Optimal Taxation
Under Capital-Skill Complementarity

Ctirad Slavík, CERGE-EI, Prague

(with Hakki Yazici, Sabanci University and Özlem Kina, EUI)

January 4, 2019

ASSA in Atlanta
Optimal capital income taxation papers: Elasticity of substitution between capital and different labor types identical.

But empirical evidence suggests different types of labor have different elasticity of substitution with capital:


CSC not taken into account by (most) optimal tax papers.

This paper fills this gap: Calculates optimal capital (and labor) income taxes in a rich quantititative environment with CSC.
Motivation

This paper bridges two literatures:

1. Large quantitative optimal Ramsey tax literature: Domeij-Heathcote (2004), CKK (2009) ...

2. Smaller optimal tax literature with CSC (not rich dynamic quantitative environments):


Calculate optimal taxes in quant. macro model with CSC.

Compare to model with a standard Cobb-Douglas p.f.

Shows that CSC **quantitatively** important for optimal $\tau_k$:

Optimal capital taxes and welfare gains with CSC much larger.

**Intuition:**

1. Capital tax↑⇒ lump-sum transfer↑ and/or labor tax↓.
2. With CSC: Capital accumulation↓⇒ skill premium↓⇒ costs borne relatively more by skilled agents who are richer, indirect redistribution from skilled to unskilled.
Rest of the Talk

- Environment.
- Quantitative results.
- Conclusion.
Environment
The Two Models

∞ horizon heterogeneous agent incomplete market models, Aiyagari (1994):

- Government, measure 1 of workers and a firm.
- 2 types of labor: skilled and unskilled.

1 Model 1 **without** complementarity: One type of capital.

2 Model 2 **with** complementarity: 2 types of capital; equipments and structures and equipment capital-skill complementarity.
Production Sector

1. \( F(K, L_s, L_u) = A \cdot K^\theta (\mu L_s + L_u)^{1-\theta}, \)

   \( A \) is TFP and \( \mu \) controls (is) the skill premium.

2. \( F(K_s, K_e, L_s, L_u) = K_s^\alpha \left( \nu \left[ \omega K_e^\rho + (1 - \omega) L_s^\rho \right]^{\eta \rho} + (1 - \nu) L_u^{\eta \rho} \right)^{\frac{1-\alpha}{\eta}}, \)

   (equipment) capital-skill complementarity:

   \[ \frac{MPL_s}{MPL_u} \]

   increasing in \( K_e \) (independent of \( K_s \)).

Repre firm hires labor, rents capital to maximize profits \( \forall t \).
Spends $G$, pays out lump-sum transfer (tax) $T$.

Linear capital income taxes $\tau_k$ and linear labor tax $\tau_n$.

Gvt BC:

1. $T + G = \tau_k (r - \delta) K + \tau_n (w_u L_u + w_s L_s)$,

2. $T + G = \tau_k [(r_e - \delta_e) K_e + (r_s - \delta_s) K_s] + \tau_n (w_u L_u + w_s L_s)$.

Ramsey optimal tax problem:

Choose taxes (transfers) to maximize average utility in steady state and finance a fixed $G/Y$. 
Agents

- Agents either skilled or unskilled, $\pi_i$ fraction of skill type $i$.
- Each period agents draw *idiosyncratic* productivity shock $z$.
- The process for $z$ is skill-type specific.
- Agent of skill type $i$ and productivity $z$ receives a wage rate $w_i \cdot z$ per unit of time, with $w_i = MPL_i$.
- Preferences over stochastic $(c_t, l_t)_{t=0}^{\infty}$ are given by

$$E_i \left[ \sum_{t=0}^{\infty} \beta^t u(c_t, l_t) \right].$$
Agent’s Problem

In a stationary equilibrium:

$$v_i(z, a) = \max_{(c, l, a') \geq 0} u(c, l) + \beta E_i[v_i(z', a')]$$

s.t.

$$c + a' \leq (1 - \tau_n)w_i z l + Ra + T,$$

where $R$ is the after-tax asset return.
Quantitative Analysis
Overview:

- Calibrate parameters of the two model economies in SRCE to the U.S. economy so that they are comparable.

- Calculate steady-state optimal taxes under various scenarios:
  1. Optimal $\tau_k, \tau_n, T$.
  2. Time permitting: Additional quant exercises.

- Compare optimal taxes, macroeconomic quantities, welfare gains and distributional consequences.
Parameterizations (calibrations) to make models comparable:

\[(2) \quad K_s^\alpha \left( \nu \left[ \omega K_e^\rho + (1 - \omega)L_s^\rho \right]^{\eta \rho} + (1 - \nu)L_u^\eta \right)^{\frac{1-\alpha}{\eta}}\]

Use \(\alpha, \eta, \rho, \delta_s, \delta_e\) from KORV.
Calibrate \(\omega\) and \(\nu\) s.t. skill premium = 1.9, labor share = 2/3.

\[(1) \quad A \cdot K^\theta (\mu N_s + N_u)^{1-\theta}\]

\(\mu = 1.9,\) labor share \(1 - \theta = 2/3,\) \(A\) calibrated so that \(Y_1 = Y_2,\) \(\delta = 0.09\) (average of economy 2).
Agents

**Comparable** in the two models:

- Cobb-Douglas utility function:

\[
    u(c, l) = \frac{\left[ c^\phi (1 - l)^{(1-\phi)} \right]^{\frac{1-\sigma}{\phi}}}{1-\sigma} - 1.
\]

- In benchmark, use \( \sigma = 2 \), and calibrate \( \beta \) and \( \phi \) s.t. average labor supply = 1/3 and \( K/Y = 3 \).

- \( \pi_s = 31.69\% \) (CPS 2010, males aged 25-60, with earnings).

- Type specific skill processes as in Krueger, Ludwig (2013).
**Identical** in the two models:

- $\tau_n = 0.28, \tau_k = 0.36$ as in Trabandt, Uhlig (2011).

- Govt. expenditure $G/Y = 0.16$ (NIPA).
All Gvt Policies Allowed to Change

<table>
<thead>
<tr>
<th></th>
<th>Calibrated Cobb-Douglas</th>
<th>Optimal Cobb-Douglas</th>
<th>Calibrated Complementarity</th>
<th>Optimal Complementarity</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\tau_k$</td>
<td>0.36</td>
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<td>0.36</td>
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<tr>
<td>$\tau_n$</td>
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<td>0.38</td>
<td>0.28</td>
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<tr>
<td>lump-sum transfer</td>
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<td>0.0230</td>
<td>0.0105</td>
<td>0.0249</td>
</tr>
<tr>
<td>$w_s$</td>
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<td>0.54</td>
</tr>
<tr>
<td>$w_u$</td>
<td>0.3144</td>
<td>0.3074</td>
<td>0.3144</td>
<td>0.3107</td>
</tr>
<tr>
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<td>1.90</td>
<td>1.90</td>
<td>1.75</td>
</tr>
<tr>
<td>total welfare gains</td>
<td>1.41%</td>
<td></td>
<td></td>
<td>2.56%</td>
</tr>
<tr>
<td>unskilled gains</td>
<td>2.96%</td>
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<td></td>
<td>6.18%</td>
</tr>
<tr>
<td>skilled gains</td>
<td>-3.47%</td>
<td></td>
<td></td>
<td>-9.04%</td>
</tr>
</tbody>
</table>
Optimal Policy

- $\tau_k, \tau_n$ as well as transfers suboptimally low (more redistribution optimal, as in CKK, 2009, and others).

- Optimal $\tau_k$ and transfer much larger with CSC. Why?

  Costs of $\tau_k \uparrow$ mostly borne by the richer skilled.
  Skilled wages decline more; indirect redistribution.

- Aiyagari (1995) condition satisfied with CD, not with CSC.
Welfare Gains

- Larger with CSC. $w_u$ decline less and transfers increase more than with Cobb-Douglas.

- Lump-sum transfer critical for w.g. (but not for capital being taxed more with CSC). Contrast to HSV tax function.

- Costly for unskilled if gvt ignores CSC.

- Welfare gains lower bound.
Distributional Consequences

With CSC at the optimal allocation:

- Wage inequality ↓ since skill premium ↓.
- Critical role of lump-sum transfer ↑:
  1. Earnings inequality ↑, unproductive work less.
  2. Asset inequality ↑, poor do not need self-insurance.
Role of wealth inequality: Benchmark model does not match wealth inequality within and across skill types.

3 exercises:

1. Match $A_s/A_u$ by calibrating $\beta_s, \beta_u$ separately. Results ‘magnified’.

2. Use CDR income process. Huge welfare gains due to lump-sum transfer. CSC still quantitatively important.

3. Combine both. Inherits features of both.
**Additional Results**

- **Government debt:**
  1. Set $B/Y = 0.32$ as U.S. domestically, privately held debt.
  2. Keep $B/Y$ constant at the optimal tax policy.
  3. Results not affected much.

- **Optimal skill dependent $\tau_n$:**
  1. Large unskilled welfare gains from type-dependent $\tau_n$.
  2. Gvt still uses indirect redistribution: $\tau_k$ larger with CSC.
Current and Future Work

1. Hold $G$ rather than $G/Y$ constant.
2. Take transition into account.
3. Nonlinear $\tau_n$.
4. Allow skill types to be endogeneous.
5. Allow for multiple skill types.
6. Optimal gvt debt with and without CSC.
Capital-skill complementarity calls for substantially larger capital taxes, in benchmark 12 percentage points.

Welfare gains almost twice as large.

Findings at odds with recent capital-tax cuts in the U.S.
Additional Slides
**Definition:** Stationary Recursive Competitive Equilibrium (SRCE) are value functions $v_u, v_s$, policy functions $c_u, c_s, l_u, l_s, a'_u, a'_s$, firm’s decision rules $K(K_s, K_e), L_u, L_s$, government policies, distribution of types $\lambda_u(z, a), \lambda_s(z, a)$ and prices $w_u, w_s, r(r_s, r_e)$ s.t.

1. The value and policy functions solve consumers’ problem given prices and government policies for all $i \in \{u, s\}$.
2. The firm maximizes profits.
3. The distribution over productivities and assets is stationary.
   
   (i) $C + G + K' = F(K, L_s, L_u) + (1 - \delta)K$
   
   (i) $C + G + K'_s + K'_e = F(K_s, K_e, L_s, L_u) + (1 - \delta_s)K_s + (1 - \delta_e)K_e$

5. Government BC is satisfied.
Find $\tau_k, \tau_n, T$ s.t. the associated steady state maximizes a utilitarian social welfare function:

$$
\max W = \max \pi_s \int_A \int_{Z_s} \nu_s(a, z_s) d\lambda_s(a, z_s) + \pi_u \int_A \int_{Z_u} \nu_u(a, z_u) d\lambda_s(a, z_u)
$$

s.t. the allocation is the corresponding SRCE allocation (given $G/Y$).

Numerical implementation: Grid search.
## Skills

### Table: Skill Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Value</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative supply of skilled workers</td>
<td>$p_s/p_u$</td>
<td>0.778</td>
<td>U.S. Census</td>
</tr>
<tr>
<td>Skill persistence skilled workers</td>
<td>$\rho_s$</td>
<td>0.9408</td>
<td>KL</td>
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<tr>
<td>Skill volatility skilled workers</td>
<td>$\text{var}(\varepsilon_s)$</td>
<td>0.1000</td>
<td>KL</td>
</tr>
<tr>
<td>Skill persistence unskilled workers</td>
<td>$\rho_u$</td>
<td>0.8713</td>
<td>KL</td>
</tr>
<tr>
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<td>$\text{var}(\varepsilon_u)$</td>
<td>0.1920</td>
<td>KL</td>
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With fixed transfers, welfare gains smaller, but still much larger with CSC than with Cobb-Douglas.

Optimal capital tax much larger with CSC allowing $\tau_n$ to decline, which is good for poor people.
Fixing labor tax, but allowing lump-sum transfers to adjust confirms the importance of lump-sum transfers.

τ_k of 70% still to the left of the peak of the Laffer curve; unlike in Trabandt and Uhlig (2011), where the peak is at 62% - 63%.
Naïve Government

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<td>-9.04%</td>
<td>-6.82%</td>
</tr>
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- Naive gvt: Reduces total welfare gains by 0.16% by reducing welfare gains to unskilled by 0.95%. Welfare losses of skilled ↓ by 2.45%