The Aggregate Demand for Treasury Debt

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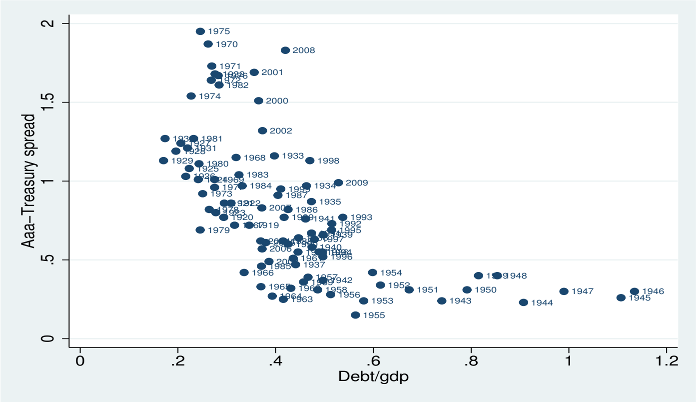
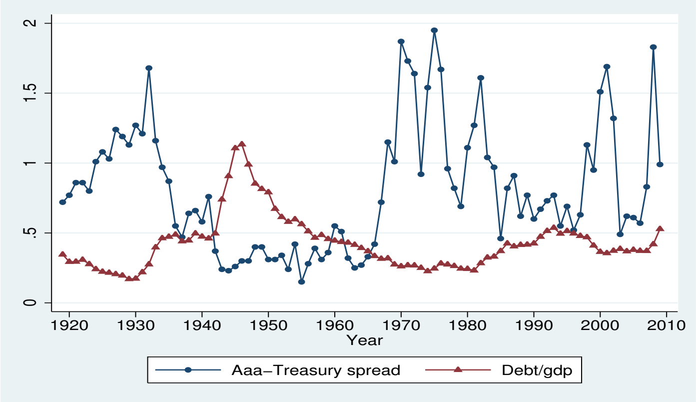
Yield spread between Moody's Aaa bond yield and long term Treasury yield versus Publicly held US Treasury Debt/US GDP. 1919-2009.



- Standard monetary theory: Money is (1) medium of exchange, (2) very liquid, (3) very safe (in nominal terms).
- Our paper: Treasury bonds offer (2) and (3). The figure is akin to a money-demand function, but for government debt.

- Time series version of the same relation:



Findings

1. Investors value U.S. Treasury bonds (beyond CCAPM value)
   - Changes in Treasury supply have large effects on a variety of yield spreads.
2. Low yield on Treasuries is due to their extreme safety and liquidity
   - Safety: Find two assets with similar liquidity but different safety. Show that Treasury supply moves spread.
   - Liquidity: Find two assets with similar safety but different liquidity. Show that Treasury supply moves spread.
3. Quantity evidence further shows that Treasuries have similarities to money (safety, liquidity)
   - When supply of Treasuries falls, reducing overall supply of liquid and safe assets, supply of bank-issued money (M2-M1, time and savings deposits) rises.
4. Average convenience yield on Treasuries is large: 72 bps.

Implications: (1) Treasury seignorage, (2) riskless rate, (3) foreign Treasury holders, (4) QE1 and QE2, and (5) optimal Treasury structure

Related prior literature

1. Money demand literature

2. Ricardian equivalence literature: Barro (1974)
   - We show that government debt is non-Ricardian. Main novelty relative to literature is looking at spreads rather than level of Treasury interest rates.

3. Non-default component of spreads (corporate-Treas, swap-Treas):
   - Literature estimates default component of spread. Large residual is referred to as non-default component.

     Collin-Dufresne, Goldstein, and Martin (2001), Longstaff, Mithal, and Neis (2005), Duffie and Singleton (1997), Grinblatt (2001), Liu, Longstaff, and Mandell (2004), Feldhutter and Lando (2005)

   - We offer a direct test of Treasury convenience value: It should be affected by the supply of the convenient asset (Treasuries).
   - Prior evidence on correlation between Treasury supply and spreads:

     Cortes (2003): Interest rate swap spreads, 1994-2003.

     Longstaff (2004): Refcorp bond yield minus Treasury yield, 1991-2001.

     Friedman and Kuttner (1998): CP-bill, 1975-1996.

   - We use a much longer sample (1919-2008), control for default risk, isolate liquidity and safety effects, provide quantity evidence on relation to money.

Related subsequent literature on supply effects in bond markets

- Is there a demand for particular Treasury maturities?
  Greenwood and Vayanos (2010): Yes, relative supply of long vs. short Treasuries drives the slope of the yield curve.
- Can corporations step in too fill in the maturity structure?
  Greenwood, Hanson and Stein (2010): Partially, corporate maturity structure responds negatively to Treasury maturity structure, but not one-for- one.
- Very recent literature on the impact of quantitative easing (buying long bonds, issuing short-term claims).

1. The convenience yield on Treasuries

- Representative agent who maximizes,

$$E\sum_{t=1}^{\infty}\beta^{t}u(C_t)$$

where C_t is the agent's consumption plus "convenience" benefits:

$$C_t = c_t + \nu(\theta_t^A, GDP_t; \xi_t).$$

Convenience assets (A=total, T=treasuries, P=private sector substitutes):

$$\theta_t^A = \theta_t^T + k^P\theta_t^P.$$

- Assume homogeneity of degree 1 in income and holdings. Define:

$$v\left(\frac{\theta_t^A}{GDP_t}; \xi_t\right) GDP_t \equiv \nu(\theta_t^A, GDP_t; \xi_t).$$

and assume and $v'(\cdot) > 0$, $v''(\cdot) < 0$, and $v'(\cdot) \to 0$ for large holdings.
- Work out spreads between corporate bonds and Treasuries (short, long).

Treasury (zero-coupon, any maturity):

$$-\frac{P_t^T}{Q_t}u'(C_t) + \beta E_t\left[\frac{P_{t+1}^T}{Q_{t+1}}u'(C_{t+1})\right] + \frac{P_t^T}{Q_t}v'(\theta_t^A/GDP_t,\xi_t)u'(C_t) = 0$$

Q_t is price level at date t. Buy zero coupon Treasury bond for a nominal price P_t^T. Real holdings θ_t^A rises by $\frac{P_t^T}{Q_t}$, which gives convenience $\frac{P_t^T}{Q_t}v'(\theta_t^A/GDP_t,\xi_t)u'(C_t)$.

$$P_t^T = \frac{E_t[M_{t+1}P_{t+1}^T]}{1 - v'(\theta_t^A/GDP_t;\xi_t)} \approx e^{v'(\theta_t^A/GDP_t;\xi_t)}E_t[M_{t+1}P_{t+1}^T]$$

where

$$M_{t+1} = \beta\frac{u'(C_{t+1})}{u'(C_t)}\frac{Q_t}{Q_{t+1}}$$

Corporate bond (zero-coupon, one-period):

$$P_t^C = E_t[M_{t+1}\left(1 - \tilde{L}_{t+1}\right)] \approx e^{-\lambda_t L_{t+1} - cov_t[M_{t+1}, \tilde{L}_{t+1}]/E_t[M_{t+1}]} E_t[M_{t+1}]$$

where $\tilde{L}_{t+1} = 0$ if no default, $\tilde{L}_{t+1} = L_{t+1}$ if default, and L_{t+1} is loss given default and default happens with probability λ_t.

Corporate bond (zero-coupon, any maturity):

$$P_t^C = \lambda_t E_t[M_{t+1}(1 - L_{t+1})|\text{Default}] + (1 - \lambda_t) E_t[M_{t+1} P_{t+1}^C|\text{No Default}]$$

Simplify using Duffie-Singleton (1997) formulation:

- Default over next period is uncorrelated with M (but changes in expectations about future default, i.e. downgrades, can be correlated with M).
- Payoff if default is fraction $1 - D_t$ of market value if no default:

$$E_t[M_{t+1}(1 - L_{t+1})] = E_t[M_{t+1} P_{t+1}^C](1 - D_t)$$

- Then

$$\begin{aligned} P_t^C &= \lambda_t E_t[M_{t+1}(1 - L_{t+1})] + (1 - \lambda_t) E_t[M_{t+1} P_{t+1}^C] \\ &= (\lambda_t(1 - D_t) + (1 - \lambda_t)) E_t[M_{t+1} P_{t+1}^C] \approx e^{-\lambda_t D_t} E_t[M_{t+1} P_{t+1}^C]. \end{aligned}$$

Prediction 1-3: Impact of Treasury supply on spreads, expected returns

1. One-period spread: $S_{t,1} = i^C_{t,1} - i^T_{t,1} = -ln\ P^C_t + ln\ P^T_t$

$$S_{t,1} = v'\left(\frac{\theta^A_t}{GDP_t}; \xi_t\right) + \lambda_t L_{t+1} + cov_t[M_{t+1}, \tilde{L}_{t+1}]/E_t[M_{t+1}].$$

$$S_{t,1} = v'\left(\frac{\theta^A_t}{GDP_t}; \xi_t\right) + \lambda_t D_t$$

2. τ-period spread:

$$\begin{aligned} S_{t,\tau} &= i^C_{t,\tau} - i^T_{t,\tau} = -\frac{1}{\tau} ln\ P^C_t + \frac{1}{\tau} ln\ P^T_t \\ &= \sum_{j=t}^{t+\tau-1} \frac{1}{\tau} E_t[v'(\theta^A_j/GDP_j; \xi^L_j)] + \sum_{j=t}^{t+\tau-1} \frac{1}{\tau} E_t[\lambda_j D_j] - \sum_{j=t}^{t+\tau-1} \frac{1}{\tau} cov_t(m_{j+1}, \tilde{R}_{j+1}) \end{aligned}$$

3. Expected excess returns:

$$E_t[M_{t+1}\tilde{R}_{t+1}] = v'(\theta^A_t/GDP_t; \xi_t)$$

$$E_t[\tilde{R}_{t+1}] = \frac{1}{E_t[M_{t+1}]}\left(v'(\theta^A_t/GDP_t; \xi_t) - cov_t(M_{t+1}, \tilde{R}_{t+1})\right).$$

(Realized excess return involves updates to expectations about future v's, future default, and future covariances – lots of noise.)

Testing predictions 1, 2, 3

Test whether increases in θ_t^T cause the spreads to fall and predicts lower excess returns.

- Regression coefficients are net of private-sector response – this is the most interesting outcome
  - But finding our hypothesized negative relation requires that $\theta_t^A = \theta_t^T + k^P \theta_t^P$ increases in θ_t^T.
  - Private sector reaction should not offset more than one-for-one. Extremely unlikely, and we can also check for this using quantities.
- Our regressions assume that θ_t^T does not respond to the spread
  - If anything government probably expands Treasury supply if spreads rise, making it harder to find our hypothesized negative relation.

Estimation of yield regressions

$$Spread_t = a + b_1 \; ln \; Debt_t/GDP_t + b_2 \; controls_t + error_t$$

- Log functional form: Only one parameter to estimate, but does not asymptote to zero. Different functional form later.
- Both left and right-hand side persistent. We run OLS, modeling error as AR(1) (based on Box-Jenkins analysis)
- Why not GLS? Convenience yield term is $E_t[\sum v'(\theta_t^A)]$, proxied by $ln \; Debt_t/GDP_t$. Measurement error magnified by GLS
- Controls for expected default: EDF, stock market volatility
- Control for time-varying risk premium (cov_t): Slope of yield curve (state of business cycle)

Estimation of excess return regressions

$$\text{Realized excess return}_t = a + b_1 \; \textit{ln Debt}_t/\textit{GDP}_t + b_2 \; \textit{controls}_t + \textit{error}_t$$

- Excess return is on long corporate Aaa/Aa index minus long Treasury index (Ibbotson)
- OLS with standard errors assuming ARMA(1,1) error terms (AR(1)+noise=ARMA(1,1))
- Controls for time-varying risk premium (cov_t): Slope of yield curve (state of business cycle).
- Good: No controls needed for expected default (doesn't affect expected excess return)
- Bad: Lots of noise in realized excess returns: Std. dev. is 3.72 pct, compared to 0.45 pct for Aaa-Treasury yield spread. Controls to remove part of noise in realized excess returns:
    - Credit hedge: Excess return of junk bonds over Baa bonds
    - Duration hedge: Excess return on long over short Treasuries (to capture any duration mismatch).

Table I. Impact of Treasury Supply on Bond Spreads: Log Specification

	Panel A: Aaa-Treasury			Panel B: Baa-Treasury	
	(1)	(2)	(3)	(4)	(5)
Period	1919-2008	1969-2007	1926-2008	1969-2007	1926-2008
log(Debt/GDP)	-0.744	-0.910	-0.797	-1.752	-1.304
	[-4.32]	[-3.35]	[-5.06]	[-5.98]	[-7.54]
EDF		0.953		1.206	
		[3.57]		[3.71]	
Volatility			1.294		6.364
			[1.90]		[6.88]
Slope		0.045	0.080	0.175	0.309
		[1.05]	[1.86]	[2.04]	[4.64]
Intercept	0.111	0.052	0.078	0.208	0.737
	[0.62]	[0.18]	[0.49]	[0.66]	[4.34]
R^2	0.447	0.623	0.568	0.669	0.690
ρ	0.572	0.402	0.528	0.066	0.012
N	90	39	83	39	83

- (1): One-σ decrease in Debt/GDP from mean value of 0.426 to 0.233 $\Rightarrow$ Convenience yield component of the Aaa-Treasury spread up by 45 bps.
- (2): One-σ increase in EDF (in volatility) $\Rightarrow$ Aaa-Treasury +21 bps (+10 bps)
- (5): One-σ decrease in Debt/GDP $\Rightarrow$ Baa-Treasury +79 bps.

Table I. Impact of Treasury Supply on Bond Spreads: Log Specification

	Panel C: CP-Bills			Panel D: CPP2-Bills
	(6)	(7)	(8)	(9)
Period	1920-2008	1969-2007	1926-2008	1974-2007
log(Debt/GDP)	-0.728	-1.006	-0.550	-1.919
	[-4.37]	[-2.21]	[-3.52]	[-3.86]
EDF		0.024		0.086
		[0.05]		[0.16]
Volatility			1.947	
			[2.33]	
Slope		-0.123	-0.085	-0.105
		[-1.30]	[-1.42]	[-1.13]
Intercept	0.095	-0.269	0.229	-0.813
	[0.56]	[-0.55]	[1.49]	[-1.58]
R^2	0.224	0.211	0.259	0.282
ρ	0.183	-0.023	0.018	0.122
N	89	39	83	34

- Short spread less likely to be affected by omitted controls for time-varying expected default or default risk premium (all callability issues)
- Literally zero defaults on A1/P1 over 1972-2000 for which Moodys provide data.

Table II. Impact of Treasury Supply on Bond Excess Returns

	(1)	(2)	(3)
Period	1926-2003	1926-2003	1926-2003
$log(Debt/GDP)$	-0.851	-1.696	-1.826
	[-1.29]	[-2.21]	[-1.83]
CreditHedge		0.160	0.121
		[2.89]	[2.22]
Slope			0.678
			[1.64]
DurationHedge			-0.117
			[-2.56]
Intercept	-0.301	-1.245	-1.127
	[-0.46]	[-1.60]	[-1.13]
R^2	0.009	0.100	0.162
N	78	78	78

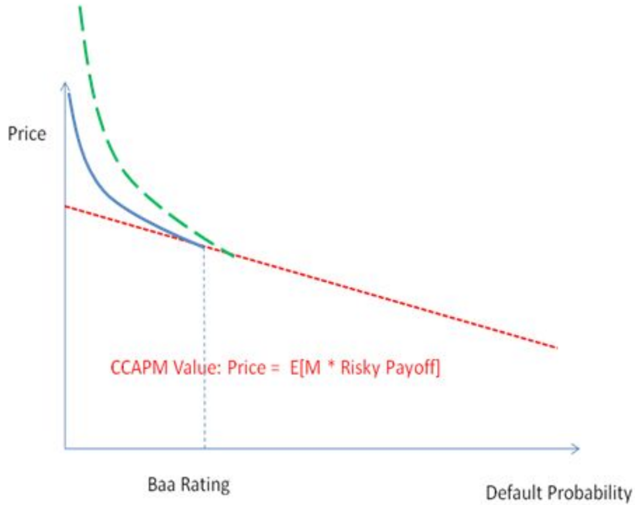
- Return results alleviate concerns about insufficent controls for expected default (doesn't affect expected returns).

2. What drives the convenience yield on Treasuries?

$v\left(\frac{\theta_t^A}{GDP_t};\xi_t\right)$ is a reduced form convenience benefit function.

1. Liquidity demand:
    - Aiyagari and Gertler (1991), Heaton and Lucas (1996), Vayanos and Vila (1998),Rocheteau (2009)
    - Comment: These are all two-agent models. So do not take our representative agent formulation literally.
2. Short-term safety demand: Stems from **absolute certainty of nominal repayment**
    - **Information costs:** Low information costs/agency costs to buying Treasuries. Related to theories of limited participation (Vissing-Jorgensen 2003).
    - **Collateral:** Safe collateral pledged in derivatives and settlement (Gorton 2010).
    - **Check-backing:** Households require that banks and money funds hold safe collateral to back checking accounts (Bansal and Coleman 1996).
    - Comment: Says that the relation b/w price and expected default is very steep for low expected default, and the slope is steeper the lower the supply of Treasuries.

Illustrating the impact of safety demand on price:



3. Long-term safety demand: Stems from absolute certainty of nominal repayment
   - Some investors (e.g. pension funds, insurance companies) demand safe long-term nominal payoffs.
   - Preferred habitat: Modigliani-Sutch (1966), Greenwood and Vayanos (2010). But with special demand for extremely safe long-term assets.

Convenience components on short-term Treasuries:

$$v_{T,short}(\cdot) = v_{liq}\left(\frac{\theta_t^T + k^{liq}\theta_t^{P,liq}}{GDP_t}; \xi_t^{liq}\right) + v_{shortsafe}\left(\frac{\theta_t^{T,short} + k^{shortsafe}\theta_t^{P,shortsafe}}{GDP_t}; \xi_t^{shortsafe}\right).$$

Convenience on long-term Treasuries:

$$v_{T,long}(\cdot) = v_{liq}\left(\frac{\theta_t^T + k^{liq}\theta_t^{P,liq}}{GDP_t}; \xi_t^{liq}\right) + v_{longsafe}\left(\frac{\theta_t^{T,long} + k^{longsafe}\theta_t^{P,longsafe}}{GDP_t}; \xi_t^{longsafe}\right).$$

Corporate-Treasury spreads are functions of both liquidity and safety components $\Longrightarrow$ Consider other spreads to test for separate existence of each Treasury attribute.

- If Treasuries have a given attribute, changing Treasury supply should affect the equilibrium price of that attribute.

Prediction 4-6: Impact of Treasury supply on price of short-term safety, long-term safety, liquidity

4. A pure short-term safety spread: P2 - P1 commercial paper

$$S_{t,1}^{P2-P1} = (k_{P1}^{shortsafe} - k_{P2}^{shortsafe}) v'_{shortsafe} \left(\frac{\theta_t^{T,short} + k^{shortsafe} \theta_t^{P,shortsafe}}{GDP_t}; \xi_t^{shortsafe} \right) + \lambda_{t,P2} D_{t,P2} - \lambda_{t,P1} D_{t,P1}.$$

Similarly illiquid:

- Little secondary market trading in any commercial paper (about 2% of total volume).
- In cross-section of short commercial paper, spreads to Treasuries are mainly determined by default risk, not liquidity (Covitz and Downing (2007)).

Different default risk:

- Moodys, 1972-2000, over 3-month period: 0.00% for A1/P1, 0.02% for A2/P2.

Prediction 4-6: Impact of Treasury supply on price of short-term safety, long-term safety, liquidity

5. A pure long-term safety spread: Baa-Aaa spread

$$S_{t,\tau}^{Baa-Aaa} = (k_{Aaa}^{longsafe} - k_{Baa}^{longsafe}) \sum_{j=t}^{t+\tau-1} \frac{1}{\tau} E_t \left[v'_{longsafe} \left(\frac{\theta_j^{T,long} + k^{longsafe} \theta_j^{P,longsafe}}{GDP_j} ; \xi_j^{longs.} \right) \right.$$
$$+ \sum_{j=t}^{t+\tau-1} E_t[\lambda_j^{Baa} D_j^{Baa} - \lambda_j^{Aaa} D_j^{Aaa}] - \sum_{j=t}^{t+\tau-1} \frac{1}{\tau} cov_t(m_{j+1}, \tilde{R}_{j+1}^{Baa-Aaa}).$$

Similarly illiquid:

- Similar high bid-ask spreads: 58 bps for Baa, 52 bps for Aaa (Chen, Lesmond and Wei (2008)).

Different default risk:

- Moodys, 1920-2004, over 10-year period: 1% for Aaa, 8% Baa.

Prediction 4-6: Impact of Treasury supply on price of short-term safety, long-term safety, liquidity

6. A pure liquidity spread: Insured bank deposits-Treasuries

$$S_{t,1}^{FDIC} = i_t^{FDIC} - i_t^T = (1 - k^{liq}) v'_{liq} \left(\frac{\theta_t^T + k^{liq} \theta_t^{P,liq}}{GDP_t}; \xi_t^{liq} \right).$$

- FDIC: Rate on 6-month CDs, post 1984 (i.e. after phasing out of Regulation Q)
- FDIC: Rate on all time and savings deposits, 1935-1965 (i.e. before Regulation Q was binding). 75% were insured. Assume 6-month average maturity.
- Other possibility: On-the-run/off-the-run spread. Works, but short sample.

Table III. Impact of Treasury Supply on Price of Safety, Price of Liquidity

	Panel A: Price of Safety Assets with similar liquidity and different safety: $S^{Baa-Aaa}$		S^{P2-P1}	
Period	1926-2008	1926-2008	1974-2007	1974-2007
$log(Debt/GDP)$	-0.506		-0.879	
	[-3.42]		[-4.47]	
log(Debt $>$ 10 year mat/GDP),		-0.310		
instr. by powers of *(Debt/GDP)*		[-2.40]		
log(Debt $\leq$ 1 year mat/GDP)				-1.453
instr. by powers of *(Debt/GDP)*				[-2.94]
Volatility	5.070	6.311	0.321	0.029
	[6.53]	[6.66]	[0.38]	[0.03]
Slope	0.229	0.209	0.014	0.054
	[4.15]	[3.24]	[0.40]	[1.14]
Constant	0.660	0.241	-0.500	-2.662
	[4.52]	[0.648]	[-2.45]	[-2.56]
N	83	83	34	34
R^2	0.600		0.486	
Estimation method	OLS	IV	OLS	IV
Error term	AR(1)	AR(1)	AR(1)	AR(1)
Impact of -1 σ supply		+41 bps		+26 bps

Table III. Impact of Treasury Supply on Price of Safety, Price of Liquidity

	Panel B: Price of Liquidity Assets with similar safety and different liquidity: $s^{FDIC\ insured\ CDs\text{-}Bills}$	$s^{Time\ \&\ Savings\ Accounts\text{-}Bills}$
Period	1984-2008	1935-1965
$log(Debt/GDP)$	-1.904	-0.639
	[-1.83]	[-2.37]
Slope	0.137	1.013
	[1.32]	[8.48]
Constant	-1.500	-0.070
	[-1.63]	[-0.41]
N	25	31
R^2	0.271	0.720
Estimation method	OLS	OLS
Error term	i.i.d.	i.i.d.
Impact of -1 σ supply	+115 bps	

3. Money and Treasuries

- Convenience yield on money (money demand function) driven by:
  1. Medium-of-exchange for goods transactions
  2. Liquidity in financial transactions
  3. Safety, as in secure store of value

  We have argued that Treasuries share (2) and (3). If so, then money should be a substitute asset for Treasuries.

- Focus on parts of money that has (2) and (3) but not (as much) (1):
  - M2-M1 (excl. MMMF holdings of Treasuries):
    Small denomination savings and time deposits – FDIC insured
  - Exclude M1 (currency, demand dep.). Has (1) and not controlled by private sector.
  - Also evidence for M3-M1 (excl. MMMF holdings of Treasuries):
    Adds large savings and time deposits, repos and Euro dollars.

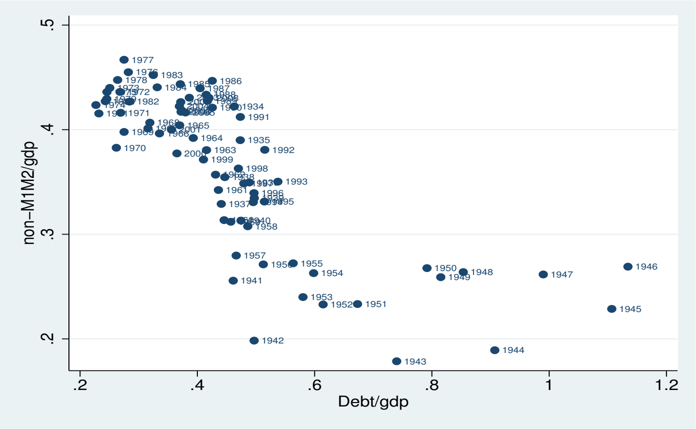
Prediction 9: Impact of Treasury supply on supply of substitute asset

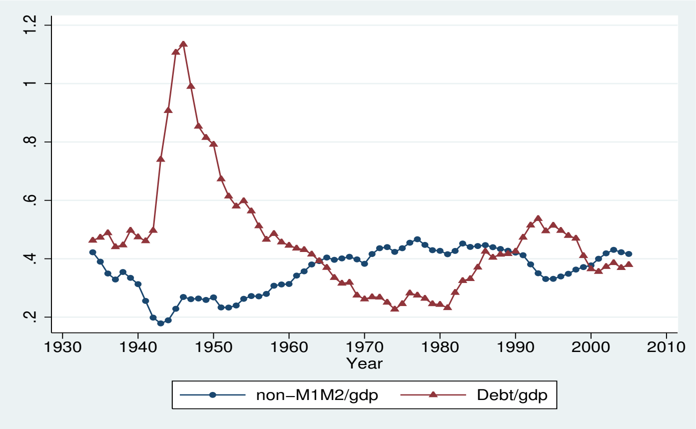
If the supply of money (specifically bank deposits) is price elastic, then θ_t^{Money} and θ_t^T will be negatively related.

Prediction 8: Impact of Treasury supply on yield of substitute asset

$$
\begin{aligned}
i_t^{corp} - i_t^{money} &= k^{liq} v'_{liq}\left(\frac{\theta_t^T + k^{liq}\theta_t^{P,liq}}{GDP_t}; \xi_t^{liq}\right) \\
&+ v'_{shortsafe}\left(\frac{\theta_t^{T,short} + k^{shortsafe}\theta_t^{P,shortsafe}}{GDP_t}; \xi_t^{shortsafe}\right) + \lambda_t D_t .
\end{aligned}
$$

Money (M2-M1) versus Debt/GDP, 1934-2008:





1.2
1
.8
.6
.4
.2
1930
1940
1950
1960
1970
1980
1990
2000
2010
Year
non−M1M2/gdp
Debt/gdp

Table V. Response of Money to Treasury Supply, 1934-2008

	Panel A: Reduced Form		
	(1)	(2)	(3)
Dep. Var.	non-M1M2/GDP	non-M1M2/GDP	non-M1M3/GDP
Period	1926-2008	1959-2005	1959-2005
Debt/GDP	-0.305	-0.352	-0.553
	[-5.52]	[-4.16]	[-3.34]
Year		0.001	0.007
		[1.86]	[5.99]
Intercept	0.502	-1.467	-12.161
	[18.26]	[-1.38]	[-5.69]
R^2	0.601	0.534	0.802
N	75	47	47
Estimation method	OLS	OLS	OLS
Standard errors	AR(2)	AR(2)	AR(2)

- When Treasury supply is reduced by $1, private sector supply of money increases by $0.55.

Table V. Response of Money to Treasury Supply, 1934-2008

	Panel B: Structural Form		
	1st Stage of IV	**2nd Stage of IV**	
Dep. Var.	$S^{Baa-nonM1M2}$	$log(non-M1M2/GDP)$	
Period	1935-1965, 1984-2008		1935-1965, 1984-2008
$Log(Debt/GDP)$	-1.587	$S^{Baa-nonM1M2}$	0.394
	[-2.10]		[2.29]
Volatility	7.942	*Volatility*	-2.717
	[2.81]		[-1.47]
Slope	0.440	*Slope*	-0.140
	[2.27]		[-1.37]
Intercept	2.279	*Intercept*	-2.439
	[3.94]		[-4.13]
N	56		56
Estimation method	OLS		IV
Standard errors	AR(1)		AR(1)
	Confirms Prediction 8	Shows that money response works via spread channel	

4. Quantifying average convenience yields

- We have fit:

$$Spread_t = f(\theta_t^T/GDP_t) + b_0 + b_1\ controls_t + error_t$$

  with a log-function for f.
- More realistic to impose that $f(\infty) \to 0$.
  Then the convenience yield is the distance between the predicted spread and the estimated asymptote.
- Specifically, assume kink function, with $f = 0$ for $\theta_t^T/GDP_t > b_2$:

$$f(Debt/GDP) = b_1 \times max[b_2 - Debt/GDP, 0].$$

  Then asymptote is b_0 and conv. yield is $f(Debt/GDP)$ (de-mean the controls).
- Estimate by non-linear least squares, again with AR(1) errors.

Table VI. Impact of Treasury Supply on Bond Spreads: Piecewise Linear Specification

	Panel A: Aaa-Treasury		Panel B: Baa-Treasury	
	(1)	(2)	(3)	(4)
Period	1919-2008	1926-2008	1919-2008	1926-2008
b_0	0.319	0.346	1.019	1.199
	[1.80]	[2.51]	[1.94]	[7.29]
b_1	2.579	3.060	4.310	4.941
	[4.02]	[5.07]	[2.64]	[6.75]
b_2	0.585	0.549	0.625	0.545
	[6.96]	[9.56]	[4.22]	[12.92]
Volatility		1.189		6.236
		[1.90]		[7.05]
Slope		0.095		0.330
		[2.38]		[5.03]
R^2	0.477	0.612	0.290	0.704
N	90	83	90	83
Avg. conv. yield		46 bps		72 bps

Average convenience yield over 1926-2008 sample: 72 bps

- Long-term safety: Lower bound from Baa-Aaa (Aaa not riskless): 26 bps
- Liquidity: Upper bound from Aaa-Treas (Aaa not riskless): 46 bps

Our average convenience yields are probably downward biased (conservative):

- Asymptote b_0 identified off of 1940s and 1950s.
- Fed set Treasury price floor for long Treasuries $\Longrightarrow$ Treasury yield artificially low $\Longrightarrow$ Spread artificially high $\Longrightarrow$ b_0 too high.
- More intervention in T-bill market (large Fed purchases, T-bills as bank reserves) $\Longrightarrow$ Short spreads not useful for calculating avg. conv. yield.

Similarly, our saturation point, b_2: Debt/GDP=0.55, is probably too low.

Summary

1. Treasuries have a convenience yield:
   - Treasury supply $\downarrow \Rightarrow$ Spread b/w non-conv. and conv. Treasury assets $\uparrow$.
   - True for many spreads, and after default controls.
   - Robust to tax issues (Treasuries exempt from state and local taxes), and callability of corporates (not relevant for short spreads).
2. Source of Treasury convenience yield: Liquidity, long-term & short-term safety attributes of Treasuries
   - Treasury supply $\downarrow \Rightarrow$ Price of liquidity $\uparrow$, Price of safety $\uparrow$.
3. Money also offers liquidity and safety and is thus a Treasury substitute
   - Treasury supply $\downarrow \Rightarrow$ Money supply $\uparrow$.
4. The average convenience yield is high: 72 bps (at the long end).

Next: Implications

Implication 1. Government seignorage from Treasuries

Government (tax-payers) benefit from being able to fund Federal debt with asset that has low yield.

- Average seignorage on government debt
  $=$ Average of (convenience yield $\times$ Debt-to-GDP)
  $=$ 0.24% of GDP
- For comparison: Seignorage on money, year 2007 (pre-QE1):
  $= M0 \times 4\%$
  $=$ 0.24% of GDP.

Implication 2. Riskless rate

Do not teach students to use Treasury yield as the riskless rate in the CAPM!

- A corporation with a beta of zero cannot borrow at the Treasury rate
- Need to add Treasury convenience yield

Do not buy Treasuries unless you want extreme safety and liquidity

- You can earn 72 bps more if you are ok with almost complete safety and less liquidity.

And the equity premium is 72 bps smaller when using the convenience-adjusted riskless rate.

Implication 3. Effect of foreign official holders on interest rates

Table VII. Debt Holdings, by Group

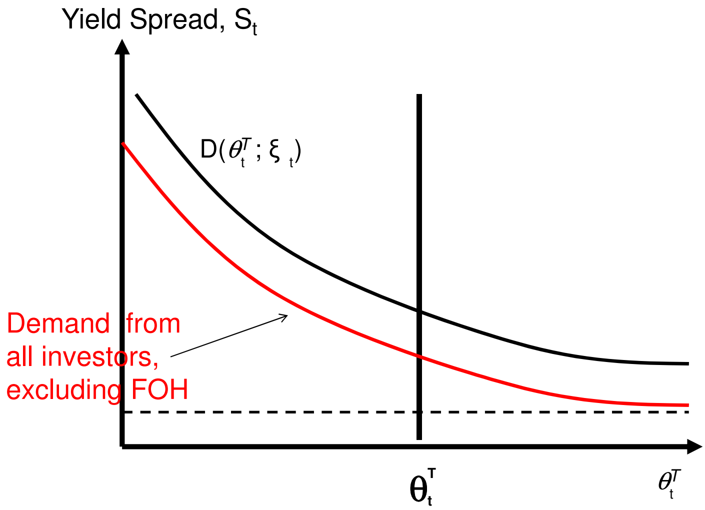
Group Debt-to-GDP	**Panel A: Who holds Treasury Debt?**				
	Mean	Std. Dev.	1945	1975	2008
Federal Reserve Banks	0.138	0.040	0.097	0.199	0.075
Foreign Official Holdings	0.113	0.088	0.010	0.141	0.367
State/Local Governments	0.088	0.042	0.022	0.064	0.076
Banks/Credit Institutions	0.201	0.116	0.416	0.222	0.017
Households and Mutual Funds	0.260	0.051	0.265	0.263	0.169
Foreign Private Sector	0.042	0.049	0.000	0.010	0.140
Fedrl/State/Local Govt. Ret.	0.035	0.022	0.006	0.006	0.045
Private Pensions	0.028	0.020	0.008	0.029	0.029
Insurance Companies	0.048	0.023	0.093	0.022	0.025

- Concern about FOH holding 37% of Treasuries. What will happen if they sell?
- More Treasury supply for others $\Rightarrow$ Lower Treasury prices, higher Treasury yields, lower spreads.

Table VII. Debt Holdings, by Group

	Panel B: Bond Market Portfolio Composition			
	Treasury	Agency	Long-term Corporate	Short-term Corporate
Federal Reserve Banks	0.983	0.017	0.000	0.001
Foreign Official Holdings	0.948	0.052	0.000	0.000
State/Local Governments	0.720	0.217	0.029	0.034
Banks/Credit Institutions	0.526	0.312	0.141	0.020
Households and Mutual Funds	0.563	0.095	0.223	0.118
Foreign Private Sector	0.240	0.084	0.479	0.197
Fedrl/State/Local Govt. Ret.	0.387	0.108	0.487	0.018
Private Pensions	0.233	0.142	0.583	0.042
Insurance Companies	0.172	0.078	0.726	0.024

- We estimate that FOH have vertical demands. Consistent with them holdings almost exclusively Treasuries.


Yield Spread, S_t
$D(\theta_t^T; \xi_t)$
Demand from
all investors,
excluding FOH
θ_t^T
θ_t^T

- FOH sale is an increase in supply available to others
- Demand curves shown have same slope – slope comes from non-FOH.
- So we can evaluate drop in yield as impact of increased supply using current overall demand curve.
- Based on estimated demand functions, and at historical average Debt/GDP:
  - Baa-Treasury, piecewise linear: Raise long Treasury yield by 59 bps
    Baa-Treasury, log: Raise long Treasury yield by 41 bps
  - CP (P2)-Bills: Raise short Treasury yield by 60 bps
- Effects will differ if they sell now: Smaller because of high current Debt/GDP, but larger if higher than average convenience demand. Hard to assess.

Implication 4. QE – Krishnamurthy and Vissing-Jorgensen (Brookings, Fall 2011)

Objective: Evaluate effects of Fed purchase of long-term Treasuries and other long-term bonds (QE1 in 2008-2009 and QE2 in 2010-2011) on interest rates.

- What are the effects on a variety of interest rates?
- What are the channels through which QE affects rates?
- The channels matter for whether all long rates react the same regardless of what you buy, or not.

Approach: Event study using a host of interest rates and derivatives data

Our main findings on QE: It matters that Treasuries are "special"

1. Inappropriate to focus only on Treasury rates as a policy target: QE works through several channels that affect particular assets differently.

   Channels: **Long-term safety channel**, signaling channel, and inflation channel for both QE1 and QE2, and MBS pre-payment channel and corporate bond default risk channel for QE1.

   - Changes in the safety convenience yield on long Treasuries (and agencies and for QE1 Aaa corporate) for both QE1 and QE2. As large as 160 bps for QE1, about 5-10 bps for QE2
   - Liquidity effect for QE works to *increase* Treasury yields, so look at (CDS-adjusted) Baa - Agencies to see full long-term safety effect.

2. Effects on particular assets depend critically on which assets are purchased.

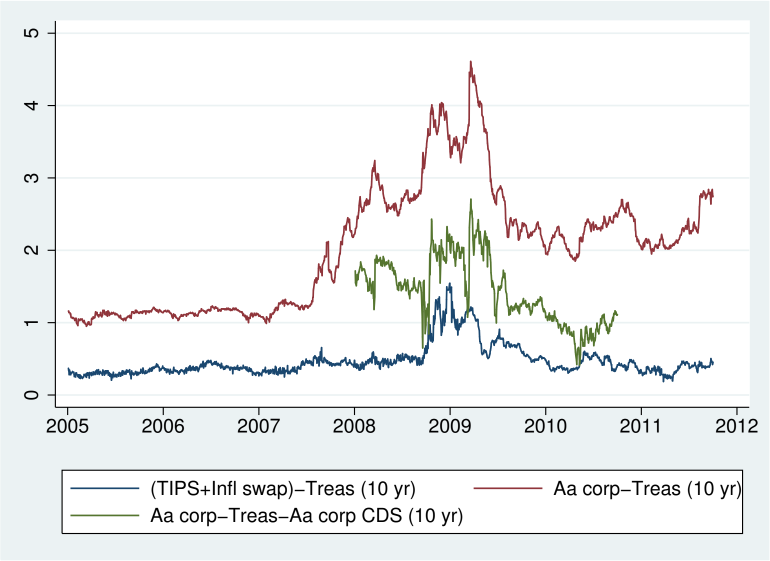
   - Treasuries-only purchases in QE2 had a disproportionate effect on Treasuries and Agencies relative to MBS and corporates
   - MBS purchases in QE1 were crucial for lowering MBS yields as well as corporate credit risk and thus corporate yields for QE1

Implication 5: Optimal Treasury structure. What are current convenience yields?

- We found that based on the average demand curve, the saturation point was Debt/GDP=0.55. As of 2011:Q2 Debt/GDP is \$9.7T/\$15.0T=0.65.
- But our estimate of the saturation point was likely too low due to intervention in the Treasury market during the war and post-war years.
- And, under QE, Fed has "taken out" a lot of the Treasury supply, \$1.6T as of 2011:Q2. If you take out current Fed holdings, Debt/GDP is about (\$9.7T-\$1.6T)/\$15.0T=0.54.
- And, if anything, current demand is probably higher than usual.
- So let us look at a bit more data to assess whether current Treasury convenience yields are positive.

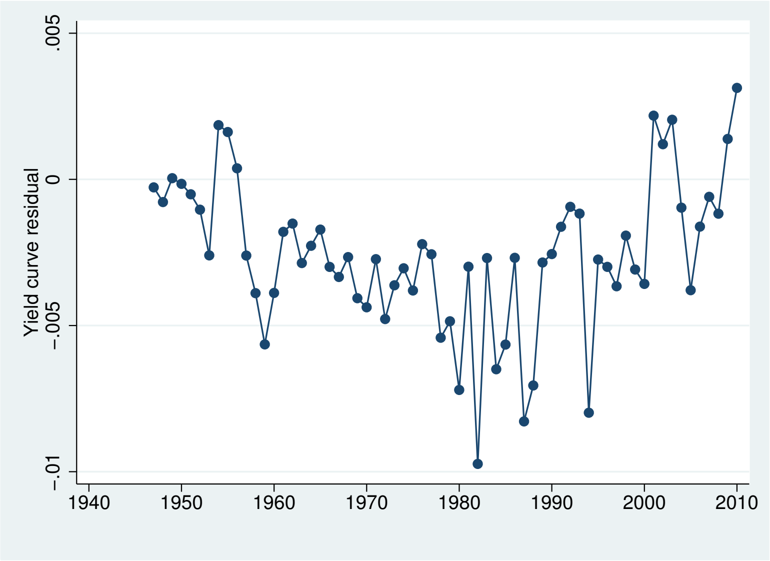
At the long end: Current convenience yield is large

- For recent years we have derivatives prices that help sort this out more precisely
- We can risk adjust corporate-treasury spreads using CDS rates on corporate bonds.
- And inflation swaps to allow us to construct another comparison for Treasuries that are not affected by default risk: TIPS+Inflation swap. Probably does not have the same safety properties (e.g. appeal to central banks, use in collateral etc.) and likely to be less liquid.


5
4
3
2
1
0
2005
2006
2007
2008
2009
2010
2011
2012
(TIPS+Infl swap)−Treas (10 yr)
Aa corp−Treas (10 yr)
Aa corp−Treas−Aa corp CDS (10 yr)

At the short end: Current conv. yield is very small, perhaps even zero

- Using the latest Fed CP data and Treasury yield data, Nov. 10, 2011:
  - A1/P1 non-financial CP, 1-month: 10 bps
  - Treasury constant maturity, 1-month: 1 bps.
  - So Treasury convenience yield relative to highly rated CP is at most 9 bps, and likely less with the slight risk in the CP.
  - Historical average A1/P1-Treasury yield, 1920-2008, is 78 bps.
- Even stronger conclusion from approach of Greenwood, Hanson and Stein (2010) of looking at whether yield-curve pricing errors are negative for the shortest T-bills.
  - Estimate regression of yields on cubic in maturity for each date, using only securities with maturities beyond 3 months (and only non-callable). Look at residuals for T-bills with maturities less than 3 months. Currently near zero.

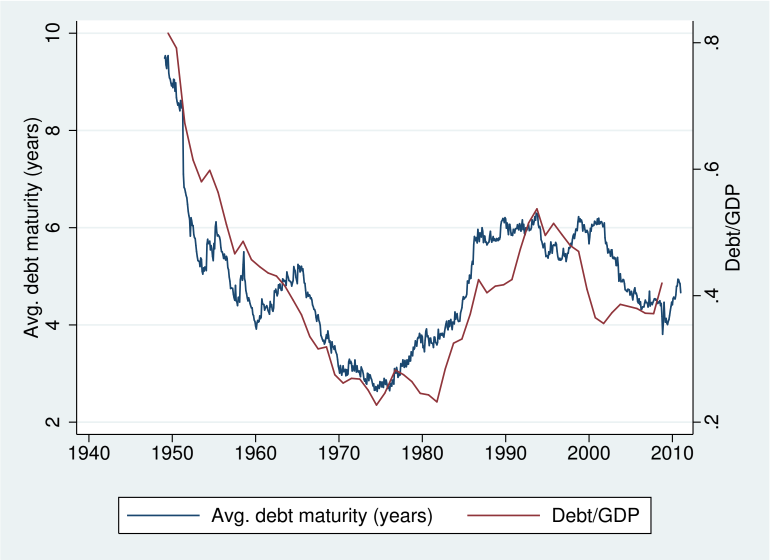

Yield curve residual
.005
0
-.005
-.01
1940
1950
1960
1970
1980
1990
2000
2010

What does this teach us about optimal Treasury maturity structure?

- Suppose tax payers think Treasury's objective should be to maximize dollar convenience yield for given amount of debt (since conv. yield is how much cheaper they borrow than what they think would be "fair" given the duration)
- Then convenience yields should be equalized across maturities
- Currently they are not. Need to have relative more long-term debt.
- In particular: No need to issue more T-bills to satisfy "money-demand" since that demand is saturated, though this is likely related to large reserve increase under QE (+$740B since 2008) and could change once QE is unwound.

Actual policy:

- Historically, the Treasury has picked higher maturity when Debt/GDP is higher.
- This is optimal, with respect to maximizing convenience yields, if the convenience demand a the long end is saturated at a slower rate than that at the short end.


Avg. debt maturity (years)
2
4
6
8
10
Debt/GDP
.2
.4
.6
.8
1940
1950
1960
1970
1980
1990
2000
2010
Avg. debt maturity (years)
Debt/GDP

Our findings also suggest another key Treasury choice variable: The number of bonds issued

Tradeoff:

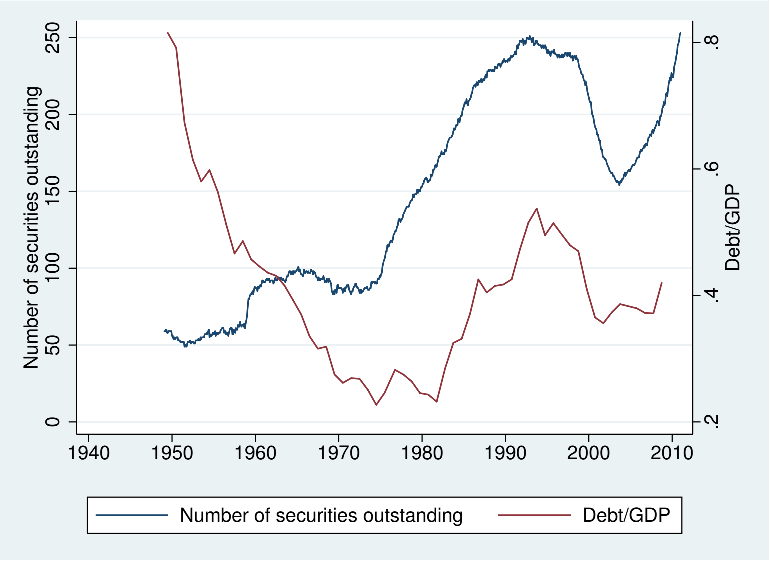
- More bonds $\Longrightarrow$ Can issue at many different maturities to match safety demand for particular maturities precisely
- But more bonds $\Longrightarrow$ Issue sizes get smaller and this reduces liquidity

Questions:

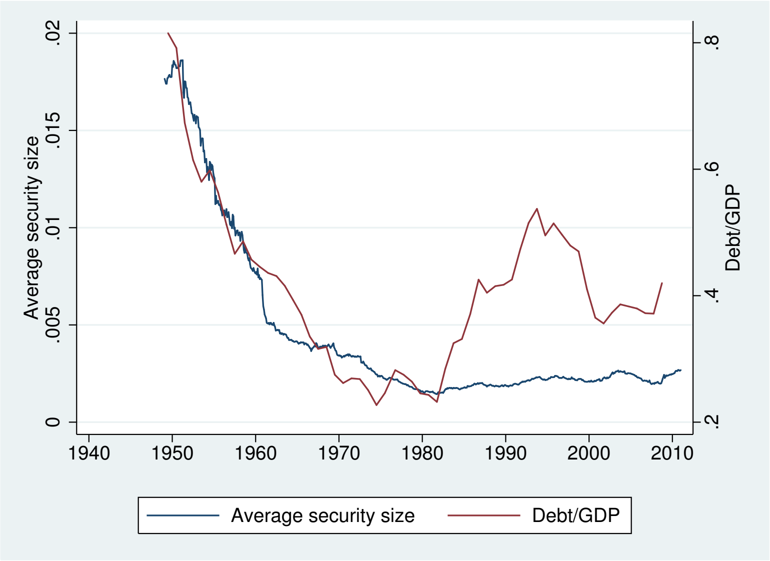
- Are we at the right number of bonds?
- How much should the number of bonds increase with funding needs?

Actual policy:

- Since around 1975, the Treasury has increased the number of issues with Debt/GDP and kept issue sizes/GDP fairly constant. We need more analysis of whether that is optimal.
- Important: This is a distinct question from how many auctions should be held per year since one can issue into an already existing CUSIP at a given auction.



0
50
100
150
200
250
Number of securities outstanding
.2
.4
.6
.8
Debt/GDP
1940
1950
1960
1970
1980
1990
2000
2010
Number of securities outstanding
Debt/GDP



Average security size
0
.005
.01
.015
.02
Debt/GDP
.2
.4
.6
.8
1940
1950
1960
1970
1980
1990
2000
2010
Average security size
Debt/GDP

Conclusion

- Liquidity and extreme safety are asset-attributes that are demanded by investors.
- There is a broad aggregate of assets that satisfy the demand.
- Treasuries are an important component of the aggregate. So are money, high-grade corporate bonds (and probably agency bonds).
- Historical average conv. yield on Treasuries is 72 bps (liquidity conv. yield $\leq$ 46 bps; long safety conv. yield $\geq$ 26 bps).
- Results have implications for many first-order issues in finance and macro.