Optimal Capital Taxation with Incomplete Markets and Schumpeterian Growth

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Motivation

- Most governments need to finance large public expenditures ($\approx 20 - 30\%$ of GDP) and undertake redistribution.
- Can use several tax instruments (goal of minimizing distortions): should capital income be taxed?
- Two main and opposing views:
  - Classical $\rightarrow$ no capital taxation in the long-run (Judd JPuBE 85, Chamley ECTA 86).
  - More recent $\rightarrow$ optimal to tax capital income heavily, tax rate $\approx 30\%$ (Conesa, Kitao and Krueger AER 09, Piketty HUP 14).
- In general, in OLG models the optimal capital income tax is positive (especially if labor taxes cannot be conditioned on age).

Contribution

- Embed a Schumpeterian growth mechanism into a rich OLG model with incomplete markets. $\rightarrow$ Explicit measurement of possible detrimental effects on the growth rate.
- Use a general specification for income dynamics to match some features of the data (i.e., rising labor earnings inequality over the life-cycle). $\rightarrow$ Demand for redistribution is taken into account.
- Use a flexible preference specification to match some features of the data (i.e., labor supply and non-unitary elasticity). $\rightarrow$ Match low Frisch elasticity of labor supply to accurately capture response to tax changes.

Preview of the Findings

- It is virtually never optimal to set a positive tax rate on capital income.
- At most, the capital tax rate that maximizes welfare is less than 0.02%.
- The fall in the growth rate is quantitatively small: for $\tau_k = 0\%$ $\rightarrow g = 1.87\%$ and for $\tau_k = 40\% \rightarrow g = 1.57\%$.
- Still sufficient to cause a decrease in welfare (lost wage growth over the working life and lower pensions).
- Moving to the optimal taxation scheme entails large welfare gains: CEV $\approx 5\%$.
- Results are robust to alternative preferences and welfare measures.

Related Literature

- Capital Taxes in OLG Models: Imrohoroglu (IER 98), Erosa and Gervais (JET 02), Conesa and Krueger (JME 06), Conesa, Kitao and Krueger (AER 09), Gervais (JEDC 12), Cozzi (JEDC 14).
- Zero Capital Tax Rates: Judd (JPubE 85), Chamley (ECTA 86), Aiyagari (JPE 95), Atkeson, Chari and Kehoe (QR 99).
- NPF and Zero Expected Capital Tax Rates: Golosov, Kocherlakota and Tsyvinski (RESTUD 03).
- Schumpeterian Growth: Aghion and Howitt (ECTA 92, MIT 98 & MIT 09), Howitt and Aghion (JEG 98), Nuno (JEG 11), Aghion, Akcigit and Howitt (AR 15), Cozzi, Pataracchia, Pfeiffer and Ratto (EER 2021), Cozzi (JMacro 23).
- + Many others: Piketty (HUP 14), ...

Ingredients of the Economic Model

- Incomplete Markets and exogenous Borrowing Constraint.
- Self-insurance through a riskless asset to smooth income fluctuations.
- Life-cycle.
- Ex-post Heterogeneity: Assets, Productivity, Longevity.
- Schumpeterian growth: intermediate goods with quality/efficiency that increases over time due to endogenous innovation.
- Production of intermediate goods is capital intensive: capital taxation affects its cost.

The Model

- A generalization of Huggett (JME 96) OLG model (age$=j$).
- The per-period utility function is defined over consumption c and leisure $l = (1-h)$: $u(c_j, l_j) = \frac{\left(c_j^{\eta} l_j^{1-\eta}\right)^{1-\sigma} - 1}{1-\sigma}$.
- In an extension (KPR) I use: $u(c_j, l_j) = \frac{\left[c_j\left(1-\psi h_j^{\theta}\right)\right]^{1-\sigma} - 1}{1-\sigma}$
- Agents face uninsurable idiosyncratic income risk and uncertain life spans (π_j^d).
- Agents enter the economy at age 21, retire at 65, and live up to 101.
- The individual labor productivity ϵ follows a rich stochastic process.

Labor Market Risk

- This is what induces the ex-post heterogeneity within/between cohorts, and the demand for redistribution (incomplete markets).
- Exogenous Component: Income Profiles à-la Storesletten, Telmer and Yaron (JPE 04 & JME 04) and Guvenen (RED 09).

$$\begin{cases} \epsilon_{ij} = \alpha_i + \varepsilon_{ij} + \nu_{ij} \\ \varepsilon_{ij} = \rho_\varepsilon \varepsilon_{ij-1} + \eta_{ij} \\ \alpha_i \overset{iid}{\sim} N(0, \sigma_\alpha^2), \nu_{ij} \overset{iid}{\sim} N(0, \sigma_\nu^2), \eta_{ij} \overset{iid}{\sim} N(0, \sigma_\eta^2) \end{cases}$$

- Endogenous Component: Labor supply. Pre-tax labor earnings $= w * h_{ij} * \epsilon_{ij}$

Income Tax Scheme: Status quo Vs. Optimal

- The status quo income tax scheme is represented by a flexible specification estimated on US data. Taxable income y is total income.

$$\begin{cases} IncomeTaxes = \kappa_0 \left[y - \left(y^{-\kappa_1} + \kappa_2 \right)^{-1/\kappa_1} \right] \\ y = ra + wh\epsilon_{j,\varepsilon,\alpha} \end{cases}$$

- The optimal income tax scheme uses the same flexible specification, optimized to maximize welfare (ex-ante or social). Taxable income y_w is labor income while capital income is taxed separately (proportionally).

$$\begin{cases} IncomeTaxes = \kappa_0^* \left[y_w - \left(y_w^{-\kappa_1^*} + \kappa_2^* \right)^{-1/\kappa_1^*} \right] + \tau_k^* ra \\ y_w = wh\epsilon_{j,\varepsilon,\alpha} \end{cases}$$

- I keep the same set-up proposed by CKK 09.
- I use different (better) numerical methods to find the $\kappa_0^*, \kappa_1^*, \tau_k^*$: pure discretization Vs. Nelder/Mead. κ_2 (or κ_2^*) balance the budget.

The OLG Model - Working-age Agents

$$V_j\left(a,\varepsilon,\alpha\right)=\max_{c,a',l}\left\{u(c,l)+\beta\left(1-\pi_j^d\right)\sum_{\varepsilon'}\pi\left(\varepsilon',\varepsilon\right)V_{j+1}\left(a',\varepsilon',\alpha\right)\right\}$$

$s.t.$

$$(1+\tau_c)c+a'=(1+r)\,a+wh\epsilon_{j,\varepsilon,\alpha}-Taxes+TR$$

$$a_0=0,\quad c\geq 0,\quad a'>-b,\quad l+h=1$$

$$Taxes=\kappa_0\left[y-\left(y^{-\kappa_1}+\kappa_2\right)^{-1/\kappa_1}\right]+\tau_R wh\epsilon_{j,\varepsilon,\alpha}$$

$$y=ra+wh\epsilon_{j,\varepsilon,\alpha}$$

The OLG Model - Retired Agents

$$V_j^R(a) = \max_{c,a'} \left\{ u(c,1) + \beta \left(1 - \pi_t^d\right) V_{j+1}^R(a') \right\}, j \geq J_R$$

$$s.t.$$

$$(1+\tau_c)c + a' = (1+r)\,a + y_R - Taxes + TR$$

$$c \geq 0, \quad a' > 0, \quad \epsilon_{j,\varepsilon,\alpha} = 0$$

$$Taxes = \kappa_0 \left[y - \left(y^{-\kappa_1} + \kappa_2 \right)^{-1/\kappa_1} \right]$$

$$y = ra + y_R$$

Schumpeterian growth

- Growth is driven by vertical innovations.
- Producers of final goods use labor and a continuum of intermediate goods M as inputs.
- The intermediate goods differ in their productivity $A_{i,t}$.
- Each of them is produced by a monopolistic firm using capital as an input.
- Entrepreneurs borrow resources and invest in R&D trying to increase their chance (i.e., probability) of displacing the current monopolist.
- A discovery in sector i due to R&D enhances $A_{i,t}$.

Final Good Sector

- The homogeneous final good is produced under perfect competition using labor and a continuum of intermediate products.

$$Y_t = F(L_t, A_{i,t}, M_{i,t}) = L_t^{1-\alpha} \int_0^{\mu} A_{i,t} M_{i,t}^{\alpha} di.$$

- Profit maximization leads to a system of demand equations $P_{i,t}$, one for each intermediate good variety:

$$P_{i,t} = \alpha A_{i,t} L_t^{1-\alpha} M_{i,t}^{\alpha-1}, \forall i.$$

- Another first-order condition delivers the labor demand schedule:

$$w_t = (1-\alpha) Y_t / L_t.$$

Intermediate Goods and Aggregation

- Each intermediate product i is produced by an incumbent monopolist using a capital-intensive production function:

$$M_{i,t} = K_{i,t}/A_{i,t}.$$

- Each incumbent monopolist solves the following (after-tax) profit maximization problem:

$$(1-\tau_f)\pi^f_{i,t} = (1-\tau_f)[P_{i,t}M_{i,t} - (r_t+\delta)K_{i,t}].$$

- In equilibrium, the final good market displays the familiar Cobb-Douglas aggregate production function in capital, labor and (endogenous) technological progress:

$$Y_t = F(L_t, A_t, K_t/A_t) = K_t^{\alpha}(A_t L_t)^{1-\alpha}.$$

Innovation and Technological Change

- At any date there is a technology frontier that represents the most advanced technology across all sectors: $A_t^{max} = \underset{i}{Max} A_{i,t}$
- In each period there is an endogenous probability $p_{i,t}$ that the productivity $A_{i,t}$ of an intermediate good in sector i jumps to the technology frontier $\rightarrow A_{i,t+1} = A_t^{max}$
- Entrepreneurs invest resources in R&D activities ($RD_{i,t}$) in an attempt to increase $p_{i,t} = 1 - exp\left\{-\frac{RD_{i,t}}{\lambda A_t^{max}}\right\}$.
- If a discovery occurs, they replace the current incumbent becoming the new monopolist (until another entrepreneur will create an even better version).

Entrepreneurs

- There is a measure μ of risk neutral entrepreneurs.
- They borrow the resources needed to finance the R&D from a competitive banking sector, maximizing the expected discounted value of becoming an incumbent in sector i in the next period:

$$\underset{RD_{i,t}}{Max} - RD_{i,t} + \left(\frac{p_{i,t}\left(RD_{i,t}\right)}{1+r_t} \right) E_t V_{i,t+1}(A_t^{max})$$

- $V_{i,t}(\overline{A})$ is the discounted flow of profits that the incumbent is expected to obtain and satisfies the following Bellman equation:

$$V_{i,t}(\overline{A}) = \underset{M_{i,t}}{Max}(1-\tau_f)\pi_{i,t}^f + \left(\frac{1-p_{i,t}}{1+r_t} \right) V_{i,t+1}(\overline{A})$$

- $\overline{A}$ is the (fixed) quality of the intermediate it managed to develop and creative destruction is internalized by $1-p_{i,t}$.

(Endogenous) Growth Rate

- The growth of the technology frontier A_t^{max} is the mechanism that drives the aggregate economic growth.
- Innovations induce knowledge spillovers, because at any point in time the technology frontier is available to any successful innovator.
- This publicly available knowledge grows at a rate proportional to the aggregate rate of innovations, and each innovation moves the technology frontier by a factor $1+\gamma$.
- A law of large numbers guarantees that the average productivity will evolve according to ($\rho \equiv \frac{RD_{i,t}}{\lambda A_t^{max}}$):

$$A_{t+1} = \int_0^{\mu} p(\rho)(1+\gamma) A_{i,t} + [1-p(\rho)] A_{i,t} di = [1+p(\rho)\gamma] A_t$$

- The growth rate along a BGP g is determined as:

$$g = \frac{A_{t+1}}{A_t} - 1 = p(\rho)\gamma$$

Calibration - US (under current Tax Regime)

Parameter	*Bench*	*KPR*	*Target*
Model Period	*Yearly*	*Yearly*	
β - *Discount factor*	1.012	1.008	*Interest rate* $= 5\%$
σ - *Risk Aversion*	3.80	2.00	*IES estimates of* 0.5
η - *Consumption share*	0.357	-	*Work time* $= 1/3$
ψ - *Work Disutility*	-	8.90	*Work time* $= 1/3$
θ - *Convexity Work Disutil.*	-	3.45	*Frisch elasticity* $= 0.5$
γ - *Spillover Effect*	0.20	0.20	*Growth rate* $= 1.7\%$
λ - *R&D Efficiency*	29.6	29.6	*Firms exit rate* $= 9.0\%$
τ_f - *Profits Tax Rate*	0.12	0.12	*Profit Taxes/GDP* $= 2.8\%$

Table: Calibration in Equilibrium - US

Calibration - US (under current Tax Regime)

Parameter	*Bench*	*KPR*	*Target*
σ_y^2 - *Var. temp. income shocks*	0.015	0.015	*Guvenen '09*
ρ_y - *Persist. temp. income shocks*	0.988	0.988	*Guvenen '09*
σ_f^2 - *Var. fixed effect*	0.058	0.058	*Guvenen '09*
δ - *Capital deprec.*	0.049	0.049	*PWT9.0*
α - *1-Labor share*	0.31	0.31	*Labor share of GDP*
$(\overline{G/Y})$ - *Gov. expenditure*	0.17	0.17	$G/GDP = 17\%$
τ_c - *Consumption tax rate*	0.05	0.05	*Mendoza et al. '94*
κ_0 - *Marginal Income Tax*	0.258	0.258	*Gouveia-Strauss '94*
κ_1 - *Progress. Income Tax*	0.768	0.768	*Gouveia-Strauss '94*
μ - *entrep. measure*	0.133	0.133	$Entrep/LF = 12\%$
g_n - *pop. growth*	0.011	0.011	$1970 - 2010$ *average*
π_j^d - *death prob.*	-	-	*Bell-Miller '02*

Table: Calibration Fixed Parameters - US

Results - Tax Schedules and Welfare changes

Case	κ_0	κ_1	τ_k	*CEV* (%)
Status quo	0.258	0.768	—	—
Fixed G	0.237	6.734	0.0000006	4.821
Fixed G/Y	0.285	7.891	0.0008659	4.761
KPR	0.287	7.929	0.0023872	5.795
CKK 09	0.23	7.0	0.36	1.330

Table: Tax Schedules Parameters and Welfare changes from Status quo to Optimal tax schedule

Results - Income Tax Functions: Status quo Vs. Optimal

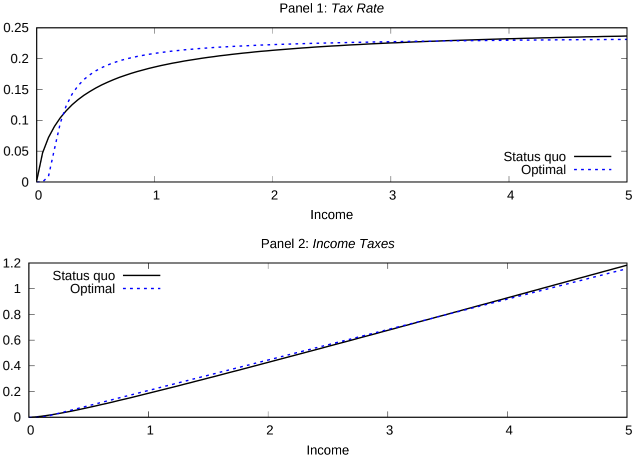


Figure: Tax Functions. Status quo Gouveia/Strauss Estimates Vs. Optimal Schedule (dashed).

Results - Cross Sectional Profiles

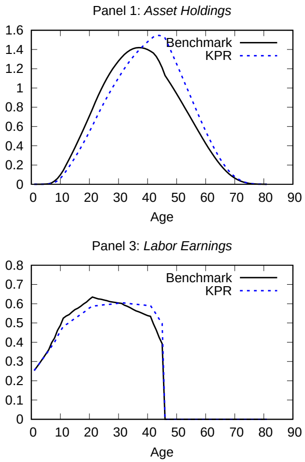


Figure: Average Cross Sectional profiles of Asset Holdings, Consumption, Hours Worked, and Labor Earnings. Benchmark model and KPR specifications (dashed).

Results - Equilibrium Aggregate Effects of Capital Taxes

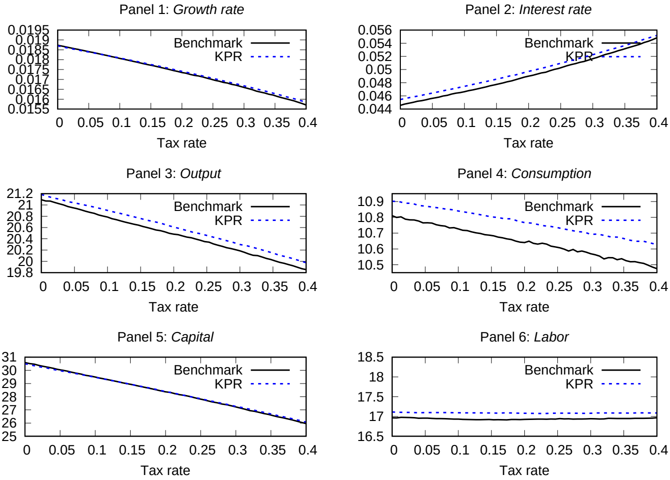


Figure: Growth Rate, Interest Rate, Output, Capital, Consumption and Labor equilibrium responses to changes in the capital tax rate. Benchmark model and KPR specifications (dashed).

Conclusions

- Contrary to some recent contributions, I find that capital income should not be taxed heavily.
- The detrimental effects on the growth rate more than offset the redistribution benefits arising from taxing wealthy (ex-post) individuals.
- Current work: some progress in modeling Wealthy/Risk averse entrepreneurs.

What is not there

- Joint taxation of couples (household head is the unit of analysis). $\rightarrow$ I'm thinking about it (comparability with CKK).
- Progressive Capital taxation. $\rightarrow$ Given the results, I don't think it would make any difference.
- Public debt (but other transfers are implicitly there).

Higher Corporate Taxes?

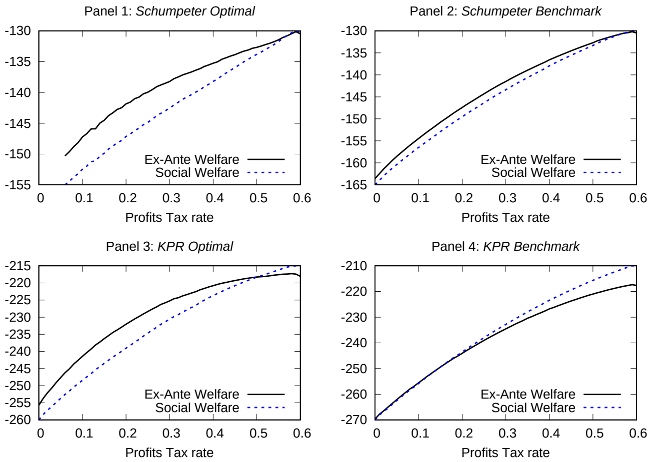


Figure: Ex-ante Welfare and Social Welfare responses to changes in the corporate tax rate. Benchmark model and KPR specifications.

Higher Consumption Taxes?

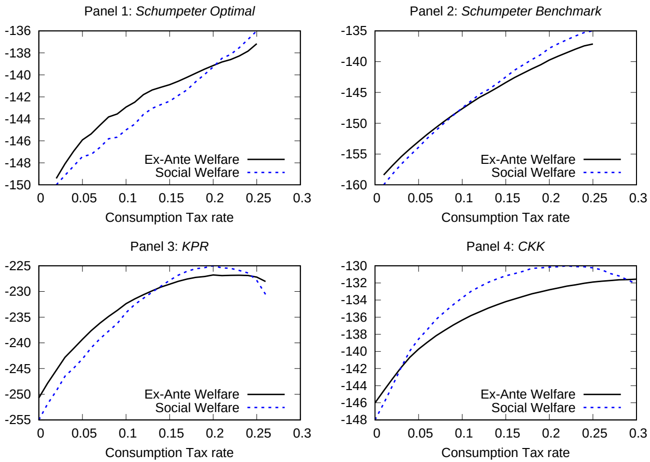


Figure: Ex-ante Welfare and Social Welfare responses to changes in the consumption tax rate. Benchmark model, KPR and CKK specifications.

Results - Income Tax Functions: Status quo Vs. Optimal

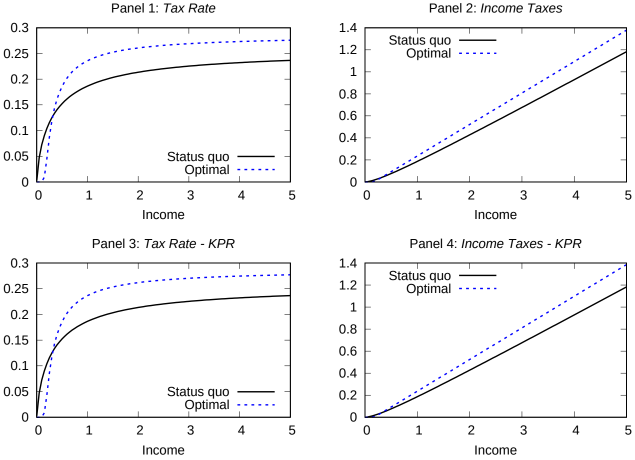


Figure: Tax Functions. Status quo Gouveia/Strauss Estimates Vs. Optimal Schedule (dashed).

Results - Life-cycle Profiles

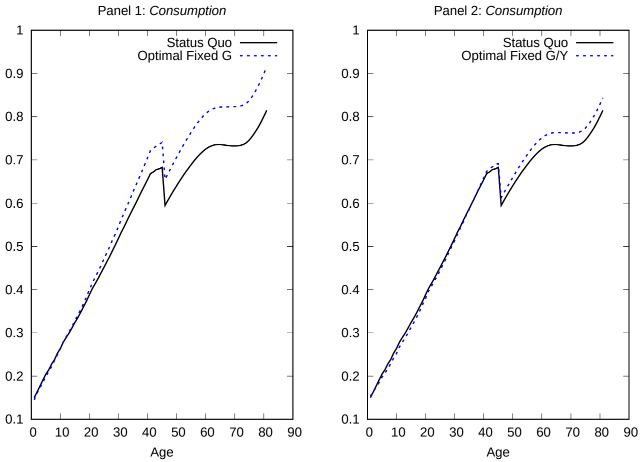


Figure: Average Life-cycle profiles of Consumption. Benchmark model and non constant G (dashed).

Results - Pre-tax Earnings Inequality: Model Vs. PSID

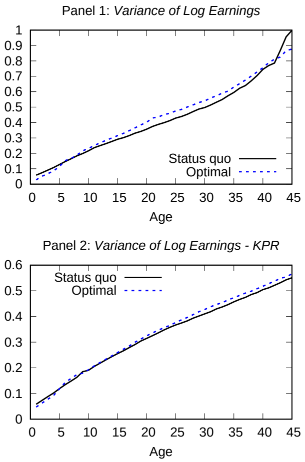
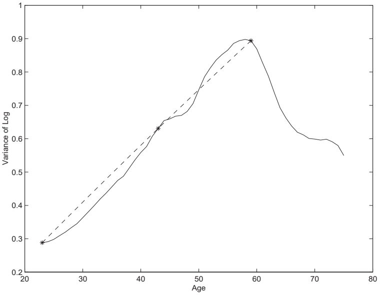


Figure: Optimal (dashed).

Figure 2
Calibration of Earnings Process



The solid line is the cross-sectional variance of earnings, based upon PSID data, and is taken directly from Figure 1. The dashed line represents the population cross-sectional variances associated with the process formulated in Section 2.1, with parameter values chosen to best match the level (*i.e.*, the intercept), the slope and the curvature of the empirical age profile. The resulting parameter values (discussed in Section 2.1) are $\sigma_\alpha^2 + \sigma_\varepsilon^2 = 0.2735$, $\sigma_\eta^2 = 0.0166$ and $\rho = 0.9989$. The asterisks represent the three sample variances which this informal calibration explicitly matches.

Figure: PSID (Storesletten et al. JME '04).

Results - Capital Taxation and Welfare

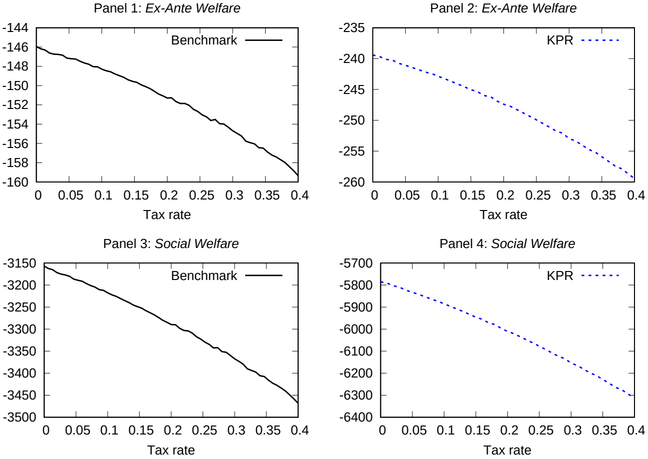


Figure: Ex-ante Welfare and Social Welfare responses to changes in the capital tax rate. Benchmark model and KPR specifications (dashed).