Macroeconomics
Lecture 12 – Fiscal Policy

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Outline

1. Government budget sustainability
2. Ricardian equivalence
3. RBC with government
4. Distortionary taxes
   - Aggregate distortions: tax smoothing
   - Taxing multiple goods: the Ramsey problem
   - Capital and labor taxation

Government budget constraint

Denote real net government asset position at beginning of period t as B_t^g.
Typically, $B_t^g < 0 \Rightarrow$ introduce a **government debt** variable $D_t = -B_t^g$.

The government budget constraint can be written with the same logic as for household:

$$
\begin{aligned}
& G_t + B_{t+1}^g - B_t^g = r_t B_t^g + T_t \\
\text{or} \quad & G_t - D_{t+1} + D_t = -r_t D_t + T_t \\
\Leftrightarrow \quad & D_{t+1} - D_t = \underbrace{\underbrace{r_t D_t}_{\text{debt service}} + \underbrace{G_t - T_t}_{\text{primary deficit}}}_{\text{total deficit}} \\
\Leftrightarrow \quad & D_{t+1} = D_t(1 + r_t) + G_t - T_t
\end{aligned}
$$

Last equation – **recursive** (as many others in course) $\Rightarrow$ can write it as an infinite sum.

Government budget sustainability

$$D_t = \sum_{k=0}^{\infty} \frac{T_{t+k} - G_{t+k}}{R_{t,t+k}} + \underbrace{\lim_{t\to\infty} \frac{D_{t+k}}{R_{t,t+k}}}_{=0}$$

where
$R_{t,t+k} \equiv (1+r_t)\cdot(1+r_{t+1})\cdot(1+r_{t+2})\cdot\ldots(1+r_{t+k}) = \Pi_{s=0}^{k}(1+r_{t+s})$
and last term being null is transversality condition.

- Future **primary surpluses** must be used to repay initial government debt
- The earlier primary surplus in the future, the more impact on debt dynamics
- **Interest rates matter** $\Rightarrow$ in short term with sticky prices, pressure on Central Bank from government. Another reason for independent status of CB with inflation targeting mandate

Outline

Government budget and private budget

Consider a flow budget constraint of an infinitely lived household:

$$C_t + \Omega_{t+1} - \Omega_t = w_t L_t + r_t \Omega_t + \Pi_t - T_t$$

$$\Omega_{t+1} = (1 + r_t)\Omega_t + w_t L_t \cancel{+ r_t \Omega_t} + \Pi_t - T_t - C_t$$

Write as infinite sum, using same algebra:

$$\Omega_t = \sum_{k=0}^{\infty} \frac{C_{t+k} - w_{t+k} L_{t+k} - \Pi_{t+k}}{R_{t,t+k}} + \sum_{k=0}^{\infty} \frac{T_{t+k}}{R_{t,t+k}} + \underbrace{\lim_{k\to\infty} \frac{\Omega_{t+k}}{R_{t,t+k}}}_{=0}$$

And use $\sum_{k=0}^{\infty} \frac{T_{t+k}}{R_{t,t+k}} = D_t + \sum_{k=0}^{\infty} \frac{G_{t+k}}{R_{t,t+k}}$ (from government b.c.) in the equation:

$$\Omega_t = \sum_{k=0}^{\infty} \frac{C_{t+k} - w_{t+k} L_{t+k} - \Pi_{t+k}}{R_{t,t+k}} + \sum_{k=0}^{\infty} \frac{G_{t+k}}{R_{t,t+k}} + D_t$$

Budget constraints combined: Ricardian equivalence

Write consumptions on the left and incomes, initial assets, government spending on the right:

$$\sum_{k=0}^{\infty} \frac{C_{t+k}}{R_{t,t+k}} = \Omega_t - D_t + \sum_{k=0}^{\infty} \frac{w_{t+k}L_{t+k} + \Pi_{t+k} - G_{t+k}}{R_{t,t+k}}$$

- ▷ The expression summarizes the budget constraint of the household
- ▷ Because of the government budget constraint, it does not depend on values of taxes
- ▷ Initial gov. debt, D_t, appears in the constraint, but its difference with Ω_t is fixed (see below)

⇒ **Given a sequence of future government expenditures $\{G_t\}_{t=0}^{\infty}$, it is irrelevant for agents' decisions how it is financed: timing of taxes and debt issuance.**

Ricardian equivalence: gov. debt vs. private wealth

We will now show that the $\Omega_t - D_t$ difference is always fixed.

Suppose in $t-1$ the government decided, to tax current generations less and to borrow more instead: $\Delta D_t = -\Delta T_{t-1}$. This is under **fixed** $\{G_{t-1+k}\}_{k=0}^{\infty}$. Reaction of household in $t-1$:

- a **positive income shock** $-\Delta T_{t-1} > 0$, but **it must be temporary** because of gov. budget constraint
- the change in fiscal policy is just shifting income in time: **increase** of current income by $-\Delta T_{t-1}$ at $t-1$, but must **decrease** future income by $\frac{\Delta T_{t-1}}{R_{t-1,s}}$ at some future date s to respect gov. budget constraint
- **same income shifting achieved by private savings** $\Rightarrow$ if household in~~de~~creases savings $\Omega_t - \Omega_{t-1}$ by same amount, it keeps its optimal consumption plan $\{C_{t-1+k}\}_{k=0}^{\infty}$
- we get that $\Delta\Omega_t = \Delta D_t$, so $\Omega_t - D_t$ fixed and not affected by how the government finances $\{G_{t-1+k}\}_{k=0}^{\infty}$.

Ricardian equivalence in various models

The result holds universally in economies that have infinitely lived households, lump-sum taxation and no market frictions. Consider 3 classes of RBC models:

1. Closed economy without capital (see flex-price NK): $\Omega_t = D_t$ must always hold (nowhere to invest apart gov. debt). $\Delta\Omega_t = \Delta D_t$ holds trivially.

2. Closed economy with capital (vanilla RBC): $\Omega_t - \Omega_{t-1} = I_t + D_t - D_{t-1}$, so $\Delta\Omega_t = \Delta D_t \Rightarrow \Delta I_t = 0$.

3. Open economy RBC: $\Omega_t - \Omega_{t-1} = I_t + IIP_t - IIP_{t-1} + D_t - D_{t-1}$. $\Delta\Omega_t = \Delta D_t, \Delta I_t = 0 \Rightarrow \Delta IIP_t = \Delta CA_t = 0$.

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RBC with government

Consider a closed economy RBC with a government. Household has 2 ways to do savings: renting capital to firms with a rental rate R_t and hold governemnt bonds that pay real interest r_t:

$$\max_{C_t, L_t, K_{t+1}, B_{t+1}} E_0 \sum_{t=0}^{\infty} \beta^t u(C_t, L_t, G_t)$$

$$\text{s.t.} \quad C_t + I_t + D_{t+1} = w_t L_t - T_t + R_t K_t + \Pi_t + (1 + r_t) D_t$$

$$K_{t+1} = (1 - \delta) K_t + I_t$$

$$D_{t+1} = (1 + r_t) D_t + G_t - T_t$$

RBC with government – closing the model

Preferences:

- Assume $u(C_t, L_t, G_t)$ **additively separable** in (C_t, L_t) and G_t
  - e.g. $\frac{C_t^{1-\sigma}}{1-\sigma} - \frac{L_t^{1+\xi}}{1+\xi} + \frac{G_t^{1-\gamma}}{1-\gamma}$
- Then u'_C, u'_L don't depend on $G_t \Rightarrow$ **no effect on behavior**

Production:

- $Y_t = Z_t f(K_t, L_t) = C_t + I_t + G_t$;
- Firm FOC: $Z_t f'_K(K_t, L_t) = R_t$; $\quad Z_t f'_L(K_t, L_t) = w_t$

$\ln G = (1-\rho_g)\ln(\omega Y) + \rho_g \ln G$

$\ln G = \ln(\omega Y)$

$G = \omega Y$

$\frac{G}{Y} = \omega$

Two independent stochastic variables now: Z_t, G_t:

- $\ln Z_t = \rho_z \ln Z_{t-1} + \epsilon_t^z$
- $\ln G_t = (1-\rho_g)\ln(\omega Y) + \rho_g \ln G_{t-1} + \epsilon_t^g \Rightarrow G = \omega Y$ in s.s.

Effect of government spending on consumer

Use $D_{t+1} = (1 + r_t)D_t + G_t - T_t$ in the household's budget constraint:

$$C_t + I_t + D_{t+1} = w_t L_t - T_t + R_t K_t + \Pi_t + (1 + r_t)D_t$$
$$C_t + I_t = w_t L_t - G_t + R_t K_t + \Pi_t$$

Both debt and taxes disappear altogether from the constraint, only G_t matters – this is Ricardian equivalence.

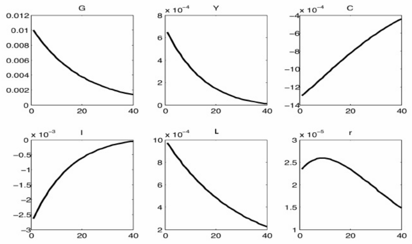
The effect of an increase of G_t is then same as a negative income shock from consumer perspective:

- Use intuition on consumption smoothing to understand response of C_t, I_t; Intuition about leisure as normal good $\Rightarrow$ response of L_t
- Persistence of G_t (parameter ρ_g) $\sim$ temporary vs. permanent income shocks
- Response of Y_t more ambiguous since $Y_t = C_t + I_t + G_t$

Impulse responses – positive shock of G

Cobb-Douglas production, $u(C_t, L_t, G_t) = lnC_t - \theta \frac{L_t^{1+\chi}}{1+\chi} + \frac{G_t^{1-\gamma}}{1-\gamma}$ and

α	β	χ	δ	θ	ρ_a	ρ_g	ω
1/3	0.99	1	0.025	4	0.97	0.95	0.2



Outline

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Distortionary taxes

Lump-sum taxes is a simplifying assumption that leads to a surprising result of Ricardian equivalence.

Proportional taxes $\Rightarrow$ strong effects on equilibrium and **welfare**.

Consider labor taxation. Disposable income of household is $(1-\tau_t^L)w_t L_t$. When used in a standard consumption leisure choice, one gets:

$$\frac{u'_L(C_t, L_t)}{u'_C(C_t, L_t)} = (1-\tau_t^L)w_t$$

Take example of GHH utility: $u(C_t, L_t) = \frac{\left(C_t - L_t^\chi/\chi\right)^{1-\sigma} - 1}{1-\sigma}$ where $\chi > 1 \Rightarrow L_t = ((1-\tau_t^L)w_t)^{\frac{1}{\chi-1}}$ – negative effect on labor supply, $\Rightarrow$ proportional tax **affects behavior**

Tax distortions

$$\frac{u'_L(C_t, L_t)}{u'_C(C_t, L_t)} = (1 - \tau^L_t) w_t$$

Proportional taxes are viewed as *wedges* in welfare analysis: they make **marginal rates of substitution/transformation** differ from **market prices**.

⇒ First Welfare Theorem does not hold: equilibrium is not optimal.

Aim of social planner is now to **minimize distortions** induced by taxes, while financing public expenditure.

Tax smoothing: a simple model

Consider a stylized (i.e. highly simplified) model of a social planner that chooses an aggregated tax rate T_t/Y_t every period.

The only aim is to minimize distortions that are given by $Y_t\xi(T_t/Y_t)$ with $\xi(0) = 0; \xi'(\cdot) > 0, \xi''(\cdot) > 0$ a ~~concave~~ convex distortion function. Convexity of the distortion function is obtained in various models when losses of utility are analyzed.

$$\min_{\{T_{t+k}/\cancel{Y_{t+k}}\}_{k=0}^{\infty}} E_t \sum_{k=0}^{\infty} \frac{Y_{t+k}\xi(T_{t+k}/Y_{t+k})}{R_{t,t+k}}$$

$$R_{t,t} = 1 + r_t$$

$$\text{s.t.} \quad D_t = E_t \sum_{k=0}^{\infty} \frac{T_{t+k} - G_{t+k}}{R_{t,t+k}}$$

$$\mathcal{L} = E_t\left[\sum_{k=0}^{\infty} Y_{t+k}\, g\!\left(\frac{T_{t+k}}{Y_{t+k}}\right) - \lambda\left(D_t - \sum_{k=0}^{\infty} \frac{T_{t+k} - G_{t+k}}{R_{t,t+k}}\right)\right]$$

$$\frac{\partial \mathcal{L}}{\partial T_t} = \frac{\cancel{Y_t} \cdot g'(T_t/Y_t)/\cancel{Y_t}}{R_{t,t}} + \frac{\lambda}{R_{t,t}} = 0 \iff$$

$$g'(T_t/Y_t) = -\lambda$$

$$E_t\, g'(T_{t+1}/Y_{t+1}) = -\lambda$$

Tax smoothing – solution

The FOC is $\xi'(T_t/Y_t) = E_t\xi'(T_{t+1}/Y_{t+1})$.

In a deterministic model, this means T_t/Y_t must be constant, so that **tax distortions are smoothed** across periods.

For a model with uncertainty, one can further assume $\xi(\cdot)$ is quadratic $\Rightarrow$ $\xi'(\cdot)$ is linear $\Rightarrow$ the FOC becomes

$$\xi'(T_t/Y_t) = \xi'(E_t T_{t+1}/Y_{t+1}) \Leftrightarrow T_t/Y_t = E_t[T_{t+1}/Y_{t+1}]$$

$\Rightarrow$ changes in tax rate only happen due to unexpected shocks.

Tax smoothing and government debt

Government debt provides a "buffer" role when taxes need to be smoothed:

- In periods with above-average spending needs (positive shock of G_t), issue additional debt not to tax too much
- In periods with below-average spending needs, additional budget surplus used to finance debt repayment.

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The Ramsey problem

We now focus on a **static** problem of choosing which goods to tax at which rate.

Main result is the **Ramsey taxation rule**: **the higher the elasticity of demand of a good for the household, the lower the optimal tax rate on that good.**

Intuition: proportional tax raises consumer prices; consumers' reaction higher if elasticity higher. More reaction $\Rightarrow$ more **distortions** with respect to the optimal equilibrium without proportional taxes.

The solution of the model will also show the **primal approach** to optimal policy solution, widely used for macro models.

The Ramsey problem: framework

N goods in the economy, produced with a linear production function using labor only:

$$y_i = a_i l_i$$

The social planner needs to finance a set of public goods $\{g_i\}_{i=1}^N$ and can only do it with proportional taxes on consumption of the goods: $\{\tau_i\}_{i=1}^N$. Think of a set of VATs.

The household consumes all the goods and provides labor. Utility function:

$$U(c_1, c_2, \dots c_N) = \sum_i u(c_i) - \theta l$$

Firms make zero profits on each good:
$\Pi_i = p_i a_i l_i - l_i = 0 \Leftrightarrow p_i = 1/a_i$
Finally, goods and labor markets clear: $y_i = c_i + g_i$;
$\sum_i l_i = l \Leftrightarrow \sum_i \frac{y_i}{a_i} = l \Leftrightarrow \sum_i \frac{c_i+g_i}{a_i} = l$

Household problem

$$\max_{\{c_i\},l} \sum_i u(c_i) - \theta l$$
$$\text{s.t.} \quad \sum_i (1+\tau_i) p_i c_i = l$$

The FOCs are $u'(c_i) - \lambda(1+\tau_i)p_i = 0$ and $\lambda = \theta$. Combining, $u'(c_i) = \theta p_i (1+\tau_i)$.

Isoelastic form of utility from consumption: $u(c_i) = \frac{c^{1-\frac{1}{\varepsilon_i}}}{1-\frac{1}{\varepsilon_i}}$.

Note that each good has its own parameter ε_i. $u'(c_i) = c_i^{-\frac{1}{\varepsilon_i}}$

The FOC then becomes:

$$c_i = (\theta(1+\tau_i)p_i)^{-\varepsilon_i}$$

We can now see that ε_i is the **demand elasticity**. Another useful interpretation is $-\frac{1}{\varepsilon_i} = \frac{u''(c_i)c_i}{u'(c_i)}$.

$$\begin{cases} u'(c_i) = \theta(1+\tau_i)p_i \\ \sum_i \underline{(1+\tau_i)p_i}\, c_i = \ell \end{cases} \Rightarrow \begin{aligned} &(1+\tau_i)p_i = \frac{u'(c_i)}{\theta} \\ &\sum_i \frac{u'(c_i)}{\theta} \cdot c_i = \ell \\ \Leftrightarrow &\sum_i u'(c_i) \cdot c_i = \theta \ell \end{aligned}$$

Primal approach to optimal taxes

We can rewrite the consumer's budget constraint using the FOC:

$$\sum_i u'(c_i)c_i = \theta I$$

This is called the **implementability constraint** – an optimality condition for HH choices where prices are eliminated.

The **primal approach** to finding optimal taxes:

1. use the implementability constraint in the social planner's optimization and solve for optimal consumption

2. use budget constraints and FOCs to find taxes that yield the optimal consumption

Primal approach – social planner's problem

$$\max_{\{c_i\},l} \sum_i u(c_i) - \theta l$$

$$\text{s.t.} \quad \sum_i u'(c_i) c_i = \theta l \qquad \text{implementability constraint}$$

$$\sum_i \frac{c_i + g_i}{a_i} = l \qquad \text{resource constraint}$$

Lagrangian needs to have two multipliers.

Manipulate the FOCs to eliminate both multipliers an get relationship between tax rates of two goods and their demand elasticities $\cancel{\frac{u''(c_i)c_i}{u'(c_i)}} \cancel{=} \varepsilon_i$.

$$\mathcal{L} = \sum_i u(c_i) - \theta l + \lambda\left(\sum_i u'(c_i)\cdot c_i - \theta l\right) + \gamma\left(l - \sum_i \frac{c_i + g_i}{a_i}\right)$$

FOC: $\frac{\partial \mathcal{L}}{\partial c_i} = 0$: $u'(c_i) + \lambda\left(\sum_i u''(c_i)c_i + u'(c_i)\right) - \gamma \cdot \frac{1}{a_i} = 0$

$\frac{\partial \mathcal{L}}{\partial l} = 0$: $-\theta - \theta\lambda + \gamma = 0$

$$1 + \lambda\left(\frac{u''(c_i)\cdot c_i}{u'(c_i)} + 1\right) = \frac{\gamma}{a_i u'(c_i)} \text{ (both sides divided by } u'(c_i))$$

$$\Leftrightarrow \begin{cases} 1 + \lambda\left(\frac{u''(c_i)\cdot c_i}{u'(c_i)} + 1\right) = \frac{\gamma}{a_i u'(c_i)} \\ \gamma = (1+\lambda)\theta \end{cases}$$

$$-\frac{1}{\varepsilon_i} = \frac{u''(c_i)c_i}{u'(c_i)}$$

$$\Rightarrow 1 + \lambda - \lambda\frac{1}{\varepsilon_i} = \frac{(1+\lambda)\theta}{a_i u'(c_i)}$$

$$\begin{cases} u'(c_i) = \theta p_i(1+\tau_i) \text{ (HH FOC)} \\ p_i = \frac{1}{a_i} \text{ (no profits)} \end{cases}$$

$$\Rightarrow u'(c_i)\frac{a_i}{\theta} = 1 + \tau_i$$

$$\Leftrightarrow 1 + \lambda - \lambda\frac{1}{\varepsilon_i} = \frac{1+\lambda}{1+\tau_i}$$

$$\Leftrightarrow 1 + \tau_i = \frac{1+\lambda}{1+\lambda-\lambda\frac{1}{\varepsilon_i}} \Rightarrow \frac{\tau_i}{1+\tau_i} = \frac{\lambda}{1+\lambda}\frac{1}{\varepsilon_i},$$

Eliminating λ: $\tau_i = \frac{\lambda\frac{1}{\varepsilon_i}}{1+\lambda-\lambda\frac{1}{\varepsilon_i}}$

can write same for good j

$$\boxed{\frac{\tau_i/(1+\tau_i)}{\tau_j/(1+\tau_j)} = \frac{1/\varepsilon_i}{1/\varepsilon_j}}$$

Ramsey taxation rule

$$\frac{\tau_i/(1+\tau_i)}{\tau_j/(1+\tau_j)} = \frac{1/\varepsilon_i}{1/\varepsilon_j}$$

$$\frac{\tau}{1+\tau} = \frac{1+\tau-1}{1+\tau} = 1 - \frac{1}{1+\tau}$$

How to read it? Note that $\tau/(1+\tau)$ is increasing in τ. Then, an **increase** in demand elasticity of i under a constant demand elasticity of j means that τ_i must **decrease** relatively to τ_j.

The higher the elasticity of demand of a good for the household, the lower the optimal tax rate on that good.

We will now study applications to optimal labor and capital taxation in macro models.

Outline

Distortionary taxes in RBC

We will now introduce labor and capital taxes in a **deterministic** RBC model. Recall a household budget constraint in a model where capital is held directly by the household:

$$C_t + \underbrace{K_{t+1} - (1-\delta)K_t}_{I_t} = w_t L_t + r_t K_t$$

where we have used that rental rate of capital R_t is equal to r_t in a deterministic economy and omitted profits that are null in equilibrium. Add proportional taxes and government debt:

$$C_t + K_{t+1} + D_{t+1} \overset{-D_t}{} = (1-\tau_t^L) w_t L_t + (1 + (1-\tau_t^{K})(r_t - \delta))K_t + r_t D_t$$

Where τ_t^L is labor income tax rate, while τ_t^K is tax rate for capital income (net of depreciation)

Primal approach to taxation in RBC

Using a no-arbitrage condition for capital and government debt $1+r_t = 1+(1-\tau_t^K)(r_t-\delta)$, one can write the budget constraint as infinite sum by expanding $K_{t+1}+D_{t+1}$:

$$\sum_{k=0}^{\infty} \frac{C_{t+k}}{R_{t+1,t+k}} = \sum_{k=0}^{\infty} \frac{(1-\tau_{t+k}^L)w_{t+k}L_{t+k}}{R_{t+1,t+k}} + (1+(1-\tau_t^K)(r_t-\delta))(K_t+D_t)$$

We will now eliminate prices and taxes to apply **primal approach** to optimal taxes. Recall the Euler equation is $\frac{u_C'(C_t,L_t)}{\beta u_C'(C_{t+1},L_{t+1})} = 1 + r_{t+1}$. Then:

$$\begin{aligned} R_{t+1,t+k} &= (1+r_{t+1})\cdot(1+r_{t+2})\dots(1+r_{t+k}) \\ &= \frac{u_C'(C_t,L_t)}{\beta^k u_C'(C_{t+k},L_{t+k})} \end{aligned}$$

The consumption-labor optimality is $-\frac{u_L'(C_t,L_t)}{u_C'(C_t,L_t)} = (1-\tau_t^L)w_t$

Primal approach to taxation in RBC

After re-arranging, we get the following implementability constraint:
$\sum_{k=0}^{\infty}[\beta^{t+k}(u_C(C_{t+k},L_{t+k})C_{t+k}-u_L(C_{t+k},L_{t+k})L_{t+k})]-$
$u_C(C_t,L_t)(1+(1-\tau_t^K)(r_t-\delta))(K_t+D_t)\cancel{)}=0$
Where period t state variables, tax and interest are treated as exogenous. We will use it, with the resource constraint, in social planner's problem. Define the Lagrangian as follows:

$$
\begin{aligned}
\mathcal{L}=\sum_{k=0}^{\infty}\beta^{t+k}[&V(C_{t+k},L_{t+k},\Phi)+\\
&\lambda(Z_{t+k}F(K_{t+k},L_{t+k})+(1-\delta)K_{t+k}\\
&-C_{t+k}-G_{t+k}-K_{t+k+1})]\\
&-\Phi Q(C_t,L_t,\tau_t^K,K_t,D_t)
\end{aligned}
$$

where $V(C_{t+k},L_{t+k},\Phi)=$
$u(C_{t+k},L_{t+k})+\Phi[u'_C(C_{t+k},L_{t+k})C_{t+k}-u'_L(C_{t+k},L_{t+k})L_{t+k}]$,
$Q(C_t,L_t,\tau_t^K,K_t,D_t)=u_C(C_t,L_t)(1+(1-\tau_t^K)(r_t-\delta))(K_t+D_t)$

Optimal capital tax in steady state

The FOC are

$$V'_C(C_t, L_t, \Phi) = \lambda_t + \Phi Q'_C$$

$$V'_L(C_t, L_t, \Phi) = \lambda_t f'_L(K_t, L_t) + \Phi Q'_L$$

$$V'_C(C_s, L_s, \Phi) = \lambda_s;\ V'_L(C_s, L_s, \Phi) = \lambda_s f'_L(K_s, L_s) \text{ for } s > t$$

$$V'_C(C_s, L_s, \Phi) = \beta V'_C(C_s, L_s, \Phi)(f'_K(K_{s+1}, L_{s+1}) + 1 - \delta)$$

Consider the last FOC in a steady state:

$$V'_C(C, L, \Phi) = \beta V'_C(C, L, \Phi)(f'_K(K, L) + 1 - \delta)$$

$$1 = \beta(f'_K(K, L) + 1 - \delta)$$

At the same time, household FOC in steady state is $1 = \beta(1 + (1 - \tau^K)(r - \delta))$ and firm FOC is $f'_K(K, L) = r \Rightarrow$ **optimal capital taxation is null in steady state**

Null capital taxation in steady state

A surprising result. Some kind of intuition exists, though.

Capital in s.s. determined by time preferences and depreciation factor, not by any kind of price. The price of capital is also determined by these factors: $1 + r = 1/\beta + \delta$ in absence of taxes.

Technically, **infinitely elastic** demand for capital in steady state: only one possible price, demand line horizontal. By Ramsey rule of taxation, tax rate is null.

Finite elasticity of leisure demand (labor supply) $\Rightarrow$ only labor is taxed in long run.

We will now see how different the optimal taxation is in the short-medium run.

Time inconsistency of capital taxation

Fiscal policy, like monetary policy, suffers from time inconsistency.

Recall what it is: policy-maker has incentive to announce one policy and then enact another. Monetary policy example: declare low inflation in the future, then increase it to boost output. Rational agents guess it and expect high inflation.

Capital taxation (in the short-medium run) leads to a related problem.

Time inconsistency of capital taxation

- Assume 2 periods
- Both labor and capital tax for period 2 announced in period 1 .
- Optimal tax calculation respects Ramsey rule: compare elasticities of capital and leisure demands
- When period 2 comes **capital stock already installed**. From that moment, capital is **perfectly inelastic** – will not react to any changes in taxation.

⇒ A benevolent (!) social planner uses **capital tax only**, since **capital taxation is then not distortionary**.

- No tax on labor, since it is still distortionary
- Rational agents then do not believe announcements of relatively high labor ~~tax~~ income tax, relatively low capital tax, decrease investment.