A Comparative Advantage Approach to Government Debt Maturity

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Introduction

- **How should the govt. manage the maturity structure of its debt?**
  - **Tax-smoothing** (Barro '79; Lucas and Stokey '83; Bohn '90): Want to smooth taxes over time since distortionary costs are convex in taxes
  - **Key theme**: If future interest rates are uncertain, debt should be long to insulate taxes from "refinancing risk"
- **Trade-off** view articulated by debt management practitioners:
  - Lawrence Summers: "I think the right theory is that one tries to [borrow] short to save money but not [so much as] to be imprudent with respect to rollover risk. Hence there is certain tolerance for [short term] debt but marginal debt once [total] debt goes up has to be more long term."
  - Postulated trade-off between "rollover risk" and "cheap" short-term debt
- Does this trade-off view make sense?
  - Doesn't make sense if "cheapness" is compensation for risk
  - This paper: Could make sense if consumers/investors value short-term "money-like" securities

Introduction

A Trade-off Model of Government Debt Maturity

- **Government:** Raises taxes and issues debt to finance a one-time expenditure (or an accumulated deficit)
  - Standard tax-smoothing motive due to convex distortionary costs
  - **New twist**: households derive greater monetary/liquidity services from short-term debt
- **Absent money demand**, govt. opts for longer-term debt
  - **Eliminates refinancing risk** (i.e., govt. needs to raise taxes when short rates rise) which enables govt. to **perfectly smooth taxes**
- **With money demand**, optimally **tilts towards short-term debt** and **incurs some refinancing risk**
  - **Central trade-off**: Govt. tries to satisfy money demand for short-term debt, but is limited by tax-smoothing costs of uncertain refinancing
- **Trade-offs appear to be reflected in U.S. government maturity choices over time**

Introduction

Adding Private-sector Money Creation

- Add **private-sector banks** who can also engage in money-creation
- **Banks want to issue short-term, safe debt because it is cheap**
  - Caballero & Krishnamurthy '08: Responding to a global shortage, US financial sector tried to manufacture "riskless" assets pre-crisis
  - Gorton '10, Gorton & Metrick '09: Money creation by unregulated shadow banking system
- **Banking sector response to cheapness may be socially excessive**
  - Stein '12: Excessive private money creation makes the system too vulnerable to crises
  - Short-term debt leads to costly fire sales in bad states, since banks must liquidate assets to repay
  - Private banks issue too much short-term debt because they do not fully internalize these fire-sale costs

Introduction

Planner's Problem

- **If households demand short-term safe debt, who should supply it?**
  - It is costly for **both** government and banks to create short-term money-like claims, but banks may not fully internalize these costs
  - **Comparative advantage approach**: If government has the lowest social cost of supplying money, it should tilt towards more short-term
- **First best**: Marginal social cost of government money creation = social cost of private money creation = social benefit of money creation.
- **Second best**: Directly regulating private money creation may be costly/difficult, so a more robust solution may be to reduce the temptation:
  - **Second best**: government **partially crowds out excessive private creation** by tilting further towards short-term debt
  - Goal is to affect the relative price of long- vs. short-term debt, reducing incentives for private money creation
  - Adds a **regulatory dimension** to the government's debt-maturity choice
- Our analysis here is **prescriptive** rather than **descriptive**

Stylized Facts

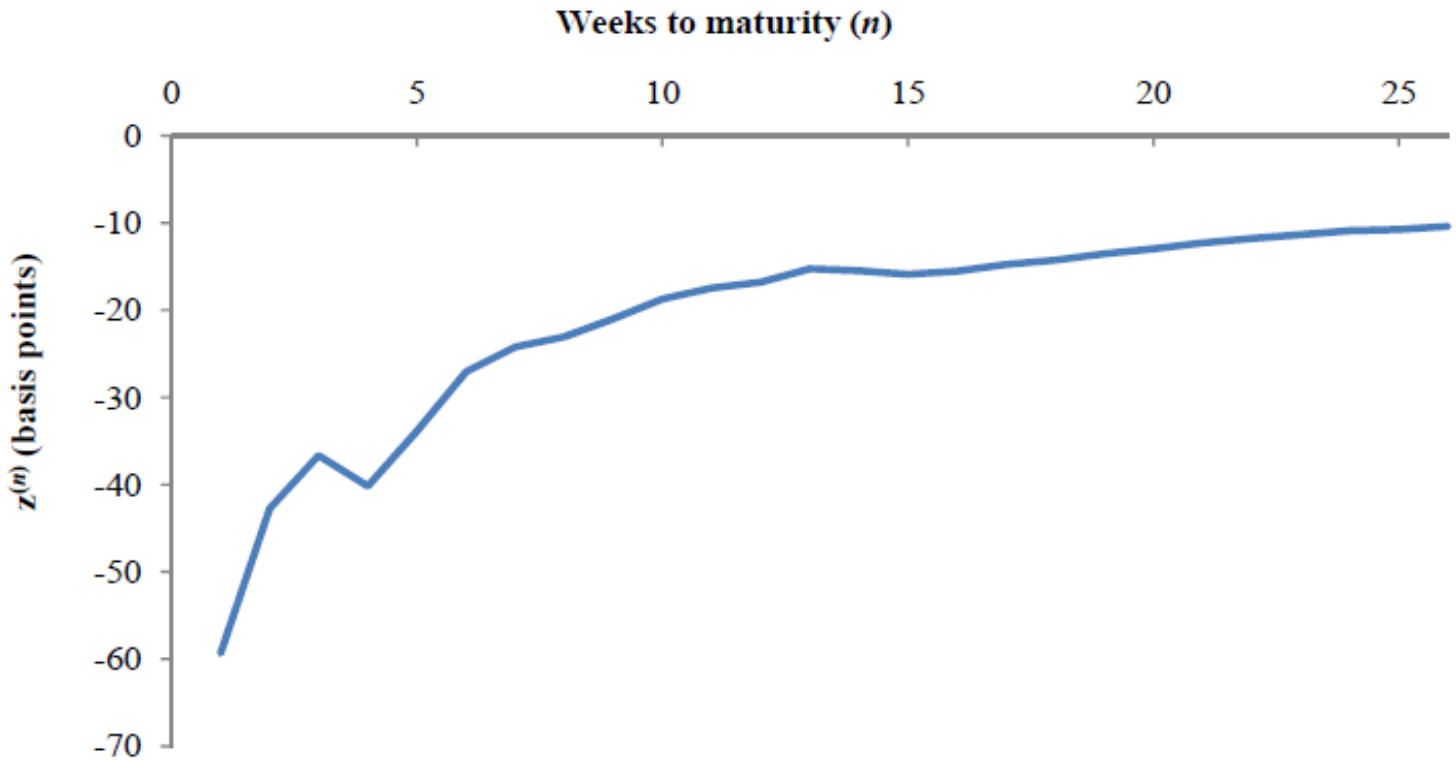
Demand for safe securities

- Krishnamurthy and Vissing-Jorgensen '12 argue that money-like securities—i.e., *liquid securities* with *absolute safety of nominal cash flow*—such as U.S. Treasuries embedded a convenience yield: have lower yields than they would in standard asset-pricing models
  - **Identification**: Downward-sloping demand for monetary services means that AAA-UST spread is high when Debt/GDP is low
- This paper: short-term safe securities (e.g., T-bills) are especially money-like: even *greater liquidity* and *absolute safety of nominal return* since have almost no interest rate risk
  - Presumably, these attributes are what make T-bills so attractive to money-market investors.

Stylized Facts

Liquidity premium for short-term T-bills

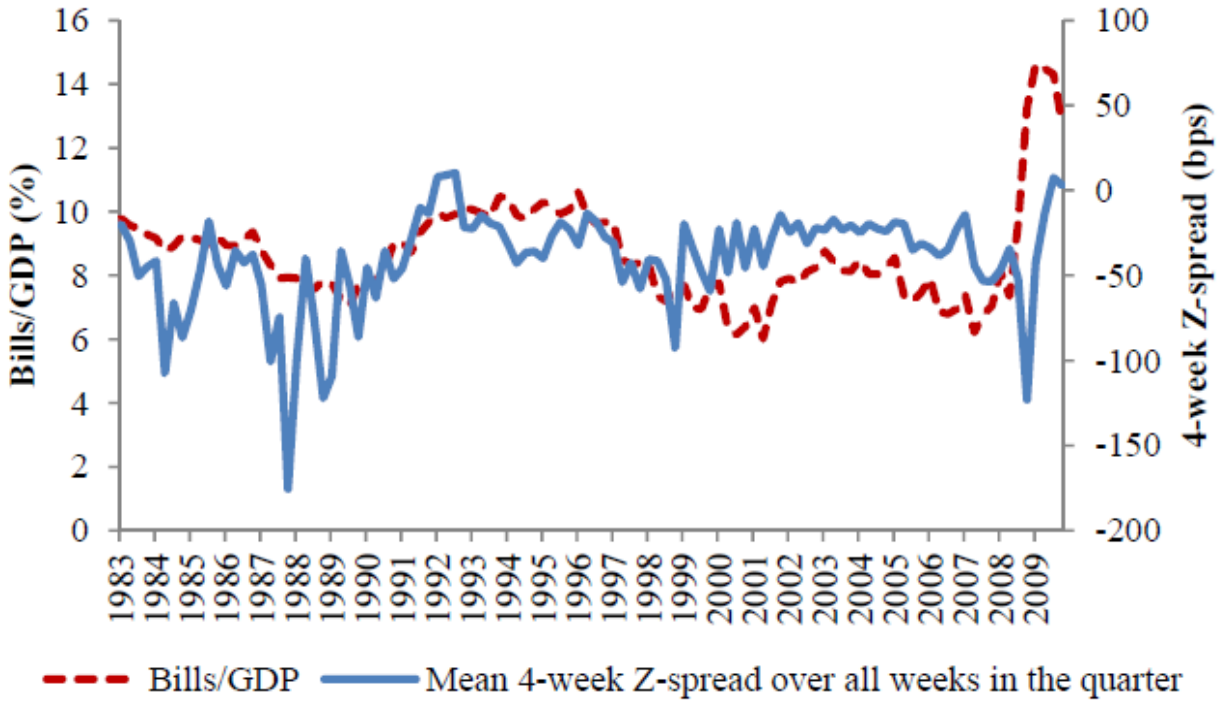
- **T-bill curve is extremely steep at front-end**
- Compare T-bills to fitted UST curve from Gurkaynak, Sack, & Wright '07
- Plot avg. spread of the w-week bill to curve $z_t^{(w)} = y_t^{(w)} - \widehat{y}_t^{(w)}$ from '83-'09
- We're controlling for the general shape of the yield curve, so probably a lower bound on the average liquidity premium of short-term T-bills



Stylized Facts

Liquidity premium varies with quantity of T-bills

- **"Money" premium is low when quantity of outstanding T-bills is large**
- Plot spread of 4-week bill to the curve $(z_t^{(4)})$ versus $(BILLS/GDP)_t$

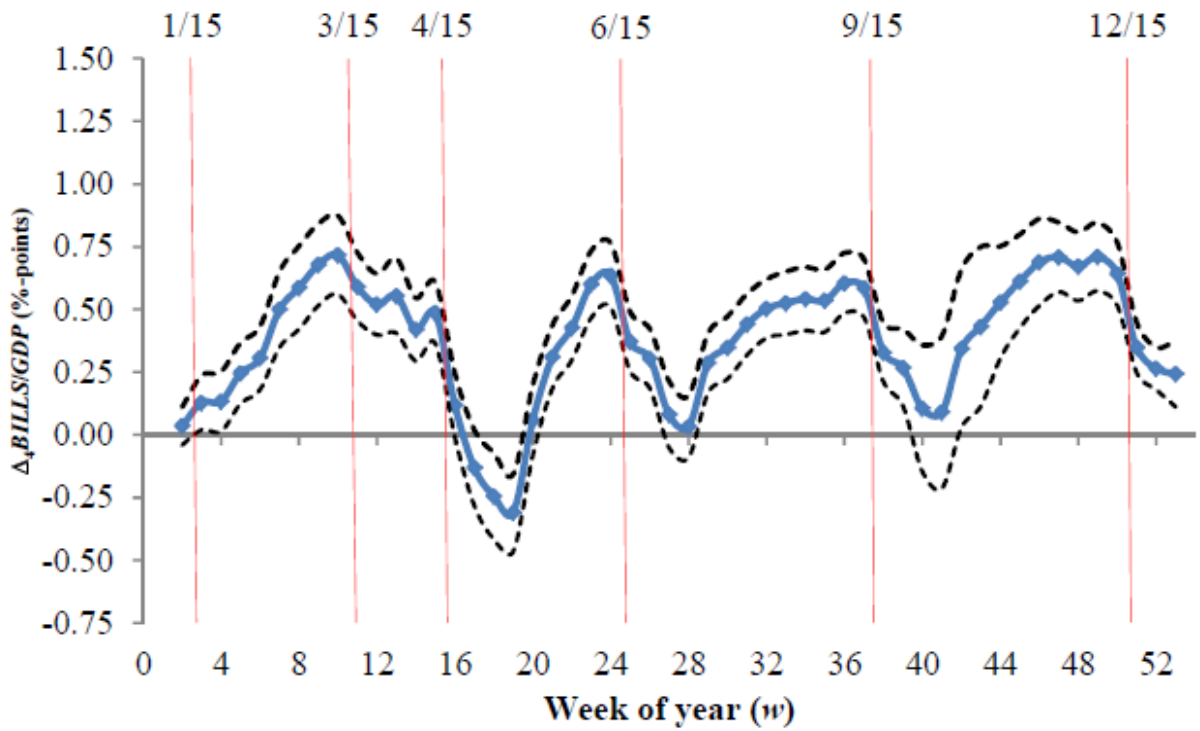


- Positive relationship, but series are persistent. And endogenous govt. supply response to money demand shocks will reduce coefficient (e.g., fall of '08).

Stylized Facts

Exploit seasonal variation in supply of T-bills

- Large seasonal variation in the supply of Treasury bills
  - Driven by the seasonal fluctuations in tax receipts: plausibly unrelated to business cycle conditions or shocks to money demand
  - Pattern became much stronger in early 1990s
- **First stage**: Regress 4-week change in bill supply on week-of-year dummies: $\Delta_4(Bills/GDP)_t = c + \sum_{w=2}^{52} d^{(w)} \mathbf{1}\{week(t) = w\} + \Delta_4 v_t$.



Stylized Facts

Exploit seasonal variation in supply of T-bills (Cont.)

- Regress 4-week changes in z-spreads on 4-week changes in T-bill supply.

$$\Delta_4 z_t^{(n)} = a^{(n)} + b^{(n)} \cdot \Delta_4 (Bills/GDP)_t + \Delta_4 \varepsilon_t^{(n)}$$

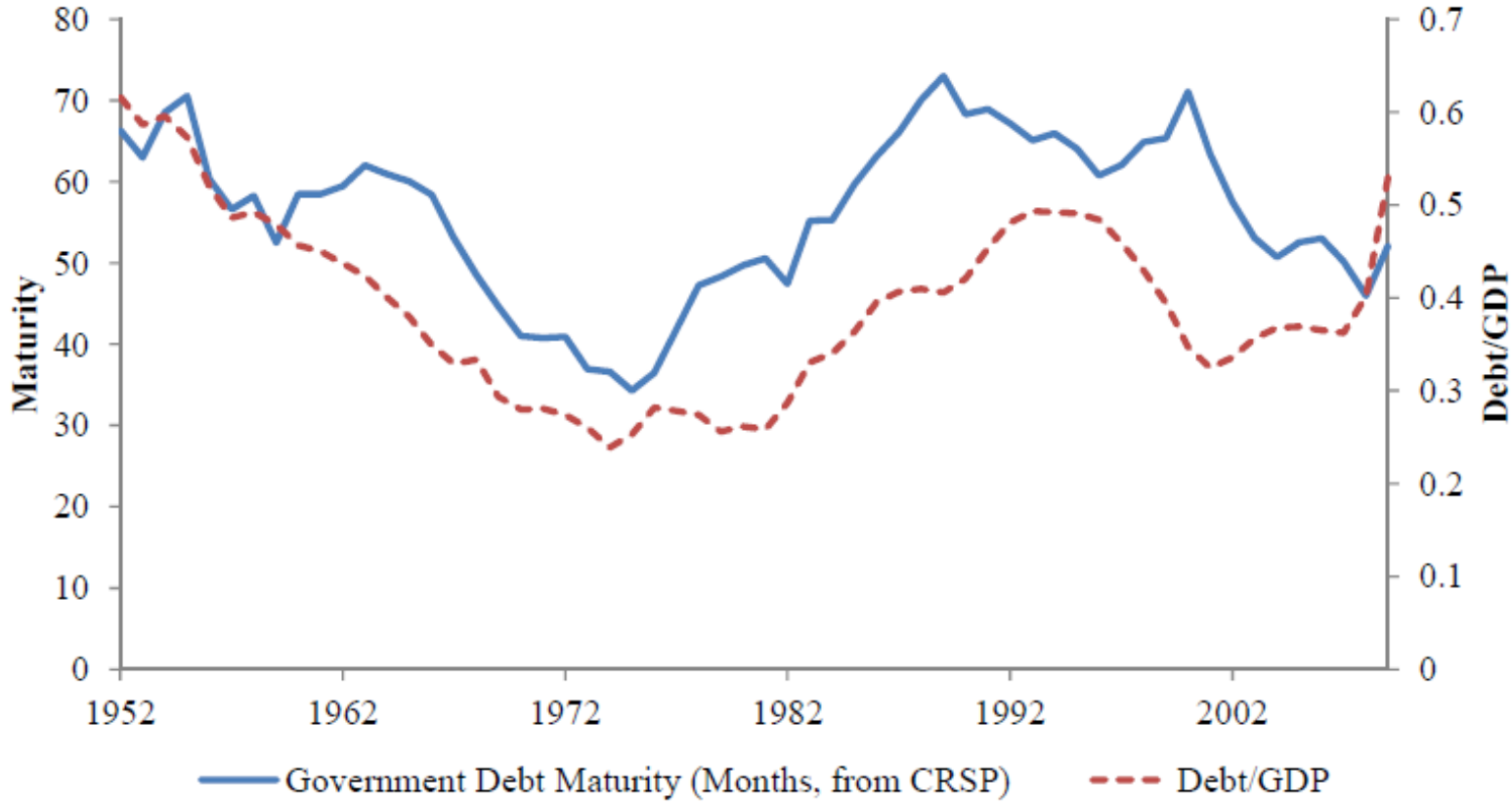
Instrument for change in T-bill supply with week-of-year dummies.

	$\Delta_4 z^{(1)}$	$\Delta_4 z^{(4)}$	$\Delta_4 z^{(10)}$
	2-week	4-week	10-week
		1983-2009	
$b^{(n)}$	29.37	10.49	6.32
$[t]$	[3.39]	[1.70]	[2.69]
R^2	0.01	0.00	0.01
		1992-2009	
$b^{(n)}$	34.74	15.52	6.02
$[t]$	[5.41]	[3.67]	[2.57]
R^2	0.06	0.02	0.01

Stylized Facts

Government Debt Maturity and Debt/GDP

- **When Debt/GDP increases, govt. debt maturity rises** ($\rho = 0.71$):

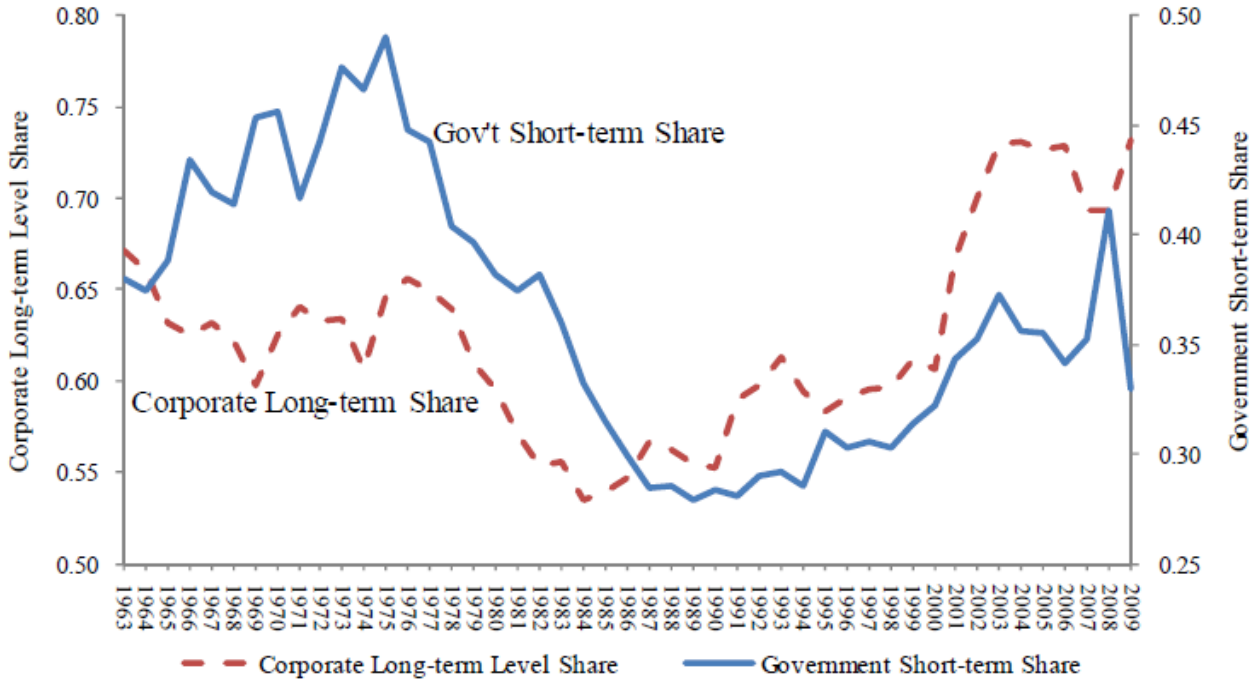


- This is not mechanical: the maturity of govt. **debt issuance** rises when Debt/GDP rises.

Stylized Facts

Crowding Out in the Maturity Dimension

- Greenwood, Hanson, Stein ('10): When government shortens its maturity structure, firms issue longer-term.



- Financial money creation is particularly responsive to supply of ST USTs.
  - Estimate $PrivateMoney_t / GDP_t = a + b \cdot X_t + u_t$ for $X_t = D_t / GDP_t$ and $X_t = D_t^S / GDP_t$ and find $b < 0$.
  - R^2 is much higher when focus in on short-term govt. debt.

Trade-off Model of Government Debt Maturity

Basic Set-Up

- Households have linear preferences over consumption at $t = 0, 1, 2$.

$$U = C_0 + E\left[C_1 + \beta C_2\right] + v\left(M_0\right)$$

  - Households have a deterministic income of 1 each period
  - **Refinancing risk**: β = Random discount rate between time 1 and 2 with $E[\beta] = 1$. Becomes known at $t = 1$.
  - $v\left(M_0\right)$ = Utility from **money services** at $t = 0$: $v' > 0$ and $v'' \leq 0$. Only derive utility from **riskless, short-term** debt at $t = 0$

- Households can transfer wealth between periods by purchasing government bonds:
  - $B_{0,1}$: ST bonds issued at $t = 0$, due at $t = 1$; $P_{0,1} = 1 + v'\left(M_0\right)$
  - $B_{0,2}$: LT bonds issued at $t = 0$, due at $t = 2$; $P_{0,2} = 1$
  - $B_{1,2}$: ST bonds issued at $t = 1$, due at $t = 2$; $P_{1,2} = \beta$

- Some notation:
  - $D = B_{0,1} + B_{0,2}$: Scale of initial government borrowing
  - $S = B_{0,1}/D$: Short-term share of government debt

Trade-off Model of Government Debt Maturity

Government and Household Budget Constraints

- Government finances a one-time expenditure G at $t = 0$
- **Government budget constraint**: Uses = Sources

$$\begin{aligned} t = 0: &\quad G = \tau_0 + B_{0,1} P_{0,1} + B_{0,2} P_{0,2} \\ t = 1: &\quad B_{0,1} = \tau_1 + B_{1,2} P_{1,2} \\ t = 2: &\quad B_{1,2} + B_{0,2} = \tau_2 \end{aligned}$$

- **Distortionary costs of taxes**: Captured through a convex function of the tax rate, $(1/2)\,\tau^2$, which induces a tax-smoothing motive
- **Household consumption**: Substitute in government budget constraint:

$$\begin{aligned} C_0 &= 1 - \tau_0 - (1/2)\,\tau_0^2 - B_{0,1} P_{0,1} - B_{0,2} P_{0,2} &&= 1 - (1/2)\,\tau_0^2 - G \\ C_1 &= 1 - \tau_1 - (1/2)\,\tau_1^2 + B_{0,1} - B_{1,2} P_{1,2} &&= 1 - (1/2)\,\tau_1^2 \\ C_2 &= 1 - \tau_2 - (1/2)\,\tau_2^2 + B_{1,2} + B_{0,2} &&= 1 - (1/2)\,\tau_2^2 \end{aligned}$$

Trade-off Model of Government Debt Maturity

Social Planner's Objective Function

- The social planner maximizes

$$U = C_0 + E\left[C_1 + \beta C_2\right] + v\left(M_0\right)$$

  subject to the government's budget constraint
- Planner values monetary services from short-term debt
- Planner wants taxes to be low and smooth over time

Trade-off Model of Government Debt Maturity

Solution without Money Demand

- Without money demand, terms involving $v(\cdot)$ disappear
  - Bond prices: $P_{0,1} = P_{0,2} = 1$ and $P_{1,2} = \beta$ is realized at $t = 1$.
- **Solution = Perfect tax-smoothing**
  - $\tau_0 = \tau_1 = \tau_2 = G/3$, $B_{0,1} = B_{0,2} = G/3$, and $D = (2/3)\,G$
  - $S = 1/2$ and $B_{1,2}(\beta) \equiv 0$ for all realizations of β
- **Intuition**: In the absence of money demand, the govt. perfectly smooths taxes over time by issuing a long-term "consol" bond that makes the same payment each period. The govt. never rolls over debt at the interim date, thus fully insulating budget/taxes from uncertain future refinancing.

Trade-off Model of Government Debt Maturity

Solution with Money Demand

- Prices: $P_{0,1} = 1 + v'(B_{0,1})$ and $P_{0,2} = 1$
  - $v'(B_{0,1})$=Money premium on ST debt
- $b \approx Var[\beta]/2$. First order condition for S:

$$\overbrace{Db(S-1/2)}^{\text{Marginal tax-smoothing cost}} = \overbrace{v'(SD)}^{\text{Marginal benefit of money}} + \overbrace{\tau_0 \cdot \left[v'(SD) + SDv''(SD)\right]}^{\text{Marginal tax-lowering benefit}}$$

Central trade-off:

1. **Tax-smoothing cost**: When $S > 1/2$, must raise taxes when ST rates are high at $t = 1$. Smoothing costs are large if D (Debt/GDP) is large or if uncertainty about ST rates (b) is high
2. **Direct money benefit**: Planner is willing to incur some tax-smoothing costs to deliver monetary services to households
3. **Tax-lowering benefit**: Can raise revenue by taxing or by selling liquidity services. If the latter is non-distortionary, this pushes further toward ST

Trade-off Model of Government Debt Maturity

Solution with Money Demand (Cont.)

- **Ignore tax-lowering benefit in what follows for simplicity**
  - Equiv. to assuming that all ways of raising revenue are distortionary
  - Same conclusions if we include this effect (Prop. 3 in paper)
- **Basic result**: In presence of money demand ($v'(\cdot) > 0$), govt. chooses a shorter maturity structure ($S^* > 1/2$), trading off the increased refinancing risk of more ST debt against the benefits of additional monetary services
- **Comparative statics for S^***:
  - Go shorter when future short rates more uncertain
  - Go longer when govt. spending and debt are large relative to GDP
  - Issue short when money demand is strong (e.g. Fall '08)

Adding Private-Sector Money Creation

Summary

- Formulation of the private-sector money creation follows Stein '12
- Continuum of banks borrow from households to invest in real projects
- Issue either ST debt or LT debt
  - ST debt is made riskless by **liquidating assets in bad state** at $t = 1$
  - **Since ST debt is riskless, it is cheap**: banks can capture money premium $v'(M_0)$
  - However, resulting **fire sales reduce the quantity of real investment**
- Banks prefer to issue cheap ST debt, even though doing so incurs risk of fire sale
  - But don't fully internalize the social cost of under-investment in bad state
  - $\Rightarrow$ **Socially excessive short-term financing** (private money creation)

Adding Private-Sector Money Creation

Banks, Investment Projects, and Financing

- For simplicity, assume that banks invest a *fixed* amount I at $t = 0$
  - Good state occurs with probability p: Project returns $F > I$
  - Bad state occurs with probability $1 - p$: Expected output $\lambda I \leq I$ with non-zero probability of $0 \Rightarrow$ LT debt is not riskless
- Bank can finance this investment by issuing:
  - Risky long-term bonds due at $t = 2$
  - ST *riskless* bonds with face value M_P: Results in savings of $M_P \cdot v'(M_0)$ relative to long-term

Adding Private-Sector Money Creation

Fire sales

- If the bad state occurs at $t = 1$, bank must liquidate fraction Δ of its assets to pay-off short-term bond holders
  - Δ satisfies $M_P = \Delta k \lambda I$ where $k < 1$ is endogenous fire-sale discount
- **Assets purchased by patient investors** (PIs) with war chest W
  - PIs can buy existing bank assets or invest K in new real projects at $t = 1$ which return $g(K)$ at $t = 2$ where $g' > 0$ and $g'' < 0$
  - **Fire sales affect real investment at $t = 1$:** In the good state, new investment is $K = W$; in the bad state, $K = W - M_P^*$
- **Imperfect pledgeability:** only fraction $\phi < 1$ of returns from new investments are pledgeable to PIs:
  - $\Rightarrow$ Banks do not fully internalize the social costs of fire sales
- **Equilibrium determination of k**: PIs must be indifferent between buying existing bank assets and investing in real new projects

$$\overbrace{1/k}^{\text{Firesale return on existing bank assets}} = \overbrace{\phi g'\left(W - M_P^*\right)}^{\textbf{PRIVATE}\text{ return on marginal real investment}}$$

Adding Private-Sector Money Creation

Private Market Solution

- **Private Market Solution:** Banks trade-off benefits of cheap short-term debt versus the cost of fire-sale liquidations, but do not fully internalize the latter
- **Contrast with social planner:** planner takes the full cost of fire sales into account (i.e. sets $\phi = 1$ in the above), so socially optimal quantity of private money, M_P^{**}, is less than private market outcome, M_P^*.

The Social Planner's Problem

First Best

- The planner's objective function is to maximize Utility from money - Distortionary costs of taxes + NPV of time 1 investment
- Assume planner can directly control private money M_P
  - Thus, planner chooses 3 variables: M_P, D, and S.

The Social Planner's Problem

First Best (Cont.)

- **Comparative advantage principle:** At the social optimum, the marginal social cost of both private and public money creation are set equal to the marginal social benefit of additional money services:

$$\begin{array}{c}\text{Fire-sale cost} \\ \text{of private money}\end{array} = \begin{array}{c}\text{Marginal benefit} \\ \text{of money services}\end{array} = \begin{array}{c}\text{Tax-smoothing cost} \\ \text{of govt. money}\end{array}$$

- May be costly/difficult to implement the first best outcome via regulations that limit private money creation
  - Private money creation may simply flow from regulated to unregulated sectors (i.e. the "shadow banking system") in response to heightened liquidity regulations ... but externality still exists
  - Regulation may otherwise create deadweight costs

The Social Planner's Problem

Second Best Implementation without Direct Regulation

- Suppose that it is impossible or prohibitively costly to directly regulate private money (will relax this below)
- However, government can still reduce the temptation to engage in private money creation by issuing more T-bills
- If govt. money creation is M_G, equilibrium private money creation is

$$\begin{array}{c}\text{Internalized fire-sale cost} \\ \text{of private money}\end{array} = \begin{array}{c}\text{Marginal benefit} \\ \text{of money services}\end{array}$$

- Defines a decreasing reaction function of private money based on public money

The Social Planner's Problem

Second Best Implementation without Direct Regulation (Cont.)

- First order condition for short-term share, S:

$$\underbrace{\text{Tax-smoothing cost of govt money}}_{} = \underbrace{\text{Marginal benefit of money services}}_{} + \underbrace{\text{Crowding out benefit}}_{}$$

  - "Crowding-out" term is positive.
- **Intuition for "Crowding-out" benefit:** The govt. depresses the premium on money-like claims by issuing more T-bills. This crowds out some private money creation and reduces under-investment in the bad state.
  - **"Crowding-out" benefit** is linked to the diff. between social and private investment return in bad state

Magnitude of the "Crowding-out" motive

A back-of-the-envelope calculation

- **Money benefit**: ≈ 40 bps based on extreme steepness of front-end of the yield curve
- **Crowding out benefit**: $(1-p)(\phi-1)g'(W-M_P^*)\partial M_P^*/\partial M_G$
  - **Annual probability of a crisis**: $(1-p)=5\%$
    - based on Barro and Ursua (2008) and Laeven and Valencia
  - **Non-pledgeable fraction of investment**: $(1-\phi)=10\%$
    - chosen somewhat arbitrarily, but seems plausible
  - **Gross fire-sale return in bad state:** $g'(W-M_P^*)=130\%$
    - based Pulvino (1998) and Campbell, Giglio, & Pathak (2011)
  - **Crowding-out impact**: $\partial M_P^*/\partial M_G=-100\%$
    - from estimates in Table 2
- **Crowding out benefit** $=0.05\times-0.10\times1.30\times-1=65$ bps

Plausibly the same magnitude as money benefit

The Social Planner's Problem

Second Best: Allowing for Direct Regulation of Private Money

- Now suppose the govt. can impose a tax on private money creation at rate θ_P
- However, regulation is imperfect/costly:
  - Pigouvian taxes create deadweight costs of $(\Upsilon/2)\theta_P^2$
  - Reduced-form way of capturing resources banks devote to evasion / regulatory arbitrage
- Government now has two tools—"crowding-out" by issuing more ST or direct regulation—both of which are costly to use
- Equilibrium private money creation is pinned down by

$$v'\left(M_P^* + M_G\right) = \theta_P + (1-p)\left(\phi g'\left(W - M_p^*\right) - 1\right).$$

- Defines a reaction function $M_P^*\left(M_G, \theta_P\right)$ with lower private money when M_G or θ_P is high

The Social Planner's Problem

Second Best: Allowing for Direct Regulation of Private Money (cont.)

- First order condition for S

$$\overbrace{D^{***} b \left(S^{***} - 1/2\right)}^{\text{Tax-smoothing cost}} = \overbrace{v' \left(M_P^* + S^{***} D^{***}\right)}^{\text{Money benefit}} + \overbrace{\Omega \left(1 - p\right) \left(\phi - 1\right) g' \left(W - M_P^*\right) \frac{\partial M_P^*}{\partial M_G}}^{\text{"Crowding-out" benefit}}$$

  where $\Omega = \Upsilon / \left(\Upsilon + \left|\partial M_P^* / \partial \theta_P\right|\right) < 1$: with direct regulation, crowding-out benefit is reduced

- Under some conditions, govt. does more crowding out and less regulation when (i) tax smoothing costs are lower or (ii) when costs of direct regulation are higher

Conclusion

- Trade-off model of optimal government debt maturity: satisfying money demand vs. tax-smoothing
  - Tax-smoothing costs loom larger when the debt is larger relative to GDP
  - Government issues more ST when the demand for money is stronger, or when there is less uncertainty about future short rates
- Extend model to allow for competing private creation of money-like securities
- Comparative advantage principle reigns:
  - If there are uninternalized costs associated with private money creation, government should crowd out private money
  - Conclusion holds so long as regulation of private money is costly/imperfect
- Open questions:
  - Implementation: Treasury vs. central bank?
  - Model is about 'long' versus 'short', but money premium appears primarily in the 'very short'

Extra Slides 1

Multiple maturities

- Suppose there are multiple maturities of debt: short, medium, and long
- Optimal maturity structure depends on type of shifts to yield curve:
- If interest rate shocks primarily involve **parallel shifts** in the yield curve:
  - Govt. can create a large volume of monetary services without incurring much refinancing risk
  - Govt. implements this by pursuing a a "barbell" strategy: issues lots of short- and long-term debt, but little medium term debt
  - Govt. keeps the average maturity of debt close to that is the perfect-smoothing (consol-bond) solution
- If there is a significant risk that the yield curve can change shape:
  - Govt. must incur more refinancing risk, so it creates a lower volume of monetary services
  - Govt. pursues less of a barbell strategy
  - Govt. shortens the average maturity of debt

Extra Slides 2

Private Money Less Valuable than Public Money

- Suppose money utility given by $v\left(k_P M_P + M_G\right)$ where $k_P < 1$
- First best private money set lower according to

$$\overbrace{\frac{(1-p)\left(g'\left(W - M_P^{**}\right) - 1\right)}{k_P}}^{\substack{\text{Fire-sale cost} \\ \text{of private money}}} = \overbrace{v'\left(k_P M_P^{**} + M_G^{**}\right)}^{\substack{\text{Marginal benefit} \\ \text{of money services}}} = \overbrace{b\left(M_G^{**} - D^{**}/2\right)}^{\substack{\text{Tax-smoothing cost} \\ \text{of govt. money}}}$$

- Second best condition for S

$$\overbrace{D^* b\left(S^* - 1/2\right)}^{\text{Tax-smoothing cost}}$$

$$= \overbrace{v'\left(k_P M_P^* + S^* D^*\right)}^{\text{Money benefit}} + \overbrace{(1-p)\left(\phi - 1\right) g'\left(W - M_P^*\right) \frac{\partial M_P^*}{\partial M_G}}^{\text{“Crowding-out” benefit}}$$

- **Summary:** Basic forces unchanged but less equilibrium private money

Extra Slides 3

- Table 2: Determinants of Private Money

	Dep Var = (M2-M1)/*GDP*		Dep Var = (M3-M1)/*GDP*	
D/*GDP*	-0.515 [-2.91]		-0.659 [-1.44]	
D_S/*GDP*		-1.529 [-3.61]		-2.952 [-2.76]
N	58	58	58	58
R^2	0.38	0.52	0.11	0.33

Extra Slides 4

- Bennett, Garbade, and Kambhu (2000):
  - "Minimizing the cost of funding the federal debt is a leading objective of Treasury debt management policy...In the most extreme form, the Treasury Department could finance any current deficit, and refinance maturing debt, with frequent sales of large quantities of shorter bills. This would concentrate Treasury indebtedness in the most liquid sector of the market: large, short-maturity, and unseasoned discount obligations."
  - "...The Treasury has historically chosen to issue at a variety of short, intermediate, and long maturities. This policy has ancillary benefits: ... it facilitates budget planning because it enhances the predictability of interest expenses during a fiscal year and over longer intervals."