What Drives Variation in the U.S. Debt/Output Ratio? The Dogs that Didn't Bark

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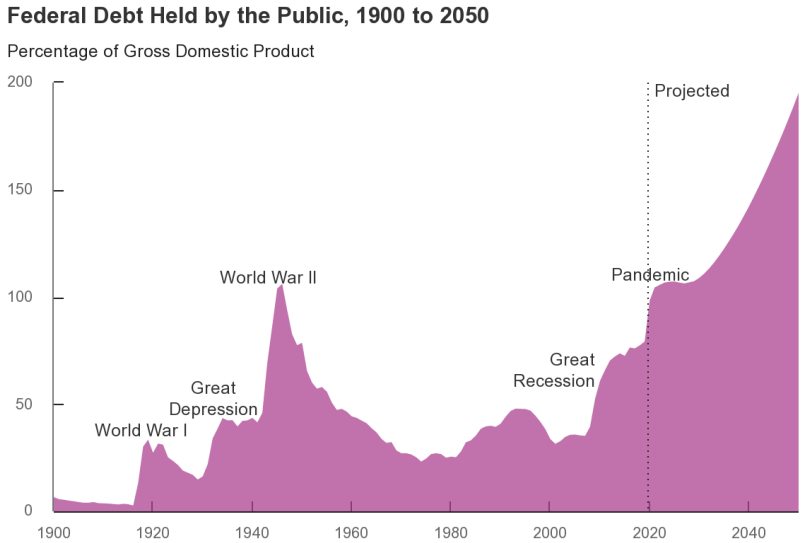
Fiscal Sustainability



Source: Congressional Budget Office

Fiscal Sustainability: Forward-looking Approach

- Ongoing debate in the U.S. about fiscal sustainability
- Current run-up in the U.S. debt/output ratio reflects:
  1. Lower future inflation-and-growth adjusted returns on government debt (Blanchard, 2019; Furman and Summers, 2020; Cochrane, 2021a) :
     - $(r - g) < 0$ debate
  2. Higher future surpluses (Bohn, 1998; Cochrane, 2020)
  3. Higher future debt/output ratio

This Paper

- Apply standard asset pricing machinery (Campbell-Shiller decomposition) to a macro question (fiscal sustainability)
- Campbell-Shiller decomposition of the U.S. debt/output ratio :
  1. **Discount rates**: No evidence that the debt/output ratio predicts real growth-adjusted returns. ✗
  2. **Cash flows**: No evidence that the debt/output ratio predicts surpluses. ✗
  3. **Residual**: higher future debt/output ratio ✓

$\Rightarrow$ Excess smoothness: Bond prices today not responsive to news about future macro fundamentals

Findings Differ From Literature

- Earlier work:
  - Bohn (1998), studying a sample that ends in the mid-1990s, finds evidence that the primary surplus increases when the debt/output ratio is high
  - Cochrane (2021a,b) finds evidence that the debt/output ratio predicts lower *nominal* returns on the government debt portfolio
  - This paper: no evidence that the debt/output ratio predicts surpluses or *real growth-adjusted* returns

- Key observation: Large small-sample bias (Stambaugh, 1999) in the slope coefficients of the return and surplus predictability regressions due to:
  1. High **persistence** of the debt/output ratio (the predictor)
  2. High **correlation** between the innovations to the predictor and the predicted variables

Related Literature

- **Stock return predictability** (Campbell and Thompson, 2007; Cochrane, 2008; Binsbergen and Koijen, 2010; Goyal and Welch, 2005; Golez and Koudijs, 2018):
  - Discount rates on stocks are remarkably volatile (Hansen and Jagannathan, 1991),
  - Valuation of stocks seems excessively volatile compared to its fundamentals (LeRoy and Porter, 1981; Shiller, 1981),
  - High valuations imply low future returns (mean reversion in valuation ratios),
- **Bond return predictability**: (Fama and Bliss, 1987; Campbell and Shiller, 1991; Cochrane and Piazzesi, 2005; Ludvigson and Ng, 2009; Cochrane, 2011) ,
  - Individual bond return predictability,
  - For entire bond portfolio: high valuations do not imply low future returns (no mean reversion in valuation ratios),
  - Valuation of bonds seems too smooth compared to its fundamentals

Related Literature

- **Statistical issues with persistent predictors** (Nelson and Kim, 1993; Hamilton, 1994; Stambaugh, 1999; Lewellen, 2004; Torous, Valkanov, and Yan, 2004; Campbell and Yogo, 2006; Boudoukh, Israel, and Richardson, 2020; Bauer and Hamilton, 2017)

- **Fiscal policy and budget constraints**: Hansen, Roberds, and Sargent (1991); Hamilton and Flavin (1986); Trehan and Walsh (1988, 1991); Bohn (1998, 2007); D'Erasmo, Mendoza and Zhang (2016); Blanchard (2019); Barro (2020), Reis (2020), Brunnermeier, Merkel and Sannikov (2020), Jiang, Lustig, Van Nieuwerburgh and Xiaolan (2019, 2020, 2021a,b,c).

- **Safe asset supply**: Gourinchas and Rey (2007); Caballero, Farhi, and Gourinchas (2008); Caballero and Krishnamurthy (2009); Maggiori (2007); He, Krishnamurthy, and Milbradt (2018); Jiang, Krishnamurthy and Lustig (2018, 2019).

Outline

1. Variance Decomposition of Debt/Output: Implementation
2. Variance Decomposition Debt/Output: Main results with/out small-sample bias correction
3. Simulation Under Null of Unit Root
4. Variance Decomposition of Transitory Component
5. Subjective Variance Decomposition

Campbell-Shiller Decomposition of Debt/Output Ratio

- Log-linearized return equation implied by the government budget constraint:

$$\widetilde{r}_{t+1} = r_{t+1} - \pi_{t+1} - x_{t+1} = \rho v_{t+1} - v_t + s_{t+1},$$

where $\rho = \exp(-(r - x - \pi))$ is a constant, v_t is log of debt/output ratio, and $s_{t+j} = sy_{t+j}/e^v$ is a scaled measure of surplus/output.
(see Gourinchas and Rey, 2007; Berndt, Lustig, and Yeltekin, 2012; Cochrane, 2021a)

  - Similar to log-linearized return for stocks:

$$r_{t+1} = \rho p d_{t+1} - p d_t + \Delta d_{t+1}.$$

- By iterating this forward T times and taking expectations, we obtain the debt valuation equation:

$$v_t = \mathbb{E}_t \sum_{j=1}^{T} \rho^{j-1} \left(s_{t+j} - \widetilde{r}_{t+j} \right) + \mathbb{E}_t \rho^T v_{t+T}.$$

Variance Decomposition

- We set $\rho = 1$ ("r=g").
- Debt/output ratio reflects either future surpluses or future returns after adjusting for inflation and growth.

$$v_t = \mathbb{E}_t \sum_{j=1}^{T} \left(s_{t+j} - \widetilde{r}_{t+j} \right) + \mathbb{E}_t v_{t+T}.$$

- Debt/output ratio varies because it either predicts future surpluses, future returns, or the future debt/output ratio:

Variance Decomposition of the Debt/Output Ratio.

$$var(v_t) = cov\left(\sum_{j=1}^{T} s_{t+j}, v_t \right) - cov\left(\sum_{j=1}^{T} \widetilde{r}_{t+j}, v_t \right) + cov(v_t, v_{t+T}).$$

Variance Decomposition: Implementation

- Estimate a system of univariate forecasting regressions for $\sum_{j=1}^{T} s_{t+j}, \sum_{j=1}^{T} \widetilde{r}_{t+j}, v_{t+j}$ using the lagged debt/output ratio as a predictor:

$$\begin{aligned}
\sum_{j=1}^{T} s_{t+j} &= a_s + b_T^s v_t + \epsilon_{t+T}^s, \\
\sum_{j=1}^{T} \widetilde{r}_{t+j} &= a_r + b_T^r v_t + \epsilon_{t+T}^r, \\
v_{t+T} &= \phi_0 + \phi_T v_t + \epsilon_{t+T}^v.
\end{aligned}$$

- More reliable estimates of long-run dynamics than VAR (Jordà, 2005)
- Cochrane (2008); Lettau and Van Nieuwerburgh (2008) adopt the same approach to implementing a Campbell-Shiller decomposition of the price/dividend ratio for stocks.
- Define fiscal sustainability as $\phi_T < 1$ for all T and $\phi_T \to 0$ as $T \to \infty$.

Variance Decomposition: Implementation

- Regression coefficients can be interpreted as the fraction of the variance of v_t explained by each component for a certain horizon j:

$$\begin{aligned} \frac{cov(\sum_{j=1}^{T} s_{t+j}, v_t)}{var(v_t)} &= b_T^s, \\ \frac{cov(-\sum_{j=1}^{T} \widetilde{r}_{t+j}, v_t)}{var(v_t)} &= -b_T^r, \\ \frac{cov(v_{t+T}, v_t)}{var(v_t)} &= \phi_T. \end{aligned}$$

- Cross-equation restriction is satisfied: $b_T^s - b_T^r + \phi_T = 1$.

Data: Decade Averages

	$\tilde{r}$	r	x	π	$x+\pi$	s/y
1947-1949	-7.8%	-1.8%	0.6%	5.4%	6.0%	1.5%
1950-1959	-3.8%	2.7%	4.1%	2.4%	6.5%	1.4%
1960-1969	-2.8%	3.9%	4.4%	2.3%	6.7%	1.4%
1970-1979	-2.5%	7.0%	3.2%	6.3%	9.5%	-0.6%
1947-1979	-3.5%	3.9%	3.6%	3.8%	7.4%	0.8%
1980-1989	4.1%	11.8%	3.0%	4.6%	7.6%	0.1%
1990-1999	1.6%	6.9%	3.2%	2.2%	5.3%	1.5%
2000-2009	0.8%	4.9%	1.9%	2.2%	4.1%	0.0%
2010-2020	-0.4%	2.9%	1.7%	1.6%	3.3%	-0.4%
1980-2020	1.5%	6.5%	2.4%	2.6%	5.1%	-0.6%
1947-2020	-0.7%	5.4%	3.0%	3.2%	6.1%	0.1%

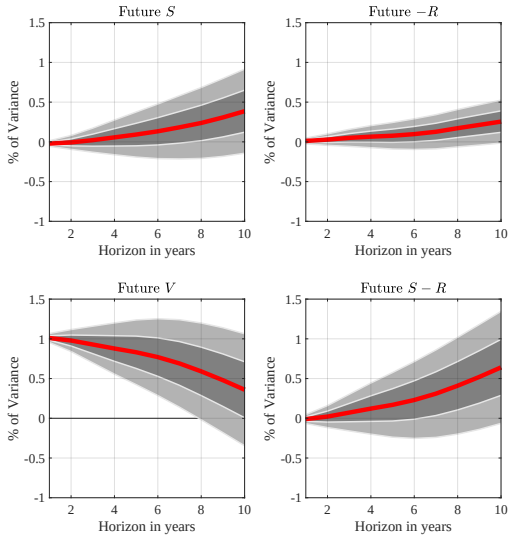
- Note that $r < g$ or $\tilde{r} < 0$ only in first half of post-war sample
- Surpluses came down over time
- Does variation in v_t predict this secular variation in $\tilde{r}_{t \to t+10}$ or $s_{t \to t+10}$?

Variance Decomposition of v_t: No Bias Correction (1947-2020)

Horizon	1	2	3	4	5	6	7	8	9	10
					Forecasting $\sum_{j=1}^{T} -\widetilde{r}_{t+j}$					
$-b_T^r$	0.01	0.03	0.05	0.07	0.08	0.1	0.13	0.17	0.21	0.25
s.e.	0.02	0.04	0.05	0.07	0.08	0.09	0.11	0.12	0.13	0.13
R^2	0.01	0.02	0.03	0.04	0.04	0.05	0.06	0.08	0.10	0.12
					Forecasting $\sum_{j=1}^{T} s_{t+j}$					
b_T^s	-0.02	-0.01	0.02	0.06	0.09	0.13	0.18	0.24	0.31	0.39
s.e.	0.02	0.04	0.08	0.11	0.14	0.17	0.2	0.22	0.24	0.26
R^2	0.02	0	0	0.01	0.02	0.03	0.05	0.06	0.09	0.11
					Forecasting v_{t+T}					
ϕ	1.01	0.98	0.93	0.88	0.83	0.77	0.69	0.59	0.48	0.36
s.e.	0.03	0.07	0.11	0.16	0.2	0.24	0.27	0.3	0.33	0.35
R^2	0.95	0.85	0.74	0.64	0.54	0.43	0.32	0.22	0.13	0.07

Nominal Return Decomposition

Variance Decomposition of v_t: 1948-2020



Small-sample Bias in Predictive Coefficients

- Small-sample bias Stambaugh (1999); Boudoukh, Israel, and Richardson (2020) for horizon T:

$$bias_T^r = \mathbb{E}\left(\widehat{b}_T^r - b_T^r\right) = \frac{1}{N}\left[T(1+\phi) + 2\phi\frac{1-\phi^T}{1-\phi}\right] \times -\frac{cov(\epsilon^v, \epsilon^r)}{var(\epsilon^v)},$$

$$bias_T^s = \mathbb{E}\left(\widehat{b}_T^s - b_T^s\right) = \frac{1}{N}\left[T(1+\phi) + 2\phi\frac{1-\phi^T}{1-\phi}\right] \times -\frac{cov(\epsilon^v, \epsilon^s)}{var(\epsilon^v)},$$

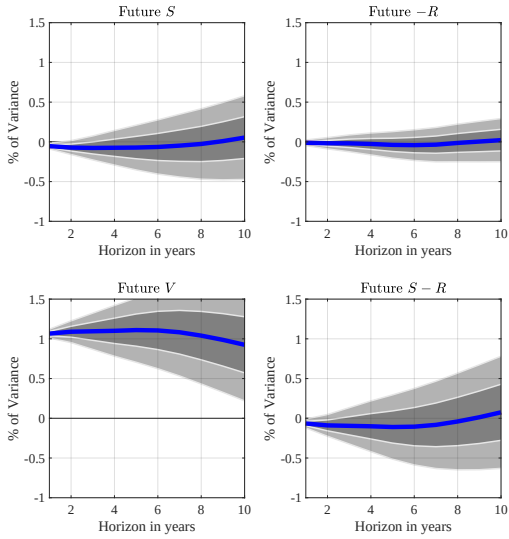
  where ϕ is first-order autocorrelation of v_t, N sample size

- Here: $\phi = .99$, $corr(\epsilon^v, -\epsilon^r) = -0.75$ and $corr(\epsilon^v, \epsilon^s) = -0.85$.

$\Rightarrow$ Biases for b_T^s and $-b_T^r$ are positive and large.

$\Rightarrow$ We are overstating the surplus and return predictability in small samples

Variance Decomposition of v_t after Bias Correction



Variance Decomposition of v_t: Bias Correction (1947-2020)

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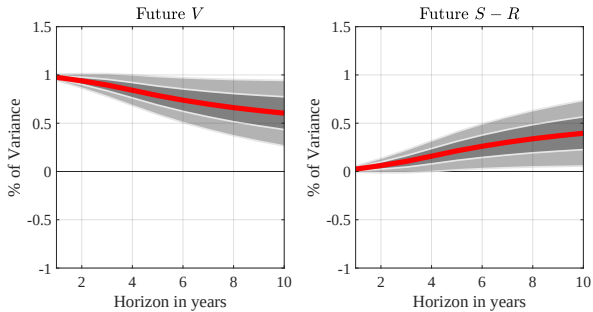
					Forecasting $\sum_{j=1}^{T} -\widetilde{r}_{t+j}$					
$-b_T^r$	0.01	0.03	0.05	0.07	0.08	0.1	0.13	0.17	0.21	0.25
s.e.	0.02	0.04	0.05	0.07	0.08	0.09	0.11	0.12	0.13	0.13
R^2	0.01	0.02	0.03	0.04	0.04	0.05	0.06	0.08	0.1	0.12
unbiased	-0.01	-0.02	-0.02	-0.03	-0.04	-0.04	-0.04	-0.01	0	0.02
					Forecasting $\sum_{j=1}^{T} s_{t+j}$					
b_T^s	-0.02	-0.01	0.02	0.06	0.09	0.13	0.18	0.24	0.31	0.39
s.e.	0.02	0.04	0.08	0.11	0.14	0.17	0.2	0.22	0.24	0.26
R^2	0.02	0	0	0.01	0.02	0.03	0.05	0.06	0.09	0.11
unbiased	-0.05	-0.07	-0.08	-0.07	-0.07	-0.06	-0.05	-0.03	0.01	0.05
					Forecasting v_{t+T}					
ϕ	1.01	0.98	0.93	0.88	0.83	0.77	0.69	0.59	0.48	0.36
s.e.	0.03	0.07	0.11	0.16	0.2	0.24	0.27	0.3	0.33	0.35
R^2	0.95	0.85	0.74	0.64	0.54	0.43	0.32	0.22	0.13	0.07
unbiased	1.07	1.09	1.1	1.1	1.11	1.11	1.08	1.04	0.99	0.92

Variance Decomposition of v_t: Longer Sample 1842—2020

- Robustness to longer U.S. Hall-Payne-Sargent sample

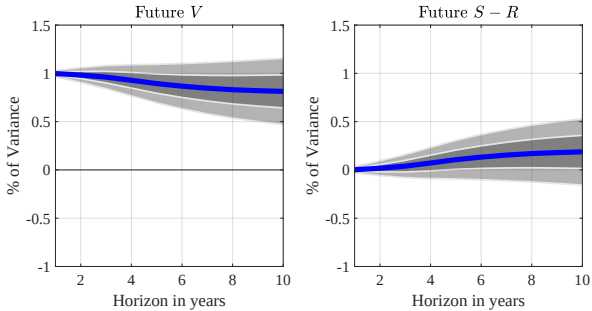
Panel A: Before Bias Correction



Variance Decomposition of v_t: Longer Sample 1842—2020

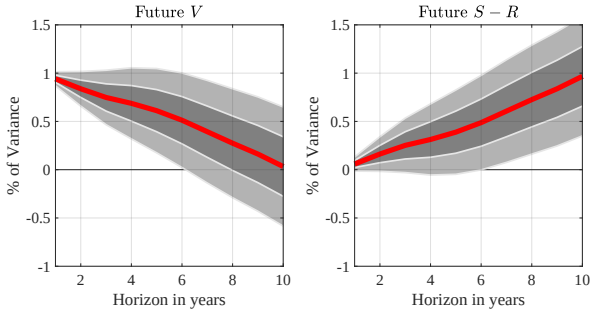
- Same conclusion after small-sample bias correction
- Now have more power to reject the null of no return predictability

Panel B: After Bias Correction



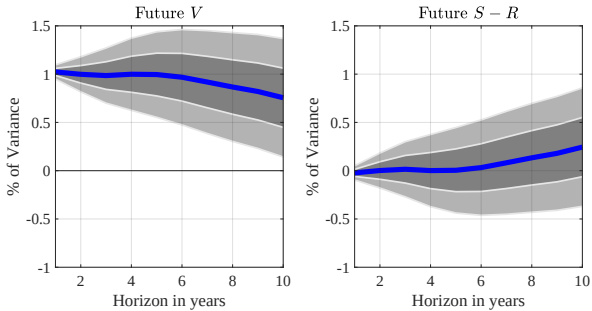
Variance Decomposition of v_t: Shorter Bohn Sample 1948—1995

Panel A: Before Bias Correction



Variance Decomposition of v_t: Shorter Bohn Sample 1948—1995

Panel B: After Bias Correction



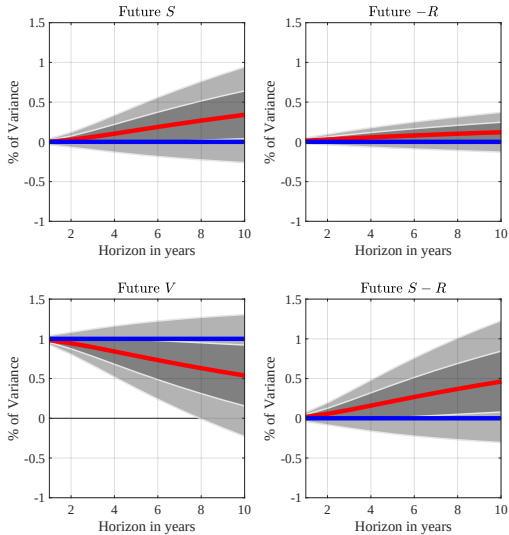
Simulation from Unit Root Model

- Evidence is consistent with a unit root in the debt/output ratio.
- Simulate under the null that there is unit root in the debt/output ratio:

$$\begin{aligned} v_{t+1} &= v_t + \Delta v_{t+1} \\ \Delta v_{t+1} &= \psi_0 + \psi_1 \Delta v_t + \epsilon^v_{t+1} \\ \tilde{r}_{t+1} &= r_0 + \epsilon^r_{t+1} \end{aligned}$$

- There is no contribution from return/surplus predictability (fundamentals): $b^s_T = b^r_T = 0 = 1 - \phi_T$ at all horizons T.
- Estimate $(\epsilon^v_{t+1}, \epsilon^r_{t+1})$ in historical data
- Draw 10,000 samples of length N with replacement from observed $(\epsilon^v_{t+1}, \epsilon^r_{t+1})$
- Simulate and estimate predictability regressions on simulated data
- Evaluate accuracy of small-sample bias correction

Variance Decomposition of v_t under Unit Root

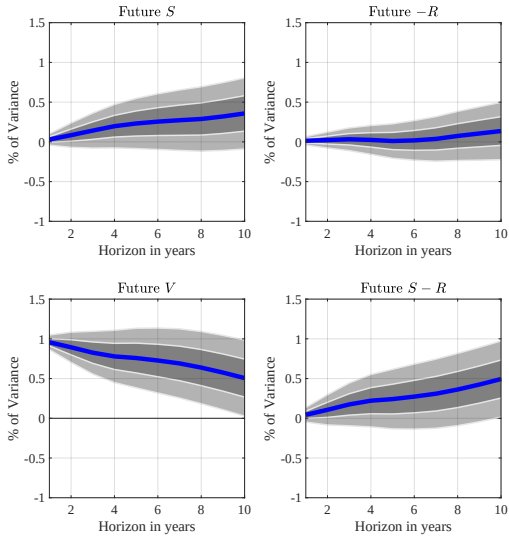


Structural Breaks

- Following Lettau and Van Nieuwerburgh (2008)'s work on stock return predictability, we allow for a structural break in the log debt/output ratio
- Chow test: 2007 is break point. Demeane the log debt/output ratio $\widetilde{v}_t = v_t - \bar{v}_t$ with a lower pre-2007 sample mean ($\bar{v}_t, t < 2007$) and a higher post-2007 sample mean ($\bar{v}_t, t \geq 2007$).
- Structural break introduces 78% point permanent increase in debt/output
- Variance decomposition of the transitory component of debt/output ratio :

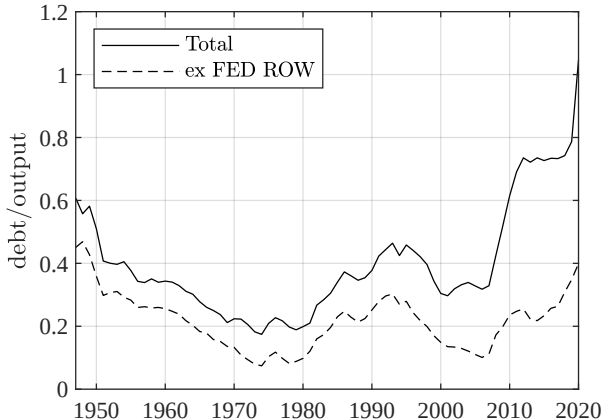
$$var(\widetilde{v}_t) = cov\left(\sum_{j=1}^{T} s_{t+j}, \widetilde{v}_t\right) - cov\left(\sum_{j=1}^{T} \widetilde{r}_{t+j}, \widetilde{v}_t\right) + cov(\widetilde{v}_t, \widetilde{v}_{t+T}).$$

Variance Decomposition of $\widetilde{v}_t$ with Break



Structural Break Candidate 1: Fed & ROW

- Why was there a structural break?
- Candidate 1: Fed and Foreign holdings of Treasurys accelerated after GFC (QE)
- Private domestic holdings (ex-Fed, ex-ROW) are candidate transitory component $\tilde{v}_t$



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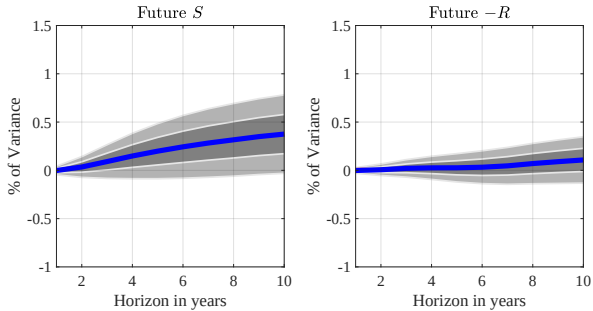


Structural Break Candidate 2: Biased Beliefs

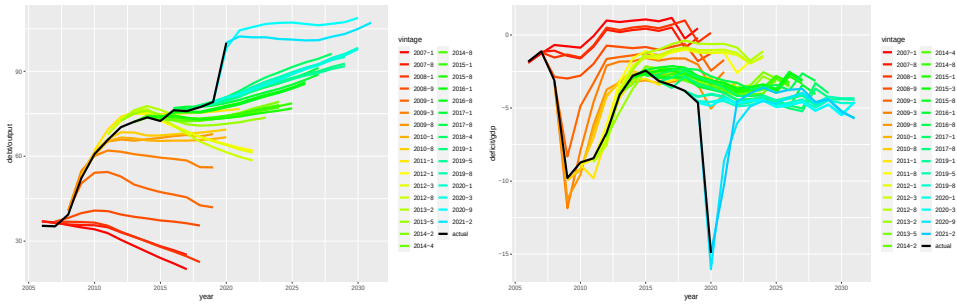
- Econometrician does not predict higher surpluses or lower returns when the debt/output ratio rises, but bond investors may.
- If investors systematically over-predict surpluses and under-predict returns when the debt/output ratio increases, their forecast error can impute a unit root in the debt/output ratio under the actual measure $\mathbb{E}$, while the debt/output ratio is stationary under the subjective beliefs measure $\mathbb{F}$

$$v_t = \mathbb{E}_t \sum_{j=1}^{T} \left(s_{t+j} - \widetilde{r}_{t+j}\right) + \underbrace{\left(\mathbb{F}_t v_{t+T} + \overbrace{(\mathbb{F}_t - \mathbb{E}_t) \sum_{j=1}^{T} (s_{t+j} - \widetilde{r}_{t+j})}^{ForcErr} \right)}_{\mathbb{E}_t v_T},$$

- $Cov(v_t, \mathbb{E}_t v_T)$ large and $Cov(v_t, \mathbb{F}_t v_T)$ small if $Cov(v_t, ForcErr) >> 0$

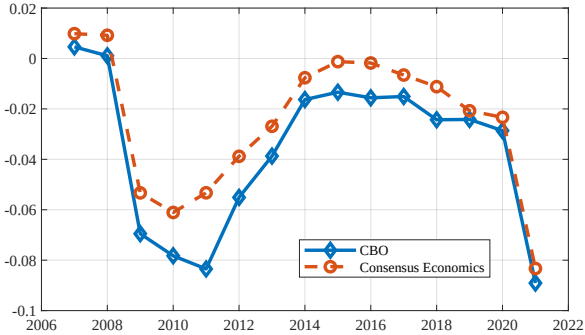
Ten-year CBO Projections

Debt/Ouput *Surplus/Ouput*



- CBO systematically over-predicts future surpluses when debt rises and underpredicts future debt/output

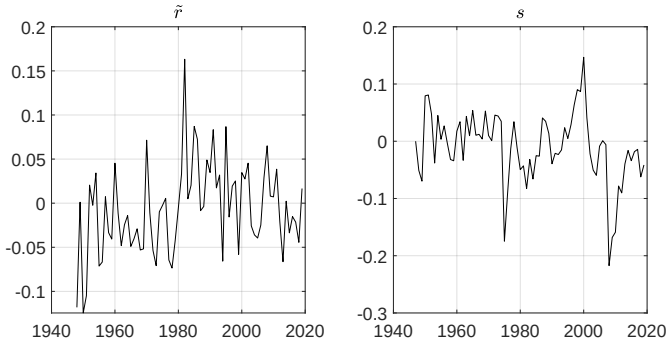
Private Forecasts Align with CBO Forecasts



Conclusion

- The U.S. bond market's valuation surprisingly insensitive to news about future surpluses or returns
- Difficult to reject null hypothesis of unit root in debt/output once small-sample bias is addressed
- Interpretations: persistent component in debt/ouput ratio (structural break after 2007) imputed by
  1. Fed and ROW purchases
  2. Bond market investors' (overly optimistic) beliefs about future fiscal rectitude

Returns and Surpluses



This figure plots the inflation-and-growth-adjusted log returns $\tilde{r}_t$ and the surplus/output ratio s_t.

U.S. Debt/Output Ratio

The full line is the demeaned log debt/output ratio. The dashed line is the demeaned log debt/output ratio, demeaned by two different sub-sample means before and after 2007.

Forecasting Nominal Returns and Inflation with v_t

Horizon	1	2	3	4	5	6	7	8	9	10
					Forecasting $\sum_{j=1}^{T} r_{t+j}$					
b_T^r	-0.05	-0.11	-0.16	-0.22	-0.28	-0.35	-0.43	-0.52	-0.6	-0.69
s.e.	[0.02]	[0.03]	[0.05]	[0.06]	[0.07]	[0.08]	[0.09]	[0.1]	[0.11]	[0.13]
					Forecasting $\sum_{j=1}^{T} x_{t+j}$					
b_T^x	0	0	0.01	0	0	0	0.01	0.01	0.02	0.03
s.e.	[0.01]	[0.02]	[0.03]	[0.04]	[0.05]	[0.06]	[0.06]	[0.07]	[0.08]	[0.08]
					Forecasting $\sum_{j=1}^{T} \pi_{t+j}$					
b_T^π	-0.04	-0.08	-0.12	-0.16	-0.21	-0.26	-0.31	-0.37	-0.42	-0.48
s.e.	[0.01]	[0.01]	[0.02]	[0.02]	[0.03]	[0.04]	[0.05]	[0.06]	[0.08]	[0.09]
					Forecasting $\sum_{j=1}^{T} \widetilde{r}_{t+j}$					
$b_T^{\widetilde{r}}$	-0.01	-0.03	-0.05	-0.06	-0.07	-0.09	-0.13	-0.16	-0.2	-0.25
s.e.	[0.01]	[0.02]	[0.03]	[0.04]	[0.05]	[0.06]	[0.06]	[0.07]	[0.08]	[0.09]

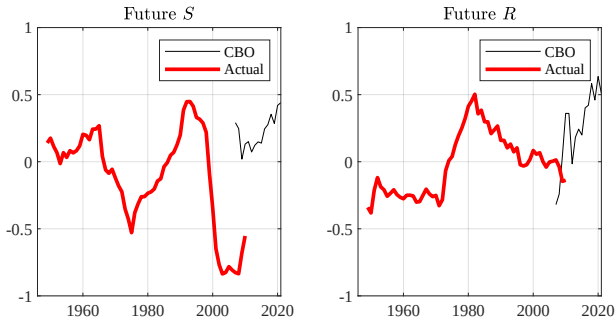
back

Forecasting Returns and Surpluses with $\widetilde{v}_t$

Horizon	1	2	3	4	5	6	7	8	9	10
	Structural Break									
	Forecasting $\sum_{j=1}^{T} -\widetilde{r}_{t+j}$									
$-b_T^r$	0.03	0.05	0.07	0.07	0.07	0.08	0.11	0.16	0.2	0.24
s.e.	0.03	0.05	0.07	0.09	0.11	0.13	0.14	0.16	0.17	0.18
R^2	0.02	0.03	0.04	0.03	0.02	0.02	0.04	0.06	0.08	0.1
unbiased	0.01	0.02	0.03	0.02	0.01	0.02	0.04	0.07	0.11	0.14
	Forecasting $\sum_{j=1}^{T} s_{t+j}$									
b_T^s	0.07	0.16	0.25	0.34	0.41	0.46	0.51	0.56	0.62	0.68
s.e.	0.03	0.07	0.11	0.13	0.16	0.17	0.19	0.2	0.21	0.23
R^2	0.04	0.12	0.2	0.29	0.36	0.42	0.47	0.5	0.53	0.57
unbiased	0.03	0.08	0.14	0.2	0.23	0.25	0.27	0.29	0.32	0.36
	Forecasting v_{t+T}									
ϕ	0.91	0.79	0.68	0.59	0.53	0.45	0.38	0.29	0.19	0.08
s.e.	0.05	0.09	0.13	0.16	0.19	0.2	0.22	0.23	0.23	0.24
R^2	0.86	0.7	0.55	0.44	0.35	0.27	0.19	0.11	0.05	0.01
unbiased	0.96	0.89	0.83	0.78	0.76	0.73	0.69	0.64	0.58	0.51

CBO Projections vs. Realized

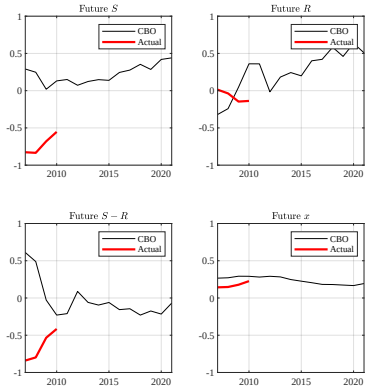
$$v_t = \mathbb{F}_t \sum_{j=1}^{10} \left(s_{t+j} - \widetilde{r}_{t+j} \right) + \mathbb{F}_t v_{t+10}$$



Decomposition of the log debt/output ratio v_t into components due to CBO-projected (and realized) future government surpluses $\sum_{j=1}^{T} s_{t+j}$, future discount rates $\sum_{j=1}^{T} \widetilde{r}_{t+k}$, for $T = 10$.

CBO Projections vs. Realized

$$v_t = \mathbb{F}_t \sum_{j=1}^{10} \left(s_{t+j} - \widetilde{r}_{t+j} \right) + \mathbb{F}_t v_{t+10}$$



Decomposition of the log debt/output ratio v_t into components due to CBO-projected (and realized) future government surpluses $\sum_{j=1}^{T} s_{t+j}$, future discount rates $\sum_{j=1}^{T} \widetilde{r}_{t+k}$, for $T = 10$. We also report future real growth $\sum_{j=1}^{T} \widetilde{x}_{t+k}$.

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