Costs of Financing US Federal Debt Under a Gold Standard: 1791-1933

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Introduction

- ⋆ 1790: US Federal government faced high debt and borrowing costs.
- ⋆ 18th-19th century: wide range of institutional changes to lower yields.
  E.g. repayment of revolutionary debts (1790), first and second bank of US (1791-1836) greenback note issuance (1862-78), National Banking System (1863-1913).
- ⋆ Quantifying impact requires estimate of nineteenth century yield curves.
  - ⋆ Post-WW2: many estimates of the yield curve.
  - ⋆ Pre-WW2: practically no estimates!
- ⋆ We take on the challenges of estimating historical yield curves!

This Paper

- ⋆ **Data:** new database of price, quantities, & cash-flows for all US Federal bonds.
  - ⋆ Available on `github`; see Hall et al. (2018).
  - ⋆ Sources: NYT, CFC, Merchant's Magazine, US Treasury Circulars, Bayley (1882), Sylla (2006), Razaghian (2002). Details
- ⋆ **Statistics:** propose a methodology to handle the limitations of historical data.
  - ⋆ Challenge: long time series but sparse cross-section at many dates.
  - ⋆ Response: statistical model with drifting parameters that interpolates gaps.
- ⋆ **Output:** gold zero-coupon yield curve on US Federal bonds for 1791-1933.
  - ⋆ + Greenback yield curve (1862-1878),
  - ⋆ + Gold-greenback exchange rate expectations (1862-1878).
- ⋆ **Current extensions:** (in Payne & Szőke (2024))
  - ⋆ Data-set and yield curve for US corporate bonds 1840-1940,
  - ⋆ Structural model connecting financial regulation to asset pricing.

Results

1. Historical features of the US Federal yield curve:
   - ⋆ US debt traded at a discount to UK debt until 1880s; At a premium after 1900. (Discount = lower price (higher yield); premium = higher price (lower yield))
   - ⋆ Downward sloping yield curve until 1870s; upward sloping yield curve afterwards.
2. Civil war: public expected Civil War greenback devaluation was temporary. (Strong "nominal anchor" during paper currency issuance)
3. Key spreads depend upon financial sector regulation:
   - ⋆ Premium on short term bonds until peak National Banking Era (1880-1917).
   - ⋆ Convenience yield appears with National Banking Era; moves at low frequency.
4. Extension: Key asset-pricing relationships can be replicated in a structural macro-model; welfare impact is ambiguous.

Literature

- ⋆ Analysis of historical interest rates
  Homer & Sylla (2004), Shiller (2015), Hamilton et al. (2016), Jordà et al. (2019), Schmelzing (2020), Officer & Williamson (2021), Chen et al. (2022)
  - ⋆ **This paper:** estimates *full* yield curve for *all* periods

- ⋆ Yield curve estimation
  Nelson & Siegel (1987), Svensson (1995), Dahlquist & Svensson (1996), Cecchetti (1988), McCulloch and Kwon (1993), Annaert et al. (2013), Daglish & Moore (2018), Andreasen et al. (2019), Diebold & Li (2006), Diebold et al. (2008), and Gürkaynak et al. (2007)
  - ⋆ **This paper:** uses Hamiltonian MC with no U turns to compute posterior distribution of time-varying Nelson and Siegel (1987) parametrization. (So we can handle stochastic volatility.)

- ⋆ Long run price and exchange rate expectations
  Mitchell (1903, 1908), Roll (1972), Sargent (1981), Gürkaynak et al. (2005), Cogley & Sargent (2005, 2015), Cogley (2005), Rudebusch & Swanson (2012), and Hazell (2020)
  - ⋆ **This paper:** includes data covering episodes with debts denominated in different currencies

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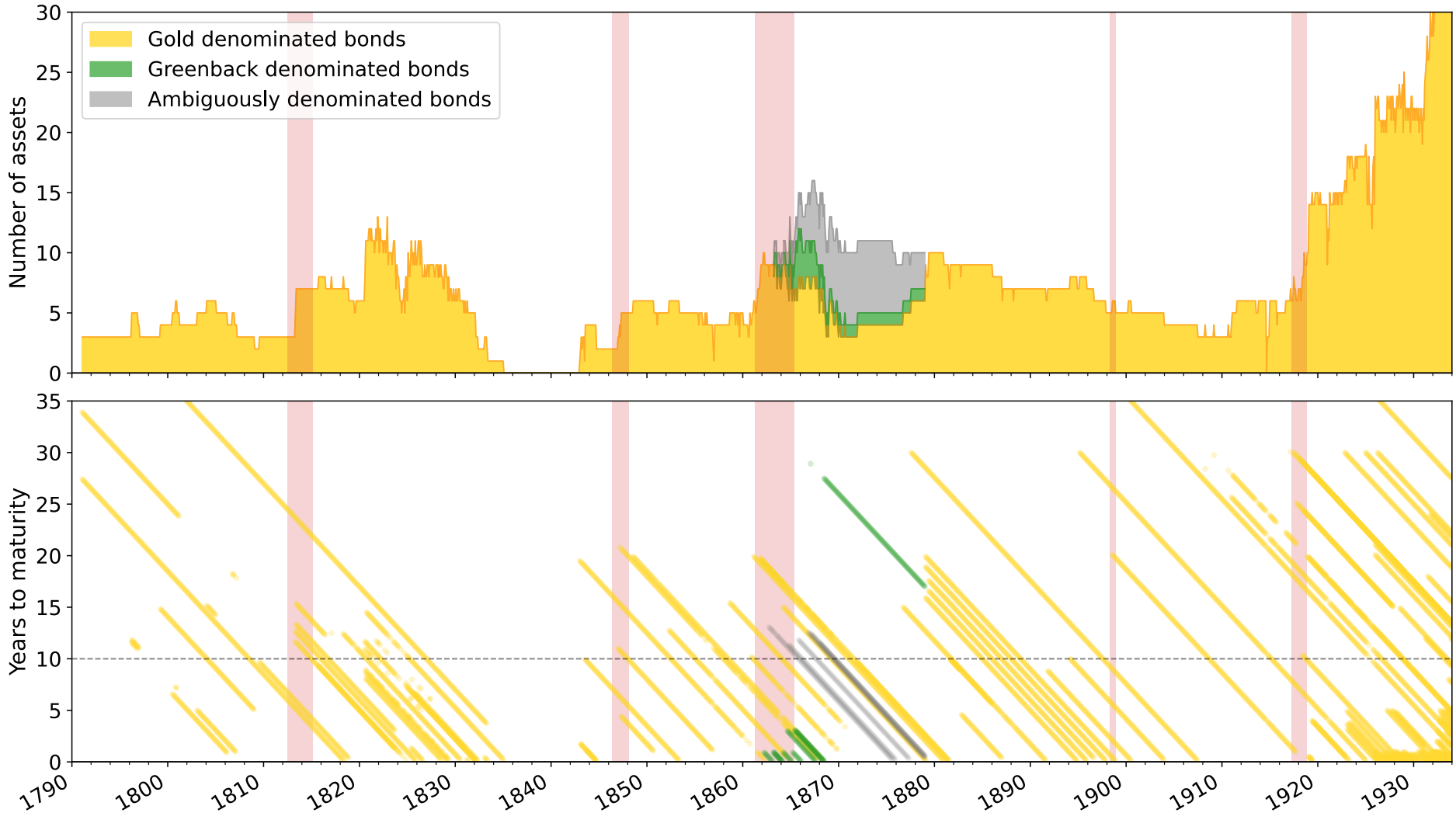
US Monetary and Banking Eras

- *1791-1862:* Bimetallism and state banks:
  - Federal government issued gold and silver coins; banks issued paper money.
  - First (1791-1811) and Second (1816-36) Banks of US "control" state banks.
  - "Free banking" state charters from 1837-63.
- *1862-1913:* Greenbacks, gold standard and the National Banking System.
  - 1862-78: Gov. issued *inconvertible* paper notes ("greenbacks") as *legal tender*.
  - 1879: US treasury started converting greenbacks into gold dollars one-to-one.
  - 1863+: National Bank Acts introduced federally regulated banks:
    - National banks could issue bank notes backed by (long term) US Federal bonds.
    - National bank notes taxed at 1% p.a.; state bank notes at 10% p.a.
- *1913:* Federal Reserve System established as lender of last resort.
- *1933:* Gold Reserve Act: restricted US citizens from holding gold coins.

Inflation

Our Dataset: Long But Shallow Panel (Infrequent Issuance)



Note: Shaded areas show major American wars.

Debt-to-GDP I | Debt-to-GDP II

Estimation Challenges

- ⋆ Periods with sparse bond data and major wars
  ⇒ Cannot estimate period by period using only cross sectional data (e.g. Gürkaynak et al. (2005))
- ⋆ Potential haircut risk on US Federal debt
  ⇒ Cannot disentangle SDF from haircut risk with only US Treasuries
- ⋆ Sparse accurate macroeconomic data
  ⇒ Cannot easily fit a macro-factor affine pricing model
- ⋆ Bonds had idiosyncratic features
  ⇒ "Standardising" bonds may introduce pricing errors

Our Approach

- ⋆ Periods with sparse bond data and major wars
  - ⇒ Cannot estimate period by period using only cross sectional data
  - Our approach: Parametrize zero-coupon yield curve and estimate parameters by pooling information across time (while allowing for time varying pooling).
- ⋆ Potential haircut risk on US Federal debt
  - ⇒ Cannot disentangle SDF from haircut risk with only US Treasuries
  - Our approach: Estimate prices of risky government promises, under the assumption of common haircut risk across US Federal bonds
- ⋆ Sparse accurate macroeconomic data
  - ⇒ Cannot easily fit a macro-factor affine pricing model
  - Our approach: only use bond price and money price data
- ⋆ Bonds had idiosyncratic features
  - ⇒ "Standardising" bonds may introduce pricing errors
  - Our approach: assume perfect foresight about discretionary bond components
- ⋆ We introduce bond specific pricing errors to diagnose problems

Nonlinear State Space Model

$$\tilde{p}_t^{(i)} = \sum_{j=1}^{\infty} q_j(\lambda_t, \tau) m_{t+j}^{(i)} \qquad \text{gold bond price interpolation}$$

- ⋆ where:
  - ⋆ $\tilde{p}_t^{(i)}$ = observed price of coupon bearing bond i,
  - ⋆ $\{m_{t+j}^{(i)}\}_{j \geq 1}$ = payments of gold dollars promised by bond i,
  - ⋆ $\{q_j(\lambda_t, \tau)\}_{j \geq 1}$ = (parameterized) gold zero-coupon discount prices at all horizons,
    - ⋆ **A.1.** Zero-coupon discount prices can be maturity specific but not bond specific, (Common "haircut risk" and "liquidity premium" across bonds not maturities.)
    - ⋆ **A.2.** Parametrization follows Nelson & Siegel (1987), (Allows for monotonic, humped, and S-shaped curves.)

Nonlinear State Space Model

$$\tilde{p}_t^{(i)} = \sum_{j=1}^{\infty} q_j(\lambda_t, \tau) m_{t+j}^{(i)} \qquad \text{gold bond price interpolation}$$

$$\lambda_{t+1} = \lambda_t + \Sigma_t^{\frac{1}{2}} \varepsilon_{\lambda,t+1} \qquad \text{yield curve parameters}$$

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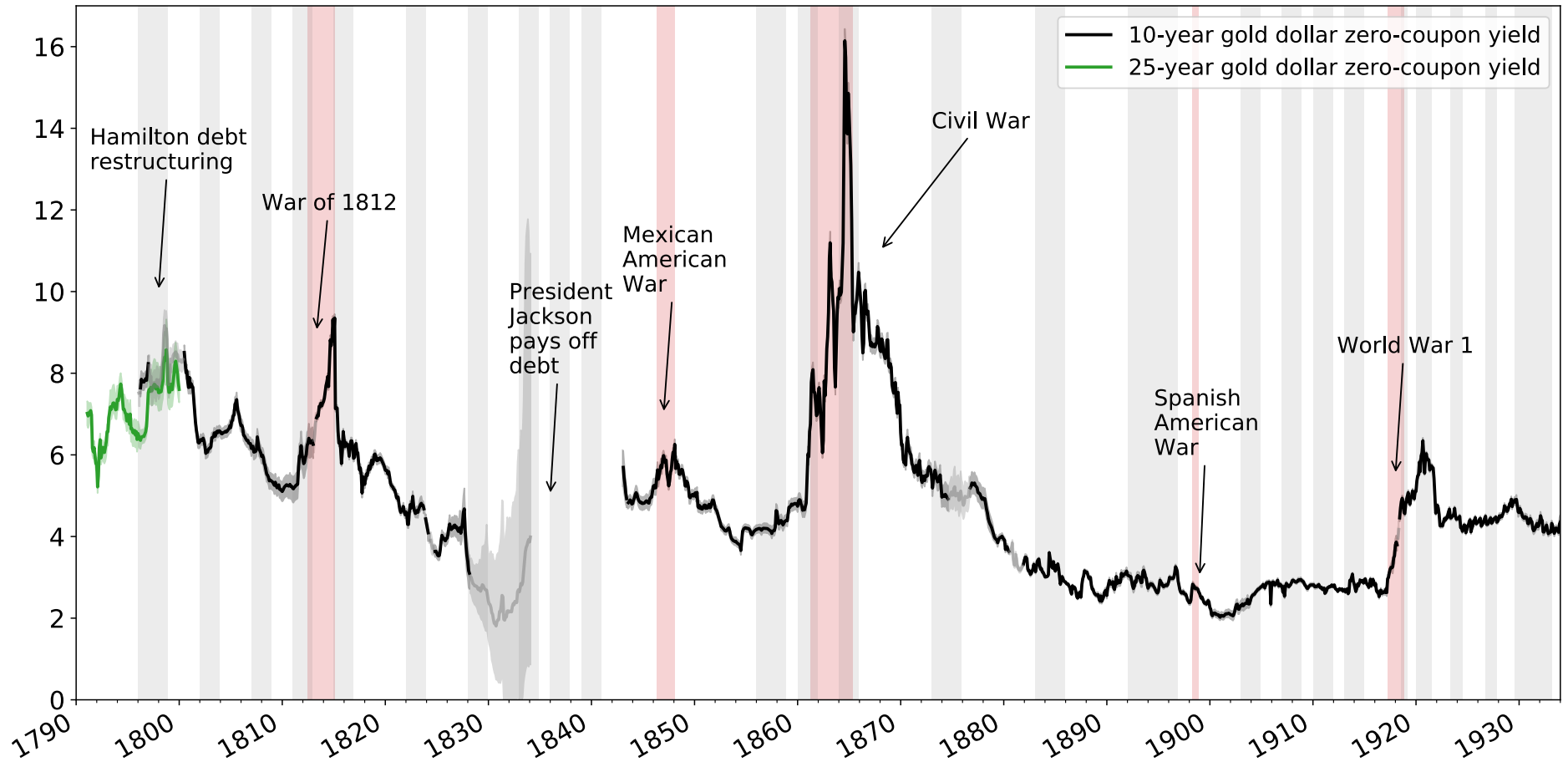
  - Σ_t governs pooling across time ($\Sigma \to 0 \Rightarrow$ full pooling; $\Sigma \to \infty \Rightarrow$ no pooling),
  - $\varepsilon_t^{(i)}$ is bond specific measurement error (helps keep unusual bonds in sample),
  - Restrict sample to gold paying bonds with maturity greater than 1 year.
  - Estimate with Hamiltonian Monte Carlo Bayesian approach.

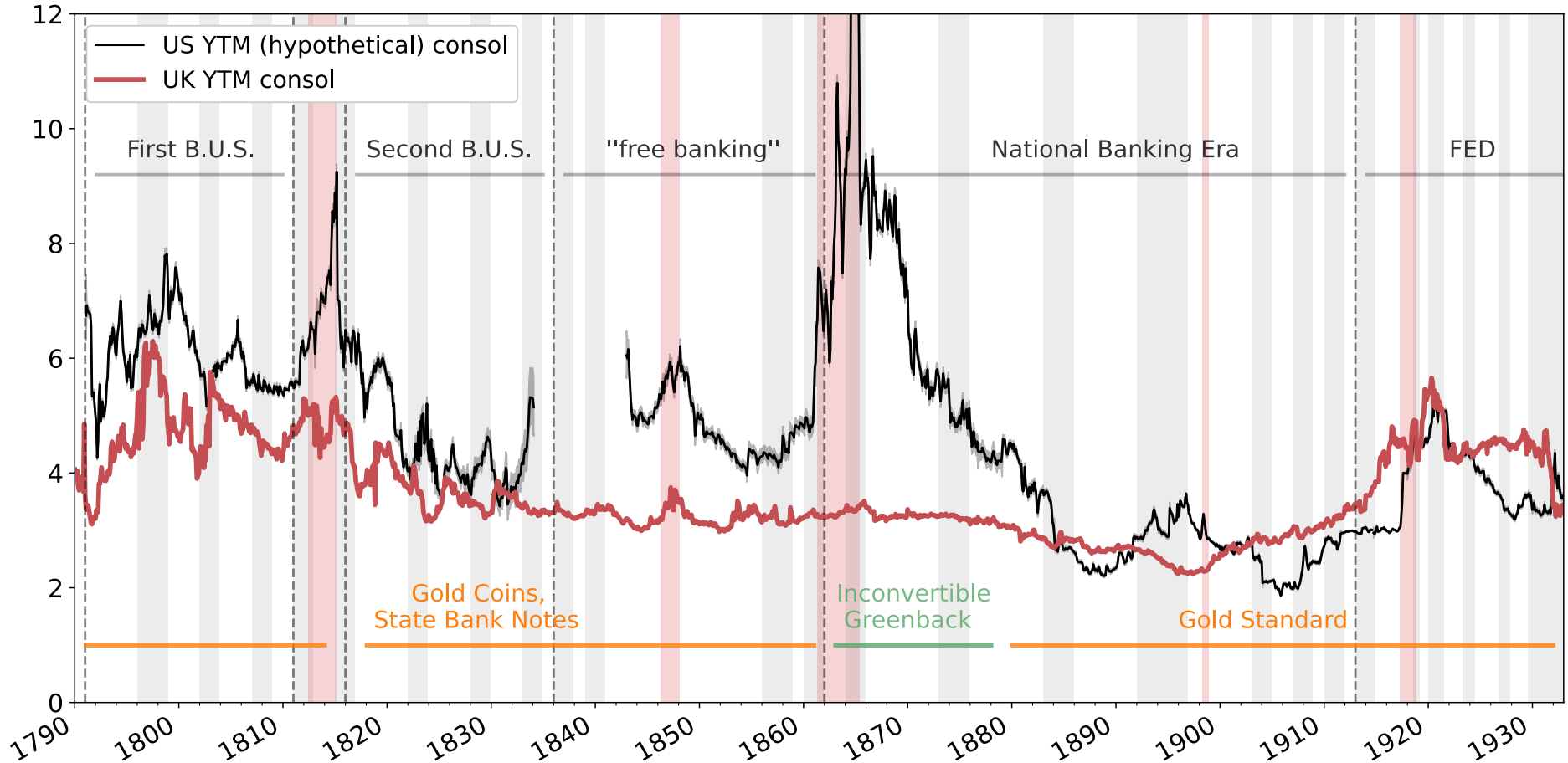
Long End of the Yield Curve



Note: Gray intervals show recessions. Red intervals show major wars. Black line is posterior mean with 5% – 95% iq-range.

Errors | Par Yields | Alternative LT | Alternative ST

Positive Spread Between US and UK Yields Until 1880s



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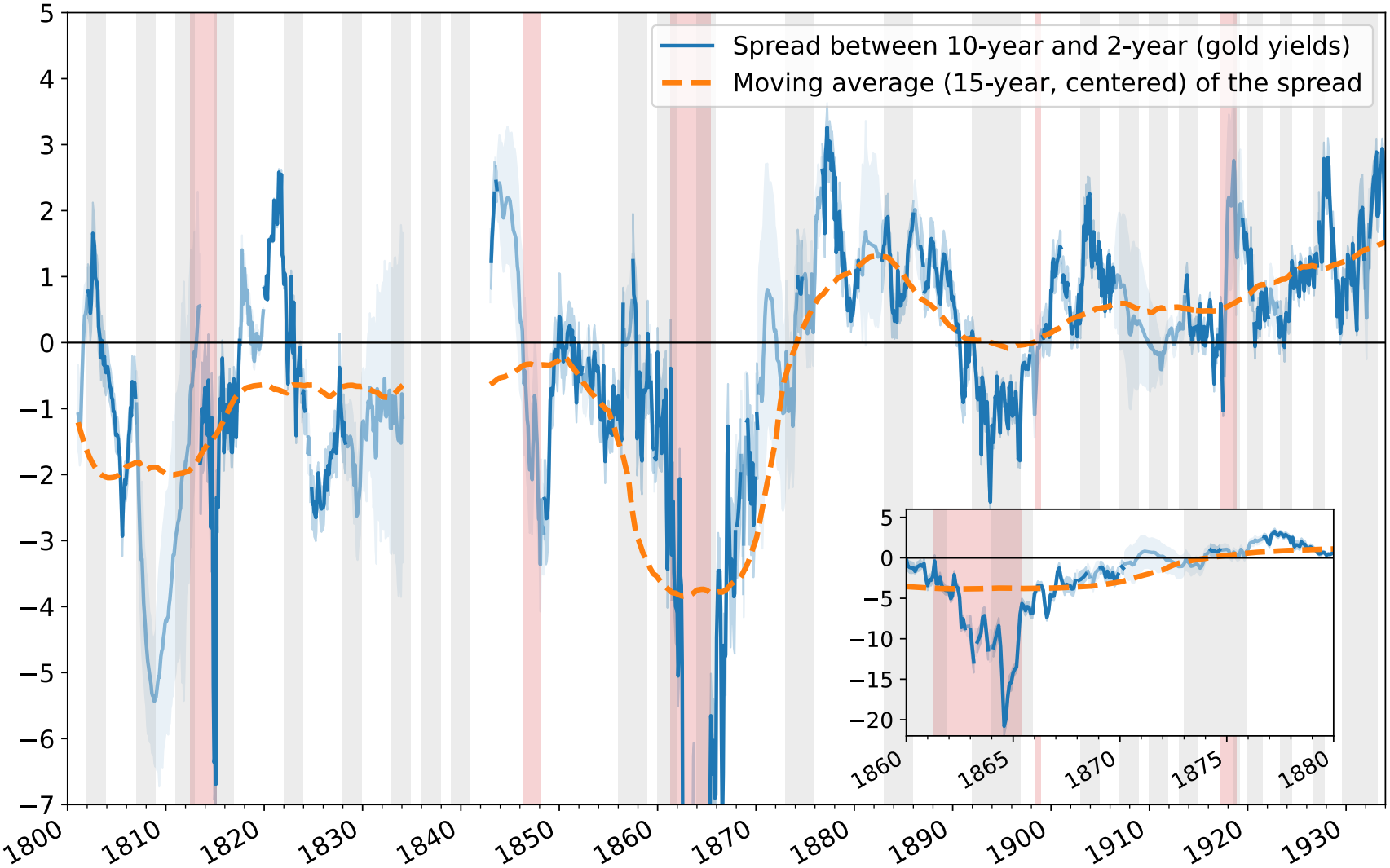
Yield Curve Slope Changes Sign After During Civil War



Note: Gray intervals show recessions. Red intervals show major wars.

Inflation | Inflation Risk | 1800-2020 | 1800-2020 + Inflation Risk | Predictive | Fama-Bliss

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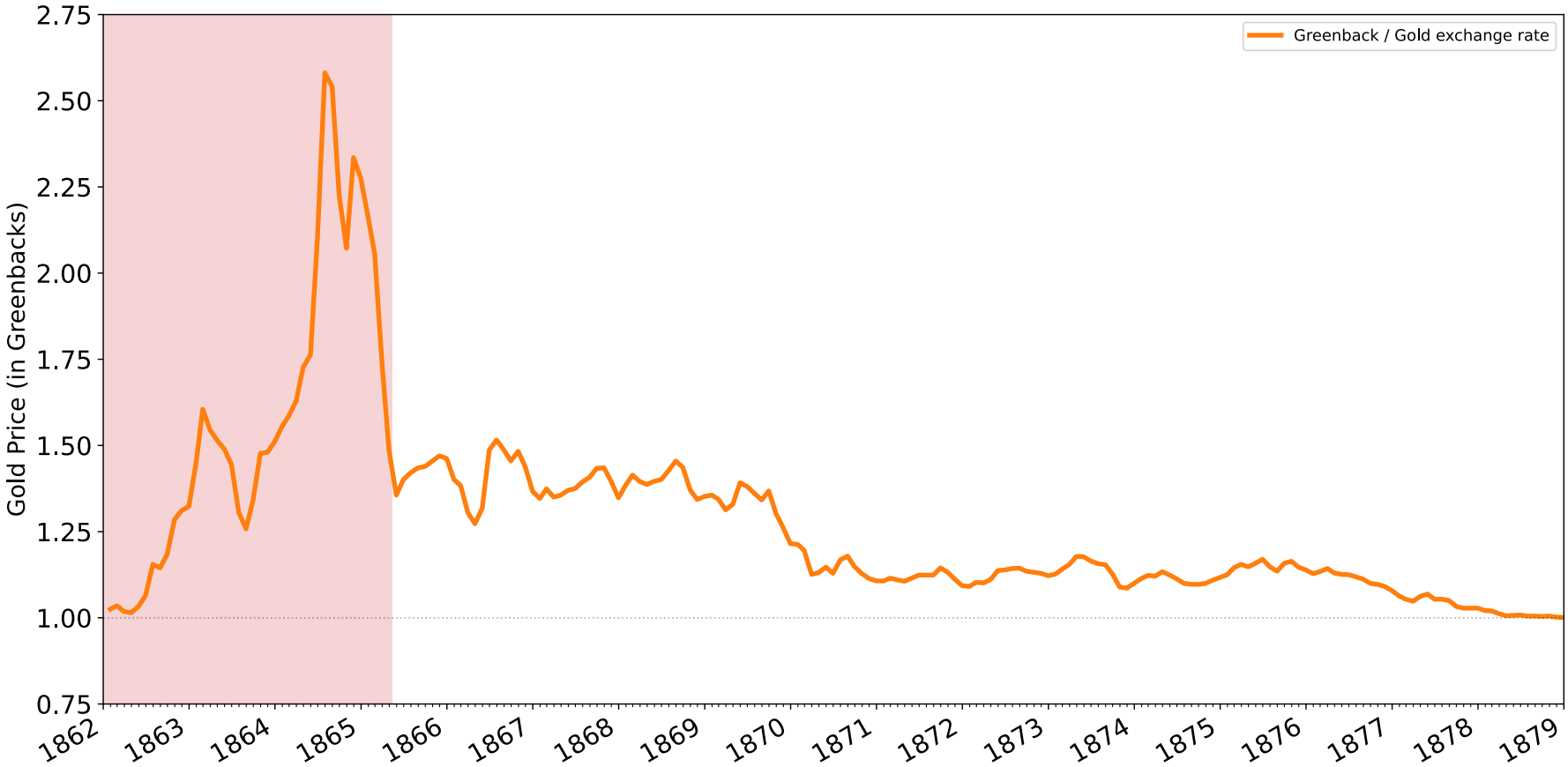
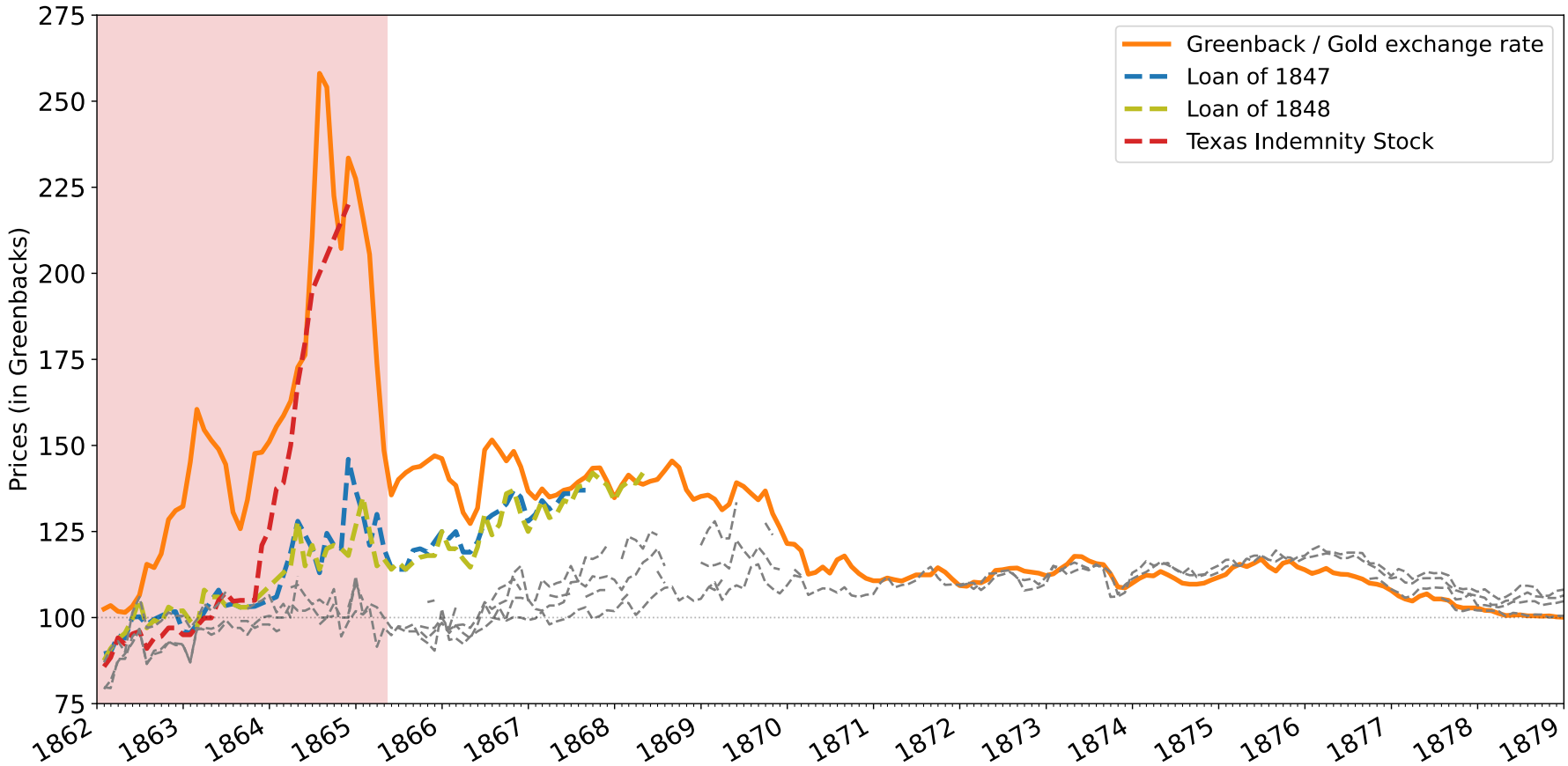
Large Greenback Devaluation During Civil War.



⋆ 1862-78: Gov. issued *inconvertible* paper notes ("greenbacks") as *legal tender*.

Large Greenback Devaluation During Civil War



- ⋆ Gold and greenback denominated bonds ⇒ exchange rate expectations.
- ⋆ Gold paying bonds converge to gold price near maturity ⇒ exchange rate anchor.

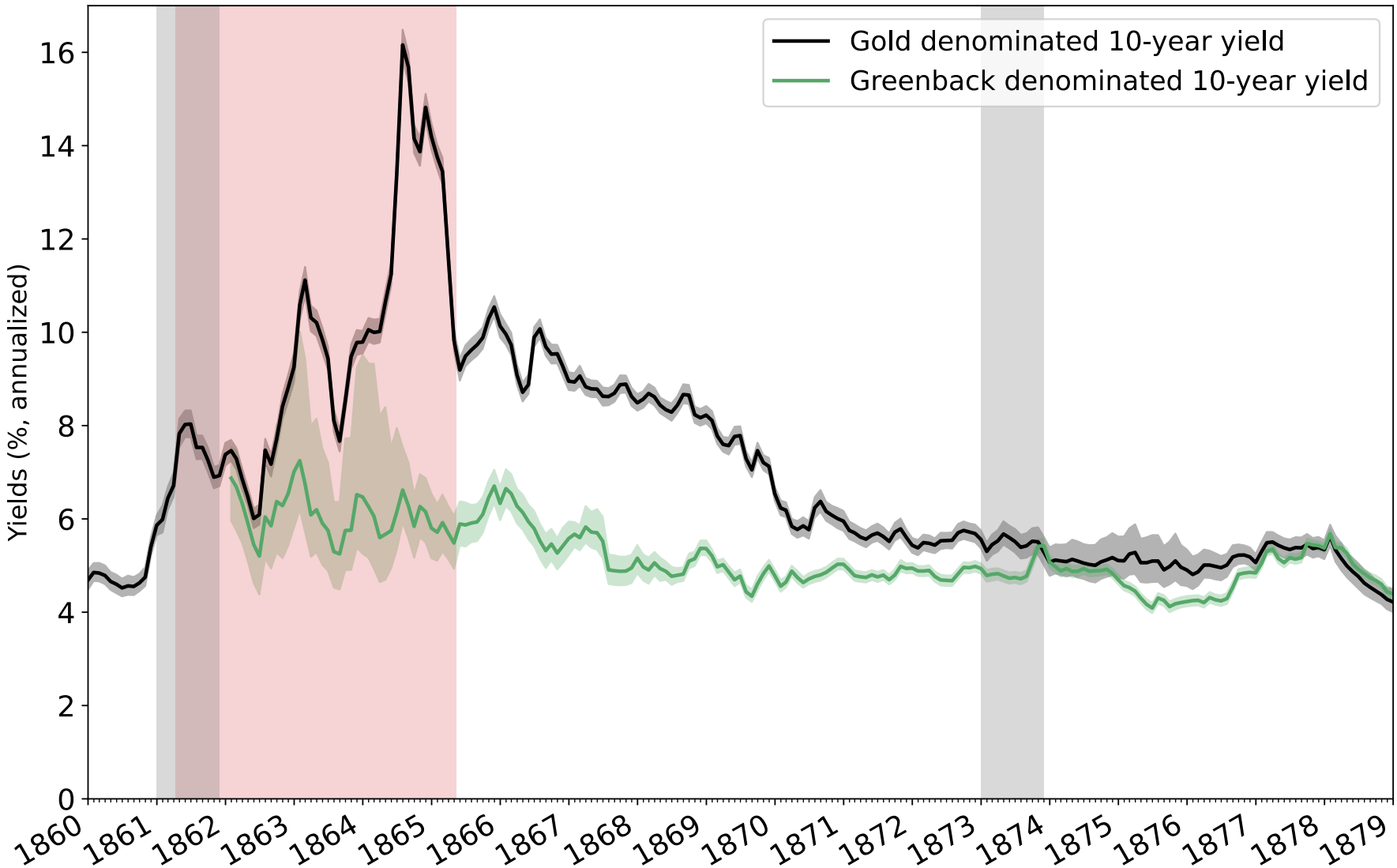
Non-linear State Space Model

$$\tilde{p}_t^{(i,g)} = \sum_{j=1}^{\infty} q_j(\lambda_t, \tau) m_{t+j}^{(i,g)} + \sigma_m^{(i)} \varepsilon_t^{(i)} \qquad \text{gold bonds}$$

$$\tilde{p}_t^{(i,d)} = \sum_{j=1}^{\infty} q_j(\lambda_t, \tau) z_j(\theta_t) m_{t+j}^{(i,d)} + \sigma_m^{(i)} \varepsilon_t^{(i)} \qquad \text{greenback bonds}$$

- where:
  - $\mathbf{z}(\theta_t)$ is the expected change in the gold-greenback exchange rate, P_t.
  - **A3.** Interest rate parity holds. Details Test
  - **A4.** P_t follows state-space model with time varying parameters θ_t. Details
  - Other variables are as before.

Low Greenback Yields During Civil War



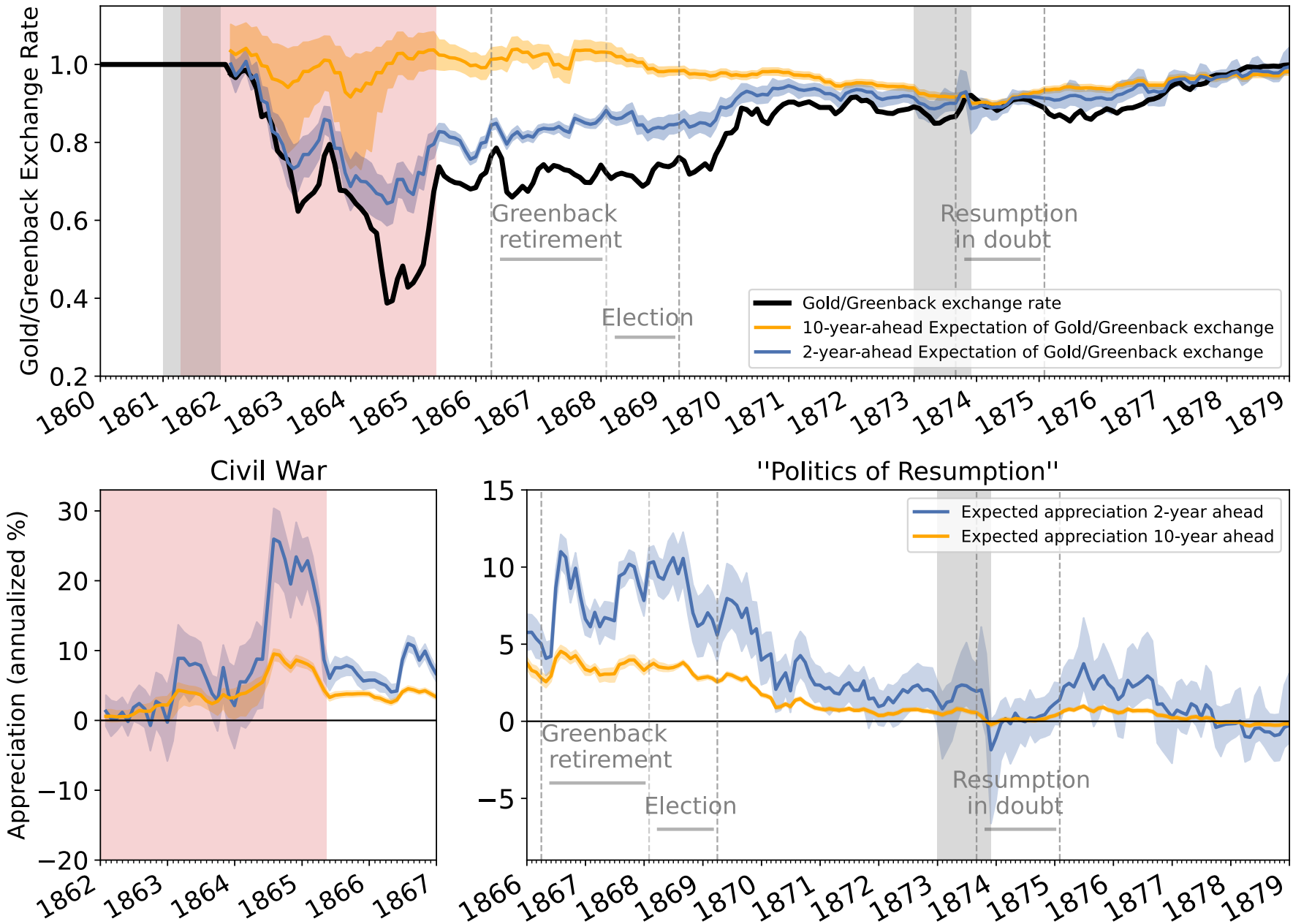
Note: Gray intervals show recessions. Red intervals show major wars.

Revisiting a Civil War Yield Puzzle

The behavior of interest rates in the United States is one of the most interesting features of the Civil War period and has puzzled most of its historians. . . . demand for loan funds must surely have been larger than any private demand that was suppressed by the diversion of resources to war use . . . Yet interest rates were unusually low . . . In our view, this is explained by speculative capital movements induced by the rise in the greenback price of gold.

Friedman and Schwartz (1963) (p. 69-70)

"Heavy Nominal Anchor" During Civil War



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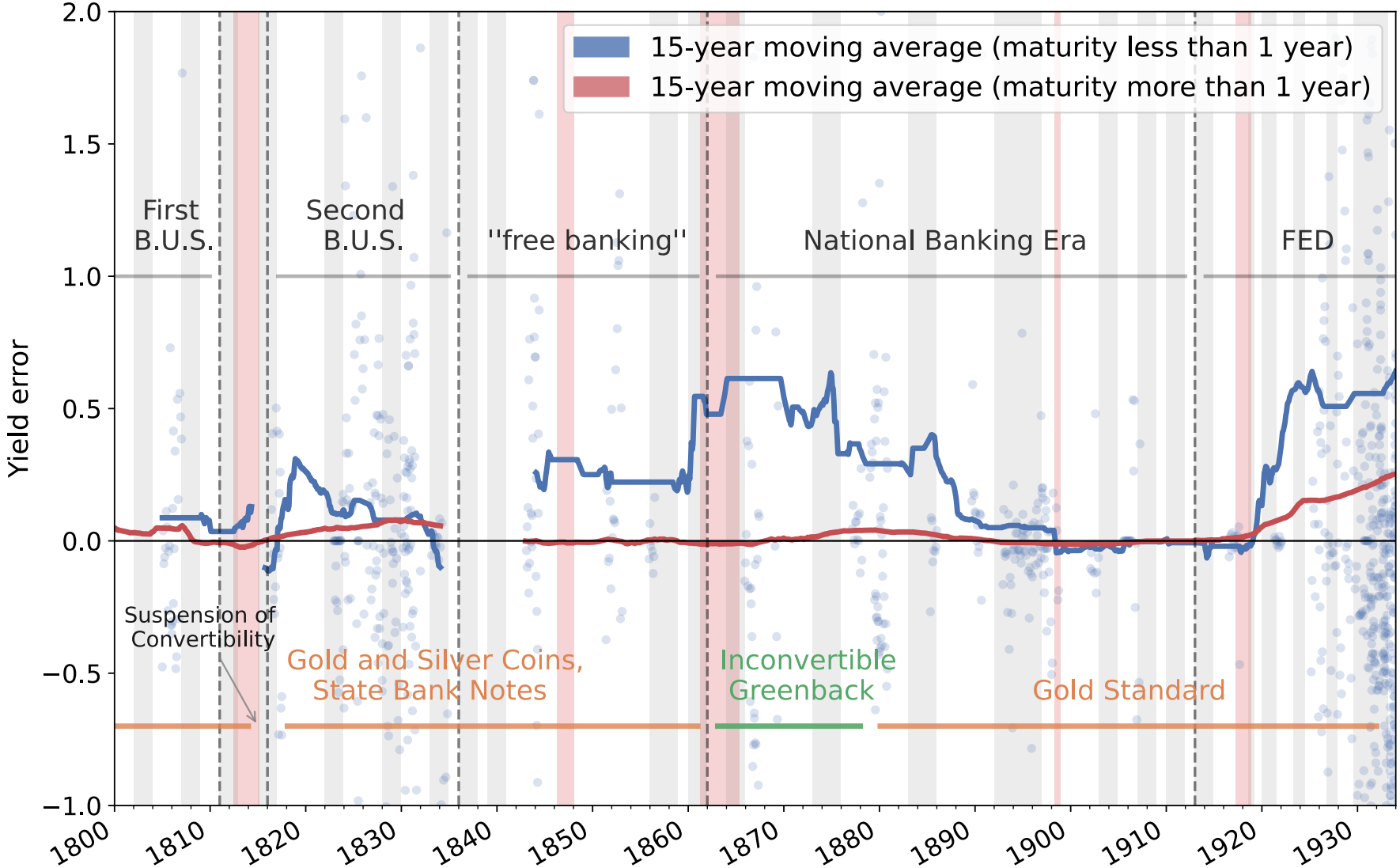
"Liquidity" Premium on Short Term Bonds



Note: Gray intervals show recessions. Red intervals show major wars. Pale blue dots depict the difference between model-implied and observed yield-to-maturities for bonds with *less than one year* to maturity.

Error | Holders | Note Issuance Puzzle | Tax Rate | Profit | FED

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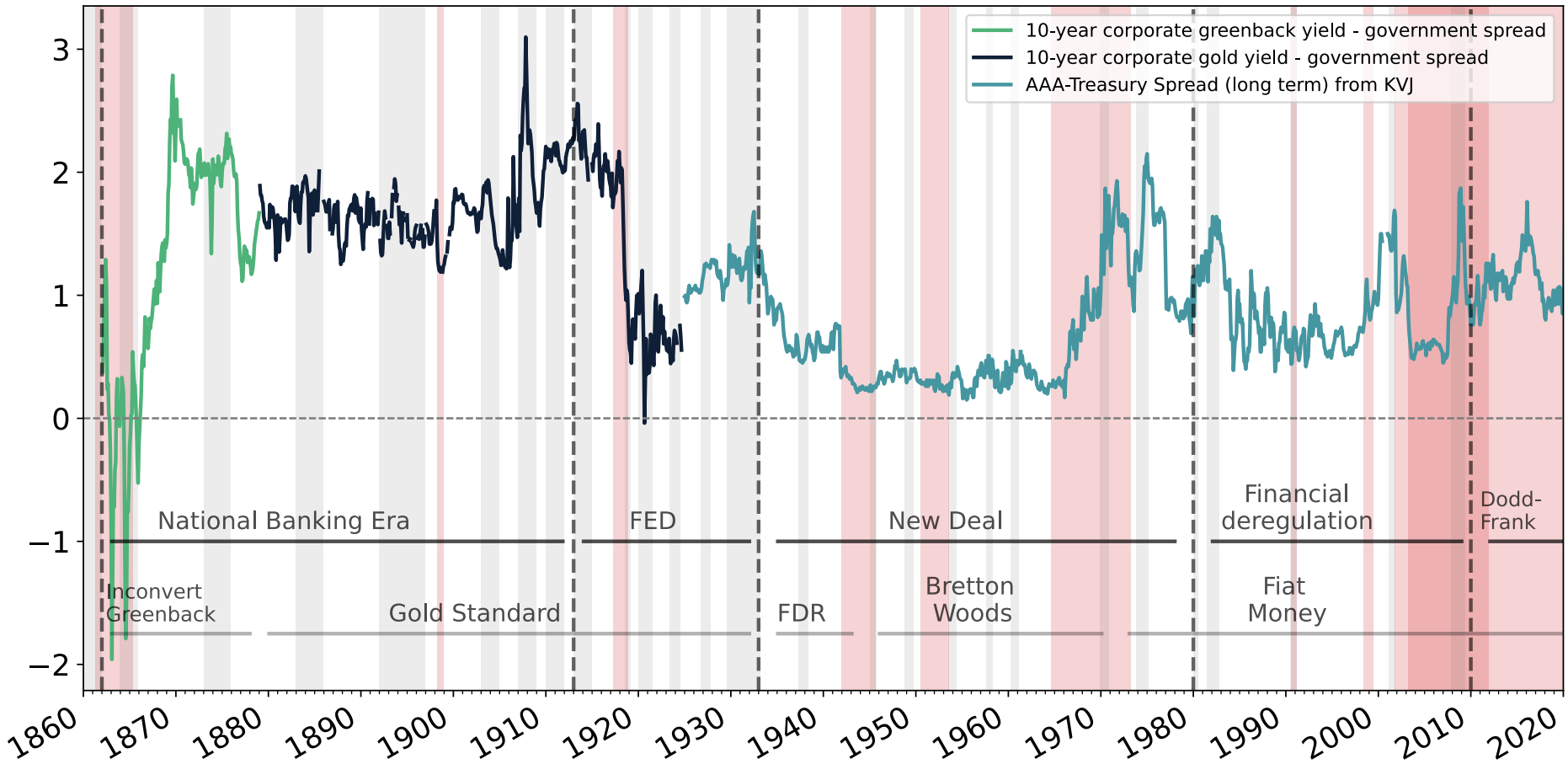
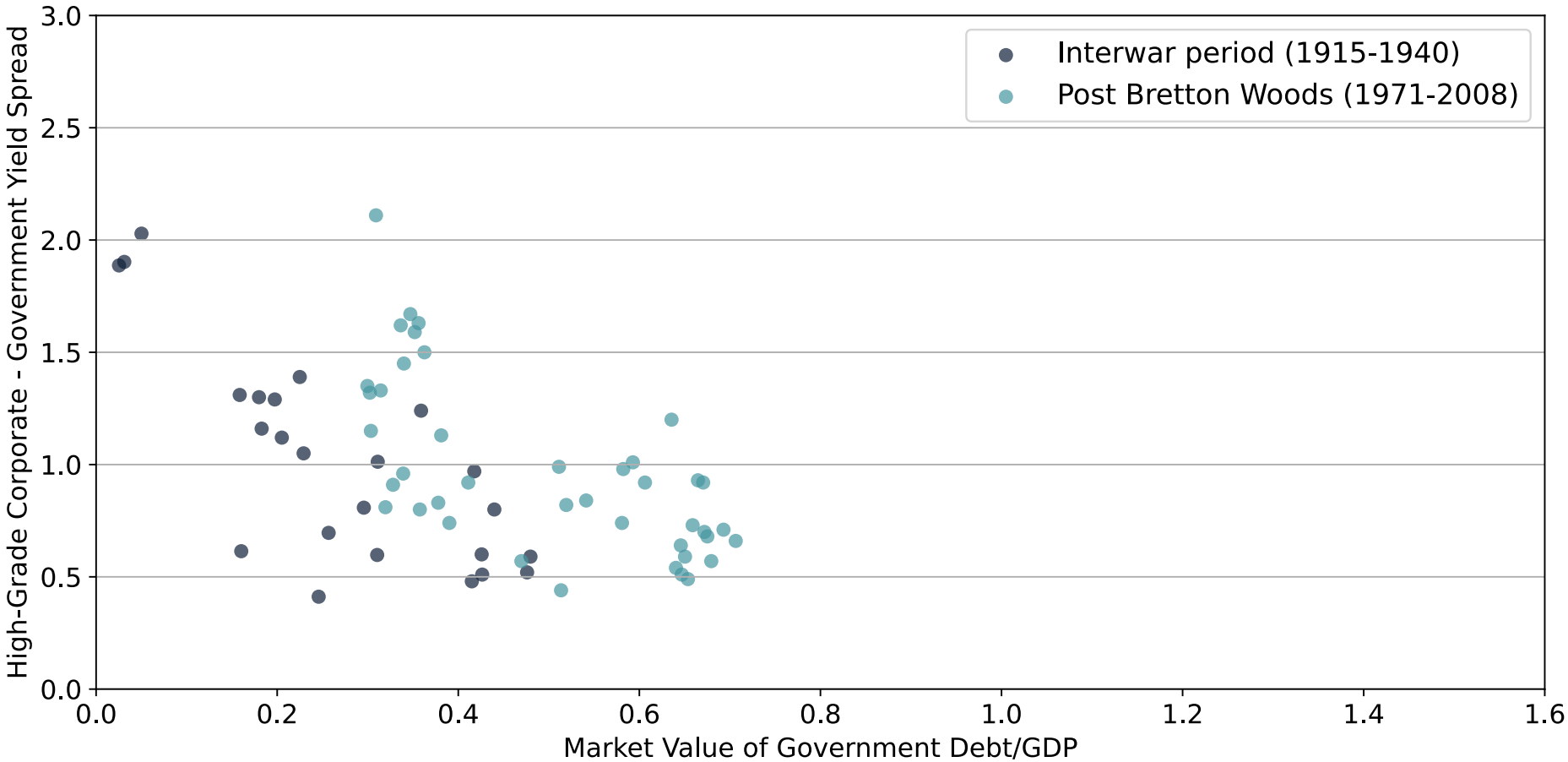
Additional Estimation: Corporate Bond Yields

- **Data:** new database of price & cash-flows for US corporate bonds (1850-1940)
  (Companion to our database for US Federal bonds (1790-1940))
  - Sources: NYT, CFC, Merchant's Magazine, US Treasury Circulars, Bayley (1882), Sylla (2006), Razaghian (2002), Macaulay (1838). Details
- **Statistics:** Deploy same methodology.
  - Same challenge: long time series but sparse cross-section at many dates.
    Response: statistical model with drifting parameters that interpolates gaps.
  - New challenge: no corporate bond ratings pre-1900.
    Response: Extract pre-1900 "AAA" bonds using Macaulay (1838) + pricing errors.
- **Output:**
  - Zero-coupon yield curve on "AAA" US corporate bonds for 1860-1940*.
  - Convenience yield = "AAA" US corporate yield - US Federal yield for 1860-2022
  - We interpret convenience yield as measuring "funding advantage" of government

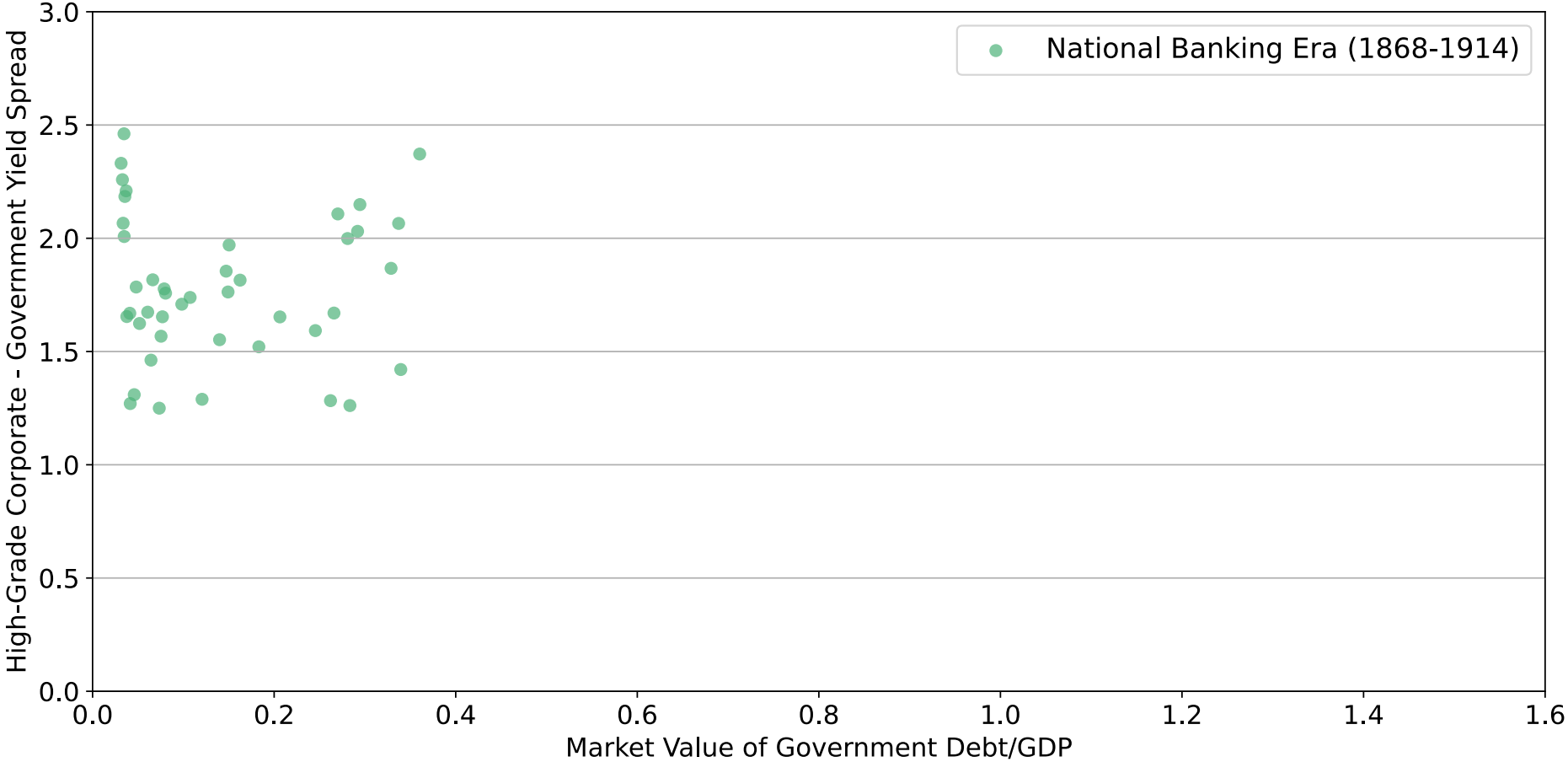
Convenience Yield Emerges After the Civil War



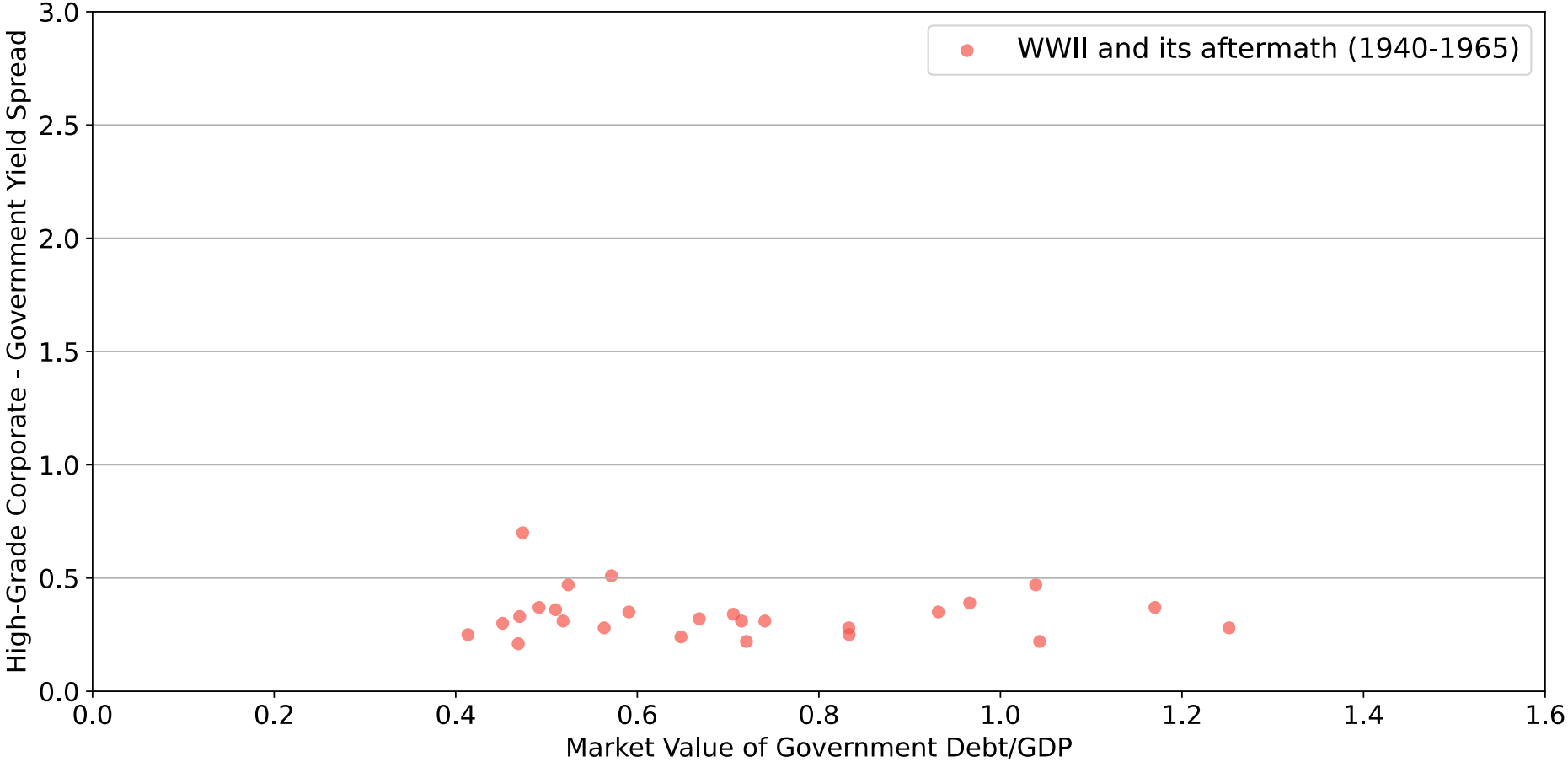
Convenience Yields: "Normal" Level of Regulation



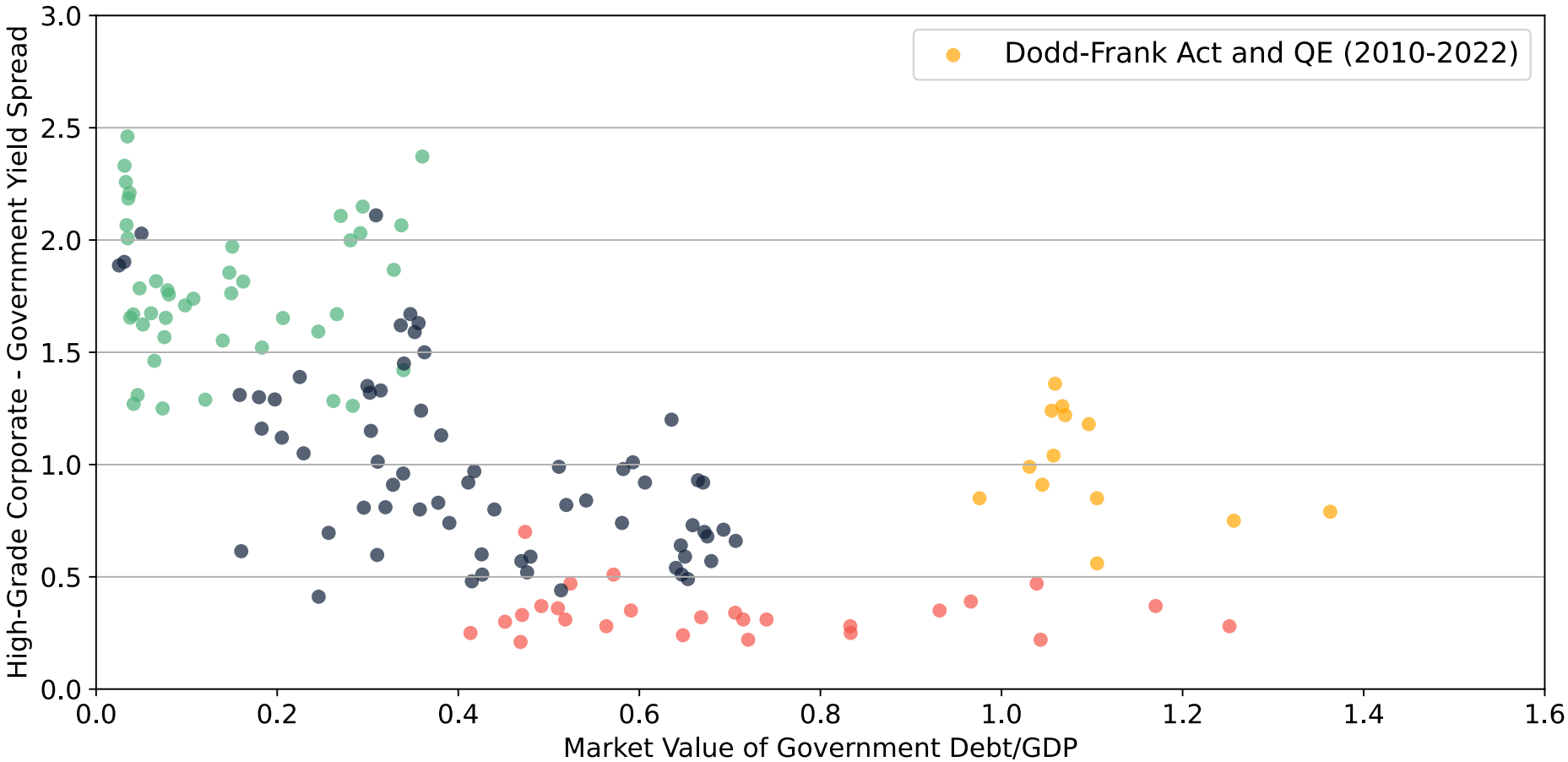
Convenience Yields: National Banking Era: 1868-1914



Convenience Yields: WWII and Aftermath: 1940-1965



Convenience Yields: Dodd-Frank Act



Summary of Descriptive Empirical Work

- ⋆ Estimated US and corporate yield curves for long but sparse samples.
- ⋆ Long time series shows the emergence of US debt as a "special" asset.
- ⋆ Financial reforms (esp. National Banking Acts) correspond to spread changes:
  1. "Short rate disconnect" (or "liquidity premium" on short-term government debt) throughout US history except during National Banking Era.
  2. National Banking Acts correspond to emergence stable convenience yield.
  3. Yield curve slope switches signs following Civil War reforms.
- ⋆ Suggests links/trade-offs in organizing monetary, financial, fiscal institutions.
- ⋆ Complicated challenge of jointly designing monetary, financial, and fiscal policy!

Conclusion

- We provide new estimates of historical US and corporate yield curves.
- Data traces out the emergence of US debt as a "special asset". Many reasons:
  - Change in US reputation for repayment,
  - Change in taxation capacity, and
  - Change in the "design"/"regulation" of the financial sector.
- Need to use a structural model to investigate role of financial sector regulation.

Thank you