Macroeconomic Effects of Capital Tax Rate Changes

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Motivation

- **Macro effects of capital tax cuts a recent subject of discussion**
    - Recent U.S. tax reform lowers the corporate tax rate from 35% to 21%
- **What are the long-run and the short-run effects on output, investment, consumption, and wages?**
    - Is such a large tax cut "self-financing"?
    - If not, does the source of financing matter for the long-run effects?
    - Does such a tax cut lead to gains for workers in terms of labor income?
- **Are short-run effects different from long-run ones?**
    - Does the monetary policy response matter for short-run effects?
    - Do adjustment frictions matter for short-run effects?
    - Does the source of financing matter for short-run effects?

Model

- **Analyze the effects of capital tax cuts analytically and numerically**
  - Long-run and short-run effects with different sources of financing
- **Standard quantitative business cycle model with balanced growth**
- **Adjustment frictions in investment and prices**
  - Realistic transition dynamics
  - A role for monetary aspects of the model
- **Other frictions in extensions**
  - Consumption habit formation
  - Variable capacity utilization

Preview of Results - Long-run Effects

- **Capital tax cuts have expansionary long-run effects**
  - For a permanent reduction of the capital tax rate from 35% to 21%, output increases by 10.8%, investment by 34.7%, consumption by 6.7%, and wages by 8.7% if lump-sum transfers adjust
- **How the tax cuts are financed matters**
  - The expansionary effects are smaller if the government has to rely on distortionary labor/consumption taxes
    - An increase in the labor tax rate by 6 % points to keep debt to GDP at the same level as the initial level
    - Output increases by 6.1%, investment by 29%, and consumption by 2.2%
    - After-tax wages decline by 0.3% and hours also go down in the long-run

Preview of Results - Transition dynamics

- **During the transition, the economy experiences a decline** in consumption, output, hours, and wages, regardless of the source of financing
- **How the tax cuts are financed matters** for the extent of this decline
  - The contraction is more severe if capital tax cuts are financed by raising labor/consumption tax rates
- **Monetary aspects of the model matter**
  - The contraction is more severe when prices are more rigid
  - The contraction is less severe when the central bank adjusts interest rates (i) more aggressively in stabilizing (fall of) inflation or (ii) more smoothly
  - When the central bank allows inflation to stabilize debt, the short-run increase in inflation helps reduce the extent of contraction

Related Literature

- **Capital tax changes**
  - Long-run effects: Trabandt and Uhlig (2011)
  - Tax reforms: Barro and Furman (2018)
  - DSGE : Forni, Monteforte, and Sessa (2009), Sims and Wolff (2017)
  - Empirical assessment: Romer and Romer (2010), Blanchard and Perrotti (2002), Mountford and Uhlig (2009), House and Shapiro (2008)
- **Normative analysis of the optimal capital tax rate**
  - Chamley (1986) and Judd (1985)
- **Debt stabilization through inflation adjustment**
  - Normative: Sims (2001)
  - Positive: Leeper (1991), Sims (1994), Woodford (1994)

Model

Household

- Representative household problem is to

$$\max_{\{C_t, H_t, B_t, I_t, K_{t+1}\}} \quad E_0 \left\{ \sum_{t=0}^{\infty} \beta^t U\left(C_t, H_t\right) \right\}$$

subject to

$$\left(1+\tau_t^C\right) P_t C_t + P_t I_t + B_t =$$
$$\left(1-\tau_t^H\right) W_t H_t + R_{t-1} B_{t-1} + \left(1-\tau_t^K\right) R_t^K K_t + P_t \Phi_t + P_t S_t,$$

$$K_{t+1} = \left(1-d\right) K_t + \left(1 - \mathcal{S}\left(\frac{I_t}{I_{t-1}}\right)\right) I_t$$

Firms

- Competitive final goods firms produce aggregate output Y_t

$$Y_t = \left(\int_0^1 Y_t\left(i\right)^{\frac{\theta-1}{\theta}} \, di \right)^{\frac{\theta}{\theta-1}}$$

  where θ is the elasticity of substitution between intermediate goods

- Continuum of monopolistically competitive intermediate goods firms

- Intermediate goods firms rent capital and hire labor in competitive markets

Firms

- Intermediate good firms problem is to

$$\max_{\{P_t(i),Y_t(i),H_t(i),K_t(i)\}} E_0 \left\{ \sum_{t=0}^{\infty} \beta^t \frac{\Lambda_t}{\Lambda_0} P_t \Phi_t(i) \right\}$$

subject to

$$Y_t(i) = \left(\frac{P_t(i)}{P_t} \right)^{-\theta} Y_t,$$

$$Y_t(i) = F(K_t(i), A_t H_t(i))$$

- Flow profit $\Phi_t(i)$ is given by

$$\Phi_t(i) = \frac{P_t(i)}{P_t} Y_t(i) - \frac{W_t}{P_t} H_t(i) - \frac{R_t^K}{P_t} K_t(i) - \Xi \left(\frac{P_t(i)}{P_{t-1}(i)} \right) Y_t$$

Monetary Policy

- Monetary policy given by an interest rate feedback rule

$$\frac{R_t}{\bar{R}} = \left[\frac{R_{t-1}}{\bar{R}}\right]^{\rho^R} \left[\left(\frac{\pi_t}{\bar{\pi}}\right)^{\phi}\right]^{\left(1-\rho^R\right)}$$

- When $\phi > 1$, the Taylor principle is satisfied

- When $\phi < 1$, inflation response will play a direct role in government debt stabilization along the transition

Government Budget Constraint

- The government flow budget constraint given by

$$\frac{B_t}{P_t\,Y_t} + \left(\tau_t^C\,\frac{C_t}{Y_t} + \tau_t^H\,\frac{W_t}{P_t\,Y_t}\,H_t + \tau_t^K\,\frac{R_t^K\,K_t}{P_t\,Y_t}\right) = \\ R_{t-1}\,\frac{B_{t-1}}{P_{t-1}\,Y_{t-1}}\,\frac{1}{\pi_t}\,\frac{Y_{t-1}}{Y_t} + \frac{G_t}{Y_t} + \frac{S_t}{Y_t}$$

where G_t is government spending on the final good

Fiscal Policy - Long-run Effects

- A permanent change in the capital tax rate τ_t^K
  - **In the long-run, $\frac{G_t}{Y_t}$ and $\frac{B_t}{P_t Y_t}$ the same as the initial steady-state**
- The government budget constraint in the long-run

$$\left(1 - \frac{\bar{R}}{\bar{\pi}\bar{a}}\right)\overline{\frac{B}{PY}} + \left(\bar{\tau}^C \overline{\frac{C}{Y}} + \bar{\tau}^H \overline{\frac{W}{PY}}\,\overline{H} + \bar{\tau}^K \overline{\frac{R^K}{P}}\,\overline{\frac{K}{Y}}\right) = \overline{\frac{G}{Y}} + \overline{\frac{S}{Y}}$$

- **Three fiscal policy adjustment rules**

  (1) Lump-sum transfers $\overline{\frac{S}{T}}$ adjustment

  (2) Labor tax rates $\bar{\tau}^H$ adjustment

  (3) Consumption tax rates $\bar{\tau}^C$ adjustment

Fiscal Policy - Transition Dynamics

- For transition dynamics, **the behavior of the monetary authority matters**

- **Four fiscal policy adjustment rules**

  (1) **Lump-sum transfers** $\frac{S_t}{Y_t}$ adjust to maintain $\frac{B_t}{P_t Y_t}$ constant

  – The monetary policy rule satisfies the Taylor principle, $\phi > 1$

  (2) **Labor tax rates** τ_t^H adjust following the simple feedback rule

$$\tau_t^H - \bar{\tau}_{new}^H = \rho^H \left(\tau_{t-1}^H - \bar{\tau}_{new}^H\right) + \left(1 - \rho^H\right) \psi^H \left(\frac{B_{t-1}}{P_{t-1} Y_{t-1}} - \overline{\frac{B}{PY}}\right)$$

  where $\psi^H \geq 1 - \beta$ is the feedback parameter on outstanding debt.

  – The monetary policy rule satisfies the Taylor principle, $\phi > 1$

Fiscal Policy - Transition Dynamics

- **Four fiscal policy adjustment rules**

(3) **Labor tax rates** τ_t^H adjust, but **not sufficiently enough**, as $0 < \psi^H < 1 - \beta$

- The monetary policy rule does **NOT** satisfy the Taylor principle, $\phi < 1$
- Inflation plays a direct role in government debt stabilization

(4) **Consumption tax rates** τ_t^C adjust following the simple feedback rule

$$\tau_t^C - \bar{\tau}_{new}^C = \rho^C \left(\tau_{t-1}^C - \bar{\tau}_{new}^C\right) + \left(1 - \rho^C\right) \psi^C \left(\frac{B_{t-1}}{P_{t-1} Y_{t-1}} - \overline{\frac{B}{PY}}\right)$$

where $\psi^C \geq 1 - \beta$ is the feedback parameter on outstanding debt

- The monetary policy rule satisfies the Taylor principle, $\phi > 1$

Definitions and Functional Forms

- The economy features a balanced growth path
  - Real variables are denoted in small case letters (e.g. $w_t = \frac{W_t}{P_t}$)
  - We normalize variables growing along the balanced growth path by the level of technology (e.g. $\tilde{Y}_t = \frac{Y_t}{A_t}$ and $\tilde{w}_t = \frac{w_t}{A_t}$)
  - Fiscal variables are normalized by output (e.g. $\tilde{b}_t = \frac{B_t}{P_t Y_t}$)
- General functional forms for preferences and technology

$$U(C_t, H_t) \equiv \frac{C_t^{1-\eta}\left(1 - \bar{\omega}\frac{1-\eta}{1+\varphi}(H_t)^{1+\varphi}\right)^{\eta} - 1}{1-\eta},$$

$$F\left(K_t(i), A_t H_t(i)\right) \equiv \left(\lambda K_t(i)^{\frac{\varepsilon-1}{\varepsilon}} + (1-\lambda)\left(A_t H_t(i)\right)^{\frac{\varepsilon-1}{\varepsilon}}\right)^{\frac{\varepsilon}{\varepsilon-1}}$$

- Investment and price adjustment costs

$$\mathcal{S}\left(\frac{I_t}{I_{t-1}}\right) \equiv \frac{\xi}{2}\left(\frac{I_t}{I_{t-1}} - \bar{a}\right)^2, \quad \Xi\left(\frac{P_t}{P_{t-1}}\right) \equiv \frac{\kappa}{2}\left(\frac{P_t}{P_{t-1}} - \bar{\pi}\right)^2$$

Calibration

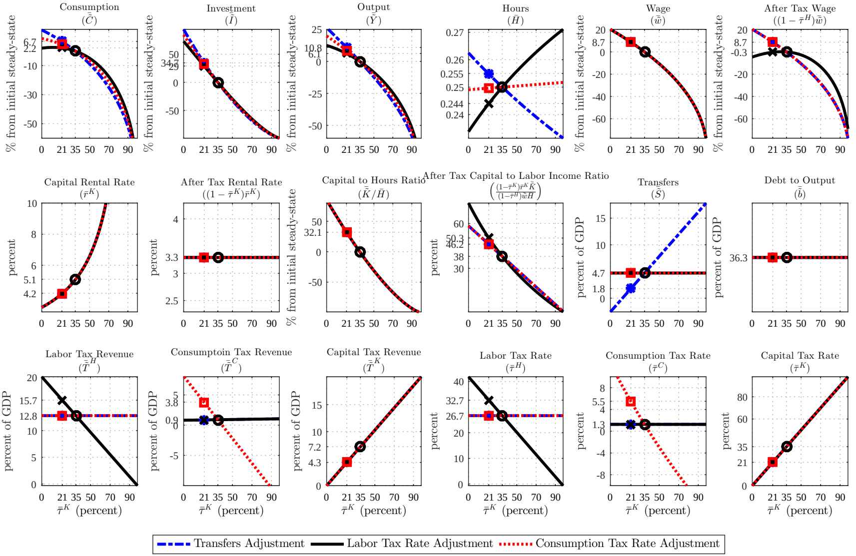
	Value	Description	References
Households			
β	0.9975	Time preference	Smets and Wouters (2007)
η	1.0	Inverse of EIS	Smets and Wouters (2007)
φ	1.0	Inverse of Frisch elasticity of labor supply	Trabandt and Uhlig (2011)
$\bar{\omega}$	7.77	Labor supply disutility parameter (Steady-state hours: $\bar{H} = 0.25$)	Trabandt and Uhlig (2011)
d	0.025	Capital depreciation	Smets and Wouters (2007)
ξ	4.0	Investment adjustment cost	Smets and Wouters (2007)
Firms			
ε	1.0	Cobb-Douglas production function	Smets and Wouters (2007)
λ	0.30	Capital income share	Smets and Wouters (2007)
κ	50	Quadratic price adjustment cost	Ireland (2000)
θ	3.1818	Elasticity of substitution between goods	Steady-state Markup: 46%
$\bar{\pi}$	1.0	Steady-state inflation rate	
$\bar{a}$	1.0054	Steady-state growth rate	Bhattarai, Lee, and Park (2016)

Calibration

	Value	Description	References
Government(Fiscal/Monetary Policy)			
$\bar{\tilde{b}}$	0.363	SS debt to GDP ratio	US Post-Volcker Data
$\bar{\tilde{G}}$	0.161	SS government spending to GDP ratio	US Post-Volcker Data
$\bar{\tilde{T}}^C$	0.009	SS consumption tax revenue to GDP ratio	US Post-Volcker Data
$\bar{\tilde{T}}^H$	0.128	SS labor tax revenue to GDP ratio	US Post-Volcker Data
$\bar{\tilde{T}}^K$	0.072	SS capital tax revenue to GDP ratio	US Post-Volcker Data
ϕ	1.5 0.5	Taylor rule Taylor rule with inflation adjustment	Bhattarai, Lee, and Park (2016)
ψ^C	0.0 0.05	No tax rate response to debt Consumption tax rate response to debt	
ψ^H	0.0 0.05 0.002	No tax rate response to debt Labor tax rate response to debt with inflation adjustment	

Long-run Effects

Long-run Effects of Capital Tax Rate Cuts



Lump-sum Transfer Adjustment

Proposition 1

Let $\bar{\tau}^K_{new} = \bar{\tau}^K + \Delta\left(\bar{\tau}^K\right)$ *where* $\Delta\left(\bar{\tau}^K\right)$ *is small. With* **lump-sum transfer adjustment** *and* $\varepsilon = 1$*,*

$$\ln\left(\frac{\bar{\tau}^K_{new}}{\bar{\tau}^K}\right) = \frac{\Delta\left(\bar{\tau}^K\right)}{1-\bar{\tau}^K},\ \ln\left(\frac{\bar{\tilde{w}}_{new}}{\bar{\tilde{w}}}\right) = -\frac{\lambda}{1-\lambda}\frac{\Delta\left(\bar{\tau}^K\right)}{1-\bar{\tau}^K},\ \ln\left(\frac{\bar{\tilde{K}}_{new}}{\bar{H}_{new}}\Big/\frac{\bar{\tilde{K}}}{\bar{H}}\right) = -\frac{1}{1-\lambda}\frac{\Delta\left(\bar{\tau}^K\right)}{1-\bar{\tau}^K},$$

$$\ln\left(\frac{\bar{H}_{new}}{\bar{H}}\right) = -\Omega\frac{\Delta\left(\bar{\tau}^K\right)}{1+\varphi},\ \ln\left(\frac{\bar{\tilde{K}}_{new}}{\bar{\tilde{K}}}\right) = \ln\left(\frac{\bar{\tilde{I}}_{new}}{\bar{\tilde{I}}}\right) = -\mathcal{M}_K\Delta\left(\bar{\tau}^K\right),\ \ln\left(\frac{\bar{\tilde{Y}}_{new}}{\bar{\tilde{Y}}}\right) = -\mathcal{M}_Y\Delta\left(\bar{\tau}^K\right)$$

$$\ln\left(\frac{\bar{\tilde{C}}_{new}}{\bar{\tilde{C}}}\right) = -\mathcal{M}_C\Delta\left(\bar{\tau}^K\right),$$

where $\Omega > 0$*, and* $\mathcal{M}_K, \mathcal{M}_Y > 0$*. Also,* $\mathcal{M}_C > 0$ *with a mild restriction that* $\bar{\tilde{G}}$ *is not very high.*

Lump-sum Transfer Adjustment

- The effects on factor prices and capital to labor ratio depend only on the production side parameters
- How hours respond is important for the level of aggregate quantities (output, consumption and investment)
  - Preference parameters (EIS and Frisch) matter qualitatively
- Effectiveness of the tax reform depends on current tax rates
  - When $\bar{\tau}^K$,$\bar{\tau}^H$, and $\bar{\tau}^C$ are currently high, a given capital tax cut will have a stronger long-run effect

Labor Tax Rate Adjustment

Proposition 2

Let $\bar{\tau}^K_{new} = \bar{\tau}^K + \Delta\left(\bar{\tau}^K\right)$, $\varepsilon = 1$, *and* $\eta = 1$. *With* **labor tax rate adjustment,**

1. New steady-state labor tax rate is given by $\bar{\tau}^H_{new} = \bar{\tau}^H + \Delta\left(\bar{\tau}^H\right)$ *where*

$$\Delta\left(\bar{\tau}^H\right) = -\frac{\lambda}{1-\lambda}\left(1 + \bar{\tau}^C\left(\frac{\bar{a}-(1-d)}{\frac{\bar{a}}{\beta}-(1-d)}\right)\right)\Delta\left(\bar{\tau}^K\right).$$

2. For small $\Delta\left(\bar{\tau}^K\right)$,

$$\ln\left(\frac{\bar{\tau}^K_{new}}{\bar{\tau}^K}\right) = \frac{\Delta\left(\bar{\tau}^K\right)}{1-\bar{\tau}^K}, \quad \ln\left(\frac{\bar{\tilde{K}}_{new}/\bar{H}_{new}}{\bar{\tilde{K}}/\bar{H}}\right) = -\frac{1}{1-\lambda}\frac{\Delta\left(\bar{\tau}^K\right)}{1-\bar{\tau}^K}, \quad \ln\left(\frac{\bar{\tilde{w}}_{new}}{\bar{\tilde{w}}}\right) = -\frac{\lambda}{1-\lambda}\frac{\Delta\left(\bar{\tau}^K\right)}{1-\bar{\tau}^K},$$

$$\ln\left(\frac{\bar{H}_{new}}{\bar{H}}\right) = \mathcal{M}_H \Delta\bar{\tau}^K, \quad \ln\left(\frac{\left(1-\bar{\tau}^H_{new}\right)\bar{\tilde{w}}_{new}}{\left(1-\bar{\tau}^H\right)\bar{\tilde{w}}}\right) = \mathcal{M}_W \Delta\left(\bar{\tau}^K\right)$$

where $\mathcal{M}_H > 0$ *with a mild restriction that* $\bar{\tilde{G}}$ *is not very high. Moreover,* $\mathcal{M}_W > 0$ *if and only if* $1 + \bar{\tau}^C \frac{(\bar{a}-(1-d))}{\frac{\bar{a}}{\beta}-(1-d)} > \frac{1-\bar{\tau}^H}{1-\bar{\tau}^K}$.

Labor Tax Rate Adjustment

- The required adjustment in the labor tax rate is basically given by the ratio of the capital to labor input in the production function
    - Since debt-to-GDP is constant, has to compensate the loss of capital tax revenue-to-GDP with gains in labor tax revenue-to-GDP
- Hours *fall* if government spending in the initial steady state is not too high
- The effects on after-tax wage rate depends on initial level of labor tax rate relative to the other tax rates
    - A further increase in labor tax rate (to finance a capital tax cut), when it is sufficiently high already, lowers after-tax wage rate

Consumption Tax Rate Adjustment

Proposition 3

Let $\bar{\tau}^K_{new} = \bar{\tau}^K + \Delta\left(\bar{\tau}^K\right)$, $\varepsilon = 1$, *and* $\eta = 1$. *With* **consumption tax rate adjustment**,

1. *New steady-state consumption tax rate is given by* $\bar{\tau}^C_{new} = \bar{\tau}^C + \Delta\left(\bar{\tau}^C\right)$ *where*

$$\Delta\left(\bar{\tau}^C\right) = -\left(1 + \frac{\bar{a} - (1-d)}{\frac{\bar{a}}{\beta} - (1-d)}\bar{\tau}^C\right)\frac{\Theta_C \Delta\left(\bar{\tau}^K\right)}{1 + \left(\frac{\bar{a}-(1-d)}{\frac{\bar{a}}{\beta}-(1-d)}\right)\Theta_C \Delta\left(\bar{\tau}^K\right)}.$$

with $\Theta_C > 0$.

2. *For small* $\Delta\left(\bar{\tau}^K\right)$,

$$\ln\left(\frac{\bar{\tau}^K_{new}}{\bar{\tau}^K}\right) = \frac{\Delta\left(\bar{\tau}^K\right)}{1-\bar{\tau}^K}, \; \ln\left(\frac{\bar{\bar{K}}_{new}/\bar{H}_{new}}{\bar{\bar{K}}/\bar{H}}\right) = -\frac{1}{1-\lambda}\frac{\Delta\left(\bar{\tau}^K\right)}{1-\bar{\tau}^K},$$

$$\ln\left(\frac{\bar{\bar{w}}_{new}}{\bar{\bar{w}}}\right) = -\frac{\lambda}{1-\lambda}\frac{\Delta\left(\bar{\tau}^K\right)}{1-\bar{\tau}^K}, \; \ln\left(\frac{\bar{H}_{new}}{\bar{H}}\right) = \mathcal{M}_H^{\tau^C}\Delta\bar{\tau}^K$$

where $\mathcal{M}_H^{\tau^C} > 0$.

Consumption Tax Rate Adjustment

- Basic intuition is the same as the labor tax rate adjustment case
  - The consumption tax base $\left(\frac{\bar{\tilde{C}}}{\bar{\tilde{Y}}}\right)$ decreases; the labor tax base $\left(\bar{\tilde{w}}\frac{\bar{H}}{\bar{\tilde{Y}}} = \frac{(1-\lambda)(\theta-1)}{\theta}\right)$ is the same
  - Required tax revenue changes in both adjustment cases are the same

$$\overbrace{\bar{\tau}^C_{new}\left(\frac{\bar{\tilde{C}}}{\bar{\tilde{Y}}}\right)_{new} - \bar{\tau}^C\left(\frac{\bar{\tilde{C}}}{\bar{\tilde{Y}}}\right)}^{\text{tax revenue changes with } \textbf{consumption} \text{ tax adjustment}} = \overbrace{\Delta\left(\bar{\tau}^H\right)(1-\lambda)\left(\frac{\theta-1}{\theta}\right) + \bar{\tau}^C\Delta\left(\frac{\bar{\tilde{C}}}{\bar{\tilde{Y}}}\right)}^{\text{tax revenue changes with } \textbf{labor} \text{ tax adjustment}}$$

$$\Delta\left(\bar{\tau}^C\right) = \frac{(1-\lambda)\left(\frac{\theta-1}{\theta}\right)}{\left(\frac{\bar{\tilde{C}}}{\bar{\tilde{Y}}}\right)_{new}}\Delta\left(\bar{\tau}^H\right)$$

  - Intratemporal optimal condition for labor supply is $\frac{\left(1-\bar{\tau}^H\right)(1-\lambda)\left(\frac{\theta-1}{\theta}\right)}{\left(1+\tau^C\right)\left(\frac{\bar{\tilde{C}}}{\bar{\tilde{Y}}}\right)} = \bar{\omega}\bar{H}^{1+\varphi}$

- Hours fall regardless of the level of government spending

$$\frac{\partial}{\partial\bar{\tau}^K}\left\{\left(1+\bar{\tau}^C\right)\left(\frac{\bar{\tilde{C}}}{\bar{\tilde{Y}}}\right)\right\} = -\lambda\left(\frac{\theta-1}{\theta}\right)\left(\frac{\bar{a}}{\frac{\bar{a}}{\beta}-(1-d)}\left(\frac{1-\beta}{\beta}\right)\right) < 0$$

Transfer v.s. Labor Tax Rate Adjustment

Proposition 4

Let $\bar{\tau}^K_{new} = \bar{\tau}^K + \Delta\left(\bar{\tau}^K\right)$, $\bar{\tau}^H_{new} = \bar{\tau}^H + \Delta\left(\bar{\tau}^H\right)$, $\varepsilon = 1$, *and* $\eta = 1$. *Denote by* $\bar{X}^T_{new}$ *and* $\bar{X}^L_{new}$ *the new steady-state variables in transfer adjustment case and in labor tax rate adjustment case, respectively. For small changes in the capital tax rate* $\Delta\left(\bar{\tau}^K\right)$, *for* $X \in \left\{\tilde{C}, \tilde{K}, \tilde{I}, \tilde{Y}, H\right\}$, *we get*

$$\ln\left(\frac{\bar{X}^T_{new}}{\bar{X}^L_{new}}\right) = -\mathcal{M}^T_L \Delta\left(\bar{\tau}^K\right) = \frac{1}{1+\varphi}\left(\frac{1}{1-\bar{\tau}^H}\right)\Delta\left(\bar{\tau}^H\right)$$

where $\mathcal{M}^T_L > 0$.

- $\bar{\tilde{C}}, \bar{\tilde{K}}, \bar{\tilde{I}}, \bar{\tilde{Y}}$, and $\bar{H}$ increase by more under lump-sum transfer adjustment
- The constant difference depends on the labor supply parameter and initial level of labor tax rate for a given change in the labor tax rate
  - If labor supply is completely inelastic, $\varphi = \infty$, there is no difference
  - Higher is the initial level of the labor tax rate, bigger is the difference

Transfer v.s. Consumption Tax Rate Adjustment

Proposition 5

Let $\bar{\tau}^K_{new} = \bar{\tau}^K + \Delta\left(\bar{\tau}^K\right)$, $\bar{\tau}^C_{new} = \bar{\tau}^C + \Delta\left(\bar{\tau}^C\right)$, $\varepsilon = 1$, and $\eta = 1$. Denote by $\bar{X}^T_{new}$ and $\bar{X}^C_{new}$ the new steady-state variables in transfer adjustment case and in consumption tax rate adjustment case, respectively. For small changes in the capital tax rate $\Delta\left(\bar{\tau}^K\right)$, for $X \in \left\{\tilde{C}, \tilde{K}, \tilde{I}, \tilde{Y}, H\right\}$, we get

$$\ln\left(\frac{\bar{X}^T_{new}}{\bar{X}^C_{new}}\right) = -\mathcal{M}^T_C \Delta\left(\bar{\tau}^K\right) = \frac{1}{1+\varphi}\left(\frac{1}{1+\bar{\tau}^C}\right)\Delta\left(\bar{\tau}^C\right)$$

where $\mathcal{M}^T_C > 0$.

- $\bar{\tilde{C}}, \bar{\tilde{K}}, \bar{\tilde{I}}, \bar{\tilde{Y}}$, and $\bar{H}$ increase by more under lump-sum transfer adjustment
- The constant difference depends on the labor supply parameter and initial level of consumption tax rate for a given change in the consumption tax rate
  - If labor supply is completely inelastic, $\varphi = \infty$, there is no difference
  - Higher is the initial level of the consumption tax rate, smaller is the difference

Labor v.s. Consumption Tax Rate Adjustment

Proposition 6

Let $\bar{\tau}^K_{new} = \bar{\tau}^K + \Delta\left(\bar{\tau}^K\right)$, $\bar{\tau}^H_{new} = \bar{\tau}^H + \Delta\left(\bar{\tau}^H\right)$, $\bar{\tau}^C_{new} = \bar{\tau}^C + \Delta\left(\bar{\tau}^C\right)$, $\varepsilon = 1$, *and* $\eta = 1$. *Denote by* $\bar{X}^C_{new}$ *and* $\bar{X}^L_{new}$ *the new steady-state variables in consumption tax adjustment case and in labor tax adjustment case, respectively. For small changes in the capital tax rate* $\Delta\left(\bar{\tau}^K\right)$, *for* $X \in \left\{\tilde{C}, \tilde{K}, \tilde{I}, \tilde{Y}, H\right\}$, *we get*

$$\ln\left(\frac{\bar{X}^C_{new}}{\bar{X}^L_{new}}\right) = -\mathcal{M}^C_L \Delta\left(\bar{\tau}^K\right) = \frac{1}{1+\varphi}\left(\frac{\Delta\left(\bar{\tau}^H\right)}{1-\bar{\tau}^H} - \frac{\Delta\left(\bar{\tau}^C\right)}{1+\bar{\tau}^C}\right)$$

where $\mathcal{M}^C_L > 0$ *with a mild restriction that* $\bar{\tilde{G}}$ *is not very high.*

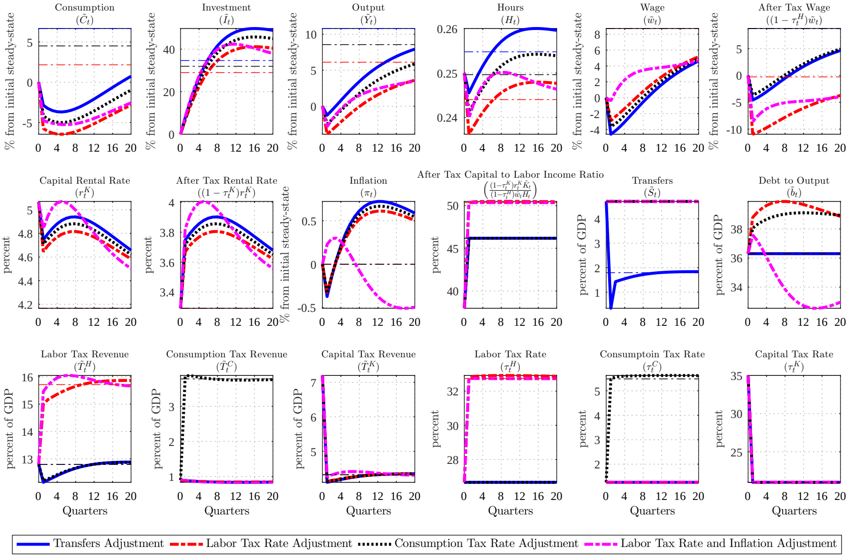
- $\bar{\tilde{C}}, \bar{\tilde{K}}, \bar{\tilde{I}}, \bar{\tilde{Y}}$, and $\bar{H}$ increase by more under consumption tax adjustment compared to labor tax adjustment
- The restriction on $\bar{\tilde{G}}$ implies that $\left(1+\bar{\tau}^C\right)\left(\frac{\bar{\tilde{C}}}{\bar{\tilde{Y}}}\right)_{new} > \left(1-\bar{\tau}^H\right)(1-\lambda)\frac{\theta-1}{\theta}$

Transition Dynamics

Transition Dynamics

- Transition dynamics following a permanent capital tax cut, from 35% to 21%
    - It takes a long time (70 quarters) for convergence to a new steady-state
- Four different fiscal/monetary policy adjustments
    - Transfers adjustment
    - Labor tax rate adjustment
    - Consumption tax rate adjustment
    - Labor tax rate and inflation adjustment
- No smoothing for now in fiscal and monetary policy rules

Numerical Comparison



Implications on Macro Variables

- A reduction in the capital tax rate leads to a decrease in the rental rate of capital
- It facilitates capital accumulation via more investment
- In the short-run, to finance this increase of investment, consumption declines
- Output also falls due to sticky prices, which renders output (partially) demand-determined and markups countercyclical
- The temporary fall in output leads to fall in hours
- Inflation depends on current and future real marginal costs
  - As wage dynamics matter more and wages drop in the short-run, the path of inflation roughly follows that of wages

Implications on Labor Income

- (After-tax) labor income decreases in the short-run because both hours and wages decrease
  - The long-run positive effects of capital tax cuts come at the expense of short-run decline of labor income
- The decrease in wages is driven by both supply and demand forces
  - The drop in consumption and the rise in marginal utility raise the supply of hours for a given wage rate
  - Labor demand declines as firms produce a smaller amount of output
  - Transfer adjustment leads to the biggest drop in wage because of the largest labor supply effects
- Transfers fall sharply and decrease below the new steady-state
  - Labor tax revenues fall, not just the capital tax revenue, forcing the government to decrease transfers

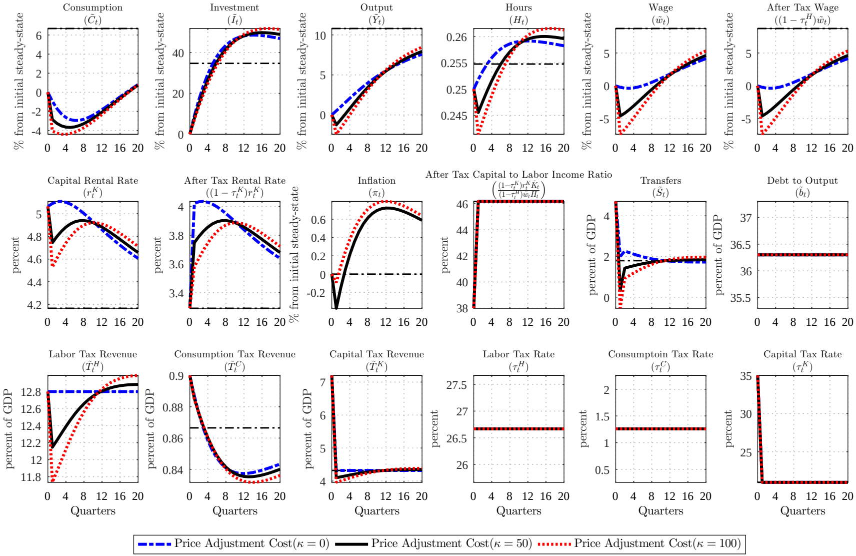
Implications of Fiscal Rules

- The drop in consumption and output is larger if labor or consumption tax adjusts
  - Increased labor/consumption tax rate decreases hours even further by discouraging workers from supplying labor
  - Hours in equilibrium fall much more, below the lower new steady-state
  - This amplifies the short-run contraction in consumption and output
- The short-run effects in consumption tax rate adjustment case are in between the transfer adjustment and labor tax rate adjustment
- In labor tax rate and inflation adjustment case, there is a short-run burst of inflation to help stabilize debt
  - This increase in inflation helps lower the short-run contractionary effects

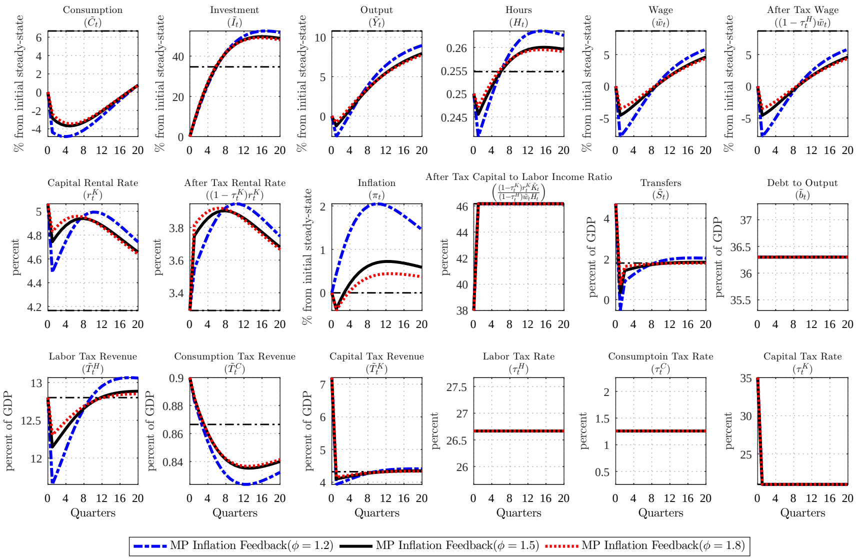
Role of Monetary Components

- Monetary aspects of the model matter for transition dynamics
  - Degree of price stickiness
  - Inflation feedback parameter (ϕ) and interest rate smoothing parameter $\left(\rho^R\right)$ in monetary policy rule
- Tax rate rule parameters matter for transition dynamics
  - Debt feedback parameters $\left(\psi^H, \psi^C\right)$ and tax rate smoothing parameters $\left(\rho^H, \rho^C\right)$ in labor and consumption tax rate rules
  - But, qualitatively results are quite robust

Degree of Price Stickiness - Transfer Adjustment



Inflation Feedback - Transfer Adjustment



Extensions

Extensions

- CES production function
- Levels of fiscal variables (“Laffer Curves”)
- Transition dynamics to an anticipated shock
- Transition dynamics to 10-year cut in capital tax rate
- Sensitivity analysis
  - Interest rate smoothing
  - Effects of different fiscal rules (feedback parameters and smoothing)
  - Comparative statics on Frisch elasticity of labor supply and EIS
  - Effects of introducing habit formation and variable capacity utilization
  - A high level of government spending in the initial steady-state experiment (consumption tax rate increase more distortionary)

▸ CES Production Function ▸ Level of Fiscal Variables ▸ Anticipated Shocks ▸ 10-Year Capital Tax Cut
▸ Interest Rate Smoothing ▸ Fiscal Rules ▸ Frsich Elasticity ▸ EIS ▸ Consumption Habit Formation
▸ Variable Capital Utilization ▸ High Level of G

Conclusion

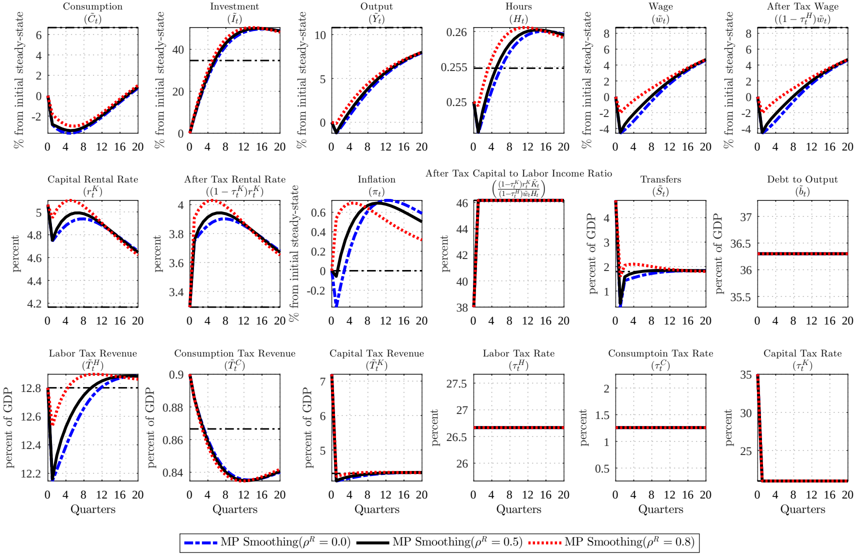
- A permanent reduction in the capital tax rate from 35% to 21% generates *a long-run increase* in output, consumption, and investment
    - When labor/consumption tax adjusts, the increases are lower
    - After-tax wages and labor income permanently decrease while income inequality is more pronounced when labor tax adjusts
- In the short-run, the economy experiences *a decline* in consumption, output, hours, wages, and labor income
    - The source of financing matters for the extent of the short-run contraction
        - It is more severe when labor/consumption tax rates adjust
    - Monetary aspects of the model matter
        - The short-run contraction is more severe when prices are more rigid
        - A less aggressive response to inflation leads to a more severe contraction and interest rate smoothing leads to a less severe contraction
        - When the central bank allows inflation to facilitate debt stabilization, the short-run increase in inflation helps reduce the extent of contraction

Conclusion

- Introducing some form of heterogeneity is a potentially important extension
  - New positive and normative insights might emerge by introducing capitalists and workers separately
  - Analysis of the short-run and the long-run suggests that the tax reform will have heterogeneous effects across generations
  - A two-sector model with durable and non-durable consumption sectors

Interest Rate Smoothing - Transfer Adjustment

Back



Lump-sum Transfer Adjustment - CES

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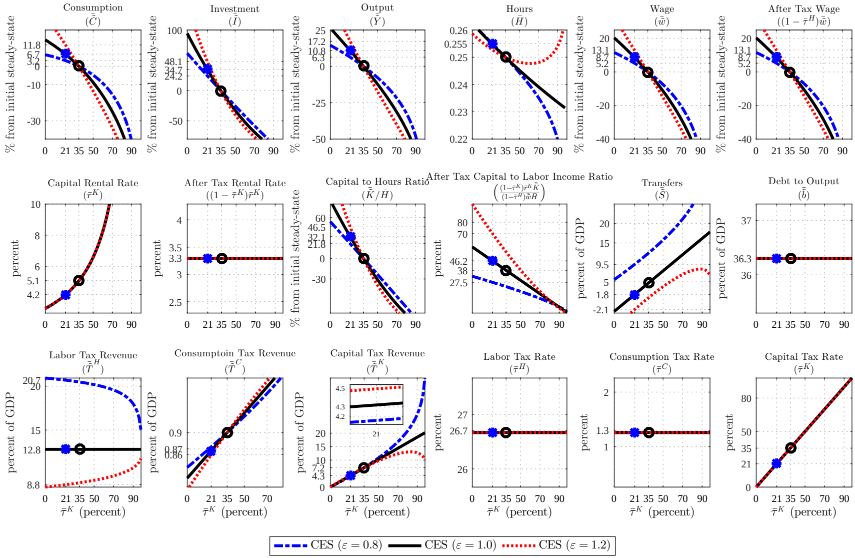

Levels of Fiscal Variables

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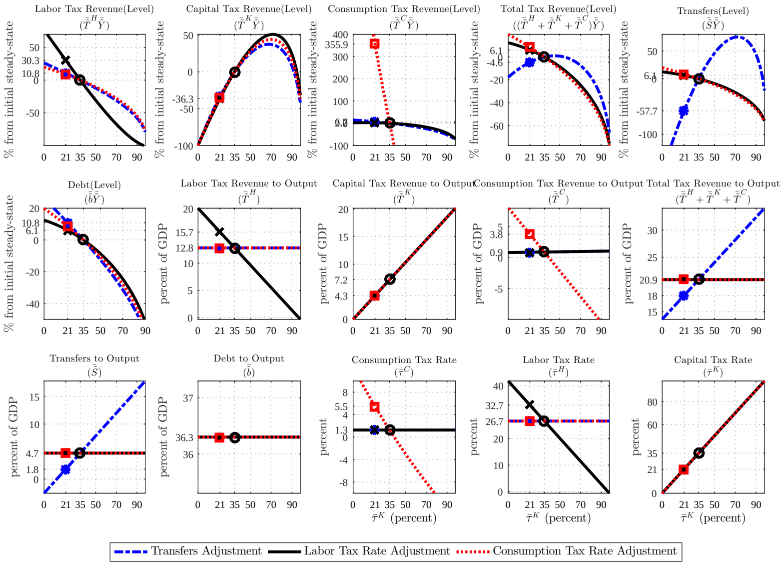
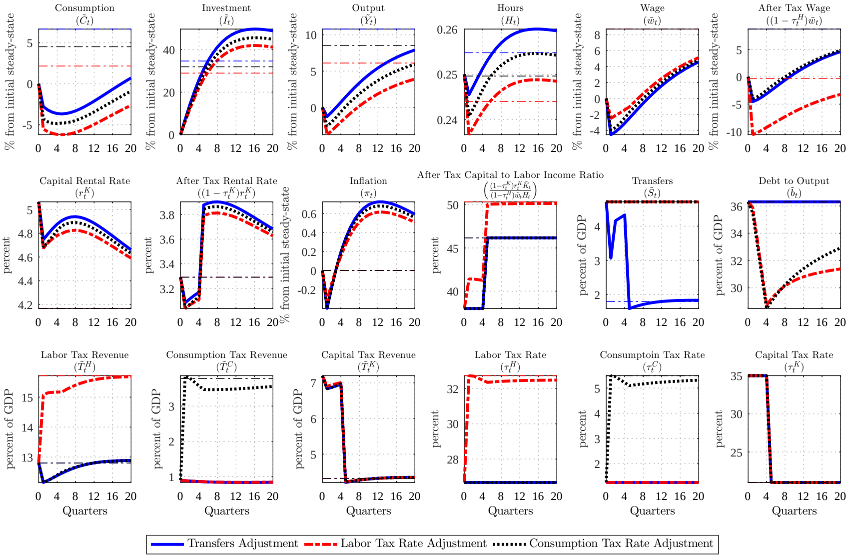
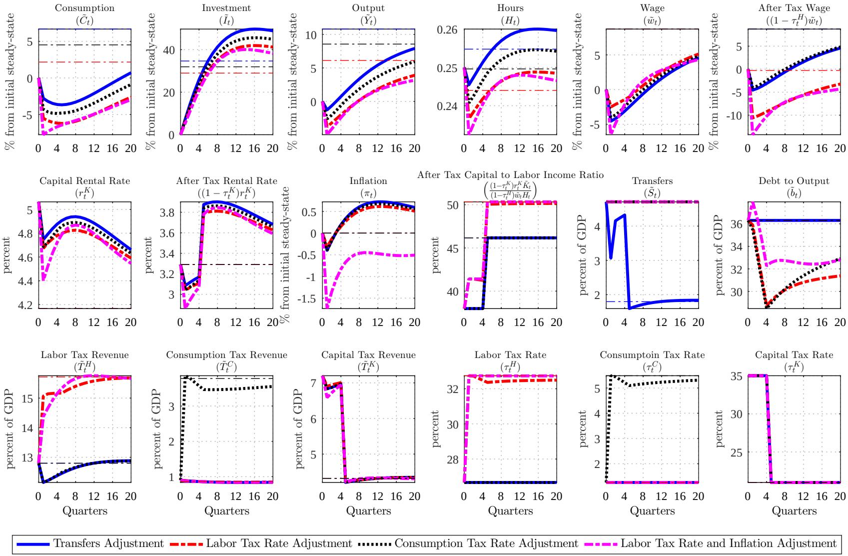


Transition Dynamics - Anticipated Shock

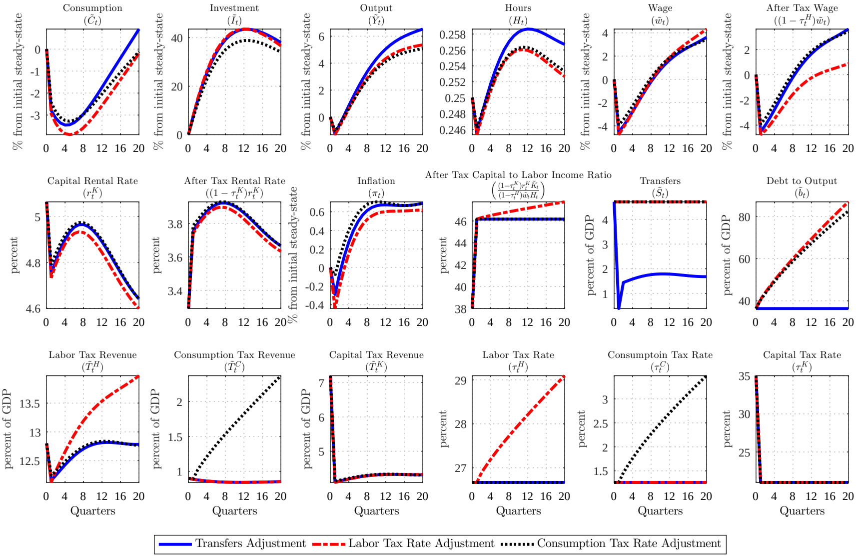


Transition Dynamics - Anticipated Shock

Back

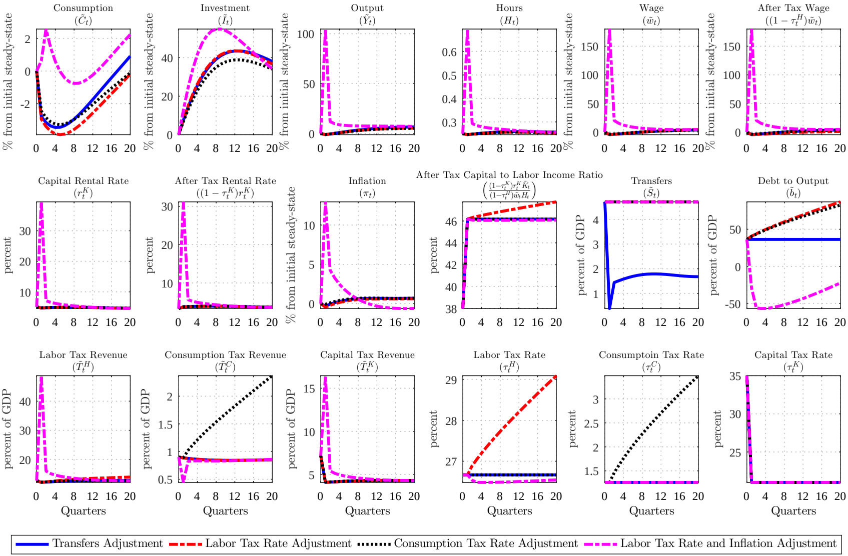


10-Year Cut in Capital Tax Rate

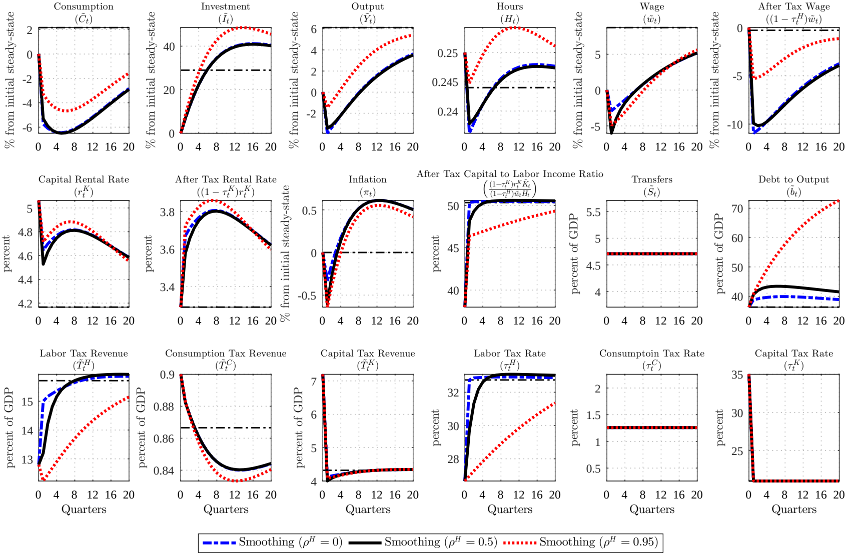


10-Year Cut in Capital Tax Rate

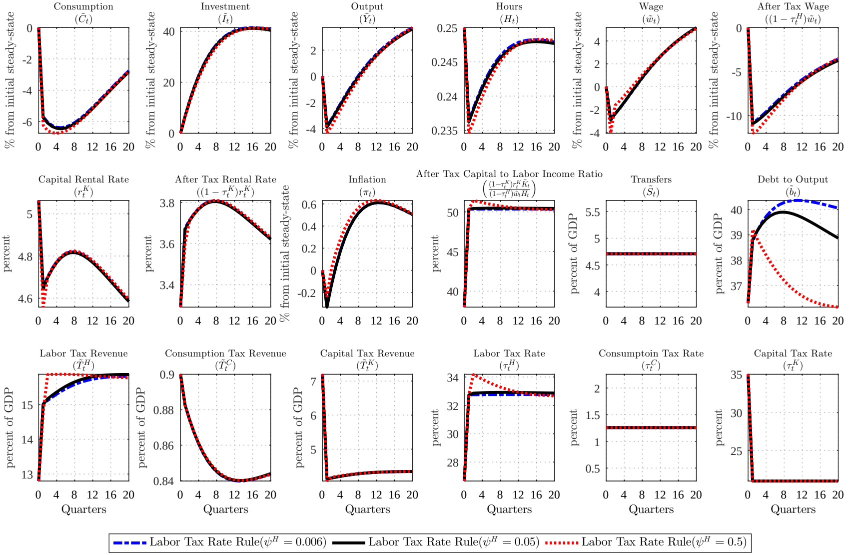
Back



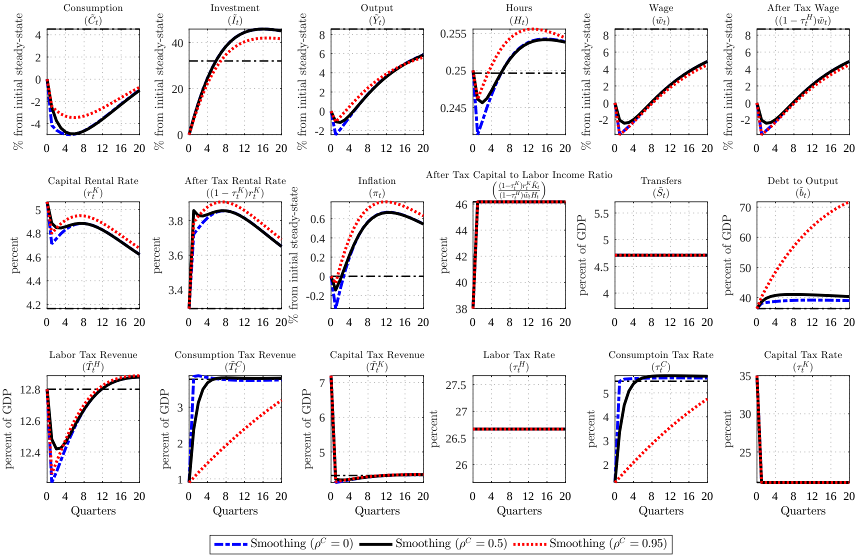
Labor Tax Rate Smoothing - Labor Tax Rate Adjustment



Debt Feedback Parameter - Labor Tax Rate Adjustment

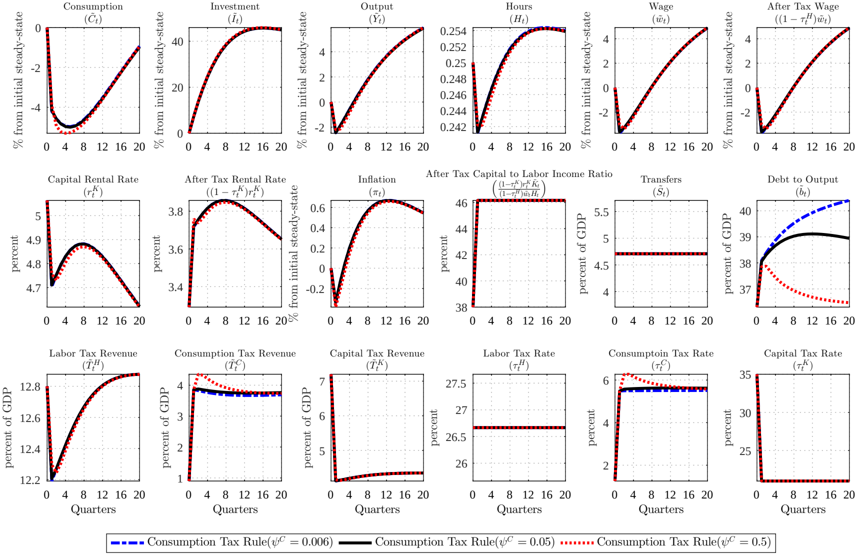


Consumption Tax Rate Smoothing

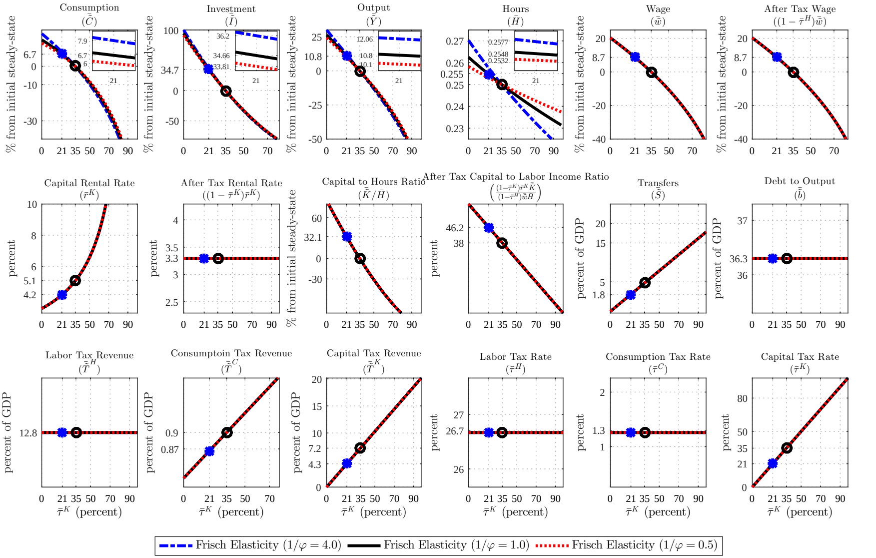


Debt Feedback Parameter - Consumption Tax Rate Adjustment

Back

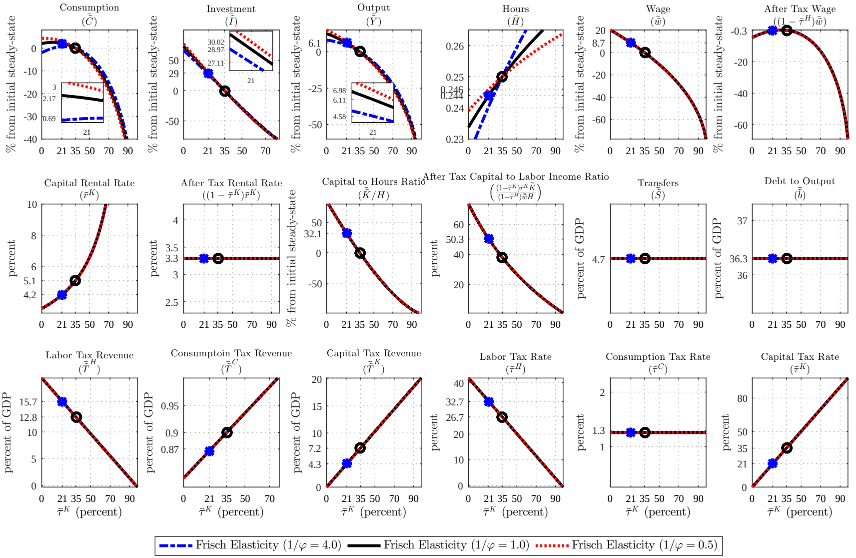


Frisch Elasticity - Transfer Adjustment

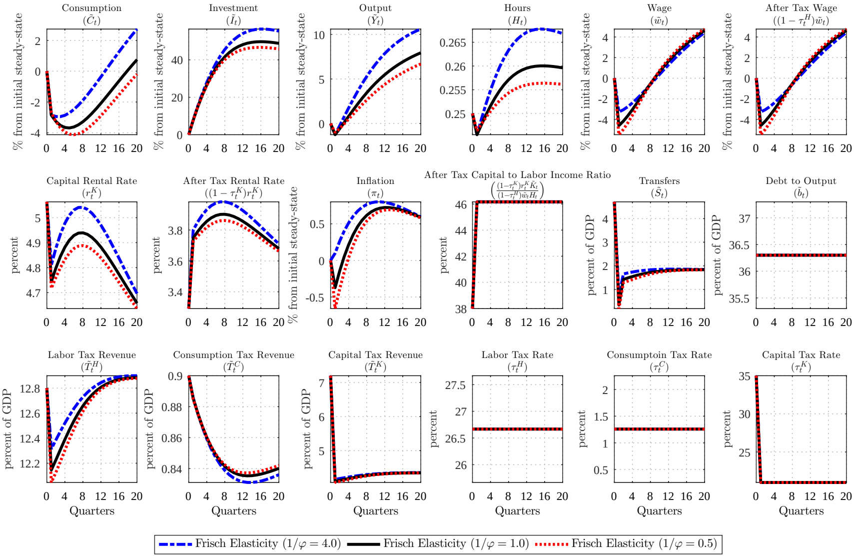


Frisch Elasticity - Labor Tax Rate Adjustment

Back



Frisch Elasticity - Transfer Adjustment



Frisch Elasticity - Labor Tax Rate Adjustment

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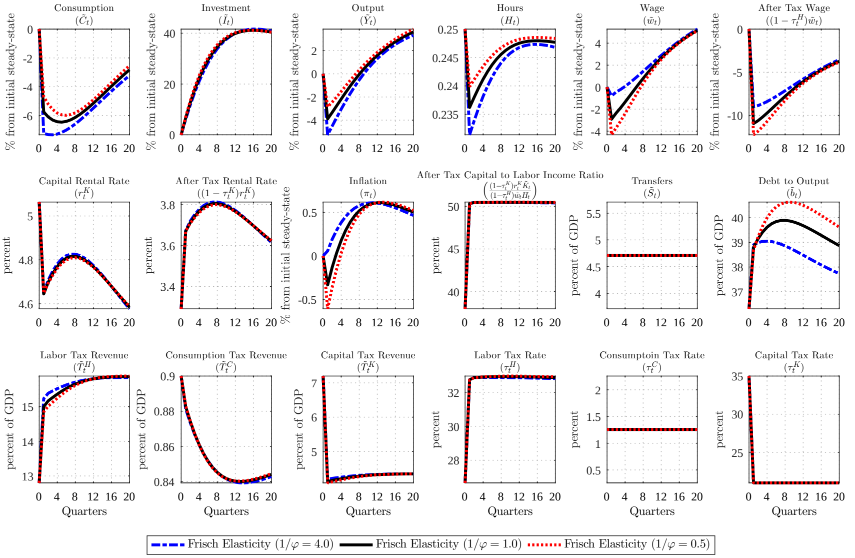
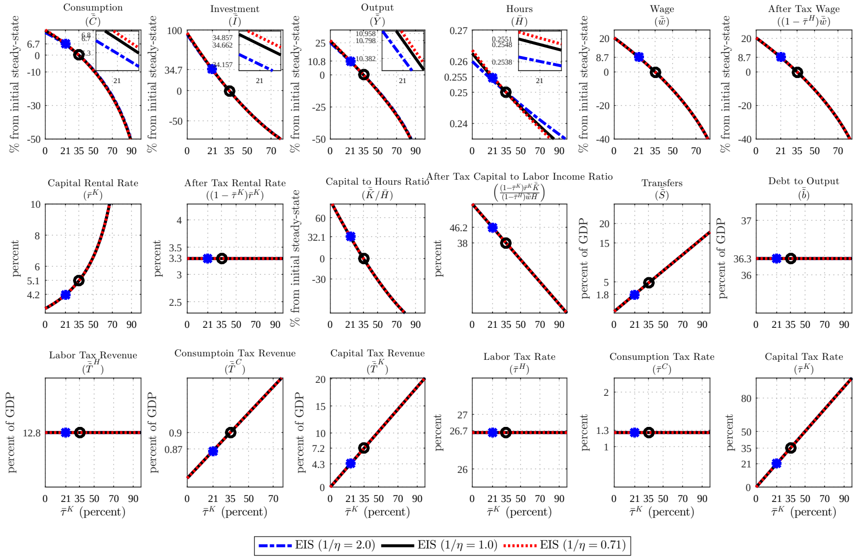
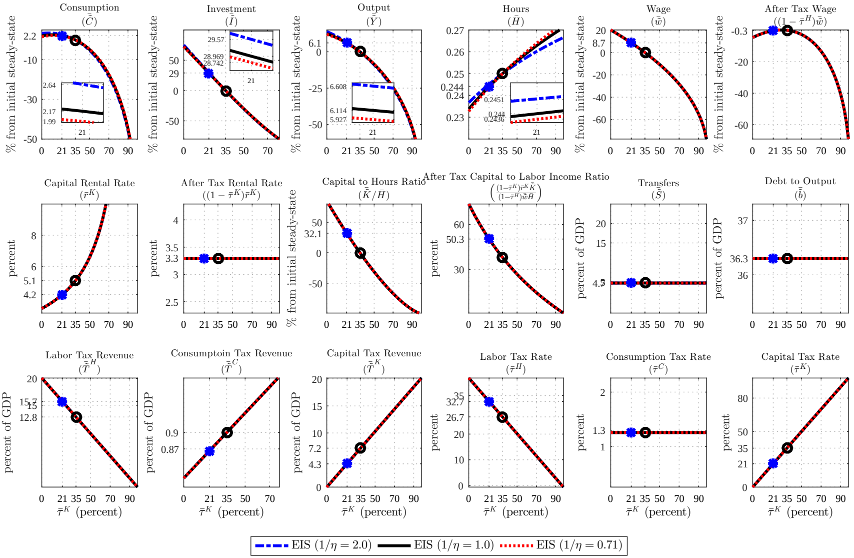


EIS - Transfer Adjustment

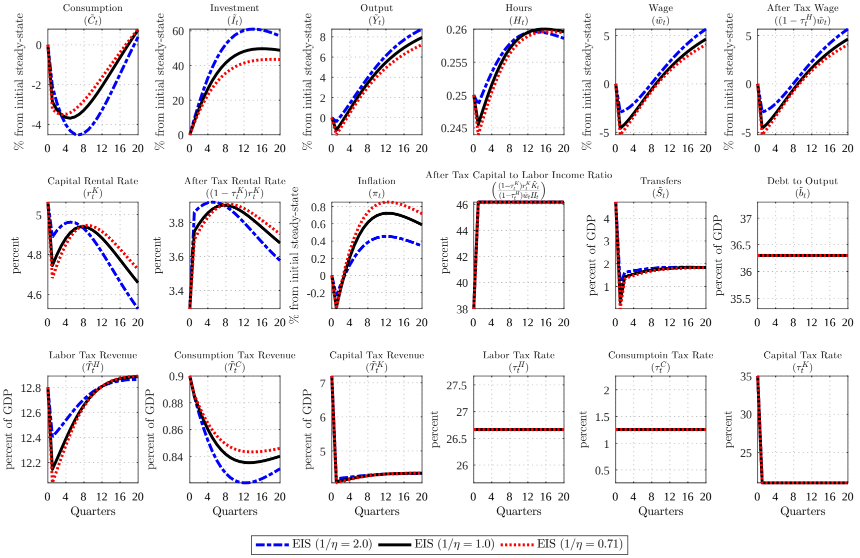


EIS - Labor Tax Rate Adjustment

Back



EIS - Transfer Adjustment



EIS - Labor Tax Rate Adjustment

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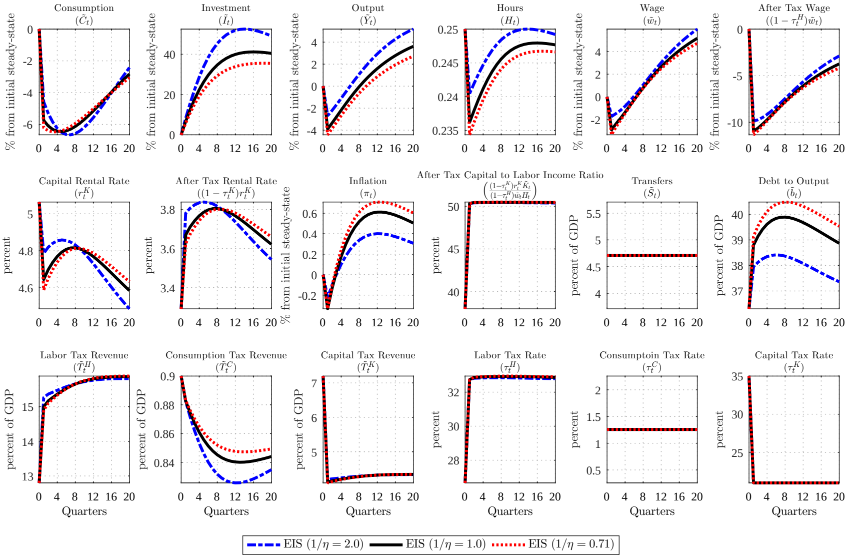
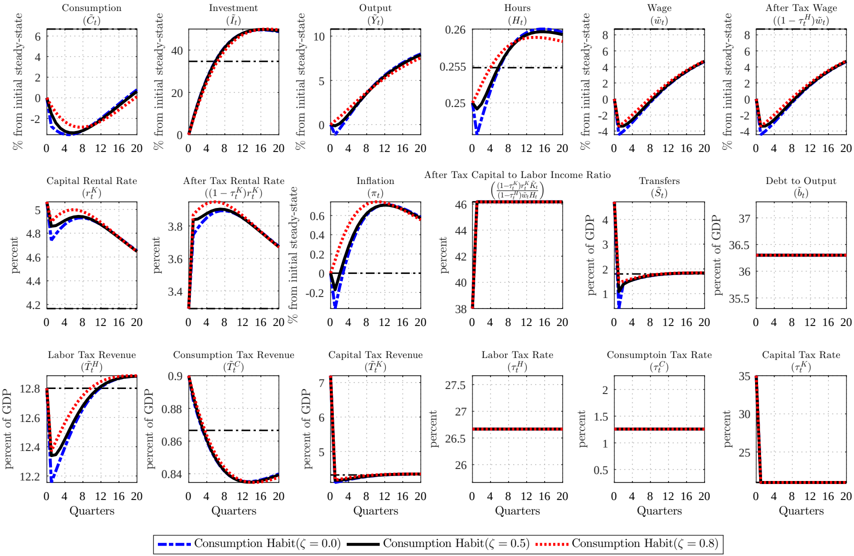
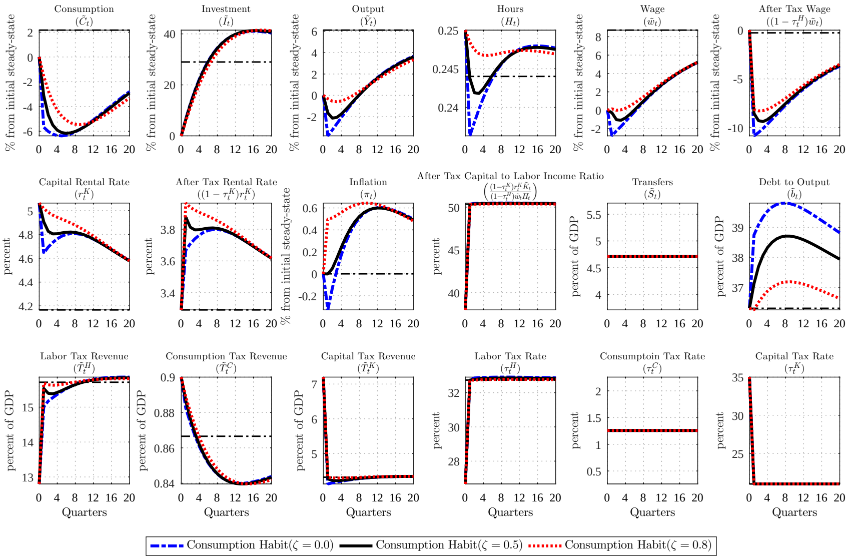


Consumption Habit - Transfer Adjustment

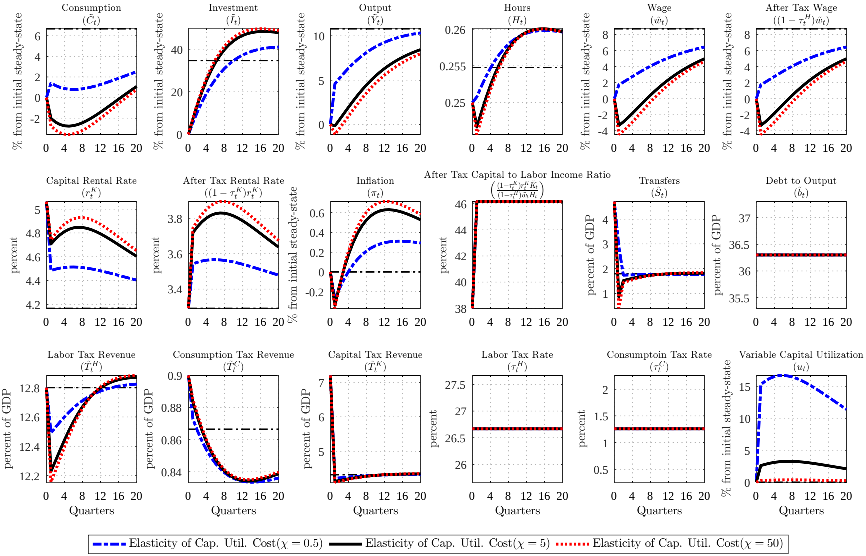


Consumption Habit - Labor Tax Rate Adjustment

Back

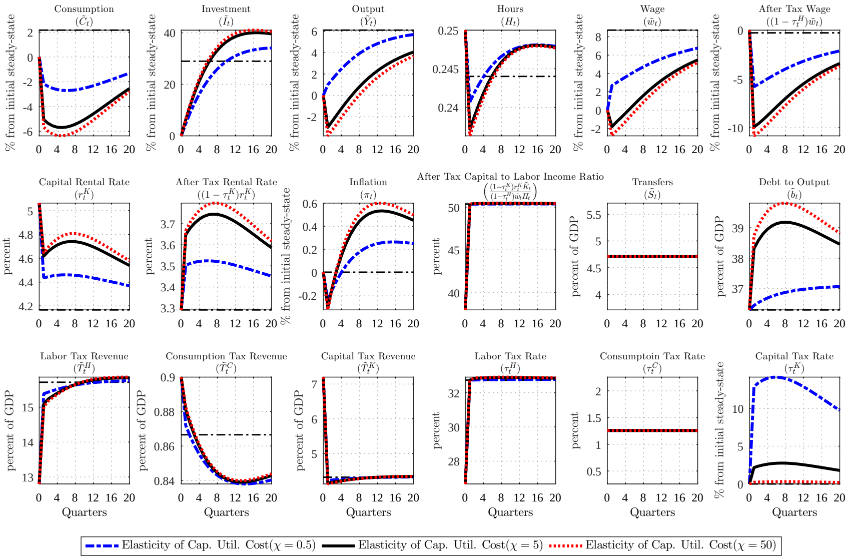


Variable Capacity Utilization - Transfer Adjustment

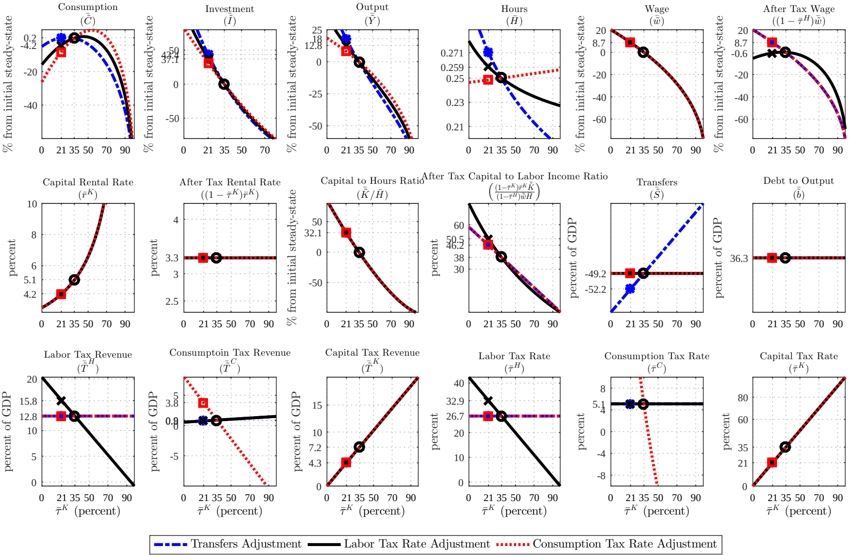


Variable Capacity Utilization - Labor Tax Rate Adjustment

Back



High Initial Level of Government Spending ($\tilde{G} = 0.7$)



High Initial Level of Government Spending $(\bar{\tilde{G}} = 0.7)$ Back