sum_{t=0}^{\infty} \beta^t u(c_t)$, where u follows the usual assumptions.

- The budget constraint is given, for all t,

$$(1+\tau_t^c)c_t + a_{t+1} = a_t(1 + r_t(1-\tau_t^k)) + w_t \ell_t (1-\tau_t^\ell) - \tau_t \qquad \forall t \qquad \text{and } a_0 \text{ given.}$$

- The household maximizes its utility, taking taxes $\{\tau_t^c, \tau_t^k, \tau_t^\ell, \tau_t\}_{t=0}^{\infty}$ and prices $\{r_t, w_t\}_{t=0}^{\infty}$ as given.

- The representative firm hires capital and labor to maximize its profit subject to a production function $F(k_t, \ell_t)$ with CRS.
  - Suppose the firm hires capital at the gross return (without depreciation) $\hat{r}_t = r_t + \delta$.

Competitive Equilibrium

Definition: The sequential competitive equilibrium with government consists of prices $\{r_t, w_t\}_{t=0}^{\infty}$, a sequence of fiscal policy $\{G_t, b_t, \tau_t^c, \tau_t^k, \tau_t^\ell, \tau_t\}_{t=0}^{\infty}$, allocations for households $\{c_t, a_t\}_{t=0}^{\infty}$, and firms $\{k_t, \ell_t\}_{t=0}^{\infty}$ where:

1. Given prices and taxes, the allocations $\{c_t, a_t\}_{t=0}^{\infty}$ solve the household's problem.
2. Given prices, the allocations $\{k_t, \ell_t\}_{t=0}^{\infty}$ solve the firm's problem.
3. Fiscal policy satisfies the government's intertemporal budget constraint.
4. Market clearing for the labor, capital, and goods markets in every period t:

$$\ell_t = 1$$
$$a_t = k_t + B_t$$
$$F(k_t, \ell_t) = c_t + k_{t+1} - (1-\delta)k_t + G_t$$

Household Solution

- The household's lagrangian:

$$\mathcal{L} = \sum_{t=0}^{\infty} \{\beta^t u(c_t) + \lambda_t [a_t(1 + r_t(1 - \tau_t^k)) + w_t \ell_t (1 - \tau_t^\ell) - \tau_t - (1 + \tau_t^c) c_t - a_{t+1}]\}.$$

- Taking the FOCs with respect to consumption and savings:

$$\beta^t u'(c_t) = \lambda_t (1 + \tau_t^c) \qquad \text{and} \qquad \lambda_t = (1 + r_{t+1}(1 - \tau_{t+1}^k))\lambda_{t+1},$$

- Put everything together to find the Euler equation:

$$u'(c_t) = \frac{(1 + \tau_t^c)}{(1 + \tau_{t+1}^c)} \beta (1 + r_{t+1}(1 - \tau_{t+1}^k)) u'(c_{t+1}) \qquad \forall t$$

- Solution for the firm's problem is usual:

$$\hat{r}_t = r_t + \delta = F_k(k_t, \ell_t) \qquad \text{and} \qquad w_t = F_\ell(k_t, \ell_t) \quad \forall t$$

Effect of Taxes in Equilibrium

- A tax is distortionary if it changes agents' decisions.

  1. The capital tax is distortionary.
  2. When there is no labor decision (inelastic labor supply), constant taxes on consumption and labor **are not** distortionary.
  3. Variations in consumption tax (i.e., $\tau_t^c \neq \tau_{t+1}^c$) are distortive.
  4. The lump-sum tax **is not** distortive.

Ricardian Equivalence

- Note that government spending G acts as a negative income effect for the household (more resources to government, less to households).
- Substituting the government's budget constraint into the household's, we see that the lump-sum tax disappears from the equilibrium conditions.
  - This implies that any lump-sum sequence satisfying the government's budget constraint is consistent with equilibrium.
- This result is known as **Ricardian Equivalence**.
  - The timing of the lump-sum tax has no effect on the model's dynamics $\Rightarrow$ it doesn't matter if the government finances itself with lump-sum or with debt.

Ricardian Equivalence

- Suppose $\tau_t^k =, \tau_t^c = \tau_t^\ell = 0$, i.e., the gov. finances **exclusively** via lump-sum taxation $T_t = \tau_t$.
  - Verify the FOCs are exactly the same as the planner's problem!

- Iterating the household's budget constraint to infinity and imposing a *no-Ponzi*:

$$a_0 + \sum_{t=0}^{\infty} \left(\frac{w_t \ell_t}{\prod_{s=0}^{t}(1+r_s)} \right) = \sum_{t=0}^{\infty} \left(\frac{c_t}{\prod_{s=0}^{t}(1+r_s)} \right) + \sum_{t=0}^{\infty} \left(\frac{\tau_t}{\prod_{s=0}^{t}(1+r_s)} \right)$$

- Observe that any tax sequence $\{\tau_t\}_{t=0}^{\infty}$ that respects the government's budget constraint does not alter the household's intertemporal budget constraint.

$$b_0 + \sum_{t=0}^{\infty} \left(\frac{G_t}{\prod_{s=0}^{t}(1+r_s)} \right) = \sum_{t=0}^{\infty} \left(\frac{\tau_t}{\prod_{s=0}^{t}(1+r_s)} \right)$$

Ricardian Equivalence

- **Intuition**: Suppose a government chooses to finance itself for 100 years solely by borrowing and in the 101st year pays off all its debt with a large lump-sum tax.
- The representative agent cares only about his **permanent income**, and, being rational, observes the government borrowing and internalizes that in 100 years he will have to pay a large lump-sum tax.
- He prepares for the event: maintains **the same** consumption allocation (given by the EE) and saves all the remaining income to pay the lump-sum tax in the future.
- The increase in government debt is offset by the increase in household savings $\Rightarrow$ Savings (households + government) are exactly the same regardless of the government's plan.

Ricardian Equivalence

- **Ricardian Equivalence** is a theoretical result that relies on fragile assumptions:
  (i) Rational agents with infinite lives (or finite-lived altruists) that believe the intertemporal government budget constraint will hold.
  (ii) Complete markets (agents can borrow without any frictions).
  (iii) No distortionary taxation (such as the lump-sum taxes).
- If any of these assumptions are not met, **Ricardian Equivalence** does not hold.

Computing Equilibrium

- Given initial and final conditions (k_0 and TVC), competitive equilibrium solutions are sequences $\{c_t, k_{t+1}\}_{t=0}^{\infty}$ that solve the system for all t:

$$u'(c_t) = \frac{(1+\tau_t^c)}{(1+\tau_{t+1}^c)}\beta(1+r_{t+1}(1-\tau_{t+1}^k))u'(c_{t+1})$$
$$F(k_t, \ell_t) = c_t + k_{t+1} - (1-\delta)k_t + G_t$$
$$\hat{r}_t = r_t + \delta = F_k(k_t, \ell_t)$$

where $\{G_t, \tau_t^c, \tau_t^k\}_{t=0}^{\infty}$ are exogenous sequences (along with the lump-sum).

Steady State

- Suppose fiscal policy eventually becomes constant:

$$\lim_{t\to\infty} G_t = G_{ss} \qquad \lim_{t\to\infty} \tau_t^k = \tau_{ss}^k \qquad \lim_{t\to\infty} \tau_t^c = \tau_{ss}^c$$

- Given the usual assumptions in the production and utility functions, the economy converges to a steady state.

- Note that only τ_k distorts the aggregate capital of economy in steady state (and thus the equilibrium is not efficient):

$$1 = \beta[1 + (F_k(k_{ss}, 1) - \delta)(1 - \tau_{ss}^k)]$$
$$F(k_{ss}, 1) = c_{ss} + \delta k_{ss} + G_{ss}$$

Equilibrium Path

- We have the initial condition k_0 (or the initial steady state) and the final steady state k_{ss} and c_{ss}.
- We know the exogenous sequence of fiscal policy $\{G_t, \tau_t^c, \tau_t^k\}_{t=0}^{\infty}$.
- We can compute the equilibrium sequence $\{k_{t+1}, c_t\}_{t=0}^{\infty}$ using the **shooting algorithm**.
- If you use the lump-sum as the adjustment variable for the gov. budget constraint, the algorithm is the same as the one used in the neoclassical growth model without government.

Recall: Shooting Algorithm

(i) Solve for the final steady state: k_{ss} and c_{ss}.

(ii) Select a sufficiently long time period S (so the economy reaches SS), and guess an initial candidate solution for consumption c_0.

(iii) Use the *Resource Constraint* and k_0 to compute k_1. Use c_0 and k_1 in the Euler Equation to compute c_1. Continue using c_t and k_t to find c_{t+1} and k_{t+1}.

(iv) Proceed until period S to find the candidate solution sequence: $\{\hat{k}_{t+1}, \hat{c}_t\}_{t=0}^{S}$.

(v) Compute $\hat{k}_S - k_{ss}$. If $\hat{k}_S > k_{ss}$, increase the guess c_0 and try again; if $\hat{k}_S < k_{ss}$, decrease the guess c_0 and try again.

(vi) Continue until finding a c_0 that makes $\hat{k}_S \approx k_{ss}$.

Shooting Algorithm

- At no point do we use the intertemporal government budget constraint. Two options:
  1. Assume the government can impose lump-sum taxation.
  2. Assume the government **CANNOT** impose lump-sum taxation.

- In the first case, the lump-sum tax serves as a residual that adjusts to keep the government budget balanced.

- The second case is more complicated:
  - It is necessary to compute an equilibrium sequence (given a sequence of fiscal policy) and check if the government budget constraint is satisfied.
  - If it is not, adjust the chosen tax sequence (or government spending) and try again until finding a sequence that balances the government budget.
  - An additional loop will be needed, and there are a large number of possibilities to adjust the government budget.

Fiscal Policy

- We will study shocks in fiscal policy, temporary or permanent.
- At $t = 0$, the economy is at the steady state, when at $t = 1$ a new fiscal policy is announced to be implemented at $t = 10$.
  - The government has access to lump-sum taxation to balance its budget.
- We will compute the transition to the final steady state.
- Note that agents are rational and react at the time of announcement.

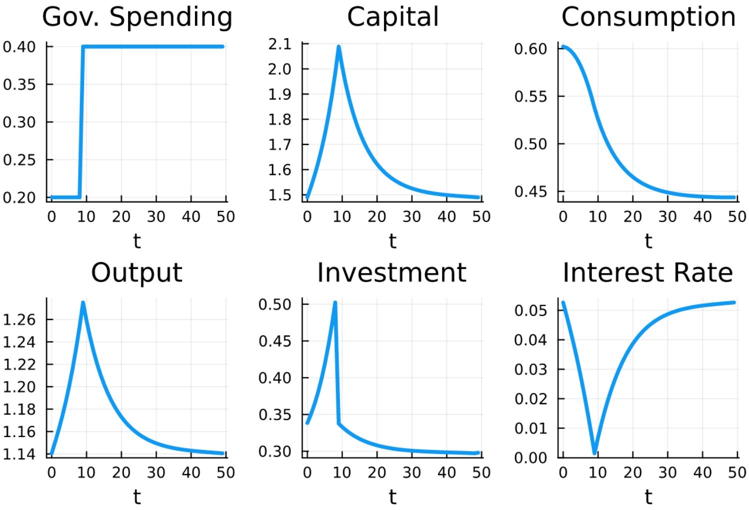
Functional Forms and Parameters

- Functional forms:

$$F(k_t, \ell_t) = k_t^{\alpha} \ell_t^{1-\alpha} \qquad \text{and} \qquad u(c_t) = \frac{c_t^{1-\gamma}}{1-\gamma}$$

- Parameters: $\alpha = 0.33$, $\beta = 0.95$, $\delta = 0.2$, and $\gamma = 2$.
- Fiscal policy in the initial steady state: $G_{ss} = 0.2$, $\tau^c_{ss} = 0.0$, $\tau^k_{ss} = 0.0$.
- We simulate the model for 50 periods.

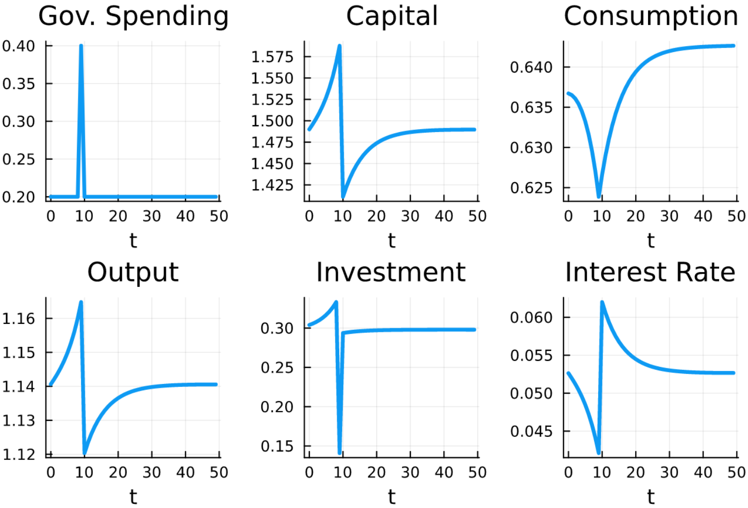
Permanent Increase in Spending



Permanent Increase in Spending

- The government announces that spending will double in $t = 10$ and remain so forever.
- The increase in government spending is a **permanent negative income effect** on household income.
- Households consume less initially and save more to smooth out this negative income effect coming from the future. After the spending increase, the economy starts to decumulate capital.
- The capital (and production) of the final steady state is the same as the initial one, but consumption is lower: if the government consumes more, households consume less.

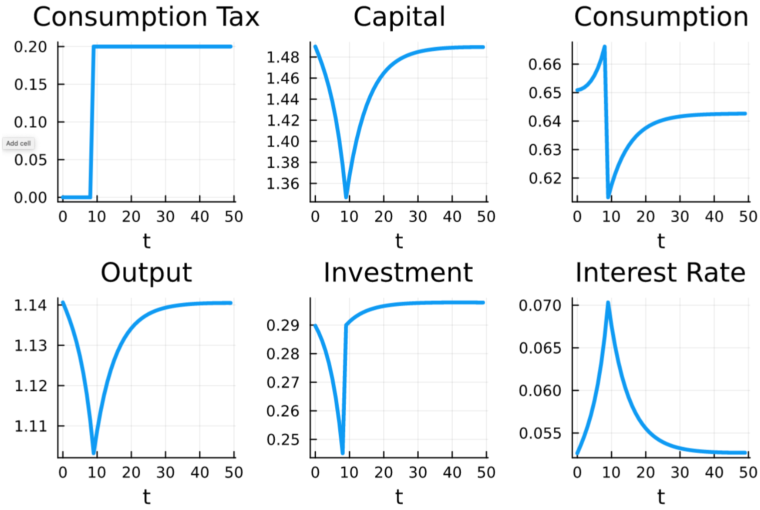
Transitory Increase in Spending



Transitory Increase in Spending

- Again, a negative income effect (but of smaller magnitude).
- Households reduce consumption at the time of announcement and then gradually reduce it to accumulate capital in anticipation of the future tax increase (or paying taxes if the government is anticipating tax collection).
- Intuitively, households are accumulating capital to increase production at the time of the expenditure increase.
- During $t = 10$, public spending *crowds-out* investment. After the transitory effect, households reduce investment and the economy returns to the steady state.

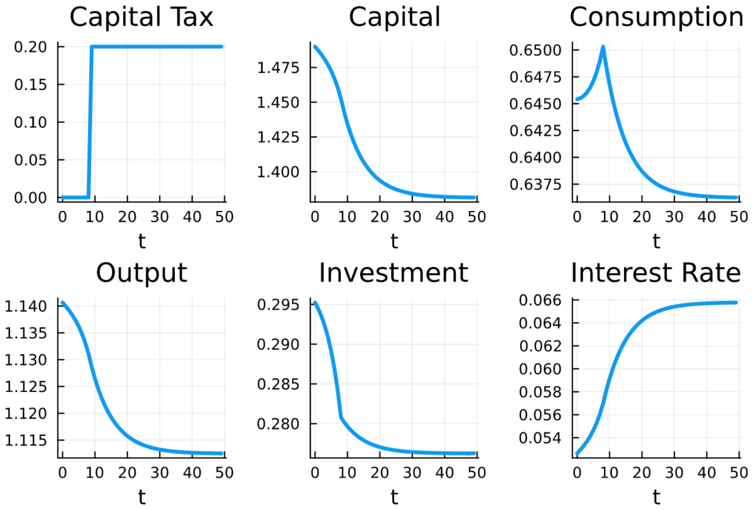
Permanent Increase in τ^c



Permanent Increase in τ^c

- Households know that consumption will be taxed in the future $\Rightarrow$ time to consume is now!
- The increase in consumption causes investment to decrease and capital to decumulate.
- At $t = 10$, the party ends: households reduce consumption and start saving again.
- The economy eventually returns to the same steady state at the cost of a period of austerity.

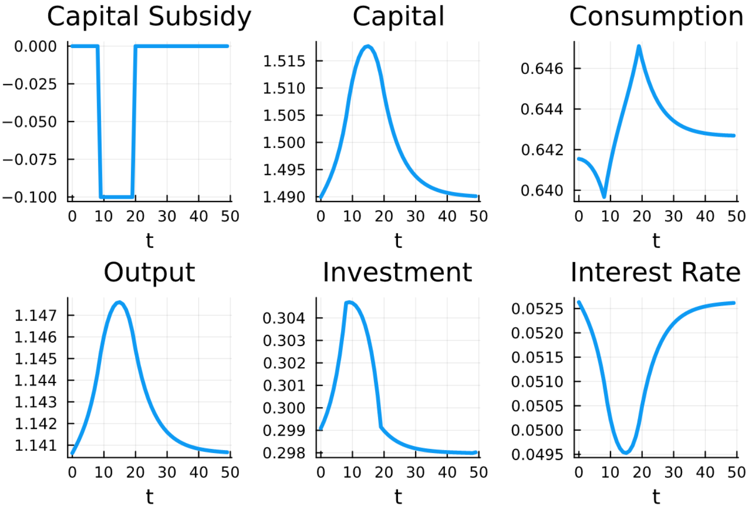
Permanent Increase in τ^k



Permanent Increase in τ^k

- The return on capital is taxed only in period 10, but it begins to lose value at the time of the announcement.
- Households start to decumulate capital and take the opportunity to consume more.
- Eventually, less capital reduces production and consumption also decreases.
- The economy reaches a new steady state with less capital, production, consumption, and higher return on capital.

Temporary Capital Subsidy



Temporary Capital Subsidy

- Knowing that there will be a capital subsidy for 10 periods, households reduce consumption and prepare for the event.
- Investment increases, and capital accumulates, reaching its peak around period $t = 15$.
- Knowing that the subsidy will end, households start to decumulate capital even before period 20.
- Given the over-accumulation of capital, households take advantage of high consumption post-subsidy. The economy eventually returns to the same steady state.

Digression: Productive Government

- Thus far, we have assumed that G does not benefit society: it is money thrown in the ocean.

- A simple way is to assume that these goods provide utility to agents. For example:

$$u(C,G) = \ln C + \xi \ln G \tag{1}$$

- Another way is to think gov. produces key infrastructure capital:

$$f(k,\ell,k_g) = k^{\alpha}\ell^{1-\alpha}k_g^{\theta} \qquad \text{with} \quad k_{g,t+1} = i_{g,t} + (1-\delta_g)k_{g,t}. \tag{2}$$

- The problem with these approach is that is very difficult to calibrate θ. In the case of xi is even worse.

Fiscal Policy in the Overlapping Generations Model

OLG with Debt and PAYG Pension

- Suppose a two-period OLG endowment economy. An individual receives y_t when young and nothing when old. The endowment grows at rate γ: $y_t = (1+\gamma)^t \omega$.
- Population grows at rate n_t, so the size of the newborn young population is: $L_t = (1+n)^t$.
- Aggregate income is: $Y_t = y_t L_t = (1+n)^t (1+\gamma)^t \omega$.
- The government runs a PAYG pension system and provides a public good G_t.
- The old receives pension p_t, which is financed by pension contribution τ_p. The pension per retiree:

$$p_t = (1+n)\tau_p y_t$$

Government & Pension

- The government finance its spending by taxing labor income τ_t. The gov. budget constraint is:

$$G_t + p_t L_{t-1} + (1+r)B_{t-1} = (\tau_p + \tau_t)Y_t + B_t$$

- Denote $b_t \equiv B_t / Y_t$, and suppose the public good is a fraction of GDP: $g = G_t / Y_t$. Then, dividing everything by Y_t:

$$g + \frac{p_t}{y_t(1+n)} + (1+r)b_{t-1} = \tau_p + \tau_t + b_t$$

$$g + (1+r)b_{t-1} = \tau_t + b_t$$

- Note that we include the social security account together with the gov. budget constraint. In this case it does not matter, but sometimes you could think as separate accounts.

HH's Problem

- Individuals maximize discounted utility s.t. budget constraints:

$$\max_{c_t^1 \geq 0,\ c_{t+1}^2 \geq 0,\ a_{t+1}} u(c_t^1) + \beta u(c_{t+1}^2)$$

$$s.t. \quad c_t^1 + a_t \leq (1 - \tau_p - \tau_t) y_t, \qquad \text{and} \qquad c_{t+1}^2 \leq p_{t+1} + a_t(1+r)$$

- Using $p_{t+1} = (1+n)(1+\gamma)\tau_p y_t$, the sequence of consumption is given by the Euler equation and the intertemporal budget constraint:

$$u'(c_t^1) = \beta(1+r)u'(c_{t+1}^2) \tag{3}$$

$$c_t^1 + \frac{c_{t+1}^2}{1+r} = \left[1 - \tau_p - \tau_t + \frac{(1+n)(1+\gamma)\tau_p}{1+r}\right] y_t \tag{4}$$

  - As usual, if we are in the case of dynamic inefficiency (i.e, $\gamma + n > r_t$) the pension system can be Pareto improving.

Ricardian Equivalence in OLG

- Note **Ricardo Equivalence does not hold** in OLG economies (without altruism).
- **Example:** consider a one-time transitory tax holiday in period t in an economy with zero initial debt ($\tau_t = 0$). Then, debt increases by: $B_t = G_t = gY_t$.
- Assume the government pays the debt next period and does not issue debt afterwise.
- The debt-financed tax cut shifts the tax burden from generation t to generation $t+1$.
- The aggregate consumption in t is: $C_t = c_t^2 L_{t-1} + c_t^1 L_t$.
  - Thus, aggregate consumption will increase in t and decrease in $t+2$. The effect in $t+1$ is ambiguous.

Debt in OLG

- In an OLG model with production, government debt can crowd-out savings that go to productive capital.
- In a dynamic inefficiently, public debt acts like a scheme of transfers from young to old.
    - Young pay taxes to the government, which transfers them to the old in form of interest payments.
- Suppose that $G_t = 0$ and the (constant) debt is financed by lump-sum τ. The gov. budget constraint (in per-capita):

$$(1+n)b_{t+1} = (1+r_t)b_t - \tau \qquad \Rightarrow \qquad \tau = (r_t - n)b$$

Debt in OLG

- From the asset market clearing condition (in per-capita):

$$(1+n)k_{t+1} + (1+n)b_{t+1} = s_t$$

- Using $s_t = s(w_t - \tau, r_{t+1})$, one could show that the law-of-motion for capital:

$$k_{t+1} = \frac{s(f(k_t) - k_t f'(k_t) - (f'(k_{t_t}) - n)b, f'(k_{t+1}))}{(1+n)} - b,$$

  so debt decreases savings through a direct and indirect effect.

- If the economy is efficient, debt would decrease capital too much.