

Macroeconomic Effects of Capital Tax Rate Changes

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- **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%

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- **Do wage, consumption, and income inequality increase or decrease?**

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- **What are the long-run effects on output, investment, consumption, and wages?**
 - Does the source of financing matter?
- **Do wage, consumption, and income inequality increase or decrease?**
- **Are the short-run effects different from the long-run ones?**

Our Model

- **Standard business cycle model with capital-skill complementarity and incomplete consumption insurance**
 - Skill-premium
 - Income and consumption inequality

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- **Standard business cycle model with capital-skill complementarity and incomplete consumption insurance**
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 - Income and consumption inequality
- **Adjustment frictions in investment and prices**
 - Realistic transition dynamics
 - A role for monetary aspects of the model

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 8.4%, investment by 31.7%, and consumption by 5.6% if lump-sum transfers adjust

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- Capital tax cuts **increase inequality** in the long-run
 - Skill premium increases by 13.7% point
 - Consumption of the skilled increases by 10%, but of the unskilled decreases by 5.6%
- How the tax cuts are financed matters
 - The expansionary effects are smaller if the government has to rely on **distortionary labor/consumption taxes**

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- During the transition, the economy experiences **a contraction**
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- **Monetary aspects** of the model matter
 - The interest rates response to inflation and how inertial are interest rate changes are important determinants of aggregate effects

Related Literature

- **Capital tax rate changes**

- Long-run effects: Trabandt and Uhlig (2011)
- Recent US Tax reform: Barro and Furman (2018)
- DSGE : Forni, Monteforte, and Sessa (2009), Sims and Wolff (2017)
- Empirical: Romer and Romer (2010), Blanchard and Perrotti (2002), Mountford and Uhlig (2009), House and Shapiro (2008), Nallareddy, Rouen, and Suárez Serrato (2018)

- **Heterogeneity in the model**

- Capital-skill complementarity: Krussell, Ohanian, Rios-Rull, and Violante (2000), Lindquist (2004), Maliar and Maliar (2011)
- TANK model: Galí, López-Salido, and Vallés (2007), Bilbiie (2017)

- **Normative analysis of the optimal capital tax rate**

- Chamley (1986) and Judd (1985)

Model

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Model

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- Two types of capital - structures(K_b) and equipment(K_e)
- Equipment capital and skilled labor are complements
- Skilled workers own capital and have access to financial markets
- Unskilled workers are hand-to-mouth consumers
 - They simply consume their disposable income in each and every period

Household

- Skilled workers' problem is to

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

subject to

$$\begin{aligned} (1 + \tau_t^C) P_t C_t^s + P_t I_{b,t}^s + P_t I_{e,t}^s + B_t^s &= (1 - \tau_t^H) W_t^s H_t^s + R_{t-1} B_{t-1}^s \\ &+ (1 - \tau_t^K) R_t^{K,b} K_{b,t}^s + (1 - \tau_t^K) R_t^{K,e} K_{e,t}^s \\ &+ P_t \chi^\Phi \Phi_t + P_t \chi^S S_t \end{aligned}$$

$$K_{b,t+1}^s = (1 - d_b) K_{b,t}^s + \left(1 - \mathcal{S} \left(\frac{I_{b,t}^s}{I_{b,t-1}^s} \right) \right) I_{b,t}^s$$

$$K_{e,t+1}^s = (1 - d_e) K_{e,t}^s + \left(1 - \mathcal{S} \left(\frac{I_{e,t}^s}{I_{e,t-1}^s} \right) \right) I_{e,t}^s q_t$$

Household

- Unskilled workers' problem is to

$$\max_{\{C_t^u, H_t^u\}} U(C_t^u, H_t^u)$$

subject to

$$(1 + \tau_t^C) P_t C_t^u = (1 - \tau_t^H) W_t^u H_t^u + P_t (1 - \chi^\Phi) \Phi_t^u + P_t (1 - \chi^S) S_t^u$$

Firms

- Competitive final goods firms produce aggregate output Y_t
- Continuum of monopolistically competitive intermediate goods firms produce with a CRS technology

$$Y_t(i) \equiv A_t (K_{b,t}(i))^\alpha \left[\mu (L_{u,t}(i))^\sigma + (1 - \mu) (\lambda (K_{e,t}(i))^\rho + (1 - \lambda) (L_{s,t}(i))^\rho)^{\frac{\sigma}{\rho}} \right]^{\frac{1-\alpha}{\sigma}}$$

using capital structures($K_{b,t}$), capital equipment($K_{e,t}$), skilled labor($L_{s,t}$) and unskilled labor($L_{u,t}$)

- **Capital-skill complementarity if $\sigma > \rho$**
- Intermediate goods firms rent capital and hire labor in competitive markets

Monetary and Fiscal Policy

- Monetary policy

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

- Government flow budget constraint

$$\begin{aligned} \frac{B_t}{P_t Y_t} + \tau_t^C \frac{C_t}{Y_t} + \tau_t^H \left(\frac{W_t^s}{P_t Y_t} L_{s,t} + \frac{W_t^u}{P_t Y_t} L_{u,t} \right) + \tau_t^K \left(\frac{R_t^{K,b}}{P_t Y_t} K_{b,t} + \frac{R_t^{K,e}}{P_t Y_t} K_{e,t} \right) \\ = R_{t-1} \frac{B_{t-1}}{P_{t-1} Y_{t-1}} \frac{1}{\pi_t} \frac{Y_{t-1}}{Y_t} + \frac{G_t}{Y_t} + \frac{S_t}{Y_t} \end{aligned}$$

- 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
- **Fiscal policy adjustment rules**
 - Lump-sum transfers ; Labor tax rates ; Consumption tax rates

Definitions and Functional Forms

- The economy features a **balanced growth path**

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- Functional forms for preferences and technology

$$U(C^i, H^i) \equiv \ln(C^i) - \bar{\omega}^i \frac{(H^i)^{1+\varphi}}{1+\varphi}$$

$$F(A, K_b, K_e, L_u, L_s) \equiv A(K_b)^\alpha \left[\mu L_u^\sigma + (1-\mu)(\lambda(K_e)^\rho + (1-\lambda)(L_s)^\rho)^{\frac{\sigma}{\rho}} \right]^{\frac{1-\alpha}{\sigma}}$$

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- **Capital-skill complementarity if $\sigma > \rho$**
- Investment and price adjustment costs

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

Calibration

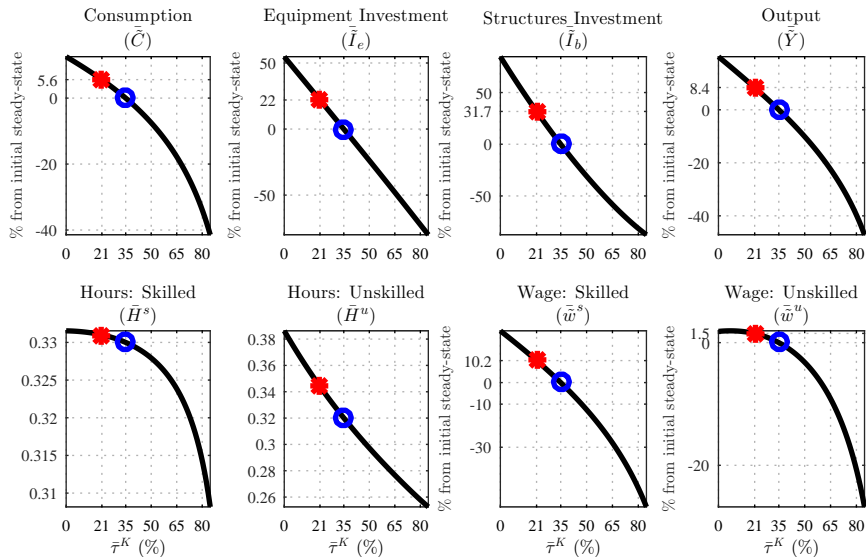
	Value	Description	References
<u>Households</u>			
N^S	0.5	Fraction of skilled labor	Lindquist (2004)
φ	1.0	Inverse of Frisch elasticity of labor supply	Trabandt and Uhlig (2011)
ξ	4.0	Investment adjustment cost	Smets and Wouters (2007)
<u>Firms</u>			
σ	0.401	EoS between unskilled labor and equipment	Krusell et al.(2000)
ρ	-0.495	EoS between skilled labor and equipment	Krusell et al.(2000)
α	0.117	Structures capital Income share	Krusell et al.(2000)
λ	0.35	Equipment capital income share	Steady-state labor share: 56%
μ	0.345	Unskilled labor income share	Steady-state skill premium: 60%
κ	50	Quadratic price adjustment cost	Ireland (2000)
θ	4.0	Elasticity of substitution between goods	Steady-state Markup: 33%

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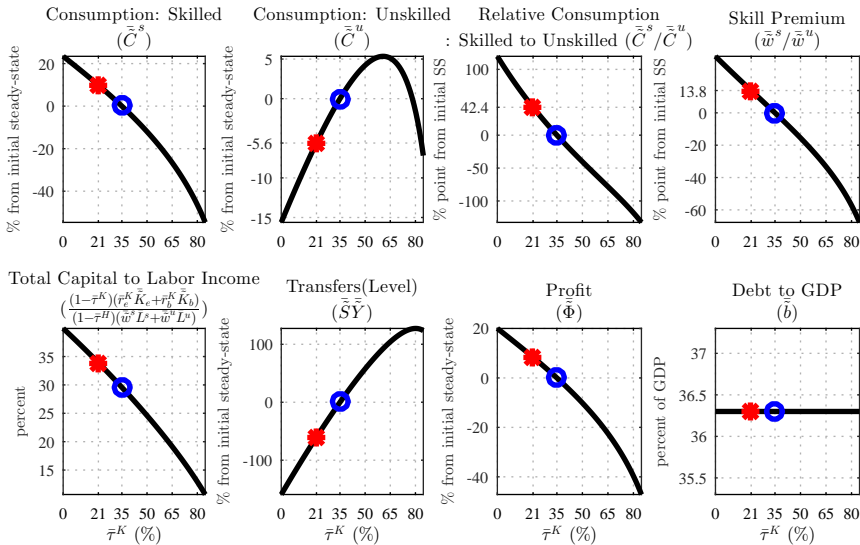
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<u>Government(Fiscal/Monetary Policy)</u>			
\bar{b}	0.363	SS debt to GDP ratio	US Post-Volcker Data
\bar{G}	0.161	SS government spending to GDP ratio	US Post-Volcker Data
\bar{T}^C	0.009	SS consumption tax revenue to GDP ratio	US Post-Volcker Data
\bar{T}^H	0.128	SS labor tax revenue to GDP ratio	US Post-Volcker Data
χ^Φ	1	Fraction of profit distribution to skilled worker	
χ^S	0	Fraction of transfers distribution to skilled worker	
ϕ	1.5	Taylor rule	

Long-run Effects

Capital tax cuts have **expansionary** long-run effects



Capital tax cuts increase inequality



Long-run Effect - Transfer Adjustment

- Capital tax cut facilitates capital accumulation and leads to an increase in aggregate output, consumption, and wages
- Skill-premium and wage inequality increase in the long-run
 - Equipment capital accumulation and capital-skill complementarity
- Skill premium increases even with complete markets (without hand-to-mouth households)
- Consumption inequality increases due to the redistribution of income

▸ Other Variables

▸ Profit/Transfer Distribution

▸ Profit/Transfer Distribution 2

▸ Labor/Consumption Tax Adjustment

▸ Complete Market and No Complementarity

▸ Complete Market

▸ No Capital/Skill Complementarity

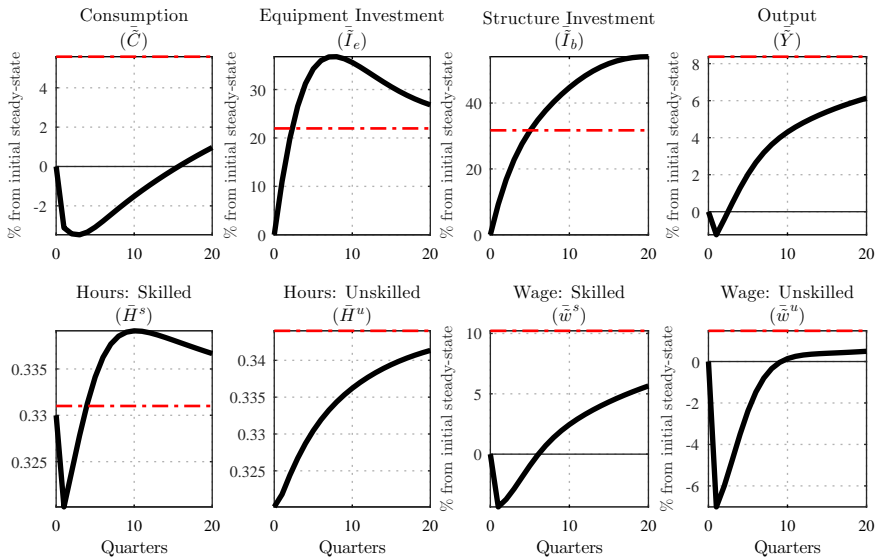
Transition Dynamics

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
- Different fiscal/monetary policy adjustments
 - Transfers adjustment with smoothing ($\rho = 0.9$)
 - $\frac{S_t}{Y_t}$ adjust to maintain $\frac{B_t}{P_t Y_t}$ constant
 - Labor (or consumption) tax rate adjustment

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

Transfers Adjustment



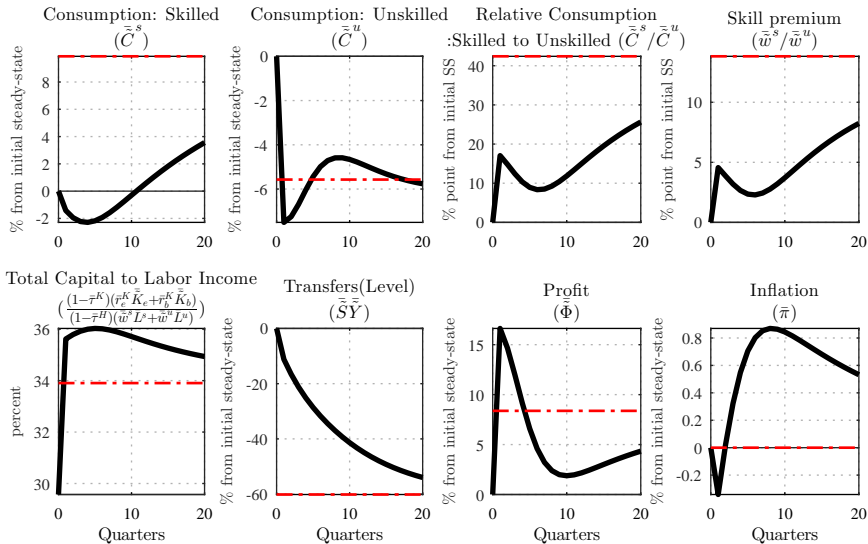
Implications on Macro Variables

- A capital tax rate cut 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 price and investment adjustment costs

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- A capital tax rate cut 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 price and investment adjustment costs
- The temporary fall in output and the increase in profits lead to fall in hours of skilled workers
- Unskilled workers work harder since the reduction in transfers leads to the decrease in their disposable income
 - Wages of unskilled workers drop more and stay below the initial steady-state for a long time

Transfers Adjustment - Inequality



Implications on Inequality

- Consumption inequality increases along the transition
 - Consumption of skilled workers slightly decreases to finance the increase in investment
 - Consumption of unskilled workers decreases a lot due to the reduction of disposable income
- Wage premium increases along the transition
 - Wages of skilled workers decrease because labor demand declines as firms produce a smaller amount of output in the short-run
 - Wages of unskilled workers decrease a lot because of the large labor supply effects
- (After-tax) capital income to labor income ratio increases
 - The long-run positive effects of capital tax cuts come at the expense of short-run decline of labor income

Extensions

- Source of financing [▶ Figure](#)
 - Transfers adjustment v.s. Distortionary tax rate adjustment
- Nominal aspects of the model [▶ Figure](#)
 - Degree of price stickiness
 - Inflation feedback parameter in monetary policy rule
- Without capital-skill complementarity [▶ Figure](#)

Conclusion

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
- In the short-run, the economy experiences a *decline* in consumption, output, hours, wages, and labor income
- Capital tax cuts increase inequality in the long- and short-run
 - Skill premium and consumption inequality increase

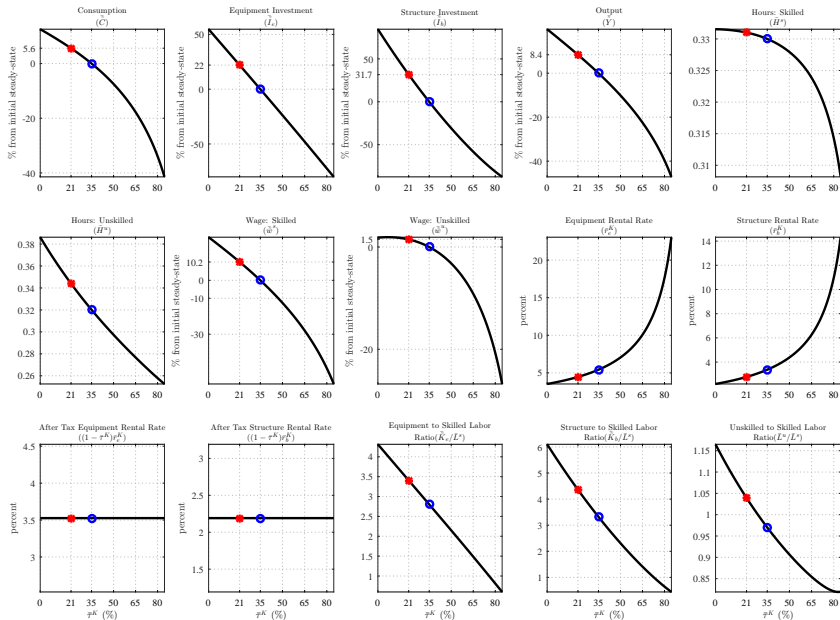
Appendix

Calibration

	Value	Description	References
<u>Households ($N^s = 0.5$)</u>			
β	0.9975	Time preference	Smets and Wouters (2007)
φ	1.0	Inverse of Frisch elasticity of labor supply	Trabandt and Uhlig (2011)
$\bar{\omega}^s$	7.7	Labor supply disutility parameters	Steady-state $\bar{H}^s = 0.33$
$\bar{\omega}^u$	4.6		Steady-state $\bar{H}^u = 0.31$
d_e	0.031	Equipment Capital depreciation	Krusell et al.(2000)
d_b	0.013	Structures Capital depreciation	Krusell et al.(2000)
ξ	4.0	Investment adjustment cost	Smets and Wouters (2007)
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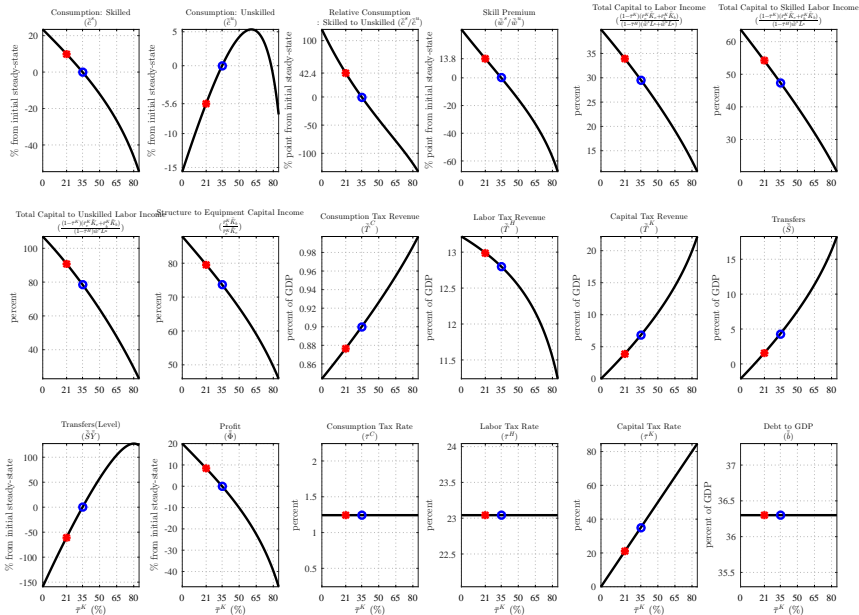
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χ^Φ	1	Fraction of profit distribution to skilled worker	
χ^S	0	Fraction of transfers distribution to skilled worker	
ϕ	1.5	Taylor rule	
ψ^C	0.0	No tax rate response to debt	
	0.05	Consumption tax rate response to debt	
	0.0	No tax rate response to debt	
ψ^H	0.05	Labor tax rate response to debt	

Aggregate Variables

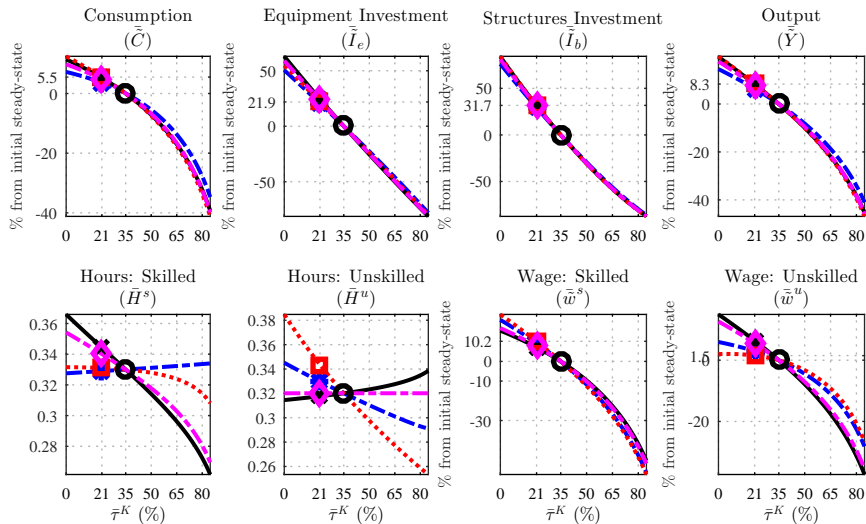


Inequality

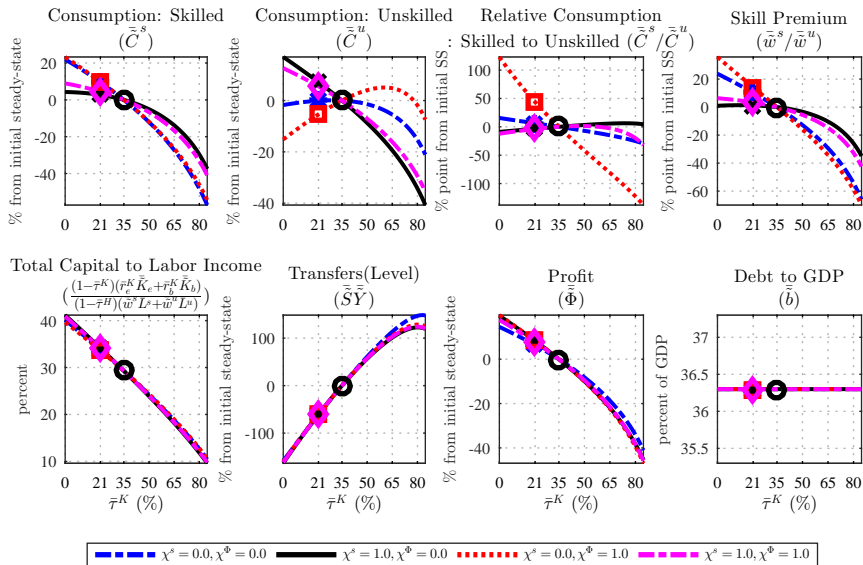
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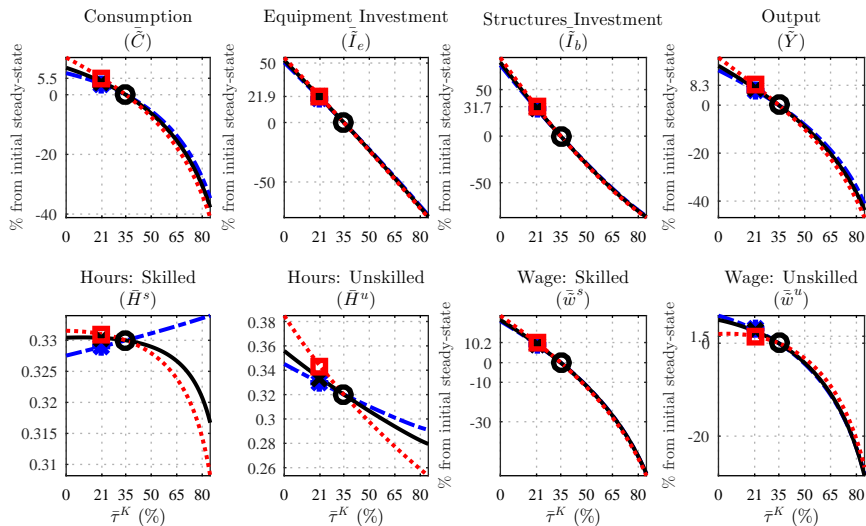
Profit/Transfer Distribution



Profit/Transfer Distribution [▶ Back](#)

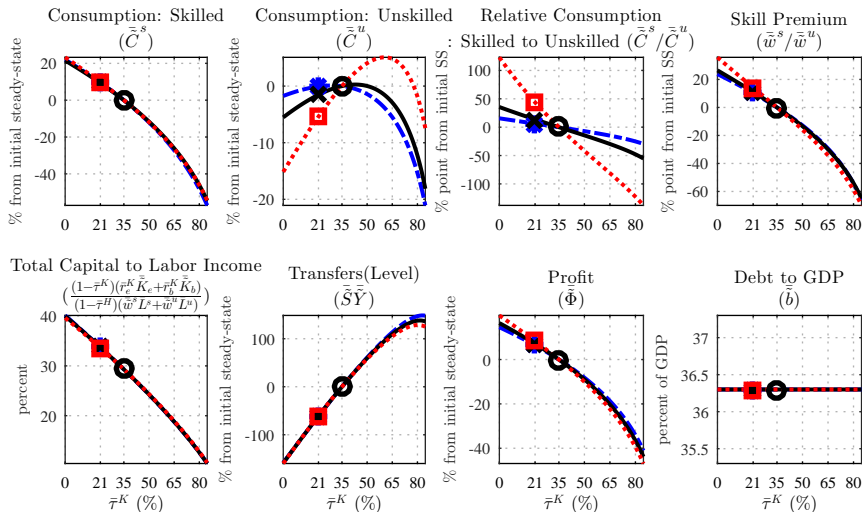


Different Profit Distribution

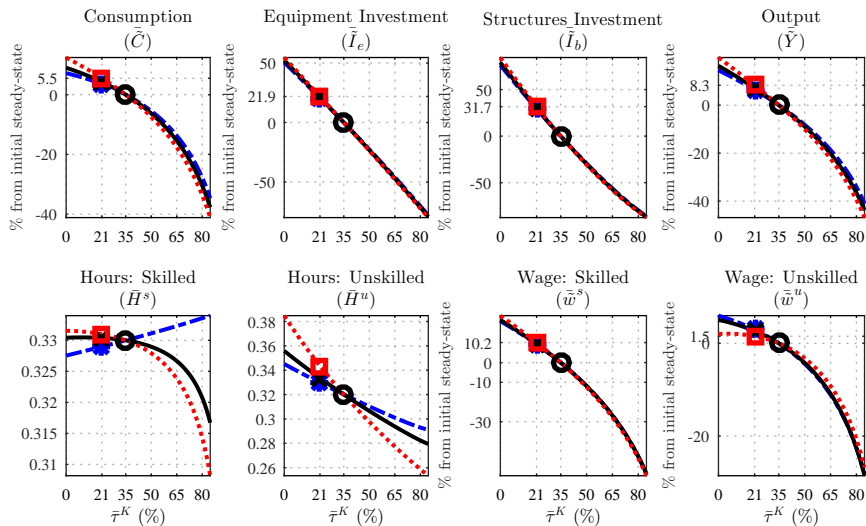


Different Profit Distribution

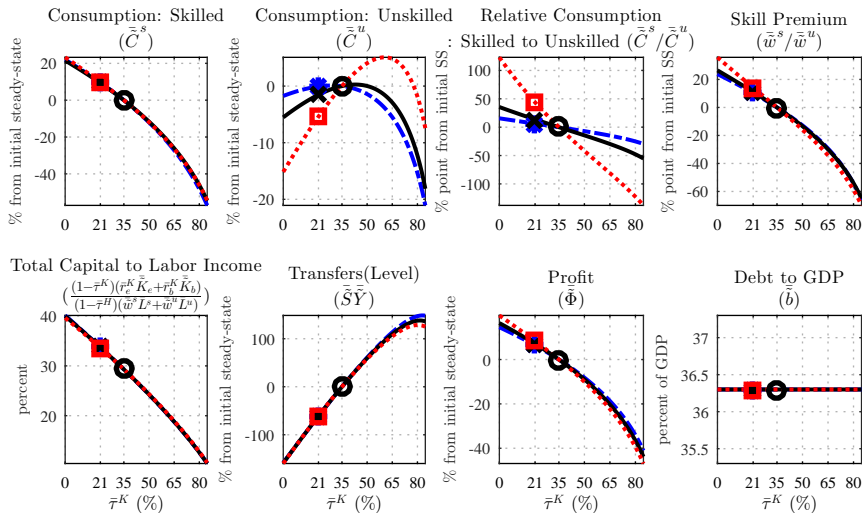
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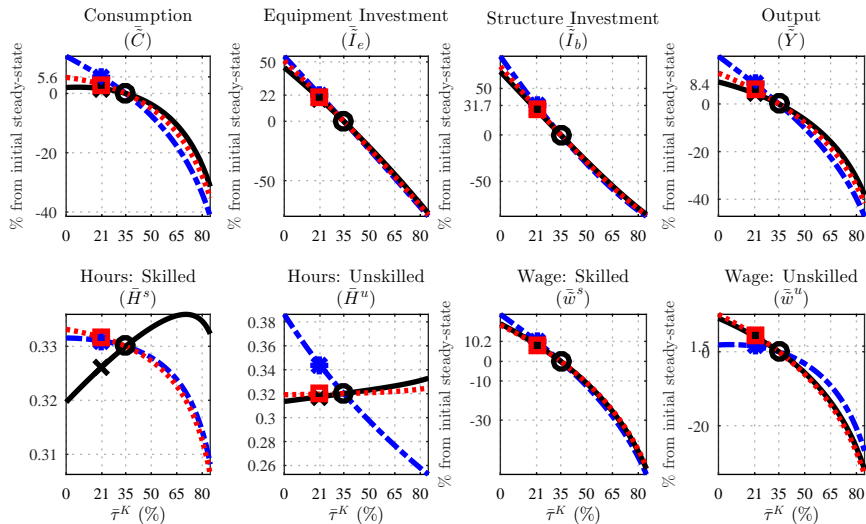
Different Transfers Distribution



Different Transfers Distribution ▶ Back

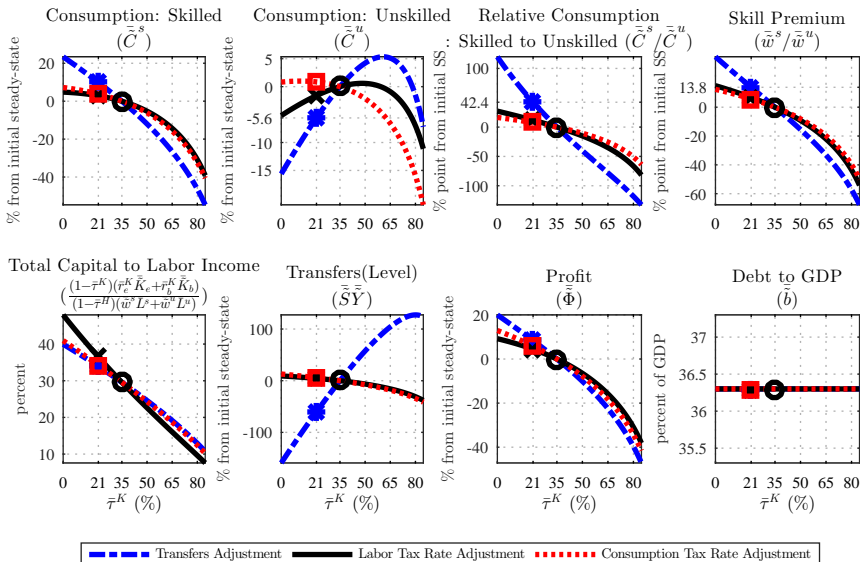


Source of Financing



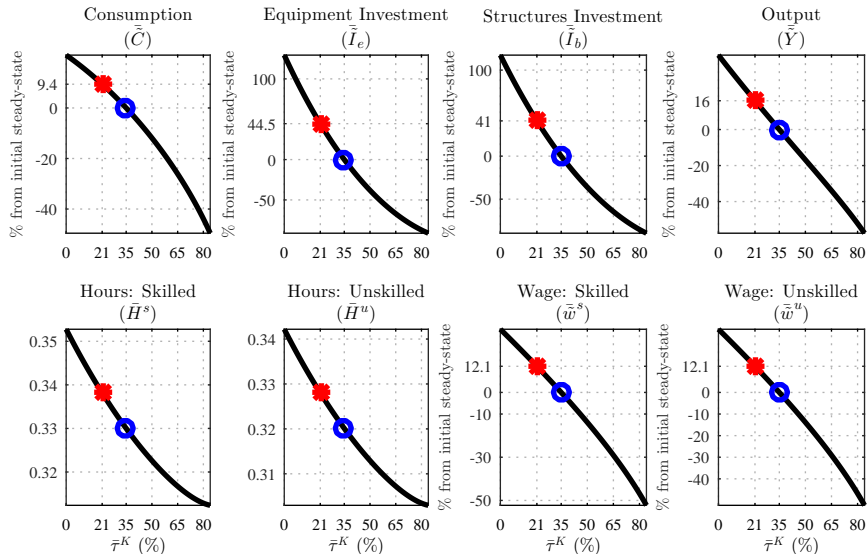
--- Transfers Adjustment — Labor Tax Rate Adjustment ... Consumption Tax Rate Adjustment

Source of Financing ▶ Back



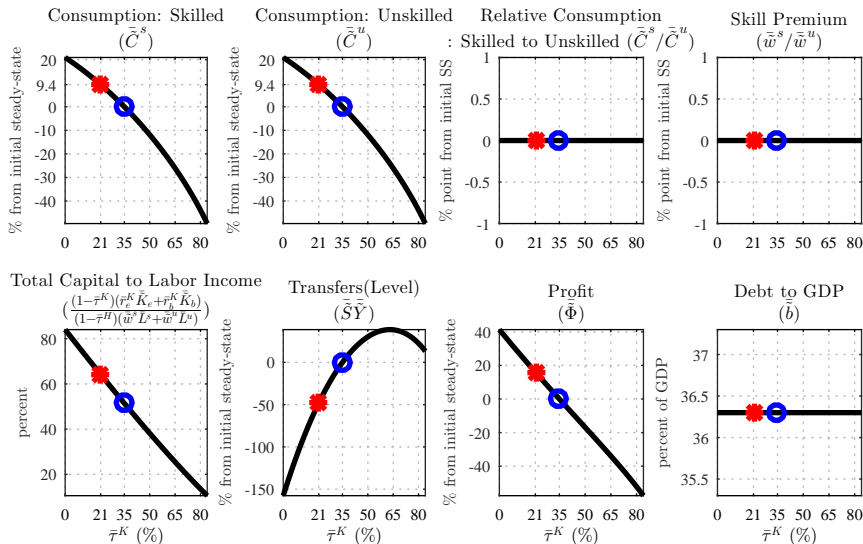
Complete Market Without Complementarity

($\sigma = \rho = 0.1$)

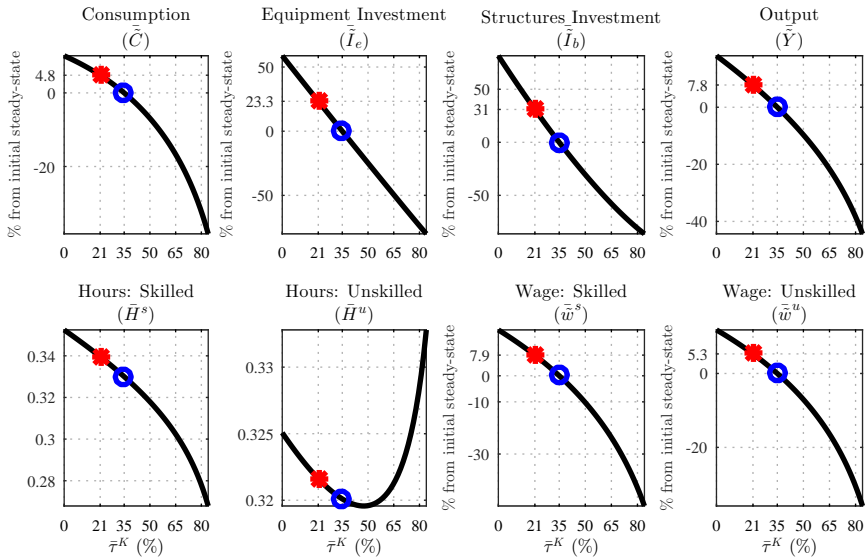


Complete Market Without Complementarity

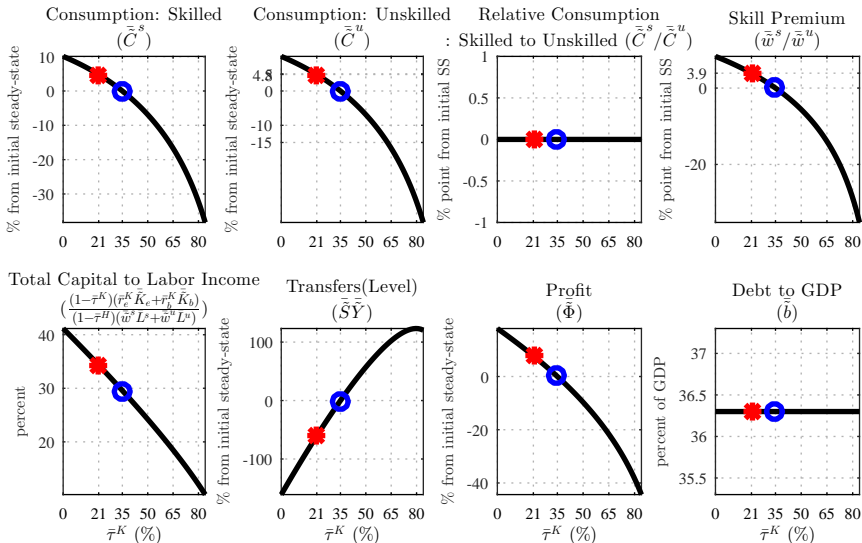
($\sigma = \rho = 0.1$) [► Back](#)



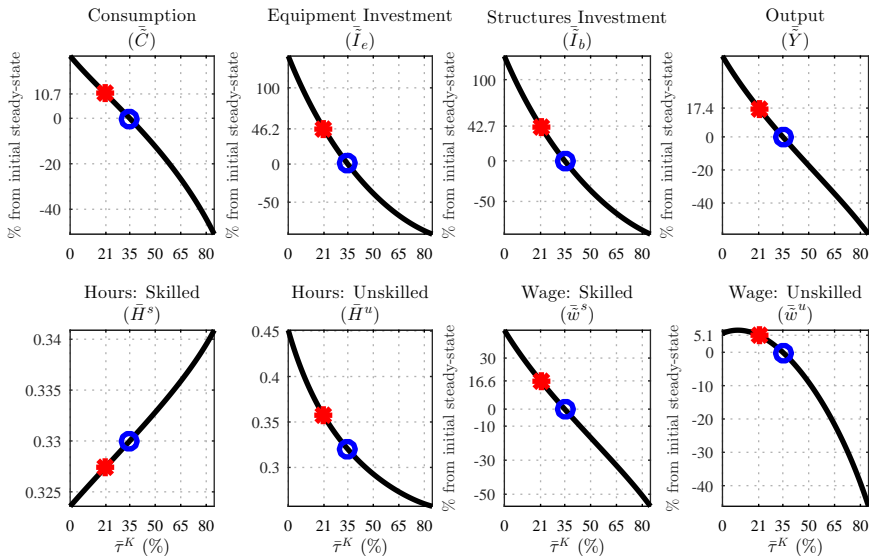
Complete Market with Complementarity



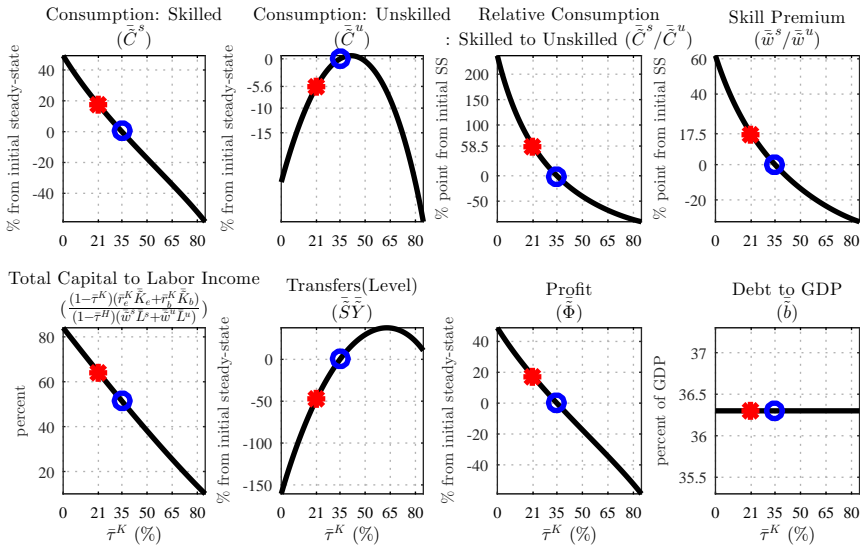
Complete Market with Complementarity [▶ Back](#)



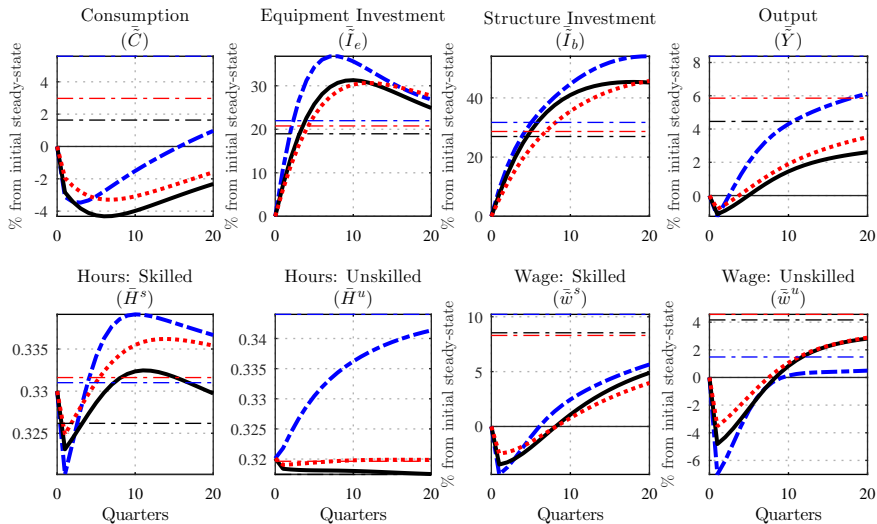
Without Complementarity ($\sigma = \rho = 0.1$)



Without Complementarity ($\sigma = \rho = 0.1$) ▶ Back



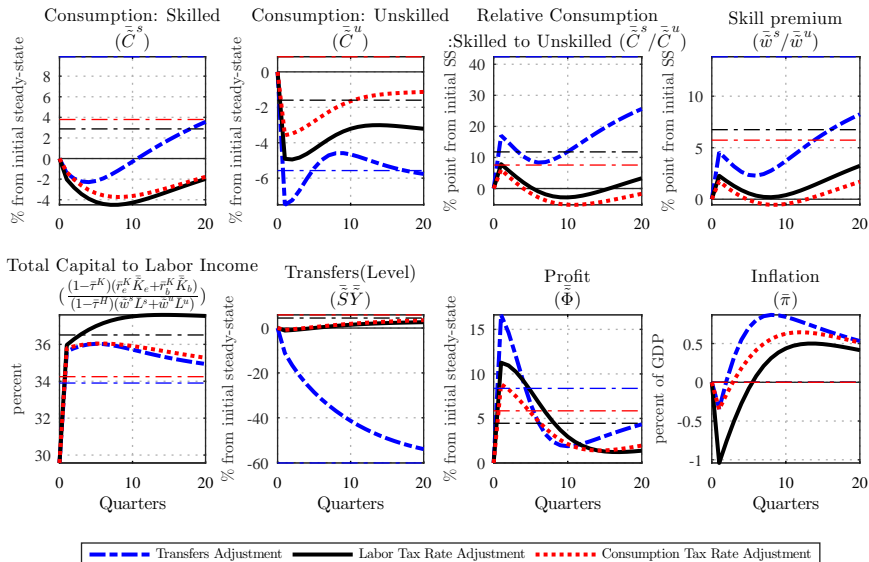
Distortionary Tax Adjustment



--- Transfers Adjustment — Labor Tax Rate Adjustment ... Consumption Tax Rate Adjustment

Distortionary Tax Adjustment - Inequality

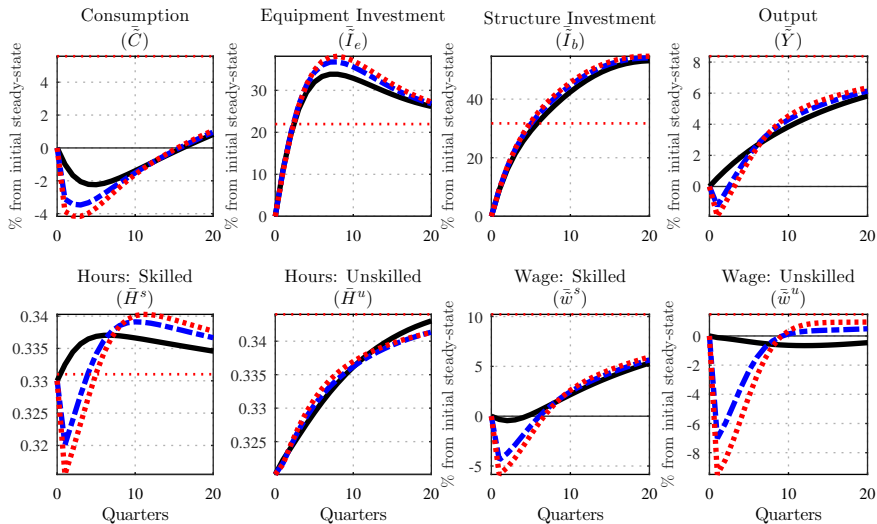
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Implications of Fiscal Rules

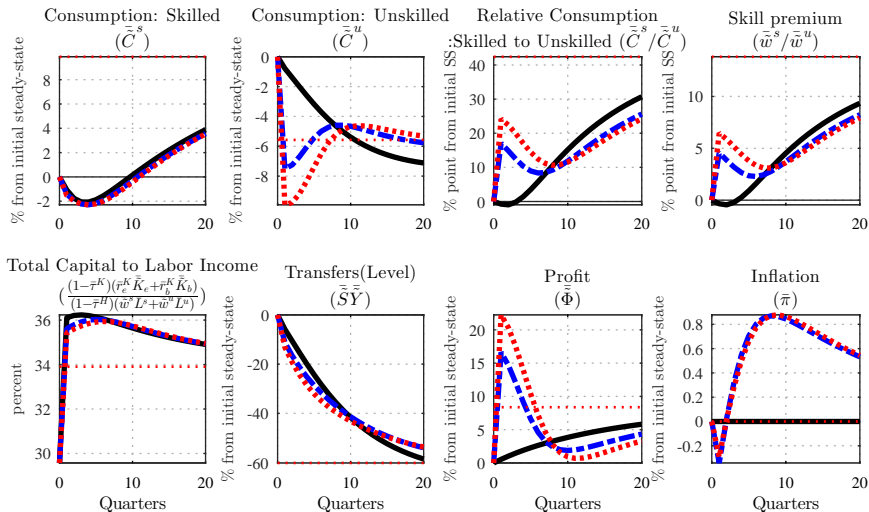
- The drop in consumption and output is larger if labor or consumption tax adjusts
 - Increased labor/consumption tax rate decreases hours even further by discouraging workers from supplying labor
 - Hours in equilibrium fall much more, below the lower new steady-state
 - This amplifies the short-run contraction in consumption and output
- The increase in inequality measures is larger if transfer adjusts
 - Government takes more resources from unskilled workers if transfer adjusts

Degree of Price Stickiness



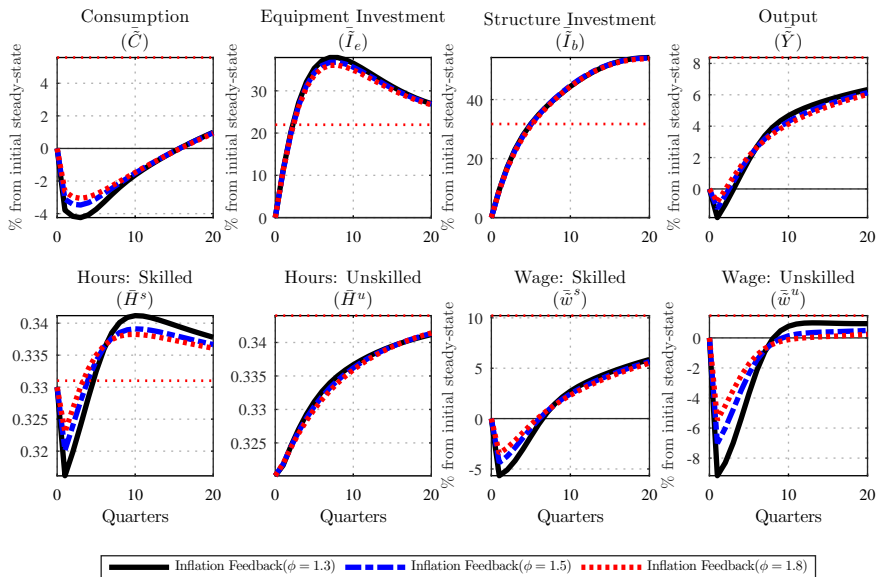
Price Adjustment Cost ($\xi = 0.0$)
 Price Adjustment Cost ($\xi = 50.0$)
 Price Adjustment Cost ($\xi = 80.0$)

Degree of Price Stickiness - Inequality



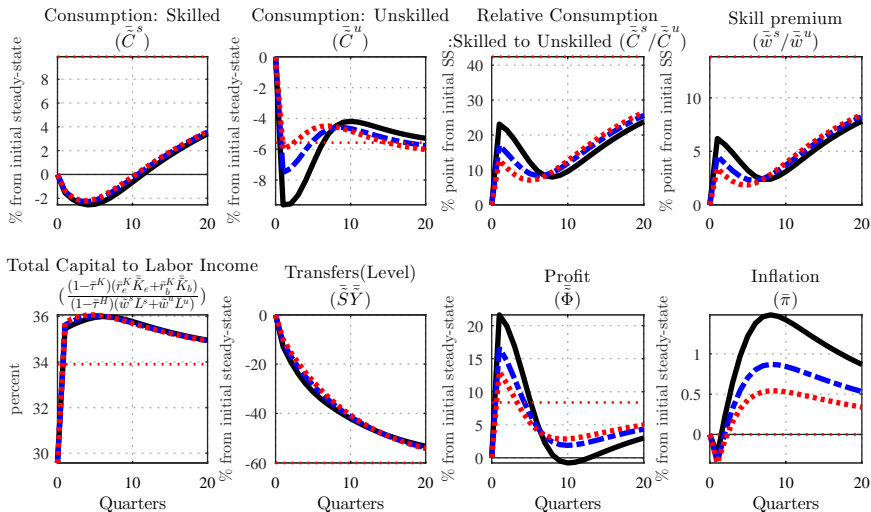
Price Adjustment Cost($\xi = 0.0$)
 Price Adjustment Cost($\xi = 50.0$)
 Price Adjustment Cost($\xi = 80.0$)

Inflation Feedback



Inflation Feedback - Inequality

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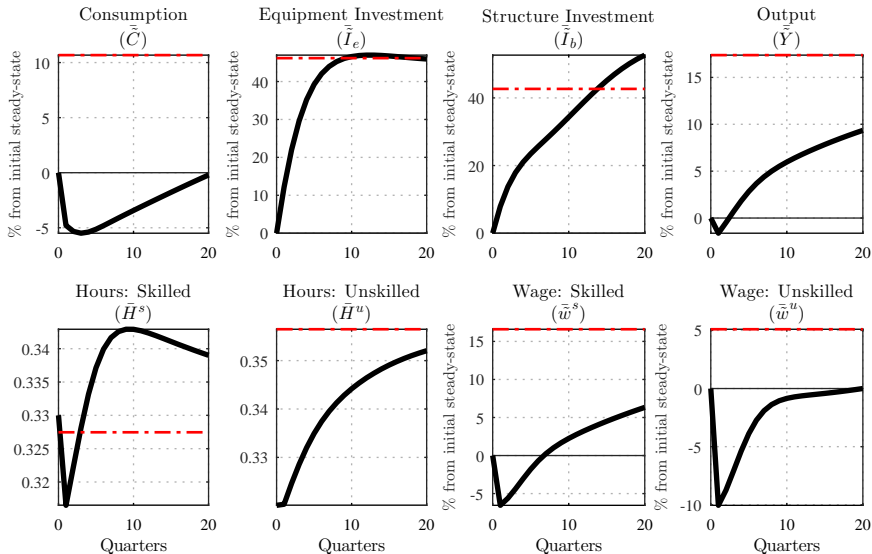


Role of Monetary Components

- Monetary aspects of the model matter for transition dynamics
 - When prices are more rigid or inflation feedback parameter (ϕ) is smaller,
 - there is a bigger short-run drop in consumption, output, and wages and a smaller drop in inflation
 - inequality increases more due to large increase in profits

Transition Dynamics Without Complementarity

($\sigma = \rho = 0.1$)



Transition Dynamics Without Complementarity

($\sigma = \rho = 0.1$)

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