Long-Run Trends in Long-Maturity Real Rates, 1311-2021

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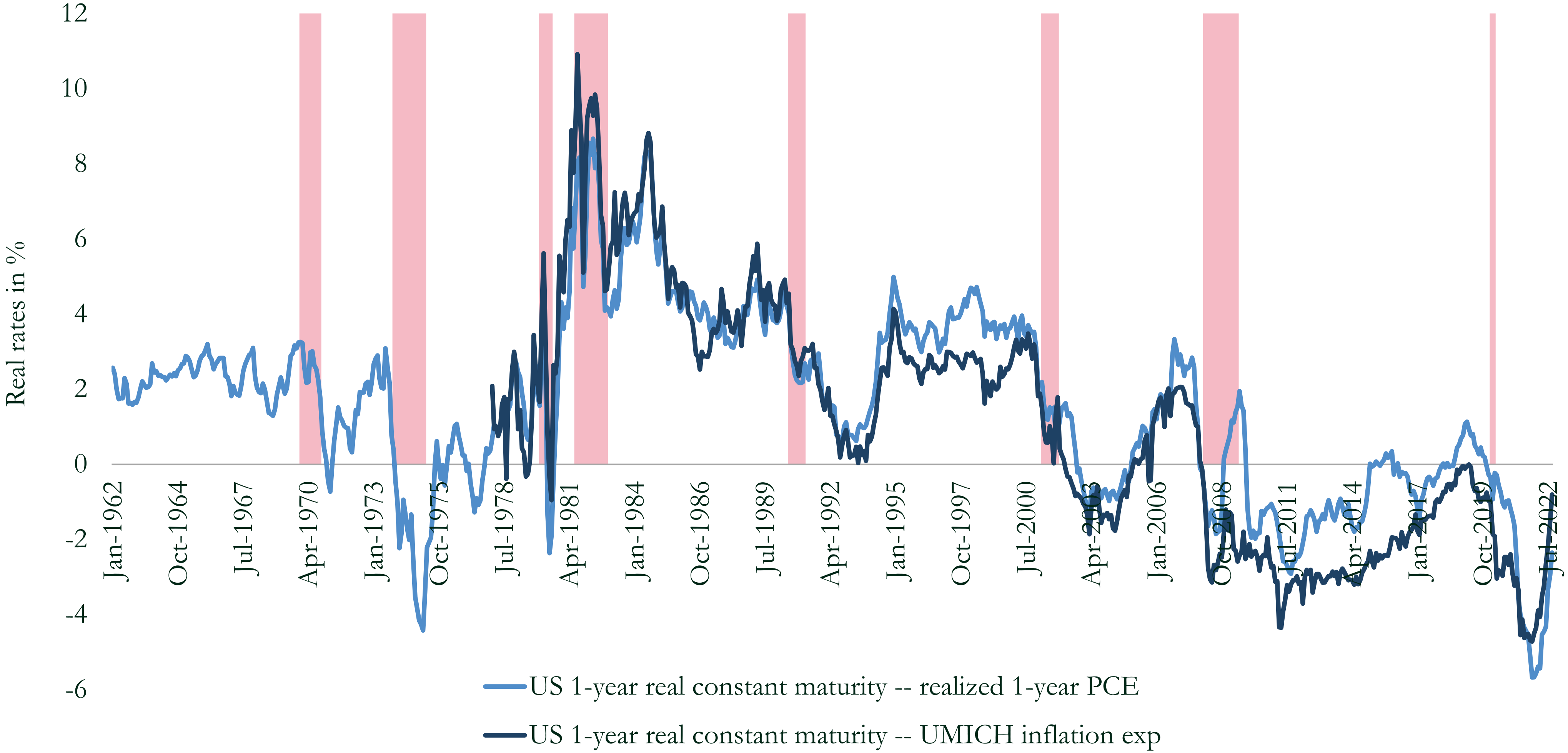
MOTIVATION: "END OF AN ERA" (SINTRA 2022)?

- Post-COVID rates have risen – but lack of long-term perspective despite "secular" debates.



Notes: monthly averaged U.S. constant maturity rates via FRED, as of October 2022. Same-month realized year-on-year PCE change used for series 1, monthly 1-year forward inflation expectations via UMICH survey used for series 2 (starting Jan-1978 for series 2). Shaded areas indicate NBER recession dates.

Motivation, existing literature

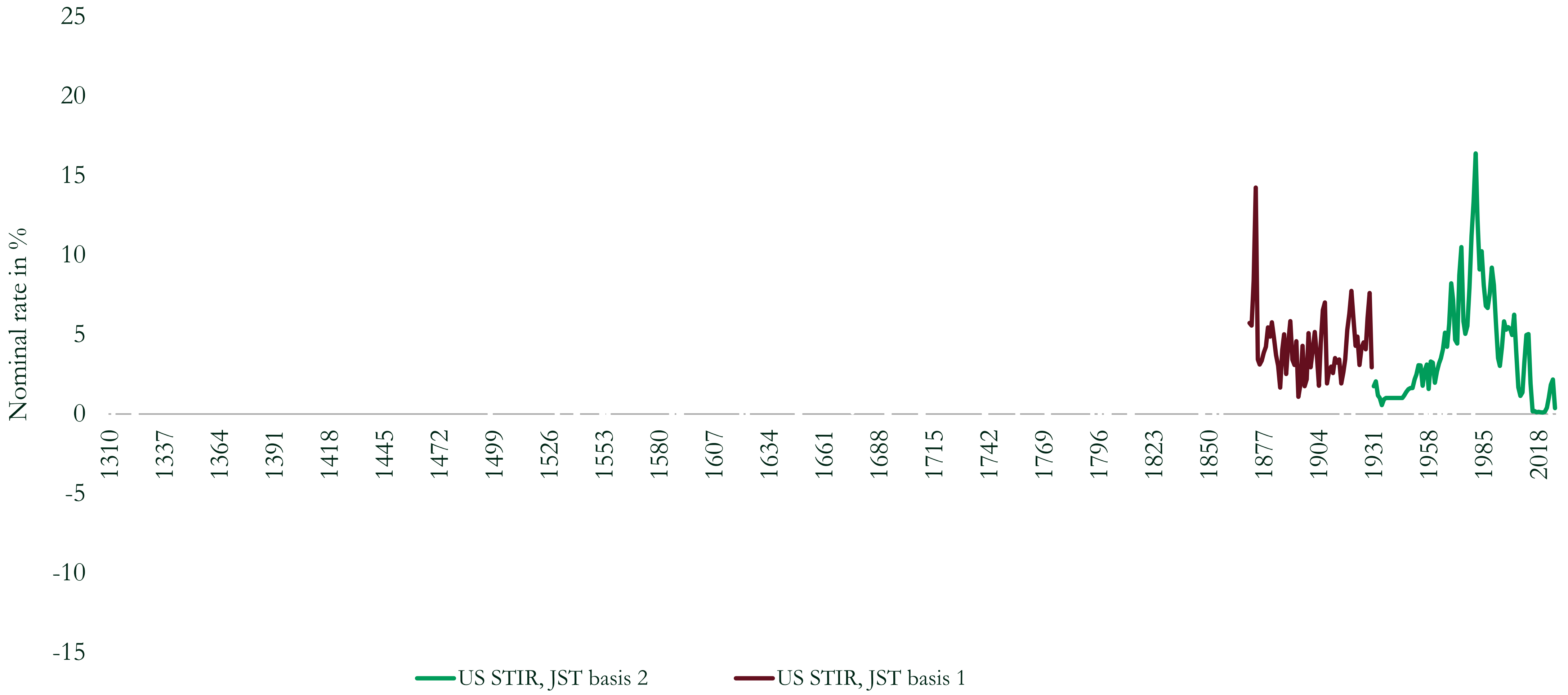
- Extensive pre-2008 literature on real rate properties
  - Nelson and Plosser (1982) – macro time series properties, non-stationarity of real rates.
  - Mankiw and Miron (1986) – the "worldwide change in interest rates in 1914", as turning point to non-stationarity.
  - Rose (1988) – analyzing U.S. short-maturity real rates 1890-1970, and corporate long-maturity bonds.
  - Garcia and Perron (1996), Ang and Bekaert (2002) – real rates subject to frequent regime shifts, focusing on 1961-1986/96.
  - Hamilton et al. (2016) – short-maturity (policy, bill) rates, autoregressive inflation expectations model – non-stationarity.
- Statistical power of long samples
  - Frankel (1986), Lothian and Taylor (1996) – ability to reject random walks highly dependent on sample length (rather than # of obs.) – FX cross series 1800-1990.
- Drivers of "post-1980s" real rate decline
  - Demographics: Hansen (1938); Cavalho et al. (2016); Goodhart and Pradhan (2021); Gagnon et al. (2021).
  - Output: Laubach and Williams (2003, 2016); Gordon (2012); Eichengreen (2015); Yi and Zhang (2017).
  - Applied dimension: Rachel and Summers (2019); Blanchard (2022).

Approach, results

- In Rogoff, Rossi, Schmelzing (2022) we
  - Intend to take advantage of significant data advances in recent years in long-run financial and econ history.
  - These advances provide much higher statistical power to apply to major current finance and macro debates.
  - Specifically, we focus on new measures of ex ante long-maturity global and DM real rates over centuries.
  - We assess econometric properties. Do real rates feature a unit root over the long-run? Are rates a random walk?
  - We assess relationship of global real rates to key related macro variables: output growth, productivity.

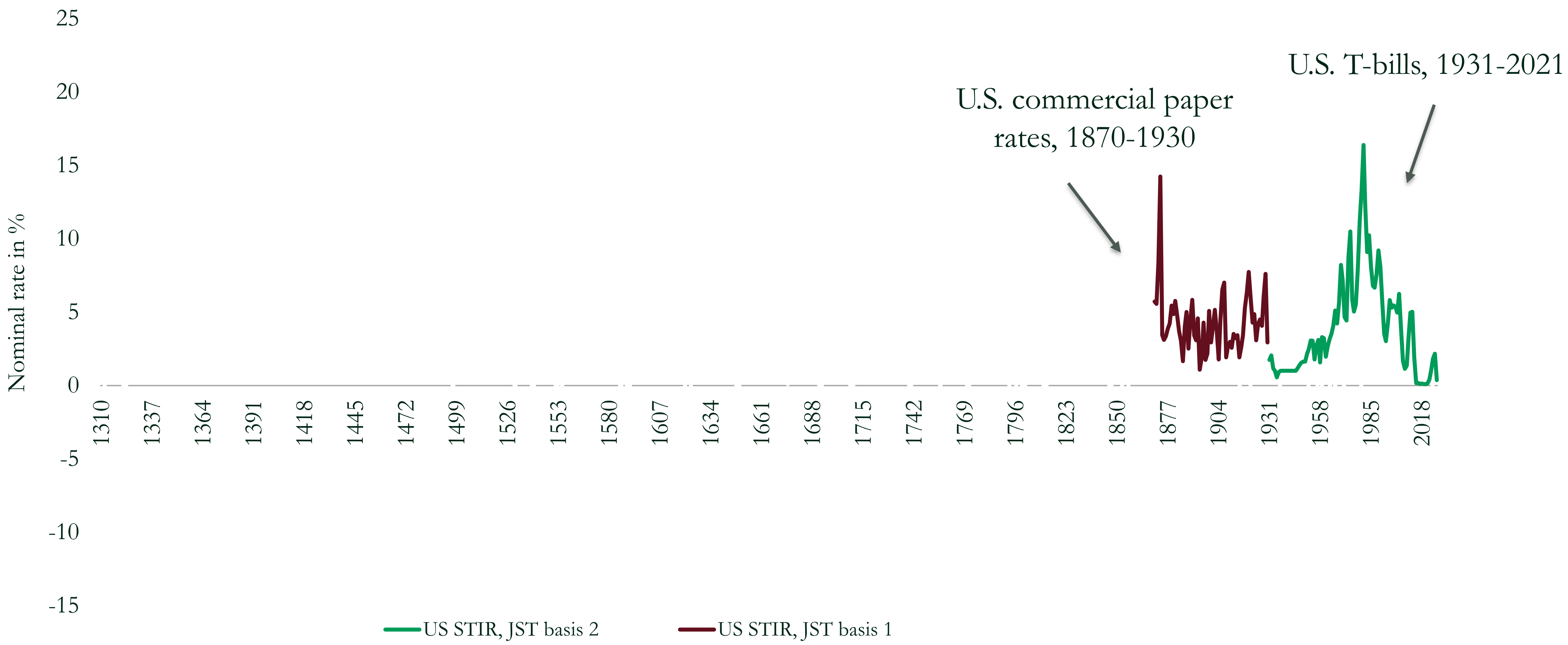
- We find that
  - We can consistently reject a unit root for global real rates with 1% statistical significance. Real rates are trend stationary.
  - Result hold for variety of inflation expectation constructions, for country levels, for different global weightings.
  - We can replicate previous results (e.g. Rose 1988) based on our inflation expectation approaches, allowing for deterministic trend.
  - Structural breaks are rare: robustly only detected for 1349 and 1557.
  - Much less support for 1914 and 1981 breaks than literature would suggest.
  - Real rates are not just "loosely positively" correlated with output growth, population growth.
    - In fact, real rates are negatively correlated with output growth, population growth over time. Late 20th C. as the anomaly.

Homer and Sylla reference vs. JST vs. Schmelzing (2022).



Notes: Homer and Sylla (2005) splices authors' "lowert nominal yield" series in (ibid., 1991, 554f.), interpolating missing values. Schmelzing real unfiltered uses the seven-year progressively-lagged inflation-adjusted nominal rates, weighted by running GDP shares based on Maddison (2010) for an eight-country DM sample over time. Both series refer to long-maturity public voluntary debt contracts, with Schmelzing (2022) average maturity over time standing at an estimated 13.2 years. The approximation of inflation expectations in Schmelzing (2022) follows the approach in Homer and Sylla (1991; 2005), but is robust to alternative methodologies.

HOMER AND SYLLA REFERENCE VS. JST VS. SCHMELZING (2022).



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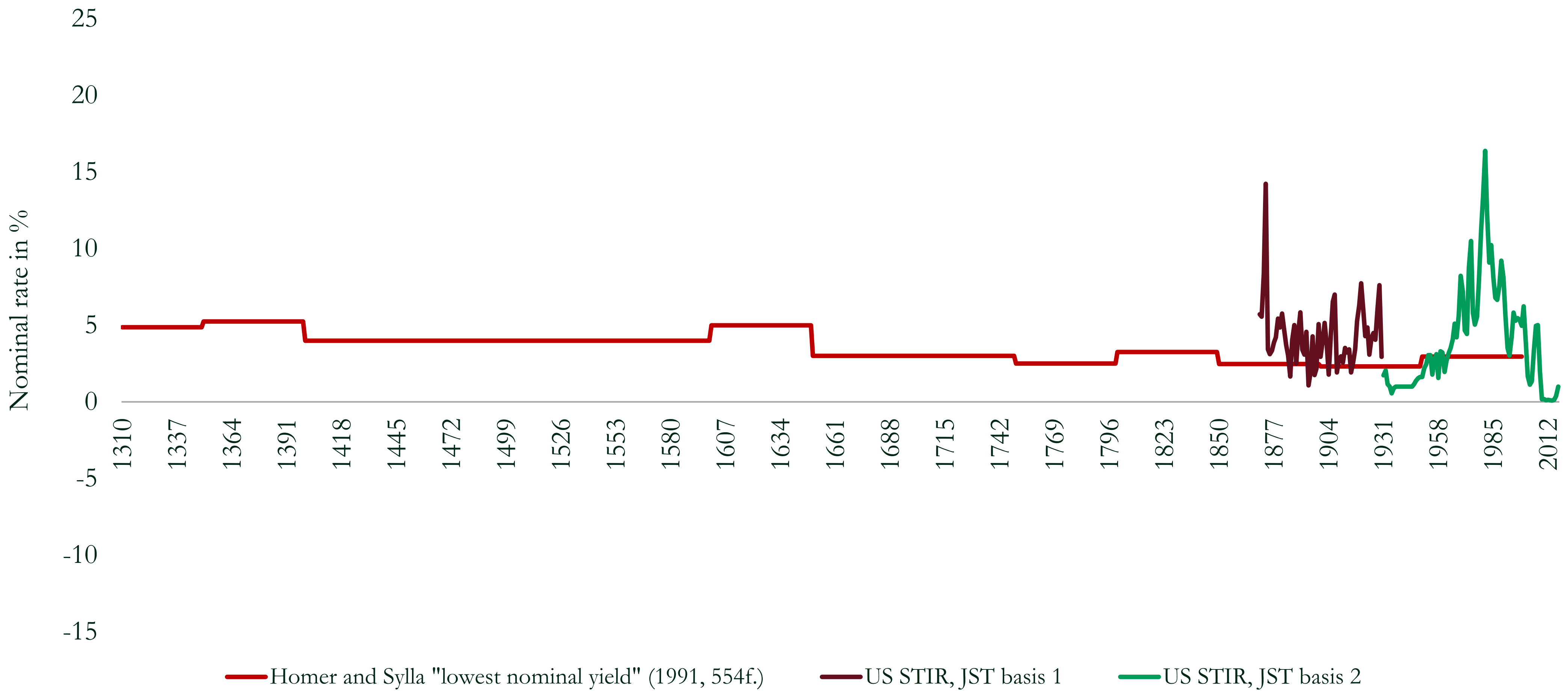

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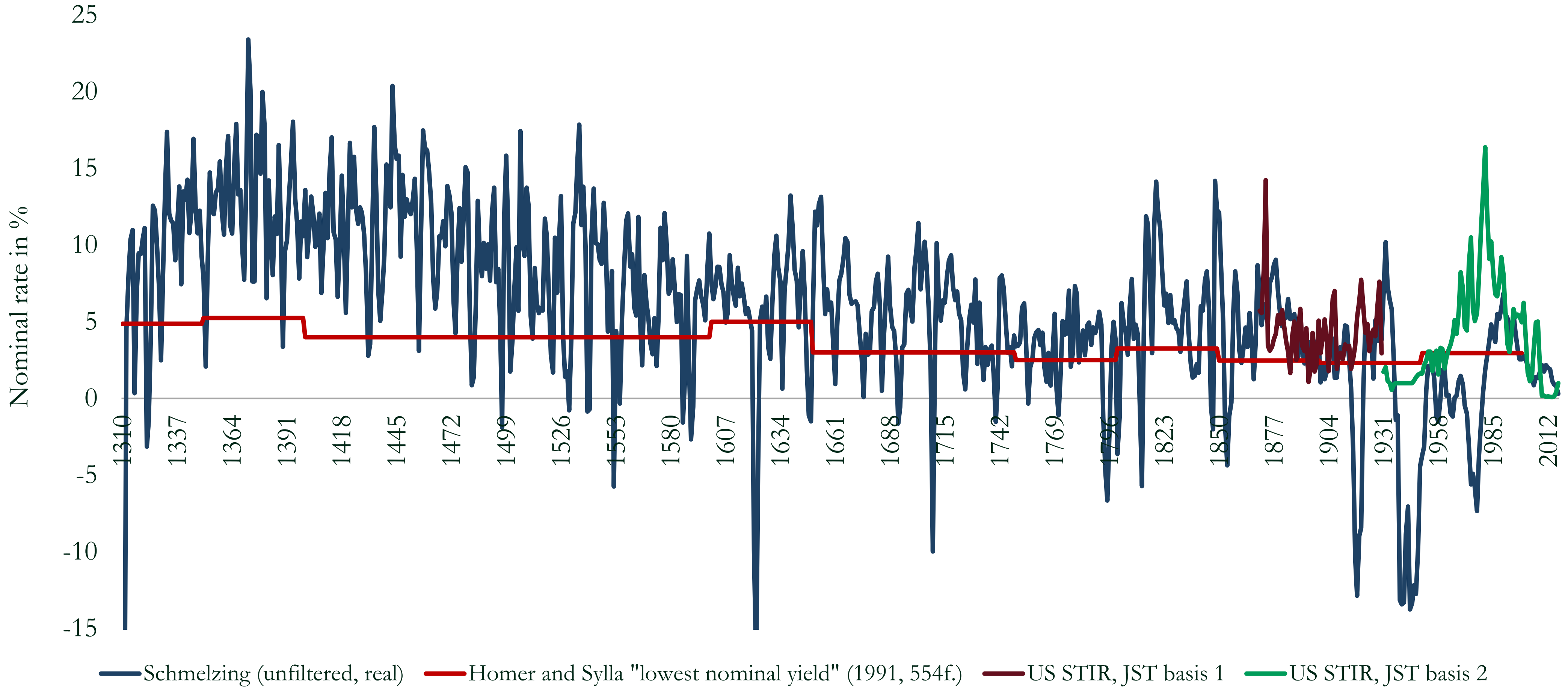

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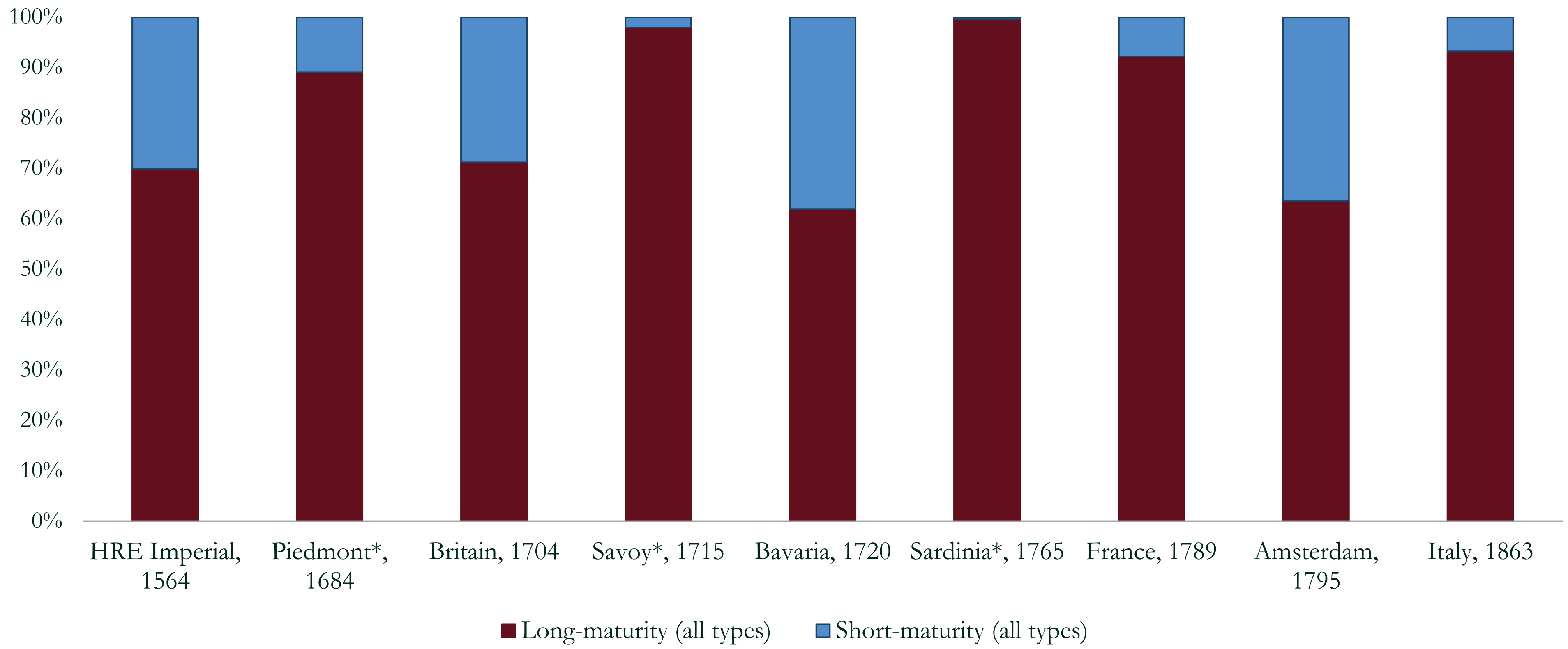
WHY LONG-MATURITY? EARLY SOVEREIGN DEBT EQUALS LONG-MATURITY SOVEREIGN DEBT.

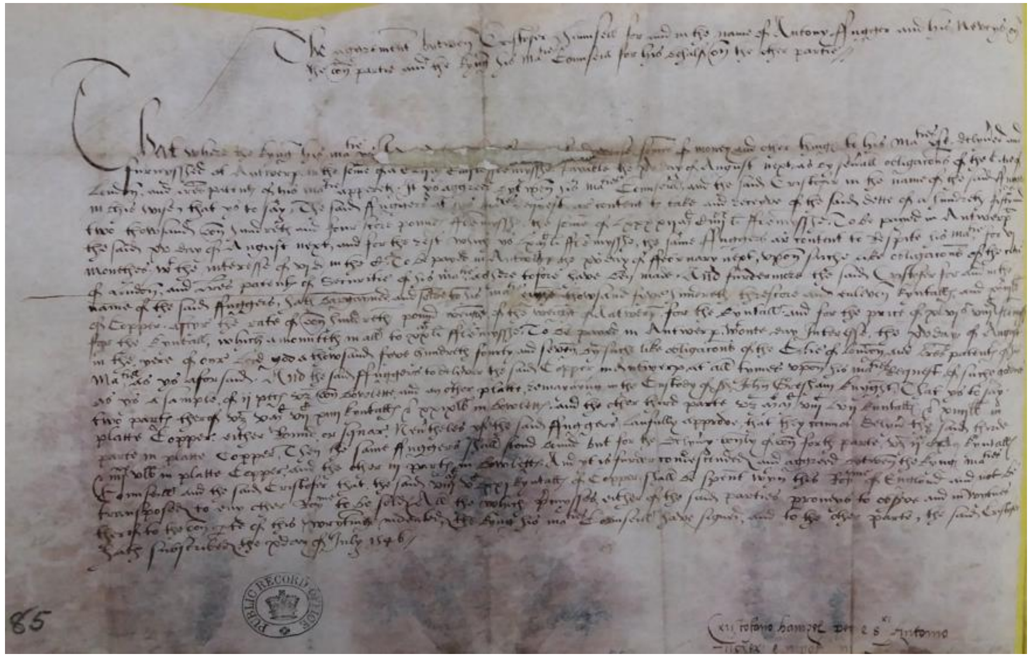
- U.S. typical in beginning regular bills issuance only by 1929. U.K. 1877 "Treasury Bills Act" (issuance: WWI).



Notes: basis is both consolidated and unconsolidated central government debt stock in respective polities, including personal loans where applicable. Sources include Necco (1915, 92), Dickson (1967) and Dimsdale and Thomas (2016) for U.K. 1706, Legay (2011, 244) for France 1789 (here excluding offices), Fritschy (2003, 79) for Amsterdam 1795, Schmelzle (1900) for Bavaria, Huber (1893) for Ferdinand I.'s HRE debts in 1564.

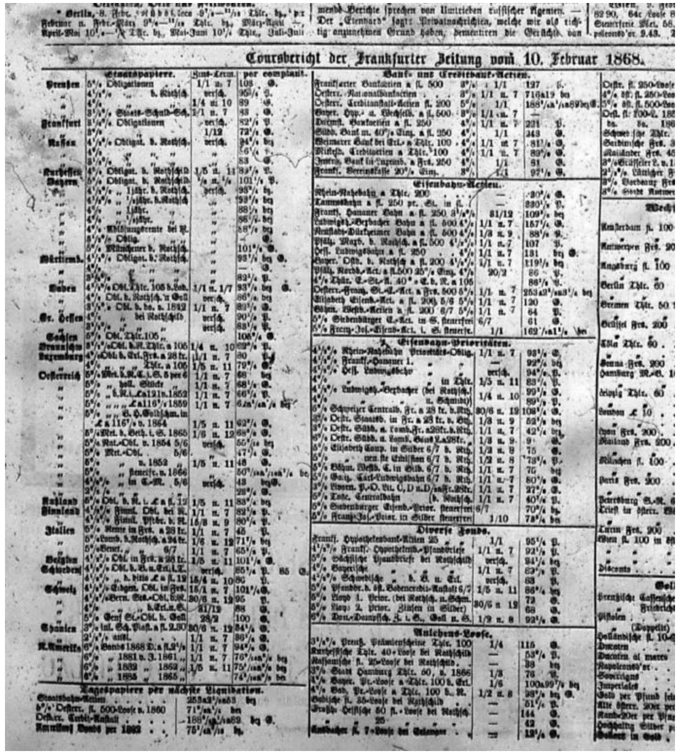
NEW DATA – PRIMARY, SECONDARY VOLUNTARY RATES.

- Careful selection of voluntary rates, average maturity 13.2 years, tradable, covering average 82% of DM over time.
- Integration of personal loans (987x), consolidated debt series (11,500x) – separate collection (exclusion) of <2y maturities, forced/intra-gvt/office loans.



The National Archives, Kew (TNA), E 101/601/16.

"152,000 Pound Flemish, for twenty-six months, at 6% interest (12% p.a.), secured by letters of obligations by the city of London".

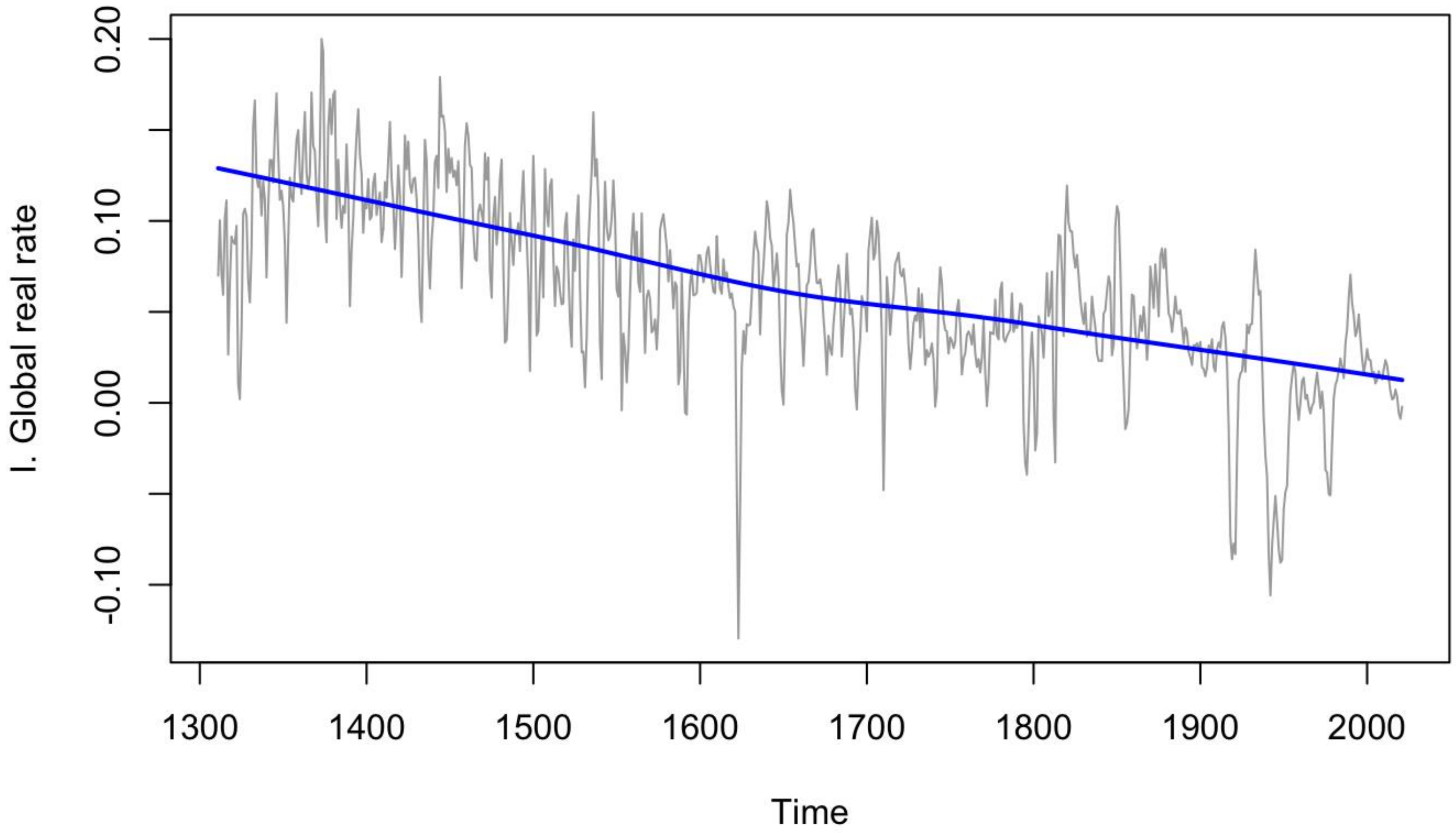


Coursbericht der Frankfurter Zeitung vom 10. Februar 1868.

Daily yields – *Frankfurter Zeitung*, February 10, 1868.
Bethmann-Archive, ISG Frankfurt.

HEADLINE GLOBAL RATES – ARE TREND STATIONARY – 1311-2021.

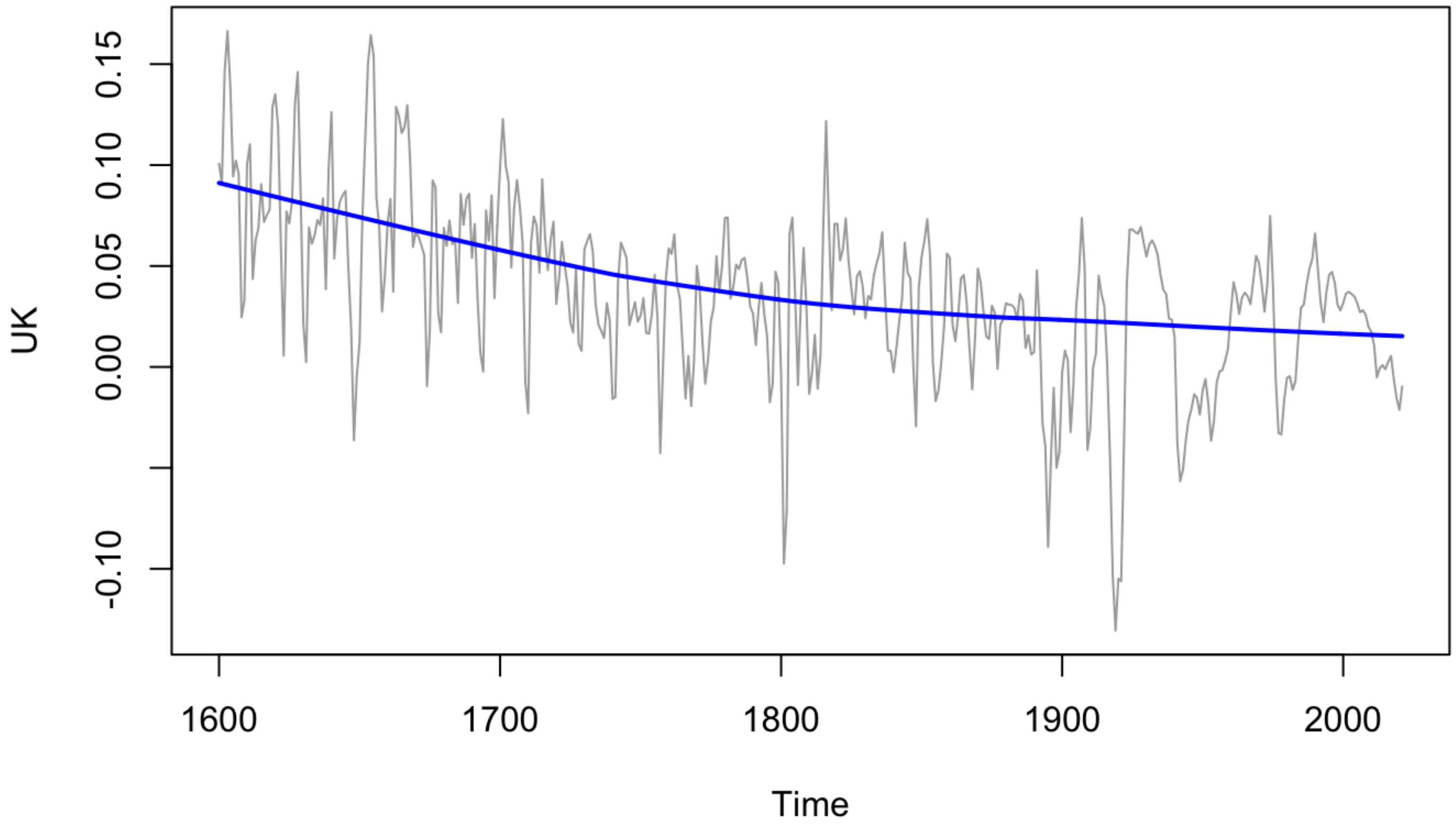
- GDP-weighted ex ante long-maturity rates, robust to multiple inflation expectation approaches (autoregression, progressive lags).
- Ability to reject null hypothesis of unit root at 5% level, using ADF-GLS and Zivot-Andrews – whether allowing for time-trend or not.



Notes: samples features following de facto central banks: Bank of Amsterdam (1611-1809), Bank of Hamburg (1655-1770), Riksbank (1668-1869), the Public Banks of Naples (1611-1805), Bank of England (1701-1869), the Banks of the United States (1792-1848), Bank of Netherlands (1815-1864), Royal Bank of Prussia (1817-1869), Danish Nationalbanken (1835-1869), Banco de San Fernando/Banco de España (1830-1869), and the Banque de France (1800-1869); post-1870 sample is based on country-level data including Asp (1898) for Finland; Svendsen and Hansen (1968) for Denmark; National Library of Australia (1920-45) for Australia; Baubeau (2018) for France; Bankverwaltungsrat der Koeniglich-Preussischen Bank (1870-1875) for Germany; Da Pozzi and Felloni (1964) for Italy's Banca Nazionale; Dutch National Archives (F1100212/2013, 457652-457793) for the Netherlands; Fregert (2014) for Sweden. Full details and asset source breakdown in FKKS (2022, A.57-85).

RESULTS HOLD FOR ALL COUNTRY CONSTITUENTS: E.G. U.K.

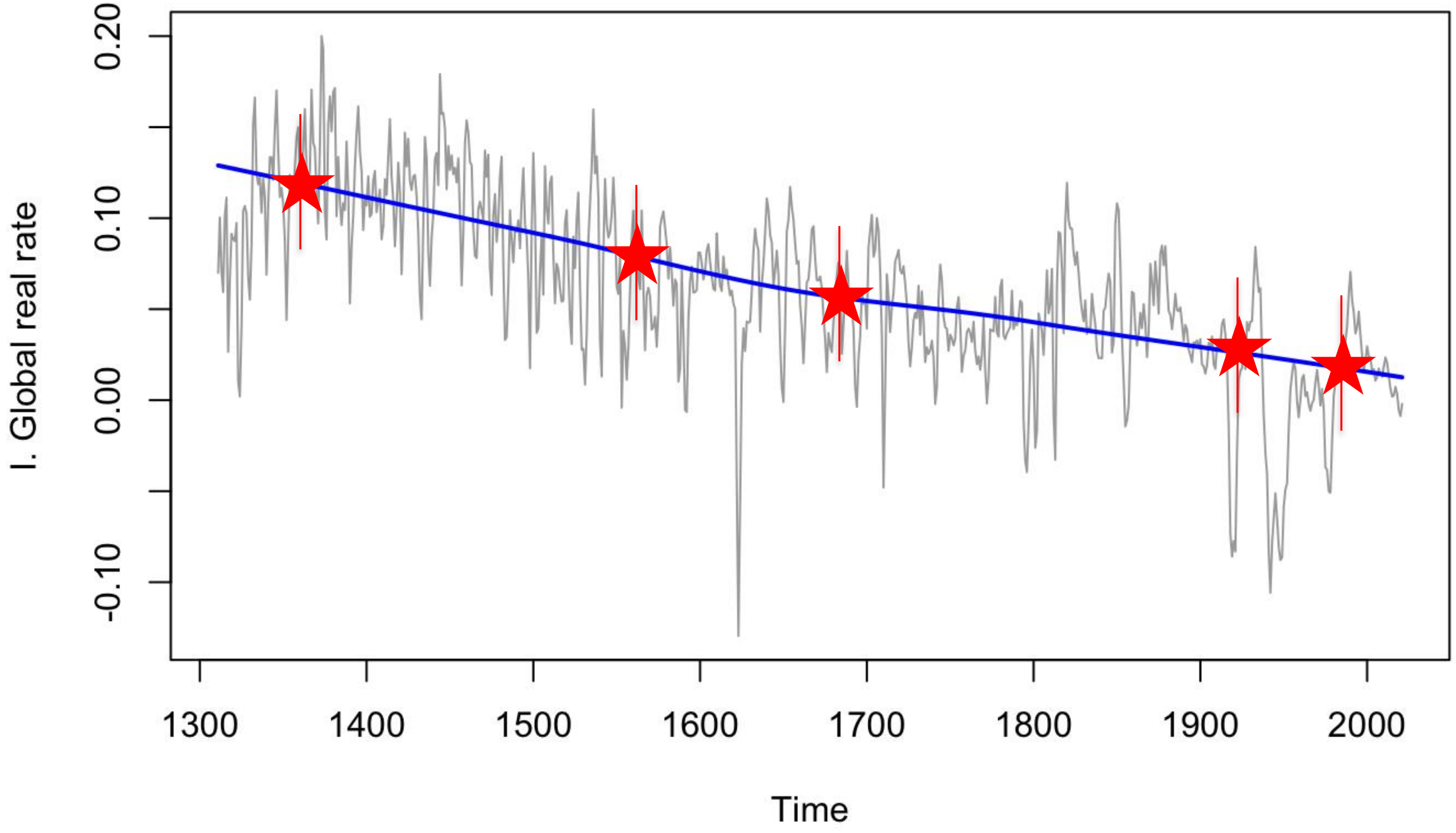
- U.K. real rates via Schmelzing (2022) or Dimsdale and Thomas (2016) confirm stationarity at 1% level via ADF-GLS.



Notes: Figure displays "Global GW basis": when reference is made to "global real rates", we refer - unless explicitly stated otherwise - to the series obtained by weighting the eight country series according to their respective rolling GDP shares over time. These GDP shares are obtained using the consistent definitions of population and per capita real GDP figures in Maddison (2010): the sum of the eight country-level aggregate GDP figures (population x per capita GDP, for each country, linearly interpolating between Maddison's benchmark years) represents the "global GDP" figure, with the U.S. and Japan entering the sample in 1790 and 1870, respectively. Alternative weighting approaches are of course possible, and while very minor, the recent advances in country-level accounting (as discussed above) have also slightly shifted the relative GDP shares over Maddison's figures - hence, our addition of the "Global AW" weighting approach in all exercises, which simply weights all eight countries with equal weights regardless of aggregate output.

GLOBAL REAL RATE INFLECTION POINTS – CHOW TEST.

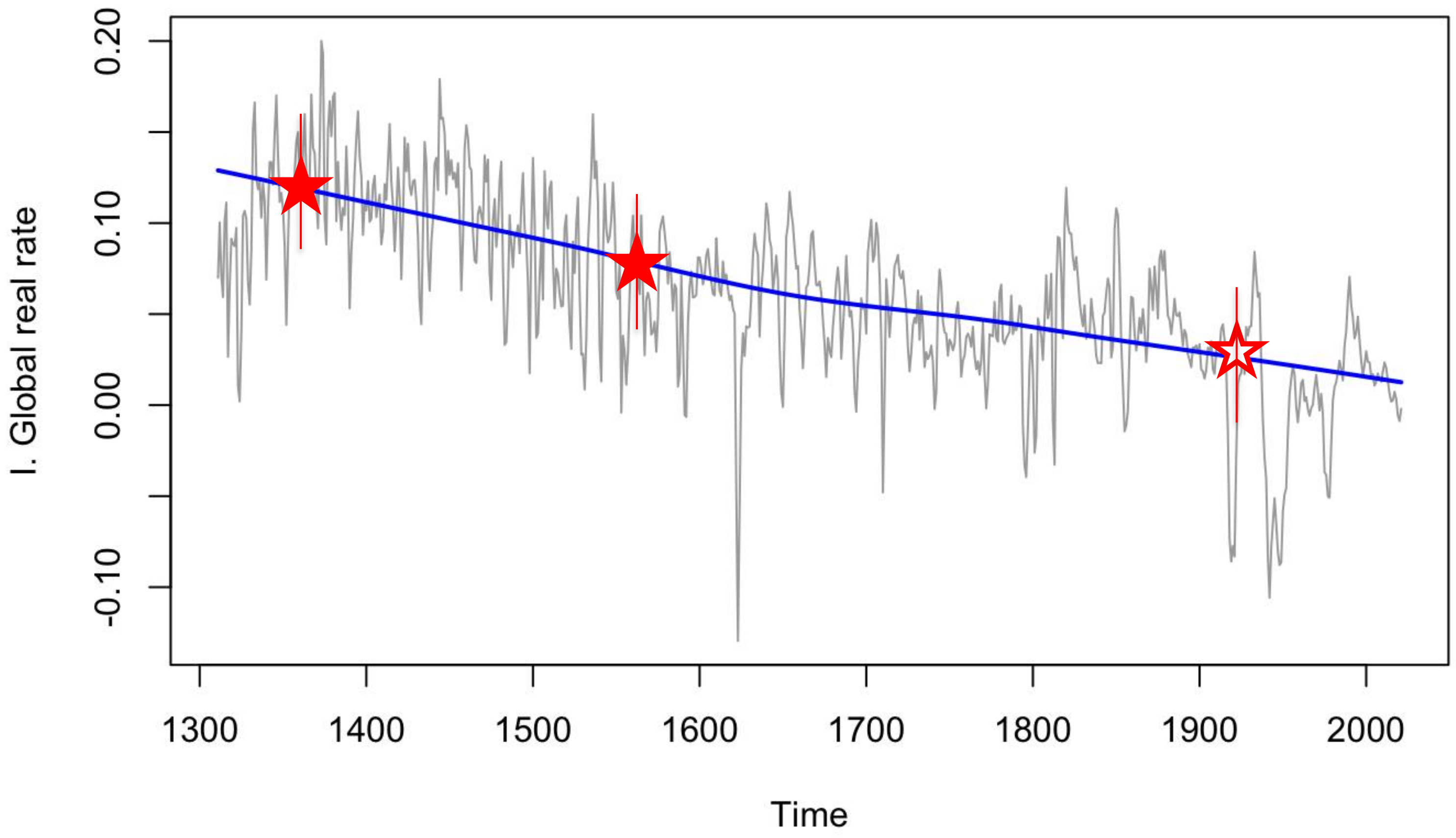
- We test the major narratives in established literature on capital market trend breaks: 1349, 1557, 1694, 1914, 1981.
- Black Death, 1557 "Trinity Default" consistent breaks. 1694, 1914, and 1981 rejected on global basis, multiple country bases.



Notes: The model includes a constant and a deterministic trend (as a fraction of the total sample size). The standard errors are based on Newey and West's (1987) Heteroskedasticity and Autocorrelation consistent (HAC) procedure with a maximum lag length of 4. The coefficient associated with "trendbreak 1349" denotes the difference of the estimated trend coefficients before and after a break in 1349 (allowing for breaks in all the other potential break dates); hence, the associated t-statistic is the Chow test for the absence of a structural break in 1349. Similarly, "meanbreak 1349" refers to a break in the mean in 1349.

Global real rate inflection points – Chow test.

- Chow test suggests only 1349 and 1557 are consistent (country and global level) inflection points in rates – 1914 only weakly confirmed.
- 1981 fully disappears in longer samples.



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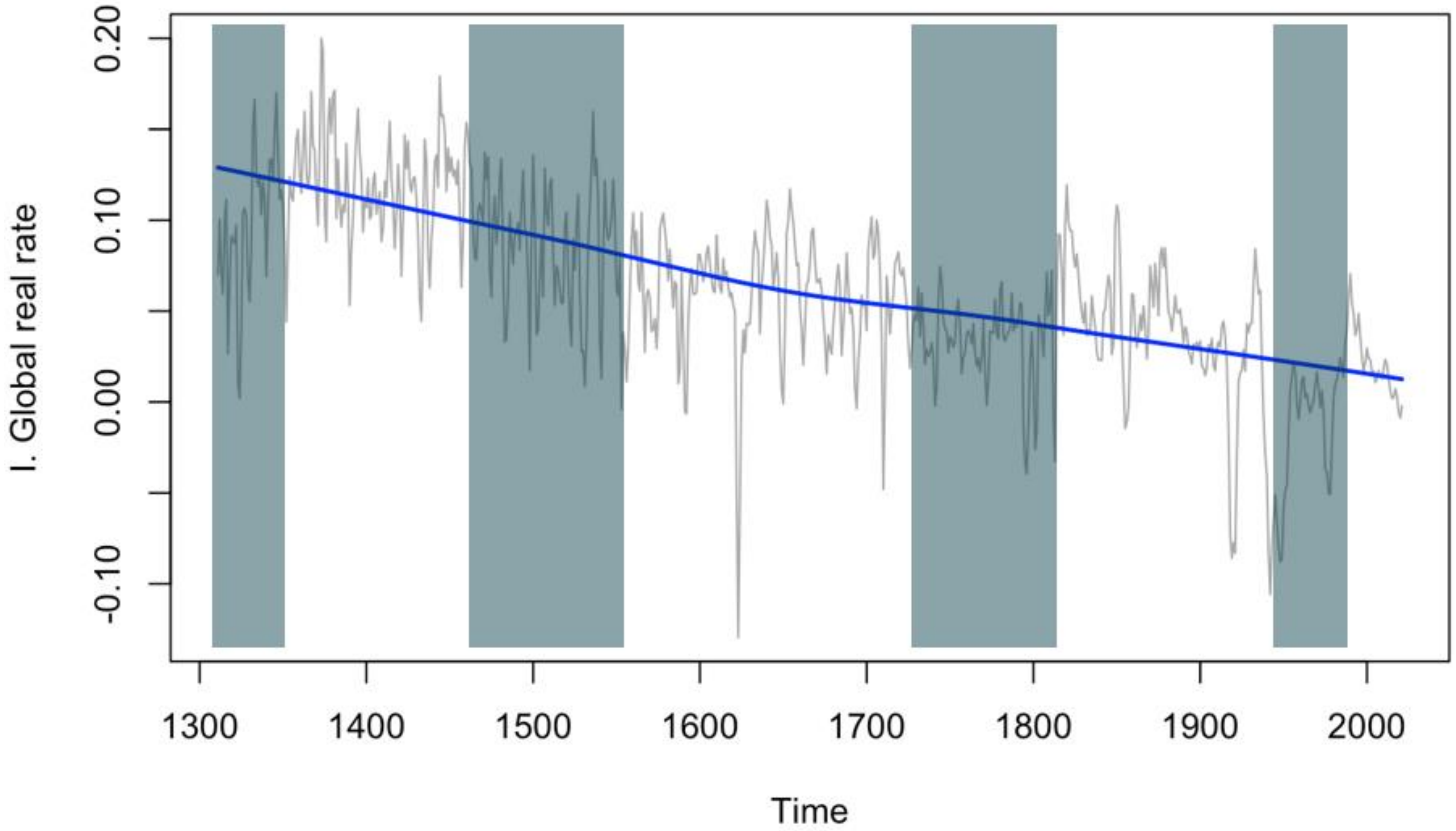
GLOBAL REAL RATES, AND THE FOUR "LOW-RATE ERAS".

- 2022 linearly implied unfiltered rate: 0.204%; 2022 BK trend-implied rate: -0.135%.
- Relatively low war intensity marks narratively-defined low-rate eras. No comparable post-1945 intra-DM peace since Saint-Sabas 1270.



Notes: shades periods are as follows: Pre-Black Death Era (1311-1353); Post-Bullion Famine (1483-1541); The 1732-1810 Boom; The Great FX Transition Era (1937-1985). All sources as per sources for Figure 1. Figure displays GDP-weighted global GW basis, approximating inflation expectations via seven-year progressively lagged realized inflation, not including current year t (following Homer and Sylla 2005). Blue line represents lowess (locally weighted average) function, fitting a non-parametric model, which is the "best fit" given the time series data

PERSISTENCE

- Half-lives of real rate – correction of 50% of shock to trend – fluctuates between 1-4 years, and mildly rises over time.
- Relevant in context of recent shocks, including 1981, 2008, 2020.
- Broadly in line with existing ranges (mainly for FX) – Rogoff (1996), Volckart and Wolf (2006), Itskhoki (2021).

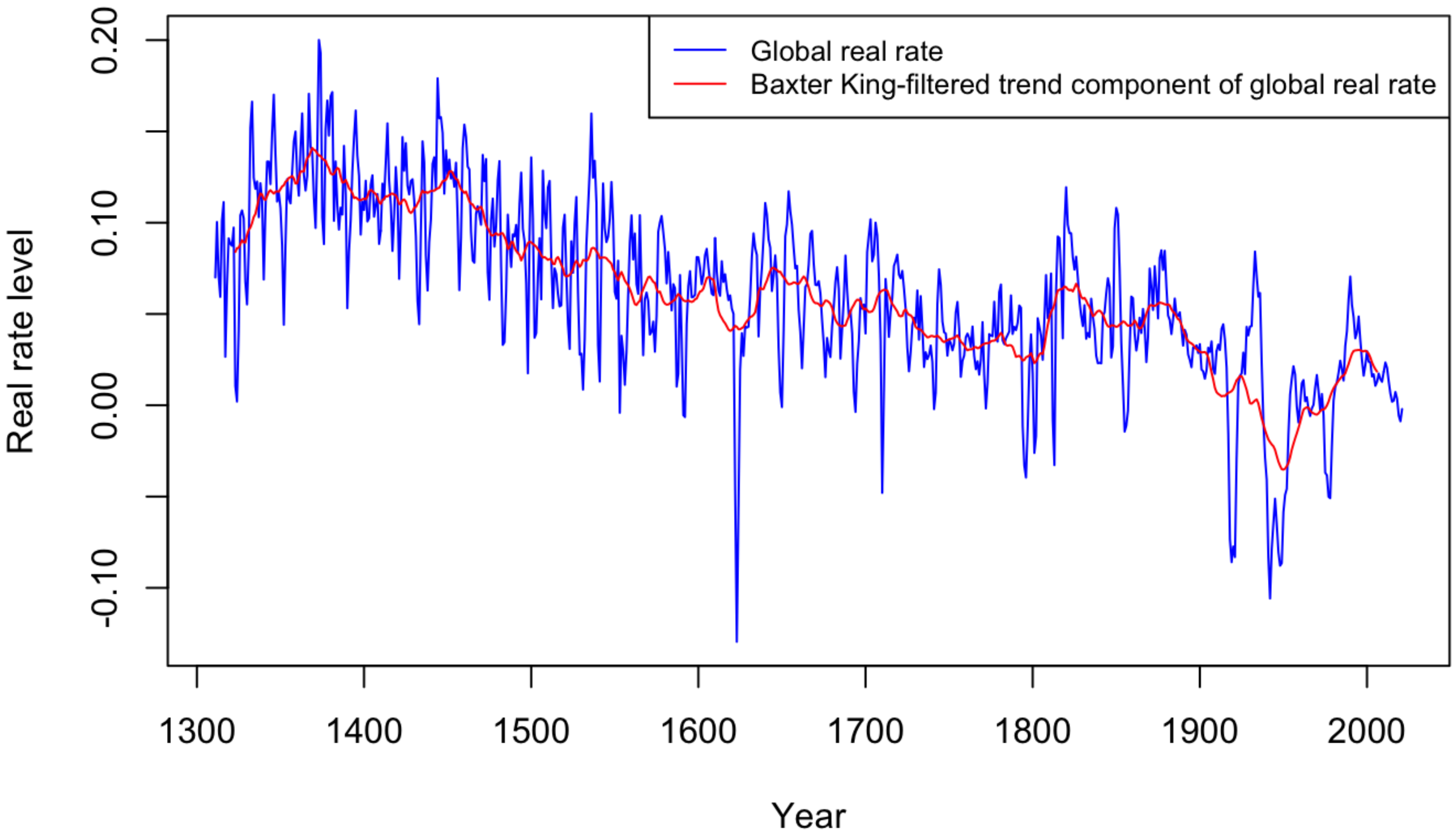
Half-Lives of Real Rates, by Sub-samples

	Period	Half-life	Confidence interval	
Global Real GW	1311-1349	1.2068	0.8219	1.7101
	1350-1557	1.4674	1.2171	1.7141
	1558-2021	2.7947	2.3746	3.7538
Global Real AW	1311-1349	1.4057	1.0381	1.8739
	1350-1557	1.4684	1.2141	1.7878
	1558-1981	2.9377	2.3892	5.1246
	1982-2021	3.1947	1.7151	8.9091
Italy Real	1311-1694	1.3487	1.1968	1.5028
	1695-2021	2.9033	2.3573	4.1928
U.K. Real	1311-1349	1.4533	1.1059	1.8816
	1350-1557	1.4208	1.1253	1.7764
	1558-2021	1.6769	1.4417	1.9141
Dutch Real	1367-1981	1.4007	1.2499	1.5634
	1982-2021	3.5355	2.0216	7.6561

Notes: The half-life is estimated as the first horizon at which the impulse response equals one-half of the initial impact effect. The impulse response is estimated using a deterministically detrended linear autoregressive model (with the number of lags chosen by the Bayesian Information Criterion) using Kilian (1999)'s bootstrap; the point estimate is based on the median unbiased response while the confidence interval is based on the 5-th and 95-th quantiles of the bootstrap distribution. The half-lives are separately estimated in each sub-sample identified by the statistically significant break dates (according to the Chow test). "Global GW" = GDP-weighted global real rate basis; "Global AW" = arithmetically-weighted global real rate basis. NA denotes situations where the half-life is infinity.

TREND COMPONENT GLOBAL REAL RATES.

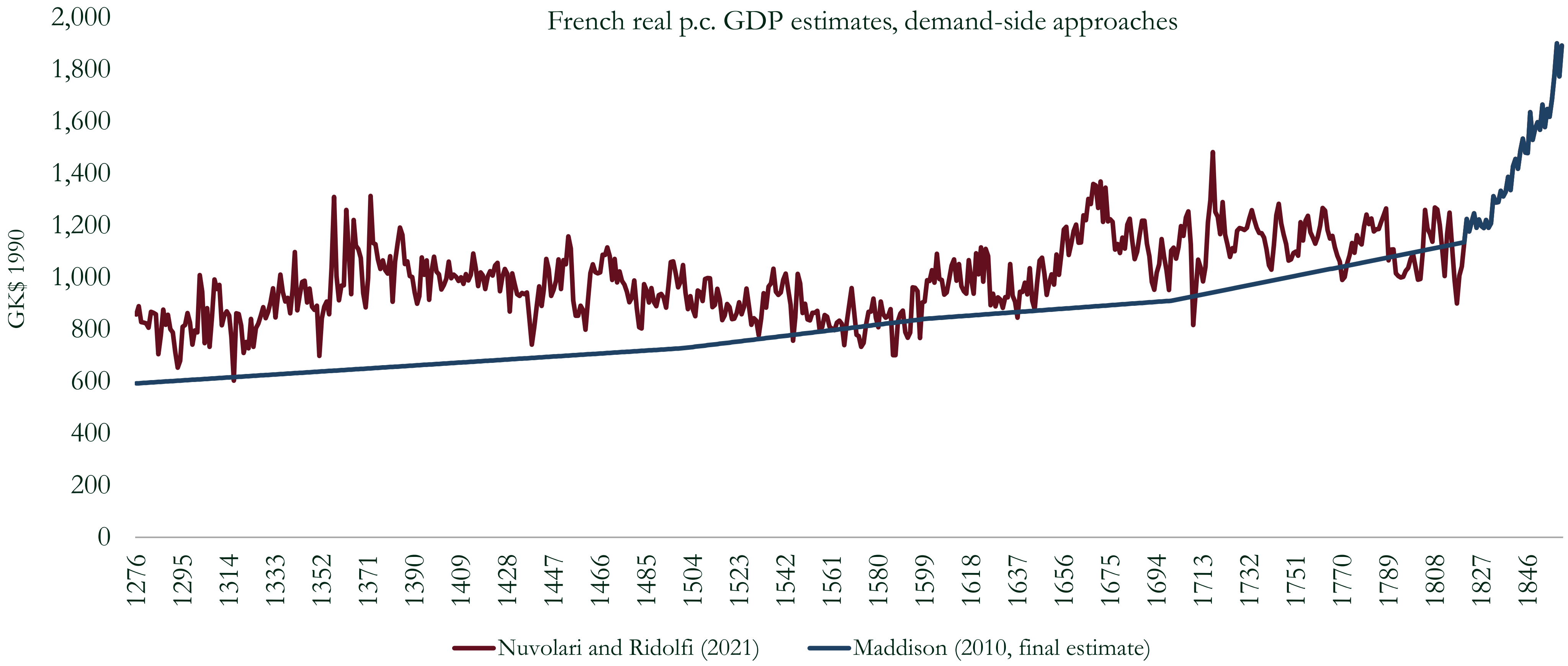
- Filtered basis to examine additional structural/permanent properties, correlations.



Notes: Figure displays "Global GW basis" (blue), weighting the eight country series according to their respective rolling GDP shares over time. These GDP shares are obtained using the consistent definitions of population and per capita real GDP figures in Maddison (2010): the sum of the eight country-level aggregate GDP figures (population x per capita GDP, for each country, linearly interpolating between Maddison's benchmark years) represents the "global GDP" figure, with the U.S. and Japan entering the sample in 1790 and 1870, respectively. Red line displays Baxter King-filtered version of global GW real rate series, with Baxter and King's bandpass filtered long-run component of the global real rate, together with its 95 percent coverage confidence interval (CI). The bandpass filter is tailored to retain fluctuations larger than 100 years. The t-statistic is obtained using Newey and West (1987) standard errors with a maximum of 4 lags..

ADVANCES IN LONG-RUN MACRO ACCOUNTING.

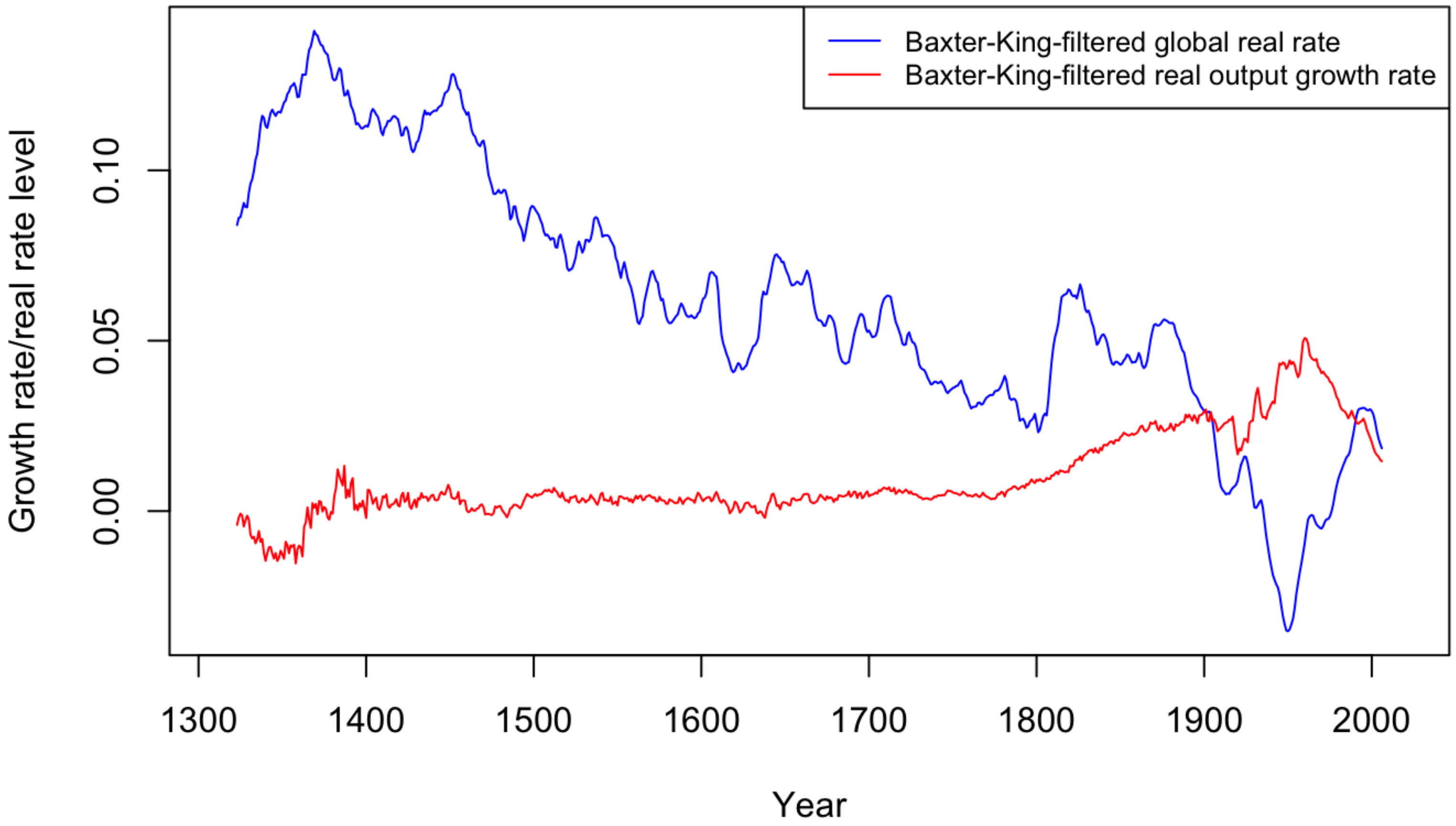
- First high-frequent demand-side real GDP data emerged over recent years for key DMs.
- Makes assumption about size of agricultural sector, expenditure shares – but major advances also in output approaches (U.K.).



Notes: Maddison (2010) horizontal file, taking linearly interpolated values between benchmark estimate years of 1000, 1500, 1600, 1700, 1820. Maddison relies on Blomme and Van der Wee's (1994) estimates for Belgium over 1500-1820. Nuvolari and Ridolfi (2021) demand-side approach, using dynamic basket weights for expenditure shares, 5% for rent input, and 26,332 annual-level nominal wage observations for agricultural workers across four geographical regions in France.

GLOBAL REAL RATES AND GLOBAL REAL OUTPUT GROWTH, 1311-2021.

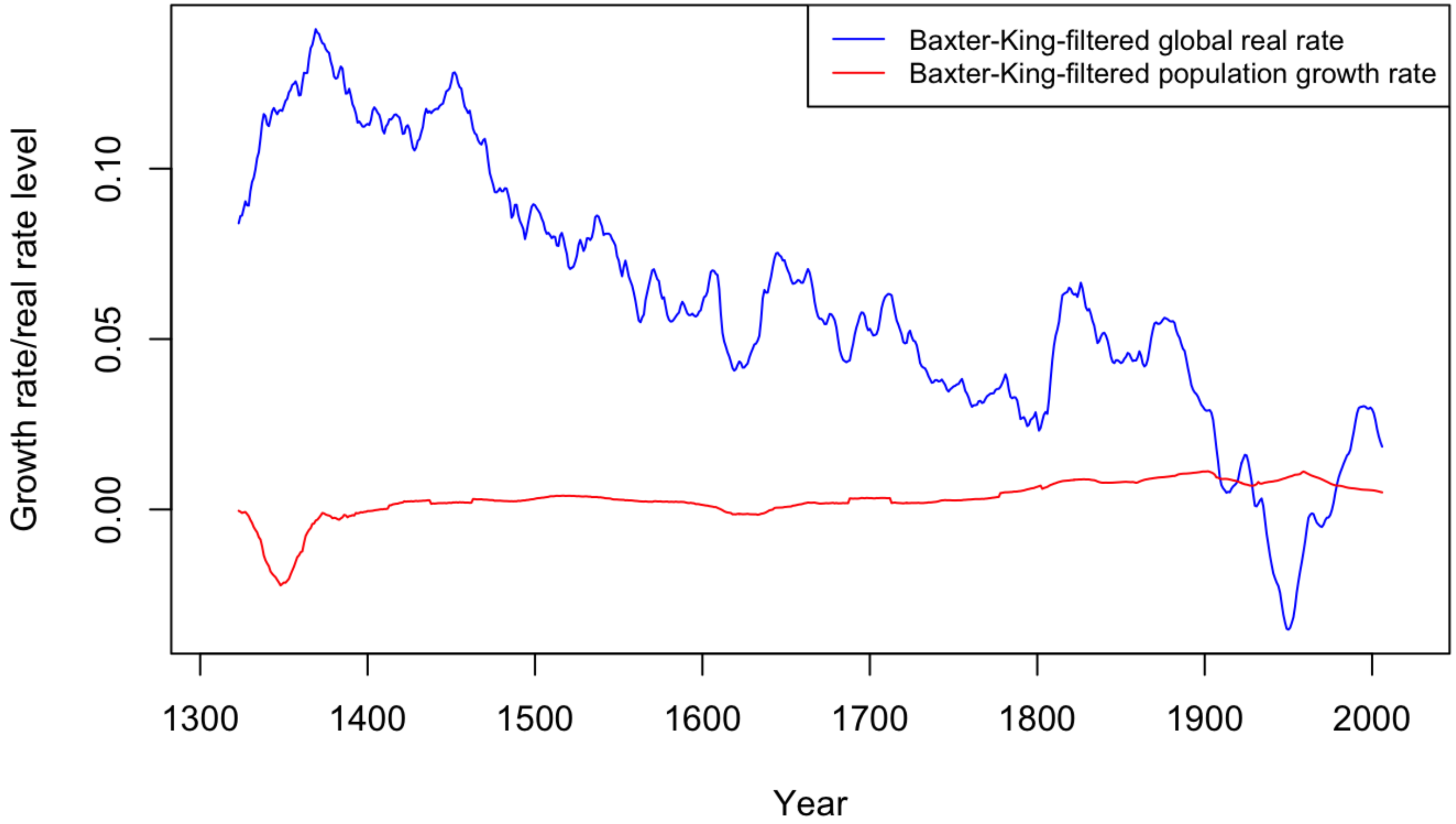
- Visually, positive association between real rates, real output growth, already appears fraught.
- Existing skepticism posits "loose positive correlation" (Hamilton et al. 2016).



Notes: Figure displays Baxter-King filtered "Global GW basis" (blue), weighting the eight country series according to their respective rolling GDP shares over time. These GDP shares are obtained using the consistent definitions of population and per capita real GDP figures in Maddison (2010): the sum of the eight country-level aggregate GDP figures (population x per capita GDP, for each country, linearly interpolating between Maddison's benchmark years) represents the "global GDP" figure, with the U.S. and Japan entering the sample in 1790 and 1870, respectively. Red line displays Baxter King-filtered version of global aggregate output growth for identical eight country set, using new country-level series including Nuvolari and Ridolfi (2021) for France, Pfister (2022) for Germany, and Broadberry et al. (2015) for the U.K. For both series, Baxter and King's bandpass filtered is tailored to retain fluctuations larger than 100 years. The t-statistic is obtained using Newey and West (1987) standard errors with a maximum of 4 lags.

GLOBAL REAL RATES, AND GLOBAL POPULATION GROWTH, 1311-2021.

- Positive association between pop growth rate – real rates as a decidedly "recent" phenomenon.
- Historical norm unambiguously *negative*, except for short-term shocks (Black Death, World Wars).



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CORRELATION RESULTS.

- "Loose positive" correlation (Hamilton 2016, Lunsford West 2019) in fact gives way to squarely negative correlation of both pairs over long samples.
- Post-1980s as historical outlier on both pairs.
- Identical results if p.c. / aggregate bases are used, country-level observations.

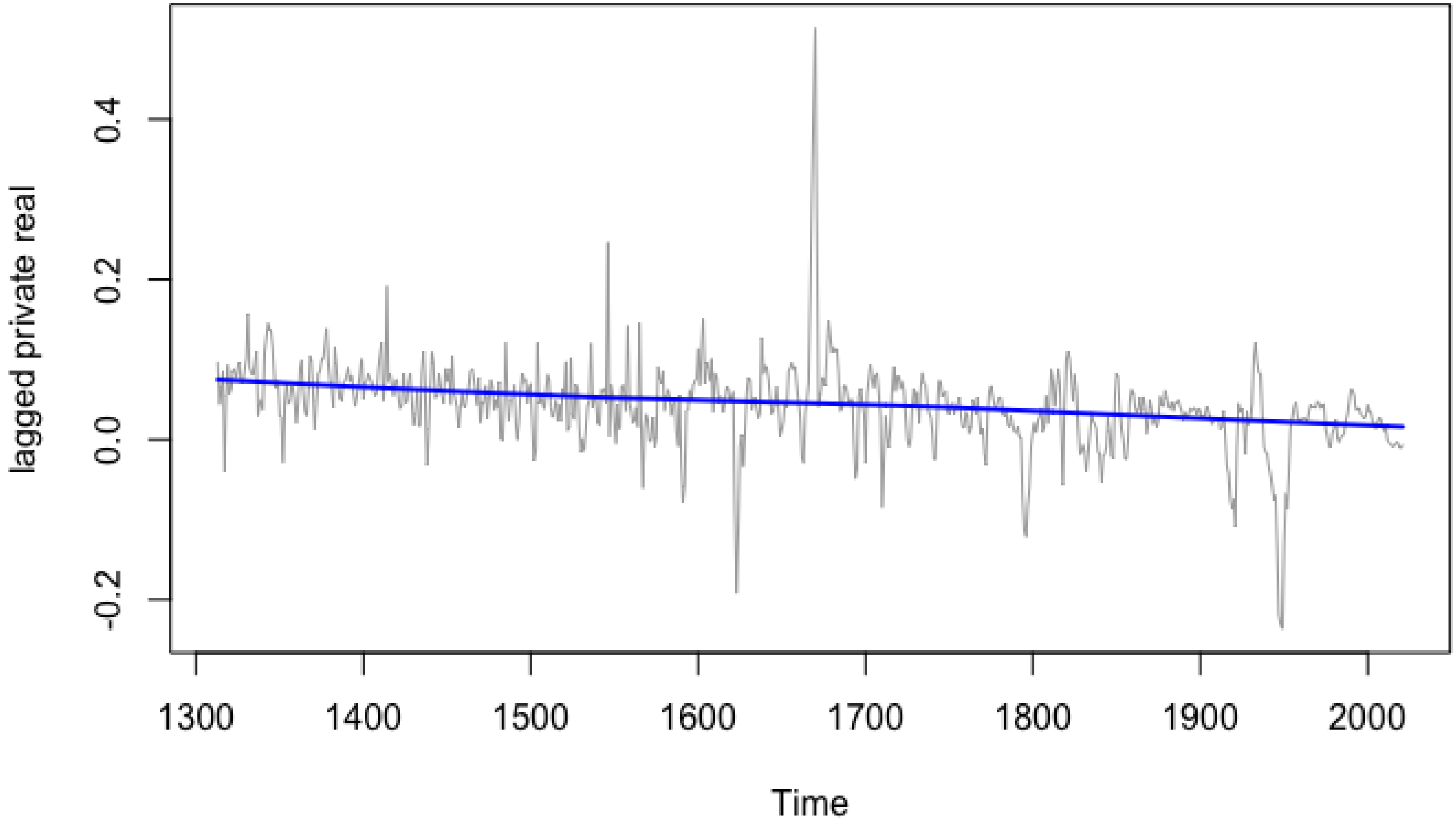
Table 7: Global Real Rates Vs. Aggregate Real Output and Population Growth

	Correlation	95% CI	t-statistic	p-value
Baxter-King-filtered Long-run Component of Aggregate Population Growth	-0.6425	(-.803, -0.482)	-7.85	0.0000
Baxter-King-filtered Long-run Component of Aggregate Real Output Growth	-0.7399	(-0.818, -0.661)	-18.50	0.000

Notes: The table reports the correlation of each series in the first column with Baxter and King's bandpass filtered long-run component of the global real rate, together with its 95 percent coverage confidence interval (CI). The bandpass filter is tailored to retain fluctuations larger than 100 years. The t-statistic is obtained using Newey and West (1987) standard errors with a maximum of 4 lags..

Phenomenon appears to extend to fixed income per se.

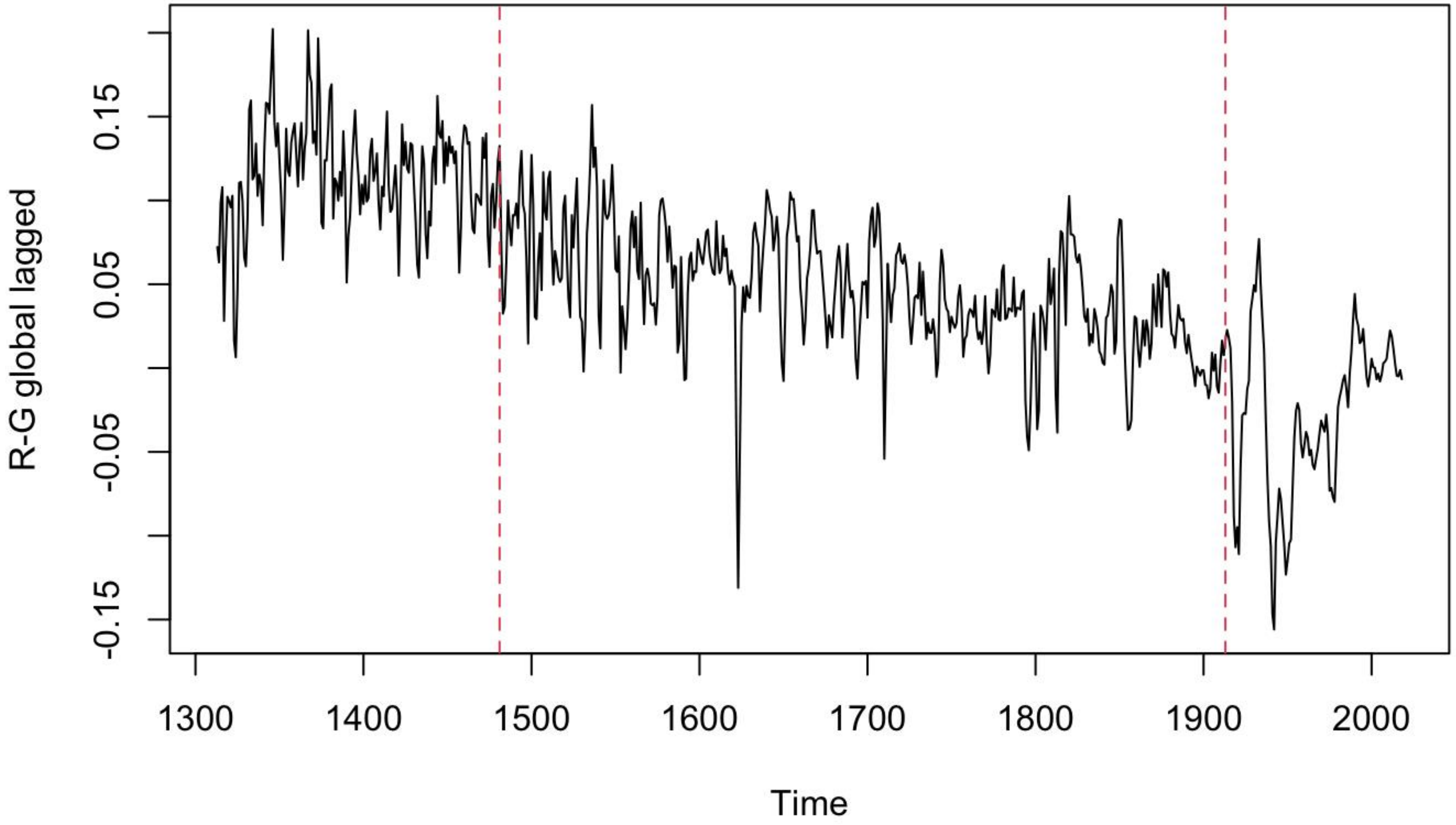
- Private ex ante real long-maturity rates, Western Europe, mortgage basis, 1311-2021.
- 1% stationarity ADF-GLS, across countries. Testing alternative long-run series (Dimsdale and Thomas 2016, corp bonds 1805-2016).
- Sovereign risk narrative?



Notes: Private long-maturity interest rates based on secured mortgage rates with German, Dutch, and French geographical basis, 1,367 observations pre-1870. Inflation expectations constructed via seven-year progressively lagged CPI equal-weighting German, Dutch, and French inflation series as defined in Schmelzing (2022), Ridolfi and Nuvolari (2021), and Allen (2001). Post-1870, data via Bundesbank (1976) and Bundesbank (2020), using German Hypothekenzinsen.

THE FUSION: ADVANCES IN G, ADVANCES IN R.

- We make no specific normative claims about "R-G" as a concept.
- 1% stationarity ADF-GLS, across countries holds for this ratio – it can for the first time be constructed on annual-level frequency over time.



Notes: Figure displays difference between unfiltered "Global GW" real rates and global growth (latter as aggregate real output growth change),. Both R and G are weighted using their respective rolling GDP shares over time. These GDP shares are obtained using the consistent definitions of population and per capita real GDP figures in Maddison (2010): the sum of the eight country-level aggregate GDP figures (population x per capita GDP, for each country, linearly interpolating between Maddison's benchmark years) represents the "global GDP" figure, with the U.S. and Japan entering the sample in 1790 and 1870, respectively. Aggregate real output growth for identical eight country set, using new country-level series including Malanima (2011) for Northern Italy, Nuvolari and Ridolfi (2021) for France, Pfister (2022) for Germany, and Broadberry et al. (2015) for the U.K. Vertical red lines represent Bai-Perron break dates, in set-up with deterministic trend and allowing for up to five break points.

Conclusions

- Strong evidence of trend stationarity of real rates once long-maturity, long samples are examined: holds for all country levels, various inflation expectation approaches, different weighting schemes.
  - Homogenous issuers and sectors.
  - Role of long-maturity basis.
  - Role of long sample.

- We do not necessarily reject short-maturity literature. Safety, liquidity features of short-rates may rationalize both results.
  - But long-maturity rates seem to us the relevant measure for all "secular" debates.

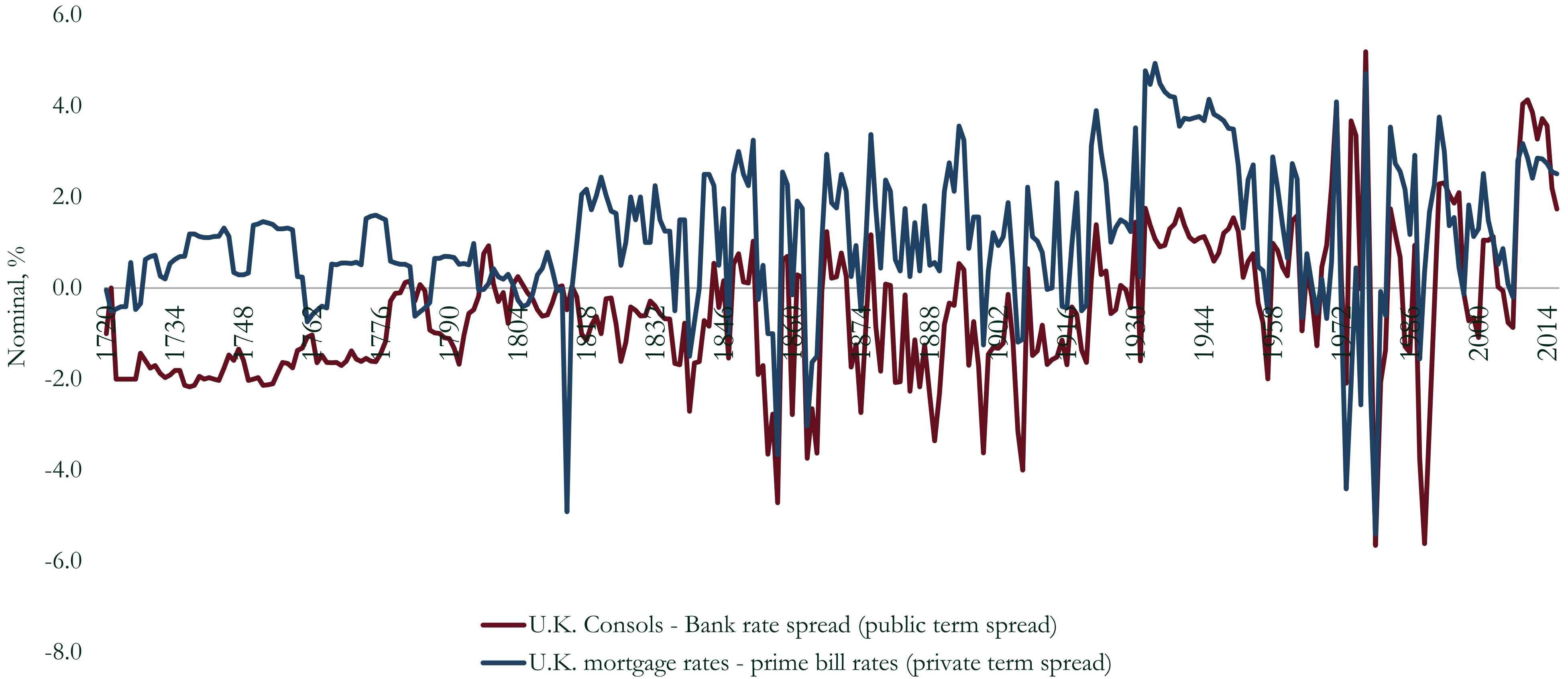
- Support for 1349 and 1557 as historical break points. Positive – but much less decisive – results for 1914 and 1981. Rejection of 1694.
- Therefore not apparent that international financial system experienced a "recent" inflection point.

- Association between (a) output growth – real rates, (b) population growth – real rates is not just positively loose.
  - In fact, the relationship is clearly <u>negative</u> over the long-run.

APPENDIX MATERIAL

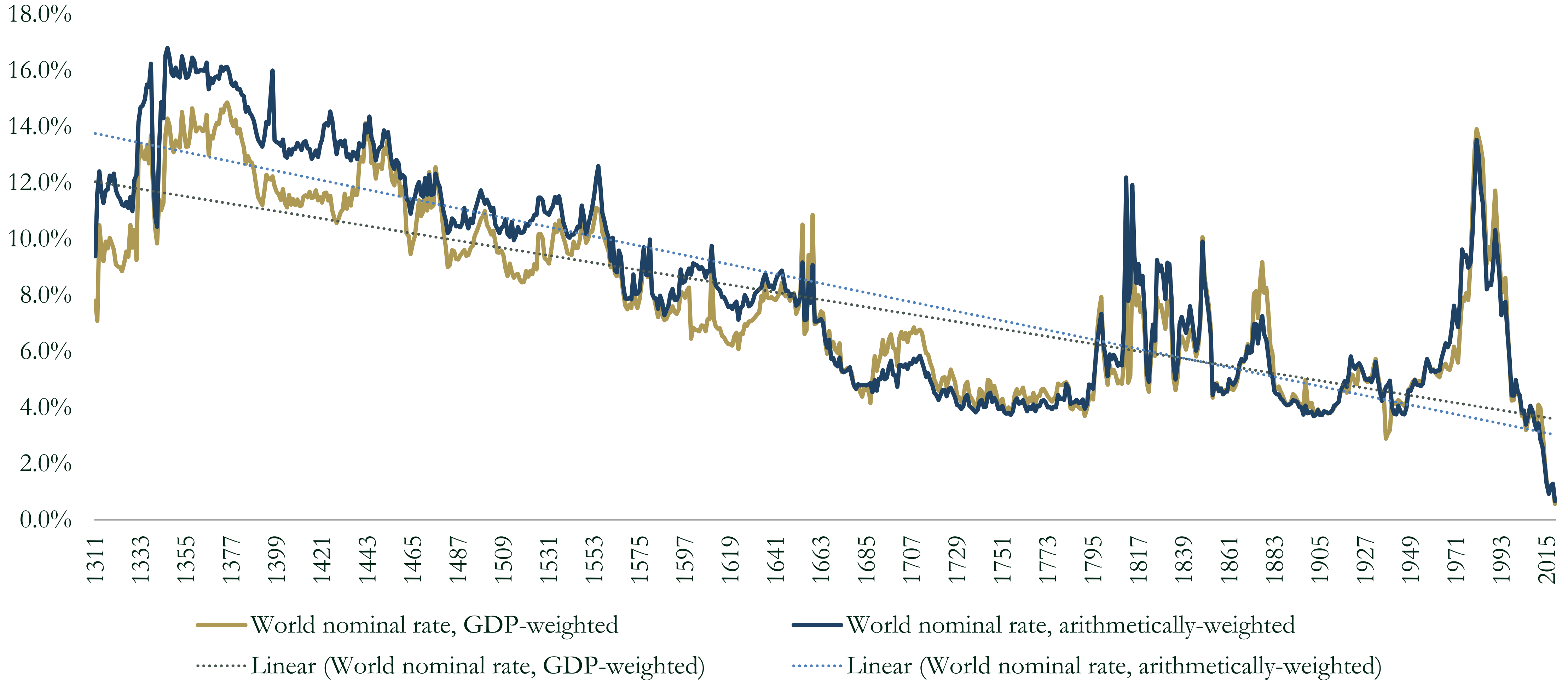
TERM SPREADS: POTENTIAL "MISSING LINK"

- Our results may yet be fully consistent with existing results on short-maturity properties.
- Specific liquidity or safety attributes for short-maturity debt may feature non-stationary properties (e.g. term structure).



Notes: Annual data via Dimsdale and Thomas (2016). "Public term spread" calculated as annual same-year difference between U.K. (perpetual) consol yields, and Bank of England policy rate. "Private term spread" calculated as annual same-year difference between long-maturity (perpetual) mortgage yields, and short-maturity corporate prime bill rates.

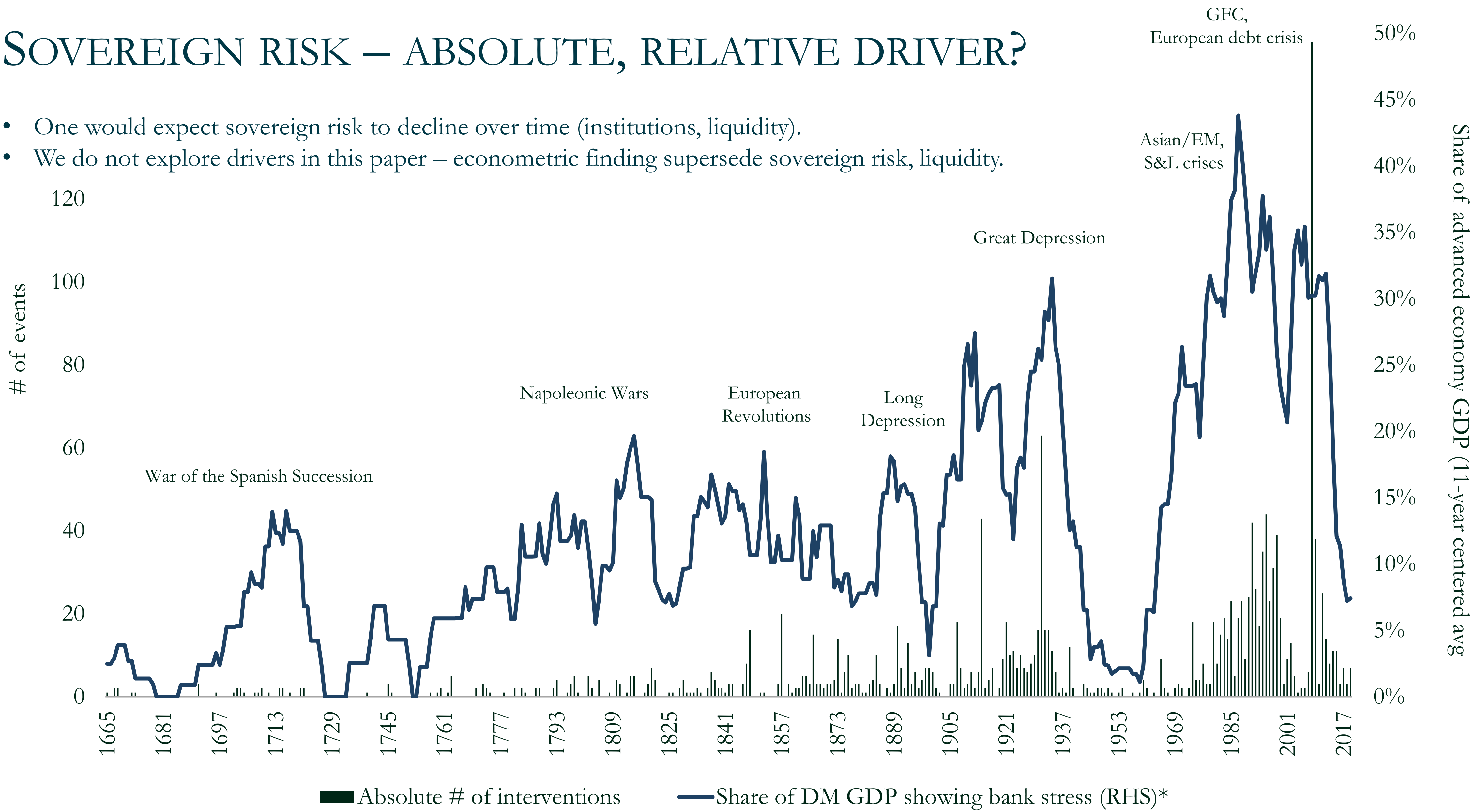
NOMINAL RATES ONLY



Notes: Share of country-years experiencing a credit boom episode, binned by the number of years since last financial crisis and respective central bank liquidity policy (mit+1 = 1). We define a country-year to belong to a credit boom episode if the credit-to-GDP ratio increased beyond +0.10 over the past three years. We label a country-year to be part of a fragile credit boom episode if in addition a financial crisis ensues during any of the three subsequent years.

Sovereign risk – absolute, relative driver?

- One would expect sovereign risk to decline over time (institutions, liquidity).
- We do not explore drivers in this paper – econometric finding supersede sovereign risk, liquidity.



*bank stress frequency: combining Reinhart/Rogoff (2009), Schularick and Taylor (2012), Laeven and Valencia (2020), Baron/Verner/Xiong (2021), Metrick and Schmelzing (2021) banking crises or bank intervention chronologies, for eight country DM sample. Frenquency=(no. of country years with stress event in any database)/(total no. of country years). Includes systemic and non-systemic events. GDP weights based on Schmelzing (2020).