# Government Taxes

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# Introduction

- Fiscal authority may be incorporated into a simplified version of our model
- Many different ways that Government could be incorporated into the model
- This lecture focuses on the effects of different government decisions regarding taxation
- Types of taxes include lump-sum non-distortionary taxes that don't alter household and/or firm decisions
- Distortionary taxes, such as income taxes or consumption taxes, affect the market price of goods and production inputs, as well as economic decisions of agents
- We consider the role of consumption tax, labour income tax, and tax on capital income

# Introduction

- Key feature of the model is that these taxes introduce a distortion as they affect the relative price of production factors and final goods
- Assume that government decides on the tax policy and consumers and firms make their decisions accordingly
- To simplify the framework we also assume that public revenues are returned to the economy through exogenous lump-sum transfers
- Can use the model to compute Laffer curves that show the relationship between fiscal revenues and the tax-rate
- Can study the dynamic effects of a change in the tax rates (either permanent or temporary and anticipated or unanticipated)
- Finally, we will study the effects of an aggregate productivity shock in an economy with distortionary taxes

# Taxes

- Introducing taxes requires a modification to the household budget constraint and/or the profit function of firms
- Lump-sum taxes can be introduced in the following way:

$$C_t + S_t = Y_t - T_t$$

  where $C_t$ is consumption, $S_t$ is saving, $Y_t$ is income and $T_t$ is a fixed amount of tax
- Income taxes may require the use of the following households budget constraint

$$C_t + S_t = (1 - \tau^y)Y_t$$

  where $\tau^y$ is the income tax rate

# Taxes

- Similarly, consumption and saving taxes can be introduced through:

$$(1 + \tau^c)C_t + (1 + \tau^s)S_t = (1 - \tau^y)Y_t$$

  where $\tau^c$ is the consumption tax rate and $\tau^s$ is the saving tax rate
- In these cases direct taxes are income taxes (i.e. labour income tax, capital income tax or corporate tax)
- Consumption taxes are indirect taxes, and cause the price of goods to be higher (i.e. VAT, import taxes, etc.)

# Taxes

- Fiscal policy models rely on realistic measures of marginal tax rates
- Mendoza *et al.* (1994) propose a method to estimate effective average tax rates that a representative agent takes into account
- Bosca *et al.* (2009) has updated data for OECD countries
- Generally find that continental Europe has higher labour income tax than the tax on capital income
- Other OECD countries have higher capital income taxes than labour income tax

# Taxes

| Country | $\tau_c$ | $\tau_n$ | $\tau_k$ |
|---|---|---|---|
| Australia | 0.095 | 0.218 | 0.45 |
| Austria | 0.147 | 0.482 | 0.176 |
| Canada | 0.098 | 0.299 | 0.334 |
| Denmark | 0.199 | 0.397 | 0.448 |
| Finland | 0.176 | 0.451 | 0.256 |
| France | 0.129 | 0.43 | 0.298 |
| Germany | 0.12 | 0.374 | 0.177 |
| Italy | 0.107 | 0.431 | 0.283 |
| Japan | 0.062 | 0.257 | 0.356 |
| Netherlands | 0.146 | 0.359 | 0.192 |
| Spain | 0.116 | 0.348 | 0.252 |
| Sweden | 0.166 | 0.523 | 0.301 |
| UK | 0.124 | 0.255 | 0.325 |
| USA | 0.039 | 0.221 | 0.299 |

# Taxes

- In the subsequent model we consider the role of separate consumption, labour income and capital income tax
- Assume that fiscal revenues are returned to the economy just as a lump-sum transfer
- Household budget constraint takes the form:

$$(1+\tau_t^c)C_t + S_t = (1-\tau_t^n)W_t N_t + (1-\tau_t^k)R_t K_t + T_t$$

  where $\tau_t^c$ is the tax rate on consumption $\tau_t^n$ is the tax rate on labour income and $\tau_t^k$ is the tax rate on capital income
- Final consumption, consumption taxes and savings cannot exceed the sum of net labour income and net capital rental income plus transfers received from the government, $T_t$

# Taxes

- Note that transfers are a fixed amount so they do not influence decisions at the margin
- However tax rates will affect the consumption-saving and labour-leisure decisions
- To simplify our analysis we assume that government budget constraint is satisfied period-to-period

$$T_t = \tau_t^c C_t + \tau_t^n W_t N_t + \tau_t^k (R_t - \delta) K_t$$

- where the agents are able to obtain a tax break on depreciating capital

# Households

- Household utility function:

$$\max_{C_t, N_t} \quad U = \mathbb{E}_t \sum_{t=0}^{\infty} \beta^t \left[ \frac{C_t^{1-\sigma}}{1-\sigma} - \frac{N_t^{1+\gamma}}{1+\gamma} \right]$$

- where $C_t$ and $N_t$ refer to consumption and labour at time $t$
- $\sigma$ represents the inverse of the intertemporal elasticity of substitution in consumption
- $\gamma$ represents the inverse of the Frisch elasticity of labour supply

# Households

- Budget constraint faced by the representative household:

$$(1+\tau_t^c)C_t + S_t = (1-\tau_t^n)W_t N_t + (1-\tau_t^k)R_t K_t + T_t$$

- Suggests that total consumption & saving cannot exceed the sum of labour & capital rental income net of taxes & lump sum transfers
- Note that tax rates are constants and can be interpreted as average marginal tax rates

# Households

- Capital stock evolves according to:

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

where $\delta$ is the capital depreciation rate which is modelled as tax deductible and where $I_t$ is gross investment

- Assuming that $S_t = I_t$, the aggregate household constraint becomes:

$$(1+\tau_t^c)C_t + K_{t+1} - K_t = (1-\tau_t^n)W_t N_t + (1-\tau_t^k)(R_t - \delta_K)K_t + T_t$$

# Households

- Lagrangian problem to be solved by the household:

$$\mathcal{L}_{C_t,N_t,K_{t+1}} = \mathbb{E}_t \sum_{t=0}^{\infty} \beta^t \left\{ \left[ \frac{C_t^{1-\sigma}}{1-\sigma} - \frac{N_t^{1+\gamma}}{1+\gamma} \right] - \ldots \right.$$
$$\left. \lambda_j \left[ (1+\tau_t^c)C_t + K_{t+1} - K_t - (1-\tau_t^n)W_t N_t - (1-\tau_t^k)(R_t - \delta)K_t - T_t \right] \right\}$$

- First-order conditions for the household:

$$\begin{aligned}
\frac{\partial \mathcal{L}}{\partial C_t} &= C_t^{-\sigma} - \lambda_t(1+\tau_t^c) = 0 \\
\frac{\partial \mathcal{L}}{\partial N_t} &= -N_t^{\gamma} + \lambda_t(1-\tau_t^n)W_t = 0 \\
\frac{\partial \mathcal{L}}{\partial K_{t+1}} &= \beta \mathbb{E}_t \lambda_{t+1} \left[ \left( \mathbb{E}_t(1-\tau_{t+1}^k)R_{t+1} - \delta \right) + 1 \right] - \lambda_t = 0
\end{aligned}$$

# Households

- Combining the first two derivatives for the Labour supply expression:

$$(1-\tau_t^n)W_t \quad = \quad (1+\tau_t^c)C_t^{\sigma}N_t^{\gamma}$$

- While the first and third derivatives provides the Euler expression:

$$\therefore \frac{(1+\tau_{t+1}^c)C_{t+1}^{\sigma}}{(1+\tau_t^c)C_t^{\sigma}} = \beta\left[(1-\tau_{t+1}^k)(R_{t+1}-\delta)+1\right]$$

# Firms

- Production of final output $Y_t$ requires labour $N_t$ and $K_t$
- Technology is given by a constant return to scale Cobb-Douglas production function,

$$Y_t = A_t K_t^{\alpha} N_t^{1-\alpha}$$

# Firms

- Maximisation problem for the firms is:

$$\max_{K_t N_t} \Pi_t = A_t K_t^{\alpha} N_t^{1-\alpha} - R_t K_t - W_t N_t$$

- First-order conditions for the firms profit maximisation:

$$\begin{aligned}
\frac{\partial \Pi_t}{\partial K_t} &= R_t - \alpha A_t K_t^{\alpha-1} N_t^{1-\alpha} = 0 \\
\frac{\partial \Pi_t}{\partial N_t} &= W_t - (1-\alpha) A_t K_t^{\alpha} N_t^{-\alpha} = 0
\end{aligned}$$

# Firms

- The first-order conditions are used to provide expressions for the production inputs:

$$
\begin{aligned}
R_t &= \alpha A_t K_t^{\alpha-1} N_t^{1-\alpha} \\
W_t &= (1-\alpha) A_t K_t^{\alpha} N_t^{-\alpha}
\end{aligned}
$$

# Equilibrium

- For the goods market must clear

$$C_t + I_t = Y_t$$

# Government

- Government budget in each period is given by,

$$\tau_t^c C_t + \tau_t^n W_t L_t + \tau_t^k (R_t - \delta_K) K_t = T_t$$

- Government keeps a fiscal balance in each period by returning revenues from taxes to household via lump-sum transfers, $T_t$
- Note that the private sector will react optimally to policy changes, and these policy changes are given exogenously

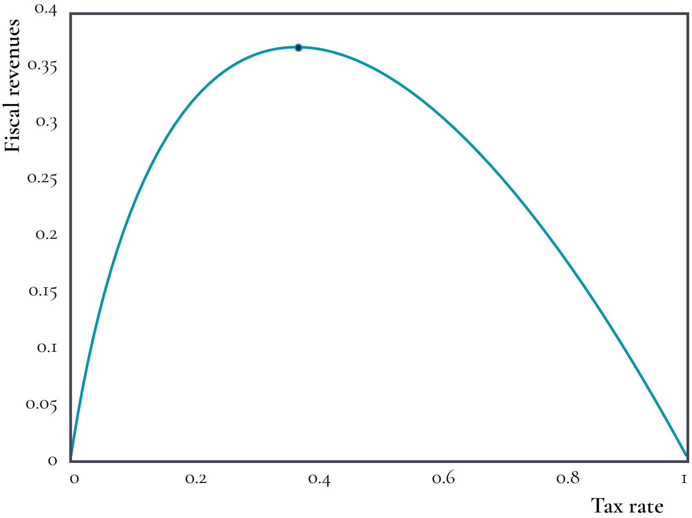
# Calibration

| Parameter | Calibrated Value | Description |
|---|---|---|
| $\sigma$ | 2 | Consumption preferences |
| $\gamma$ | 1.75 | Inverse Frisch parameter |
| $\alpha$ | 0.35 | Share of capital in production |
| $\beta$ | 0.97 | Discount factor |
| $\delta$ | 0.06 | Capital depreciation rate |
| $\rho_A$ | 0.95 | TFP autoregressive parameter |
| $\sigma_A$ | 0.01 | TFP standard deviation |
| $\tau^c$ | 0.116 | Consumption tax rate |
| $\tau^l$ | 0.348 | Labour income tax rate |
| $\tau^k$ | 0.225 | Capital income tax rate |

# Laffer curve

- Laffer (1981) relationship considers the level of taxes and the level of tax receipts (fiscal revenues)
- Should see that the curve intially increases before it starts to decrease when high taxes result in a decrease in production
- Position of the economy along the Laffer curve allows for the design of an optimal tax policy to maximise fiscal revenues
- When on the decreasing part of the Laffer curve a reduction in tax rates would improve economic activity and fiscal revenues
- When on the increasing part of the Laffer curve a reduction in tax rates would lead to improved economic activity, but at the expense of a decrease in tax revenues
- Slope of the Laffer curve represents the elasticity of fiscal revenues

# Laffer curve

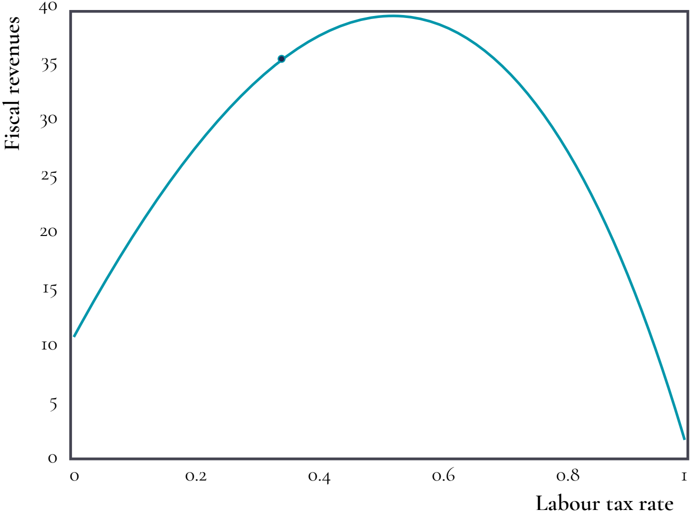


# Laffer curve

- Once we have calibrated the model, we are then able to compute the steady-state values for all the variables
- Including fiscal revenues for different tax rates
- Able to plot individual Laffer curves for consumption, labour income and capital income taxes
- Estimates represent the fiscal revenues at the steady state for each tax rate

# Laffer curve

Income tax

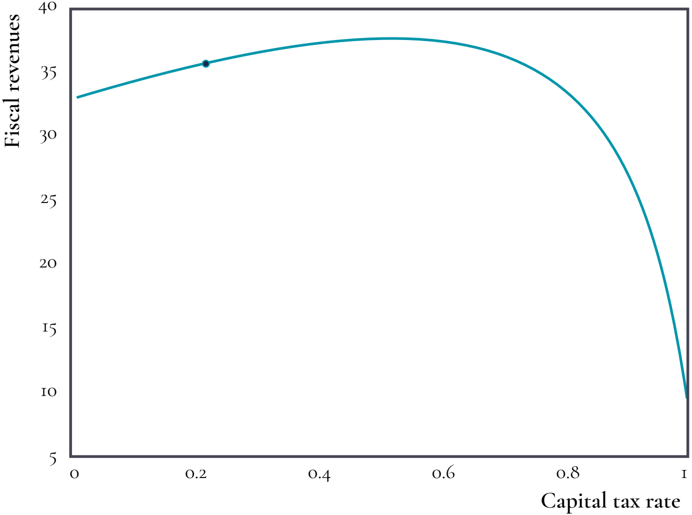


# Laffer curve

- Laffer for the labour income tax has a standard shape
- Dot indicates the calibrated level for the labour income tax rate that is used in the simulation, at 34.4%
- This falls in the increasing part of the curve, indicating that one can increase fiscal revenues by increasing this tax rate

# Laffer curve

Capital tax

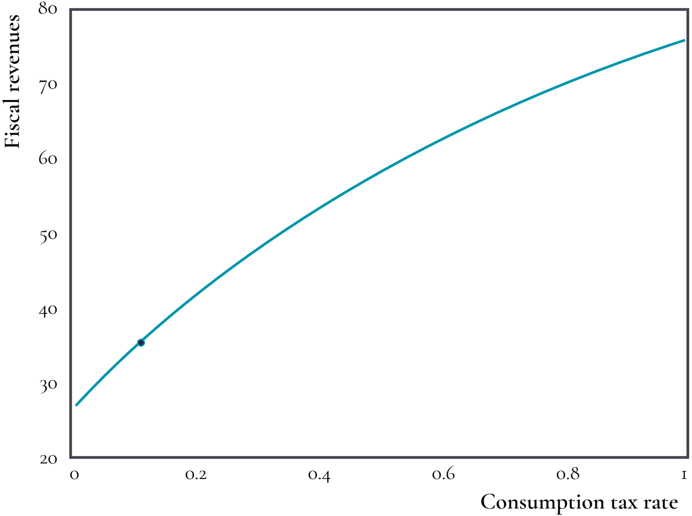


# Laffer curve

- Laffer curve for a tax on capital income is very flat curve at the increasing part, but very steep in the decreasing part
- Caused by the distortionary effects of this tax on the process of capital accumulation and economic activity
- As we increase the tax rate on capital income, fiscal revenues also increase, but they do so by a very small amount
- This is because capital income is only a small proportion of total income of the economy
- When it reaches the maximum of the curve, further increases in the tax rate cause fiscal revenues to decrease rapidly

# Laffer curve

## Consumption tax



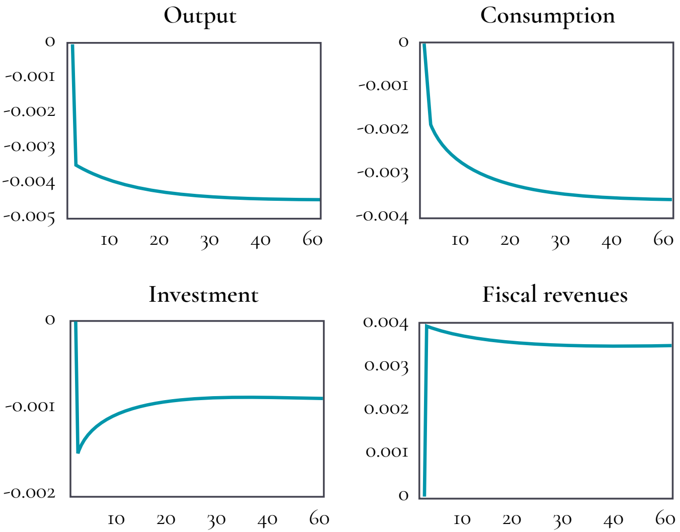
# Laffer curve

- Laffer curve for consumption taxes are slightly more difficult to work with
- This particular tax rate may exceed 1 given that this is an *ad-valorem* tax and not a percentage on income
- Laffer curve is always positive for this tax rate and no maximum exists
- This tax does not adversely affect economic activity through the supply of production factors
- Increasing the consumption tax rate decreases consumption by a smaller proportion than the change in the tax rate

# Tax changes

- Consider the case of a non-announced permanent increase in the consumption tax
- Initial consumption tax is 11.6% and changes to 13%
- Output reduces instantaneously, followed by a slow decline to the new steady state (0.4% lower than the initial steady state)
- Similar behaviour is observed for consumption
- Investment displays an overshooting effect, as investment is reduced on impact by an amount larger than the new steady state value
- Fiscal revenues increase almost instantaneously
- Distortionary effects of this tax rate arise through intertemporal effects that gives rise to substitution between consumption & leisure and a change in investment decisions

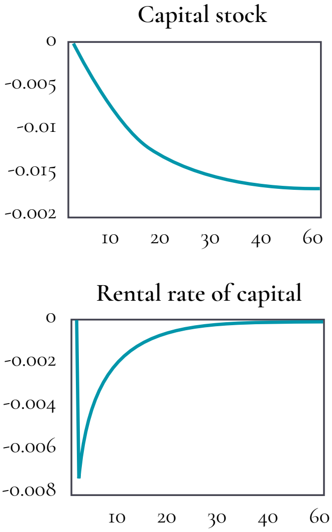
# Tax changes


Output
0
-0.001
-0.002
-0.003
-0.004
-0.005
10
20
30
40
60
Consumption
0
-0.001
-0.002
-0.003
-0.004
10
20
30
40
60
Investment
0
-0.001
-0.002
10
20
30
40
60
Fiscal revenues
0.004
0.003
0.002
0.001
0
10
20
30
40
60

# Tax changes

- Dynamic behaviour of capital stock, labour, rental rate on capital and wages is influenced by the intertemporal substitution effects between consumption & saving and by the substitution effect between leisure & labour
- Rise in the tax reduces the purchasing power of wages and labour supply
- Reduction in labour plus the reduction in capital stock causes a decline in output
- Steady state values for the relevant variables are reduced as a result of higher tax rates

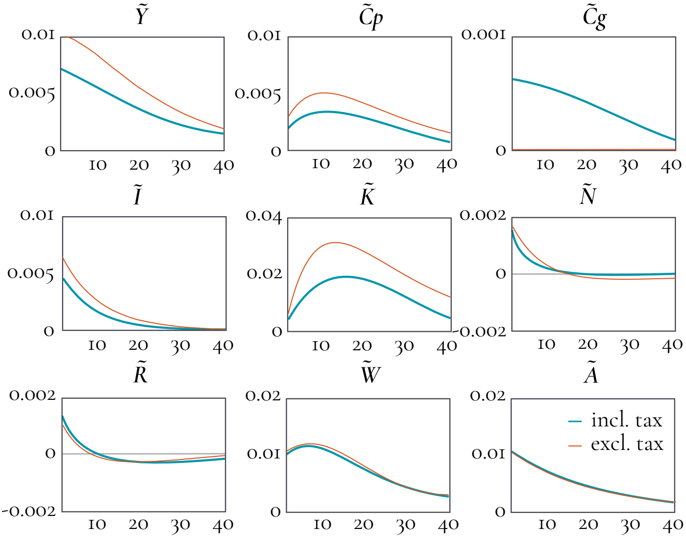
# Tax changes


Capital stock
0
-0.005
-0.01
-0.015
-0.002
10
20
30
40
60
Hours
0
-0.001
-0.002
-0.003
10
20
30
40
60
Rental rate of capital
0
-0.002
-0.004
-0.006
-0.008
10
20
30
40
60
Wage
0.006
0.004
0.002
0
-0.002
10
20
30
40
60

# Total Factor Productivity shock

- Comparing the IRFs generated by the model economy with ones that pertain to a model without taxes (i.e. setting the rates to 0%)
- Effect on output is much lower, in quantitative terms, in a model with taxes
- Productivity shock has a positive effect on investment, but smaller in model with taxes
- Capital stock's steady state value increases in small amounts when compared to model without taxes
- Rise in rental rate of capital and the wage are quantitatively the same as those obtained in the basic model without taxes
- However, net of tax income generated by production factors is different, since a fraction of the income goes to government
- Shock results in an increase in output and fiscal revenues

# Total Factor Productivity shock



# Conclusion

- Introduced a fiscal authority in a model with distortionary taxes
- Different taxes included: consumption, labour income and capital income tax
- Also assumed that the government budget constraint is fulfilled in each period and revenues are returned to households
- These taxes have distortionary effects on the decisions of individuals
    - Labour income & consumption taxes affect the labour supply directly
    - Capital income tax (and changes in consumption tax) affect investment decisions directly

# Conclusion

- After establishing such a model we can construct Laffer curves for each tax type
- Assists with the creation of an optimal tax system
- Can also consider the effects of temporary and permanent changes in the tax rate
- Distortionary effects of tax ensures that a positive productivity shock has less expansionary effects