A Ramsey Theory of Financial Distortions

Wei Cui (UCL) **Marco Bassetto** (Minneapolis Fed)[1]

July, 2020

[1] This paper reflects the views of the authors and not necessarily those of the Federal Reserve Bank of Minneapolis or the Federal Reserve System.

Intertemporal Distortions

- Capital taxes are used throughout the world
- $r < g$ frequently for government bonds with shortage of these safe/liquid assets
- Low rates of return in years following fiscal shocks
  - Reinhart & Sbrancia (2015) (financial repression)
  - Berndt, Lustig, & Yeltekin (2012)

Are capital taxes and low interest rates on debt optimal?

- Not in a Ramsey problem with a neoclassical growth economy.
  - with distortionary taxes on labor and capital.
- Not optimal to distort the intertemporal margin
  - Long run: neither capital tax nor low rates on government debt (Judd, 1985, Chamley, 1986). Rely on labor alone in the long run.
  - Fiscal shocks: absorbed by quick devaluation and immediate low return (Lucas - Stokey, 1983, and Siu, 2004,...);
  - or, by future taxes, smoothed by debt (Barro, 1979, and AMSS, 2002).
- Our view: optimal policy with imperfect substitutes between public and private liquidity
  - *Idiosyncratic investment risks + liquidity frictions in financing investment*
  - partially liquid private claims;
  - fully liquid government debt (but costly in terms of distortionary taxes)

Optimal financial distortions: Results

- Two-period model - if public liquidity is insufficient, we have a trade-off
  - want to subsidize investment which is underprovided
  - but credit frictions make the capital supply inelastic; optimal to tax it when gov budget is tight
- Infinite-horizon model - provide as much public liquidity as possible:
  - either attain unconstrained solution (sufficient self-financing), standard Ramsey, zero capital taxes
  - or, get to the "top of the Laffer curve:'
    - shortage of safe/liquid assets remains
    - low interest rates
    - positive capital taxes
- Our model can be related to broader financial distortion policies.
  - capital controls / banking regulation / collateralized borrowing requirements...

Part 1: The two-period model

- Periods 1 and 2
- A continuum of families, with preferences:

$$\sum_{t=1}^{2} \beta^{t-1} \left[u(c_t) - v\left((1-\chi)\ell_t\right)\right] \tag{1}$$

  - only in period 1: workers (population $1-\chi$) and entrepreneurs (population χ)
  - reunite at the end of period 1 and period 2
- Firms
- Government (with legacy debt B_0)

An entrepreneur of a family in period 1

- An entrepreneur with (exogenous) government debt $b_0^e = B_0^e/\chi$ finances k_1^e

$$k_1^e \leq b_0^e + q_1 s_1^e \tag{2}$$

- ...financial claims s_1^e sold at price q_1; s_1^e less than ϕ_1 units of investment k_1^e:

$$s_1^e \leq \phi_1 k_1^e \tag{3}$$

A worker of a family in period 1

- Each worker begins with government bonds $b_0^w = B_0^w/(1-\chi)$
  - works and earns $w_1\ell_1$;
  - buys government bonds and financial claims.
- At the end of period 1:
  - workers rejoin entrepreneurs and pool assets together

$$c_1 + B_1 + \chi(k_1^e - q_1 s_1^e) + (1-\chi)q_1 s_1^w = (1-\tau_1^\ell)w_1\ell_1(1-\chi) + B_0 \qquad (4)$$

  - government bonds $B_1 = (1-\chi)b_1^w$; capital $K_1 = \chi(k_1^e - s_1^e) + (1-\chi)s_1^w$

The family in period 2

- Capital return r_2 and wage rate w_2
- The budget constraint:

$$c_2 = (1-\tau_2^k) r_2 K_1 + (1-\tau_2^\ell) w_2 (1-\chi) \ell_2 + R_1 B_1 \tag{5}$$

- The HH maximizes utility in (1)
  - budget constraints in period 1 and period 2
  - financing constraints in period 1

Firms

- Goods produced by competitive firms
- Period 1: $w_1 = A$
$$Y_1 = AL_1$$
  $L_1 = (1-\chi)\ell_1$: hours from workers
- Period 2: $w_2 = F_L(K_1, L_2)$, $r_2 = F_K(K_1, L_2)$, and
$$Y_2 = F(K_1, L_2)$$
  $L_2 = (1-\chi)\ell_2$: hours from workers

Government

- Benevolent (same objective as households)
- Exogenous spending G_1 and G_2
  - Taxes labor at rate τ_1^ℓ and τ_2^ℓ and capital at rate τ_2^k
  - Issues bonds B_1 in period 1 (interest rate rate R_1)
- Period 1:

$$G_1 + R_0 B_0 = B_1 + \tau_1^\ell w_1 L_1$$

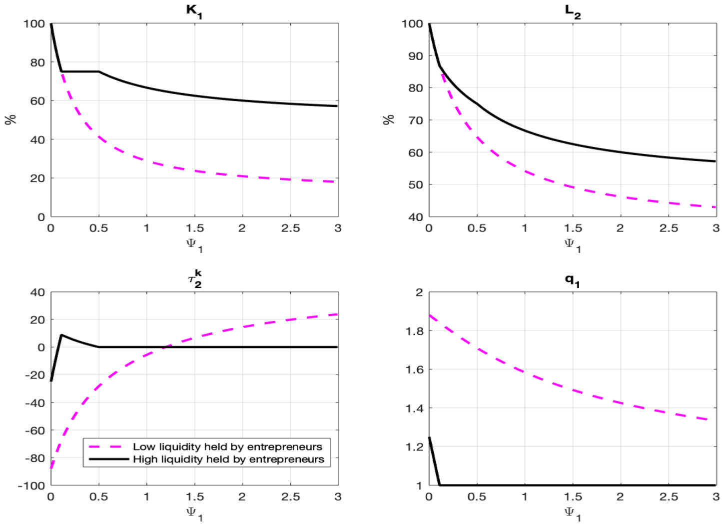
- Period 2:

$$G_2 + R_1 B_1 = \tau_2^k r_2 K_1 + \tau_2^\ell w_2 L_2$$

- Solution strategy:
  - Compute optimal competitive-equilibrium allocation (primal approach);
  - back out taxes and prices.

To be or not to be (financing constrained)?

Ψ_1: shadow cost of government revenue; quasi-linear utility example



Part 2: The ∞-horizon model

- Idiosyncratic investment risks repeated many times
- Financing constraints tied to endogenous asset liquidity and price
  - (ϕ_t, q_t) pairs determined through directed search
  - avoid kinks but does not matter for the fundamentals
  - other good co-movement properties between ϕ_t and q_t; see Cui & Radde (2016, 2019) and Cui (2016)
- The planner chooses $\{C_t, L_t, K_t, B_t, \phi_t\}$ for $t \geq 0$ given K_{-1} and B_{-1}
  - deterministic model: as if with (aggregate) state-contingent bonds
- New results (compared to the 2-period model)
  - low rates and capital tax
  - may not be able to provide enough liquidity

The "best" competitive equilibrium

- Private FOC for bonds:

$$1 = \frac{\beta u'(C_{t+1})}{u'(C_t)} R_{t+1} (1 + \chi \rho_{t+1})$$

  - $u'(C_t)\chi\rho_t > 0$ measures tightness of financing constraint
  - reflects the liquidity service provided by government debt.

- Note: asset price q_t and ρ_t are functions of ϕ_t
- Public FOC for bonds:

$$\Psi_{t+1} = (1 + \chi \rho_{t+1})\Psi_t + \chi \gamma_{t+1}$$

Ψ_t: shadow cost of government revenue (measures gov't budget tightness)
γ_t: shadow cost of financing constraints

Long-run result

Proposition

If the economy converges to a steady state, there are two possibilities.

(1). Slack financing constraints in the limit, capital tax $\tau^k = 0$, and the interest rate $R = 1/\beta$. Tightness Ψ_t and converges to finite constant.

(2). Financing constraints bind in the limit, budget tightness $\Psi_t \to \infty$, $R < 1/\beta$, and $\tau^k \neq 0$. Sufficient conditions for $\tau^k > 0$:
(1). $u(c) = c$; (2). β close to 1 □

- *The key FOC for bonds shows Ψ_t is non-decreasing:*

$$\Psi_{t+1} = (1 + \chi\rho_{t+1})\Psi_t + \chi\gamma_{t+1}$$

- The growth rate of Ψ_t reflects supply of government debt. Make budget tighter and tighter; when to stop?
    - liquidity is satiated
    - top of the Laffer curve with low rate and capital tax

Conclusion

- Financial distortions can be optimal
  - A new trade-off: the tightness of government budget and the tightness of financing constraint
- If provision of public liquidity cannot undo financing constraint, then it provides a reason to tax capital and run low interest rate:
  - a wedge between returns
  - distorting the inter-temporal margin (different from secular stagnation)
  - endogenous capital price important: bond in the utility / capital adjustment cost is not enough
- ... more to come with the ∞-horizon model
  - response to adverse MIT shocks: more debt issuance in the short run
  - aggregate risks can generate a finite Ψ and low rates: government debt not aggregate-state contingent as in AMSS (2002)

Thank You!

Literature

- *Liquidity frictions: Woodford (1990); Holmstrom - Tirole (1998); Kiyotaki - Moore (2012); Shi (2015); Cui - Radde (2016, 2019)...*
- *Ramsey plans* under various asset market structures: Lucas - Stokey (1983); Chari - Kehoe (1999), Aiyagari et.al. (2002), Farhi (2010), Chien - Wen (2019)...
- *Optimal public supply of liquidity*: Angeletos et.al. (2013), Azzimonti - Yared (2017, 2019)...
- Our paper: why government will distort the inter-temporal margin with capital taxes/subsidies
  - government debt is chosen not to fully insure idiosyncratic risks

Eqm conditions

- Labor supply: for $t = 1, 2$

$$(1 - \tau_t^{\ell}) w_t u'(C_t) = v'(L_t) \tag{6}$$

- Demand for bonds

$$\frac{1}{R_1} = \frac{\beta u'(C_2)}{u'(C_1)} \tag{7}$$

- Demand for claims and supply for claims:

$$q_1 = \frac{\beta u'(C_2)}{u'(C_1)} (1 - \tau_2^k) r_2 \tag{8}$$

$$q_1 = \max\left\{1, \frac{K_1 - B_0^e}{\phi_1 K_1}\right\} \tag{9}$$

using $(1 - \phi_1 q_1) K_1 \leq B_0^e$

- Feasibility

$$AL_1 = C_1 + K_1 + G_1 \tag{10}$$

$$F(K_1, L_2) = C_2 + G_2 \tag{11}$$

The primal approach

- The planner maximizes welfare (1), subj. to
  - feasibility constraints (10) and (11);
  - implementability constraint (financing-constrained adjusted)
- Maximum level of investment when $q_1 = 1$ (slack financing constraint)

$$K^* := \frac{B_0^e}{1-\phi_1}$$

- The implementability constraint:

$$\sum_{t=1}^{2} \beta^{t-1}[u'(C_t)C_t - v'(L_t)L_t] - u'(C_1)B_0$$
$$= \begin{cases} 0 & \text{if } K_1 \leq K^* \\ \left(\frac{1}{\phi_1} - 1\right) u'(C_1)(K_1 - K^*) & \text{if } K_1 > K^* \end{cases}$$

- What happen when the asset market is fully liquid ($\phi_1 = 1$)?

An analytical case

- Production: $F(K_1, L_2) = AK_1^{\alpha} L_2^{1-\alpha} + (1-\delta)K_1$. Preferences (no interest rate effect)

$$u(c,\ell) = c - \frac{\mu \ell^{1+\nu}}{1+\nu}$$

- Ψ_1: multiplier w.r.t. the implementability constraint; measures legacy debt B_0 (or, PV of gov spending)
- The planner's FOC:

$$\beta \left[A\alpha \left(\frac{K_1}{L_2} \right)^{\alpha-1} + 1 - \delta \right] = 1 + \begin{cases} 0 & \text{if } K_1 \leq K^* \\ \frac{\Psi_1(\phi_1^{-1}-1)}{1+\Psi_1} & \text{if } K_1 > K^* \end{cases}$$

- Recall the HH FOC:

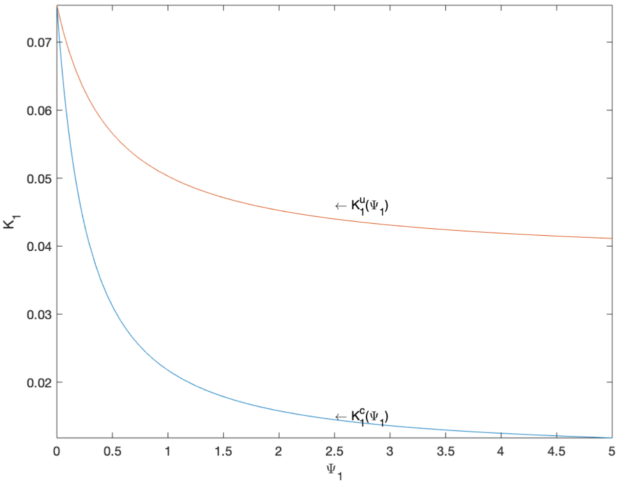
$$\beta(1-\tau_k^2) \left[A\alpha \left(\frac{K_1}{L_2} \right)^{\alpha-1} + 1 - \delta \right] = q_1$$

Government financing and individual financing constraint

- If financing constraint is slack, $\tau_k^2 = 0$, independent of Ψ_1 (e.g., $\phi_1 = 1$)
  - private cost: 1; private rewards βr_2
  - social cost: $1 + \Psi_1$; the social reward: $\beta r_2 (1 + \Psi_1)$
  - reward / cost are the same (only related to technologies)
- If financing constraint is binding, $\tau_k^2 \neq 0$, interacting with Ψ_1
  - the private return needs to be adjusted by financing constraint
- Subsidy initially when government financing is flexible, but tax later (the quasi-rent)
  - a higher q_1 tightens the implementability constraint, raising Ψ_1
  - thus, using more distortionary taxes, affecting investment and q_1 again

To be (financing constrained) or not to be

$$\beta = 0.96,\ \phi = 0.5,\ \delta = 0.95,\ \text{and}\ A = 1$$



Households

- Preferences:

$$\sum_{t=0}^{\infty} \beta^t \left[u(c_t) - v((1-\chi)\ell_t)\right] \tag{12}$$

- $\forall t$, liquidity held by entrepreneurs $b_t^e = \chi B_t$
- The financing constraint

$$(1-\phi_t q_t)k_t^e \leq R_t b_{t-1} + \phi_t q_t (1-\delta) k_{t-1}$$

- The budget constraint

$$\begin{aligned} c_t + b_t + q_t^S k_t = & (1-\tau_t^\ell) w_t (1-\chi)\ell_t + R_t b_{t-1} + (1-\tau_t^k) r_t k_{t-1} \\ & + \left[q_t^S - \chi \phi_t \left(q_t^S - q_t\right)\right](1-\delta)k_{t-1} \\ & + \left[q_t^S - 1 - \phi_t \left(q_t^S - q_t\right)\right]\chi k_t^e \end{aligned}$$

- $q_t^S \geq q_t$ because of financial intermediation

Goods and Financial Firms (optional)

- w_t and r_t are marginal products of labor and capital
- Competitive financial intermediaries: cost is $\eta(\phi_t)$ per unit of capital intermediated

$$q_t^S - q_t = \eta(\phi_t) \tag{13}$$

  - Search-and-matching to link ϕ_t and q_t
  - $\eta(\phi_t)$ is increasing and convex w.r.t. ϕ_t
- Think about paying cost for each asset orders processed
  - ϕ_t is also the probability to fill sell orders

Directed search / competitive search (optional)

- An entrepreneurs brings back: $k_t^e - s_t^e = (1-\phi_t)k_t^e$
- Therefore, the financing constraint (2) becomes

$$\underbrace{\frac{1-\phi_t q_t}{1-\phi_t}}_{\text{replacement cost}} \quad (k_t^e - s_t^e) \leq B_0^e/\chi$$

- Replacement cost is similar to down-payment
- Financial intermediaries open sub-markets (ϕ_t, q_t); search is directed with price posting

$$\min_{(\phi_t, q_t)} \frac{1-\phi_t q_t}{1-\phi_t}$$

  s.t. the zero-profit (13).
- The solution is

$$q_t = 1 + (1-\phi_t)\phi_t \eta'(\phi_t)$$

Permanent fiscal expansion

$\beta = 0.96$, $\delta = 0.1$, $\alpha = 1/3$, $\delta = 0.1$, $\nu = 1$, $\eta(\phi) = \eta_0 \phi^2$, $\mu = 1$
$u(c) = \frac{c^{1-\sigma}-1}{1-\sigma}$, $\sigma = 0.1$; G/Y is 36.7%

Table: Steady state of the Ramsey allocation for different government expenditures

	$G = G^*$	$G = 1.02G^*$	$G = 1.04G^*$	$G = 1.06G^*$
Capital: K	100%	103.33%	106.78%	110.49 %
Capital tax: τ^k	11.88%	11.40%	10.49%	9.15%
Labor tax: τ^ℓ	53.85%	53.84%	53.83%	53.77%
Interest rate:	4.17%	4.10%	3.90%	3.53%
Debt-to-output: B/Y	81.93%	66.20%	49.01%	29.49%
Asset Liquidity ϕ	0	0.0660	0.1337	0.2064

Permanent worsening financial conditions

Table: The long-run economies with different financial intermediation

	$\eta_0 = 0.2$	$\eta_0 = 0.4$	$\eta_0 = 0.8$	$\eta_0 = 1$
Capital: K	100%	99.94%	99.74%	99.50%
Capital tax: τ^k	11.21%	10.81%	9.58%	8.38%
Labor tax: τ^ℓ	53.85%	53.84%	53.82%	53.79%
Interest rate:	4.07%	3.94%	3.56%	3.18%
Debt-to-output: B/Y	62.20%	60.99%	57.12%	53.10%
Asset Liquidity ϕ	0.0821	0.0866	0.1006	0.1149

Inter-temporal substitution (optional)

Table: The long-run economies with different intertemporal substitution

	$\sigma = 0$	$\sigma = 0.2$	$\sigma = 0.8$	$\sigma = 1.0$
Capital: K	100%	98.81%	85.46%	76.64%
Capital tax: τ^k	11.48%%	12.35%	17.53%	21.37%
Labor tax: τ^ℓ	50.00%	57.61%	77.75%	83.39%
Interest rate:	4.17%	4.17%	4.17%	4.17%
Debt-to-output: B/Y	84.32%	79.18%	58.73%	51.58%
G-to-output: G/Y	33.10%	39.99%	61.10%	68.42%
Asset Liquidity ϕ	0	0	0	0