Why So Low for So Long? A Long-Term View of Real Interest Rates*

Claudio Borio,[a] Piti Disyatat,[b] Mikael Juselius,[c] and Phurichai Rungcharoenkitkul[a]

[a]Bank for International Settlements
[b]Bank of Thailand
[c]Bank of Finland

Prevailing explanations of the long-term decline in real interest rates are premised on the notion that real interest rates over long periods are driven by variations in the underlying real forces governing desired saving and investment. Based on long historical data stretching back to 1870 for 19 countries, we cast doubt on this view. While it is possible to find some relationships consistent with the theory in some periods, particularly over the last 30 years, they do not survive over the extended sample. This holds both at the national and at the global level. Among external factors, interest rates of financially dominant countries appear important in explaining real interest rates across countries, pointing to the possible role of global financial factors.

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Author contact: Rungcharoenkitkul (corresponding author): Senior Economist, Bank for International Settlements, phurichai.rungcharoenkitkul@bis.org; Borio: Head of Monetary and Economic Department, Bank for International Settlements, claudio.borio@bis.org; Disyatat: Assistant Governor, Bank of Thailand, pitid@bot.or.th; Juselius: Research Advisor, Bank of Finland, mikael.juselius@bof.fi.

1. Introduction

Global real (inflation-adjusted) interest rates, short and long, have been on a downward trend throughout much of the past 30 years and have remained exceptionally low since the Great Financial Crisis (GFC). This has triggered a debate about the reasons for the decline. Invariably, the presumption is that the evolution of real interest rates reflects changes in underlying saving-investment determinants (e.g., Bernanke 2005, Caballero, Farhi, and Gourinchas 2008, Broadbent 2014, and Summers 2014). These are seen to govern variations in some notional "equilibrium" or natural real rate, defined as the real interest rate that would prevail when actual output equals potential output, towards which market rates gravitate.

The presumption that real interest rates are anchored to the natural rate over longer horizons is the foundation for much of the work that examines the evolution of real interest rates empirically. One strand focuses on *observed* real interest rates and relates them to the evolution of factors that underpin the economy's saving-investment balance (e.g., Bean et al. 2015, Carvalho, Ferrero, and Nechio 2016, Gagnon, Johannsen, and Lopez-Salido 2016, Rachel and Smith 2017). In effect, it assumes that over the relevant horizon, variations in the observed rate are anchored on the unobserved natural rate. A second strand uses theory-prescribed relationships, such as the Phillips curve and the IS curve, to pin down the *natural* rate in a filtering system (e.g., Justiniano and Primiceri 2010, Laubach and Williams 2015). Neither approach directly tests the link between *observable* variables, such as demographics, and real interest rates. And much of the analyses are concentrated on the period since the mid-1980s, when real interest rates have been declining. This makes it harder to distinguish their true drivers from variables that are temporarily correlated due to similar trends.

We aim to fill this gap by systematically examining the empirical link between real interest rates and the posited determinants from a long historical perspective. Based on data starting in the 19th century for 19 economies, we find only a tenuous link between real interest rates and observable proxies for the main saving-investment determinants. Some variables, notably demographics, do exhibit the expected relationship with real interest rates in *some* subsamples, especially in the more recent one. But there is little evidence of a stable relationship across subsamples. This applies to both domestic and global variables. Among external factors, interest rates of financially dominant countries play an important role, consistent with the view that these countries act as global anchors for real interest rates across countries. This suggests that co-movements in real interest rates across countries are more closely related to global financial factors, captured to some extent by monetary policy in anchor countries, than to common variations in global saving-investment determinants, including factors such as a global saving glut.

Our focus on direct links between real interest rates and observable factors using long historical data is similar in spirit to Hamilton et al. (2016) and Lunsford and West (2019). The former studies several countries but focuses mainly on GDP growth, while the latter looks at the United States but considers up to 30 variables. Our paper bridges the two by combining many countries and many variables, with the latter encompassing also fiscal variables that have been highlighted in recent debates (e.g., Rachel and Summers 2019). In terms of the global dimension of real interest rate movements, our work complements that of Jordà and Taylor (2019) and Kiley (2019) who document a large global component in real interest rates. Our contribution is to discern more clearly between the role of common variations in global saving-investment determinants and other factors potentially related to monetary policy of anchor countries.

The rest of the paper is organized as follows. Section 2 provides an overview of existing approaches to explaining real interest rates, highlighting their limitations. Section 3 analyzes the relationship between real interest rates and a standard set of real-sector determinants for a cross-section of countries over a long time span. Section 4 explores the global dimension of real interest rate determination and lays out the numerous robustness check performed. The final section concludes.

2. Real Interest Rate Determination: An Overview of Approaches

Prevailing approaches to explaining real interest rates are premised on the notion that the desired (ex ante) supply of saving and the desired (ex ante) demand for investment determine some notional equilibrium real interest rate consistent with full employment or output at potential, also known as the "natural rate." This notion takes root in the "loanable funds" framework, in which saving-investment determinants drive the demand for, and supply of, funds that pin down the market-clearing interest rate (in equilibrium at the marginal product of capital).[1] The framework therefore focuses on the determinants of saving and investment.

On the saving side, the standard building block is grounded on households' optimal intertemporal consumption decisions, as captured by the Euler equation. The derived saving function depends positively on unobserved intertemporal preferences and expected consumption growth, the latter being pinned down by the steady-state output growth in equilibrium. This establishes a positive link between equilibrium real interest rate and potential output growth in many standard macroeconomic models (see Galí 2015).[2] With household heterogeneity, demographic variables and income distribution also come into play. A higher life expectancy influences life-cycle decisions, raising desired saving and lowering the equilibrium real interest rate. A higher dependency ratio lowers saving and raises the real interest rate, as the working-age population saves more than younger and older cohorts. Population growth influences both the demographic dynamics and the capital-to-labor ratio, resulting in offsetting effects on interest rates (Carvalho, Ferrero, and Nechio 2016).[3] Higher income inequality increases saving, as richer households have a higher marginal propensity to save. Finally, in the

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[1] See Borio and Disyatat (2011, 2015) and Mankiw (2013) for a discussion.

[2] Higher potential output growth would increase households' desired consumption immediately, as they attempt to smooth consumption in response to higher permanent income. Given the decline in saving, a higher real interest rate is then required to maintain the goods market equilibrium. In other models with habit formation, e.g., in Carroll and Weil (1994), higher income growth could be associated with higher saving, weakening the link between interest rates and growth.

[3] Lower population growth raises the old-age dependency ratio, increasing the equilibrium real interest rate. But it also raises the capital-to-labor ratio and lowers the marginal product of capital. The net effect on the equilibrium real interest rate is a priori ambiguous.

absence of Ricardian equivalence, higher fiscal deficits or public debt may reduce saving and increase interest rates.[4]

On the investment side, firm profit maximization and the resulting demand function for physical capital point to the relevance of factors such as the relative supply of labor and capital, population growth, investment profitability, productivity growth, and the relative price of capital to that of output. Cheaper physical capital—for example, from technological advances—means that less output needs to be devoted to maintain the same level of production—investment falls. But cheaper capital also encourages investment. Provided the former (income) effect always dominates, as is typically assumed (e.g., in Rachel and Smith 2017), a fall in the relative price of capital should go hand-in-hand with lower desired investment, and hence lower real interest rates.

The theoretical influence of saving-investment factors on interest rates spans both safe and risky assets. Indeed, shifts in investors' risk preferences have been proposed as one reason why risk-free real interest rates have been declining despite relatively stable marginal product of capital (the "safe asset shortage hypothesis" of Caballero, Farhi, and Gourinchas 2008). More generally, a higher risk premium may lower desired investment and raise desired saving, driving a wedge between returns on risk-free bonds and risky capital.[5] Similarly, saving-investment factors can exert cross-border influences if economies are financially integrated. For example, the saving glut hypothesis (Bernanke 2005) posits that desired saving in emerging markets has put downward pressure on real rates globally.

The corresponding explanations for declining and persistently low real interest rates draw on these theoretical hypotheses and follow essentially two approaches. The first, which focuses on *observed* real interest rates and relates them directly to the evolution of the factors that underpin the economy's saving-investment balance,

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[4]In addition to household saving, corporate saving could also influence interest rates. Chen, Karabarbounis, and Neiman (2017) document the rise in global corporate saving and argue that it contributes to lower interest rates.

[5]The risk premium is defined as the difference between the cost of capital and the risk-free rate. Risk premium shifts may originate from a repricing of risks (e.g., due to demand for safe assets, as in Gourinchas and Rey 2016 and Del Negro et al. 2017) or changes in underlying risks (e.g., the degree of productivity growth uncertainty, as in Vlieghe 2017).

comes in two variants. One is largely narrative: it tells plausible stories relating real interest rates to their determinants, typically based on informal inspection of the behavior of the relevant variables (e.g., International Monetary Fund 2014, Bean et al. 2015, and Eichengreen 2015). The other is calibration: this systematically uses theory to identify factors behind shifts in real interest rate trends, and data to calibrate the corresponding structural models (e.g., Carvalho, Ferrero, and Nechio 2016, Gagnon, Johannsen, and Lopez-Salido 2016, Rachel and Smith 2017, Vlieghe 2017). In this variant of the first approach, theory dictates the relationships, and the data are only used to gauge their quantitative importance conditional on the theory being true. The second approach is filtering: this recovers equilibrium real interest rates statistically by anchoring them to some economic relationships, notably the link between economic slack and inflation—the Phillips curve (e.g., Laubach and Williams 2003, 2015; Justiniano and Primiceri 2010; Del Negro et al. 2017; and Holston, Laubach, and Williams 2017).

How far does the resulting empirical evidence support the hypothesis that saving-investment imbalances have driven real interest rates to such low levels? Existing studies have provided estimates of the extent to which saving-investment determinants can explain real interest rate movements *conditional* on specific theory relationships, but not evidence supporting the underlying relationships themselves.

This conclusion is obvious for the narrative and the calibration approach, in which the validity of the underlying theory is taken as given, and is not subject to a test. The filtering approach faces similar challenges, as a typical maintained hypothesis is that inflation helps identify cyclical deviations of the market rate from the natural rate. Yet, the empirical link between economic slack and inflation has met challenges (Stock and Watson 2007, Forbes, Kirkham, and Theodoridis 2017). Recent work has also found that financial cycle proxies capture cyclical output variations better than inflation variations (Kiley 2015, Borio, Disyatat, and Juselius 2017), yielding generally higher natural interest rate estimates (Juselius et al. 2017). Moreover, the reliance on unobserved variables, such as potential growth and time preference, means the maintained hypothesis ends up having a decisive influence on the end result (Lubik and Matthes 2015).

All this highlights the importance of confronting the various hypotheses more directly with the data, examining systematically relationships between real interest rates and *observable* variables. And yet, there are very few studies that do this. Much of this work examines an earlier period—the surge of real interest rates in the early 1980s (Barro and Sala-i-Martin 1990, Orr, Edey, and Kennedy 1996). Hardly any have covered the more recent phase of declining rates. More recent work has focused on a few specific factors, mainly those related to demographics, and only on the most recent period (Aksoy et al. 2019, Ferrero, Gross, and Neri 2019, Kiley 2019). Two exceptions are Hamilton et al. (2016) and Lunsford and West (2019). The former looks at the evidence for 17 advanced economies, focusing largely on real output growth. They find only a modest link with real interest rates, and the results are also sample specific. Lunsford and West (2019), on the other hand, focus on the United States for the period 1890–2015 and evaluate the bivariate correlation between real interest rates and a large number of factors. The authors find weak evidence overall, particularly for variables representing aggregate growth (GDP, consumption, total factor productivity (TFP)), though they do find some support for demographic variables. Our paper complements these papers by considering a large set of countries in tandem with a large number of factors (including fiscal variables), conducting joint-specification analysis to allow for interactions between explanatory variables, and exploring also the global dimension.

3. Real Interest Rate Determination: The Role of Real Factors

We utilize long historical data and cross-country variation to test for long-term relationships between real interest rates and prominent saving-investment determinants suggested by theory. We impose no prior restrictions on these relationships and allow the data to speak about their nature and stability. The aim is not to test the saving-investment framework nor analyze the detailed mechanics underpinning it (i.e., how individual factors shift the saving-investment schedules); rather, it is to critically evaluate and test narratives based on it. Before turning to the data and estimation results, we outline the empirical approach.

3.1 The Empirical Strategy

The standard saving-investment framework relies on the assumption that money is neutral "in the long run," so that only real factors drive real interest rates. Consider the following decomposition:

$$r_t = r^* \left(X_t ; \beta \right) + r_t^{NF}, \tag{1}$$

where r_t is the ex ante real interest rate; r^* is the equilibrium real interest rate, which is a function of long-term saving-investment determinants, X_t, with parameters β; and r_t^{NF} captures movements in the real rate due to short-term factors such as nominal frictions and monetary policy. Long-run neutrality implies that the r_t^{NF} factor has no lasting effects in (1). The question is how to best operationalize this idea. We consider two broad alternatives.

In line with, e.g., King and Watson (1997) and Bullard (1999), our first and main notion of long-run neutrality is that r_t^{NF} is stationary ($r_t^{NF} \sim I(0)$) with zero mean, so that r_t^{NF} does not affect real interest rates in the steady state.[6] For instance, suppose that $r^* \left(X_t ; \beta \right) = \beta' X_t$ and $r_t^{NF} = (1 - \gamma L)^{-1} \varepsilon_t$ where L is the lag operator, $|\gamma| < 1$, and ε_t is a white-noise process that embodies temporary shocks on r_t including monetary policy innovations. This specification implies an estimation equation for r_t of the form

$$r_t = a r_{t-1} + b_0' X_t + b_1' X_{t-1} + \varepsilon_t, \tag{2}$$

where $a = \gamma$, $b_0 = \beta$, and $b_1 = -\gamma\beta$. In this case, the long-run relationship, $r^* \left(X_t ; \beta \right) = \beta' X_t$, can be derived from (2) by setting $r_t = r_{t-1} = \ldots$, $X_t = X_{t-1} = \ldots$, and $\varepsilon_t = 0$ for all t and solving. For a more general autoregressive distributed lag process,

$$r_t = \sum_{l=1}^{K} a_l r_{t-l} + \sum_{l=0}^{K} b_l X_{t-l} + \varepsilon_t, \tag{3}$$

[6]King and Watson (1997), among others, suggest a test for long-run neutrality based on the idea that monetary policy shocks should not enter the trend component of a Beveridge and Nelson (1981) decomposition of a real variable, implying that their moving-average representation in the real variable is stationary. This is what we assume, leading to (2) or (3) above.

the long-run parameters are given by $\beta = \left(\sum_{l=0}^{K} b_l\right) / \left(1 - \sum_{l=1}^{K} a_l\right)$. The factor $\left(1 - \sum_{l=1}^{K} a_l\right)$ describes the speed with which changes in the real interest rate correct deviations between the real interest rate and its steady state. We refer to this parameter as the *adjustment parameter* below.

If the roots of the polynomial $1 - \sum_{l=1}^{K} a_l L^l$ in L are all inside the unit-circle, it is clear from (3) that r_t is stationary only if X_t is a stationary process. On the other hand, if X_t is non-stationary (e.g., a unit-root process or a break process), r_t will inherit non-stationarity from X_t (and either co-integrate or co-break). In this case, r_t and X_t vary together at the zero frequency relative to the sample length. This gives a lot of statistical power to estimate β, and the long-run relationship $r^* (X_t; \beta)$ can be directly estimated from a static version of (2).[7] While this is less efficient in finite samples, we will utilize this property where convenient. However, if (1) is not true and the variables are non-stationary, it could also generate "spuriously" strong correlation between the real interest rate and the saving-investment factors in specific subsamples. In this case the correlations are likely to be unstable and strongly subsample dependent. Hence we place high emphasis on the stability of the β estimates over different subsamples

Identifying long-run neutrality with stationarity is intuitively appealing, but it does not translate easily into calendar time. An alternative approach that does so is to assume a frequency cut-off for the temporary component, r_t^{NF}. One can then remove higher-frequency variation from r_t and X_t and then estimate the steady-state relationship from the remaining variations. We try several alternatives. First, we pre-filter the real interest rate using the Holston, Laubach, and Williams (2017) procedure to obtain a direct measure of the natural rate. We also apply a Hodrick-Prescott (HP) filter with a smoothing parameter of 100, which identifies the "long run" as fluctuations with cyclicality of eight years or longer. Finally, we try 5-year and 10-year averages of the data as another way to

[7] Under the unit-root assumption, estimates of β are super-consistent and can therefore be obtained from a static specification. The same idea underlies the Engle-Granger two-step procedure. Co-breaking has similar properties.

smooth out cyclical variations. This is similar in spirit to Lunsford and West (2019).

For the main part of the analysis, we use *long-term* real interest rates as a measure of r_t, as these rates should be less influenced by cyclical factors such as monetary policy. A drawback, however, is that this requires estimates of long-term inflation expectations over the sample period, which introduces an additional source of noise in the analysis. We employ several different modeling strategies to reduce the risk that mismeasured inflation expectations drive our results. For instance, we redo all results with short-term interest rates, estimate specifications under the rational expectations assumption, and exclude observations after large break events, such as world wars.

Throughout the analysis, we rely on two statistical criteria to evaluate the results. First, we require the effects of saving-investment factors to be statistically different from zero and have signs that accord with typical narratives based on this framework. Moreover, the size of the effects should ideally also explain the bulk of its trend variation. Second, we require the effects of the saving-investment factors, β to be reasonably stable over different subsamples. Given that we are looking at trends, if a particular set of factors have indeed played an important role in the decline in interest rates, then they should exhibit a stable relationship with it. This would be so regardless of whether the factors shift the saving or investment schedules. The reduced form will still imply stable correlation between the variables. Parameter instability could be indicative of spurious correlation, possibly due to coincidentally matching trends in specific subsamples or omitted persistent factors. This possibility may be of particular concern because the real interest rate and the saving-investment factors display low-frequency trends that may co-move across countries and are difficult to distinguish from unit roots. To check parameter stability we split our sample into several subsamples and also run rolling regressions. We exclude the two world wars throughout the analysis.

3.2 Data and Definition of Variables

The data are annual and cover 19 (currently) advanced economies over the period 1870–2016. Table 1 summarizes the key independent

Table 1. Saving-Investment Determinants: Definition and Theoretical Predictions

Factor	Expected Relationship	Variable Definition
Marginal Product of Capital	+	Labor productivity (the ratio of GDP to hours worked) divided by capital intensity (the ratio of the total capital stock to total hours worked) times a constant capital share
Output Growth	+	Annual real GDP growth
Productivity Growth[1]	+	Annual total factor productivity (TFP) growth
Dependency Ratio[2]	+	Size of the dependent population (aged 65 or above and 19 or under), divided by the size of the working-age population
Life Expectancy[3]	–	Life expectancy at birth
Population Growth	+/–	Annual population growth
Relative Price of Capital	+	The capital price index divided by the consumption price index, and since 1929, the gross private domestic investment deflator divided by the personal consumption expenditures deflator
Inequality	–	Income share of the top 1 percent of the population
Risk Premium[4]	–	(i) Higher moments of annual GDP growth and inflation, as measures of fundamental risks,[5] (ii) U.S. equity risk premium
Public Debt	+	Government debt to GDP ratio
Fiscal Balance	–	Fiscal revenues minus fiscal expenditures divided by GDP

[1] Considered in robustness exercises (online Appendix B.4). TFP growth is largely subsumed by GDP growth in the baseline analysis.
[2] In the robustness exercise, we also consider the alternative "savers' ratio" where the dependency ratio is redefined using 40–64 as the working-age bracket (online Appendix B.5).
[3] We use life expectancy at birth for its more complete coverage. Life expectancy at a higher age, say 20 years, shares a very similar trend over our sample (e.g., the correlation between the two series is close to 90 percent even for the first 40 years of the sample, suggesting that child mortality was not the dominant driver of the upward trend). In robustness exercises, we also control for time variation in the retirement age (itself negatively related to interest rates), using the labor force participation above age 65 as a proxy for it (online Appendix B.6).
[4] Considered in robustness exercises (online Appendix B.7).
[5] Skewness, measured as the third standardized moment, should have a positive relationship with real rates, as greater downside tail risk raises the risk premium.

variables used, the predicted sign of their influence on real rates, and our choice of proxies. Appendix A provides details about data sources and coverage.

The dependent variable is the ex ante real interest rate—a nominal rate minus expected inflation, based on a CPI index.[8] For the baseline, we use 10-year government bond yields (or their closest proxies). We proxy expected inflation by recursively projecting an autoregressive (AR) model, and compute its average over the relevant horizons. As in Hamilton et al. (2016) and Lunsford and West (2019), we use an AR(1) process estimated over a rolling 20-year window to allow for time variation in inflation persistence.[9]

Note that we capture any cross-border effects (à la global saving glut) to the extent that the shifts in saving and investment can be traced back to the set of explanatory variables and countries considered. We will investigate more specifically the role of global aggregates of saving-investment factors in explaining individual countries' real interest rates in Section 4.

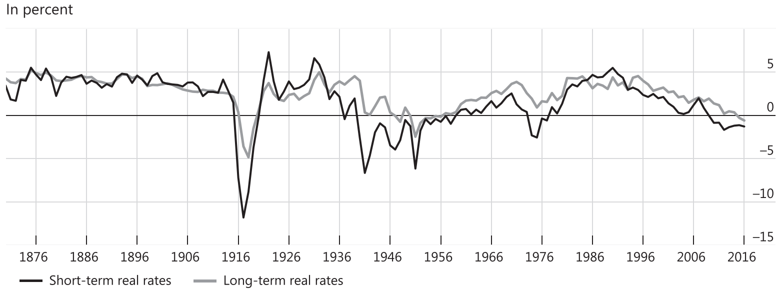
3.3 A First Look at the Data

Figure 1 shows the time series of global real interest rates, captured by the cross-country median. We see that real rates of both long and short maturities tend to co-move closely, although short-term rates are naturally more volatile. Excluding the world wars, when

[8]In keeping with the notion that the natural interest rate is determined by *desired* rather than *realized* saving and investment, we use the ex ante rather than ex post real interest rates throughout. We will show that the key finding is not sensitive to alternative measures of ex ante real interest rates.

[9]This procedure is a parsimonious way to allow for potential breaks in inflation dynamics. The 20-year estimation window is shorter than the 30 years in Hamilton et al. (2016) but the same as in Lunsford and West (2019). This choice does not appear materially to affect the results. We measure expected inflation with at least 10 years of input data, though the vast majority of countries have real interest rate series that start from 1870 (Appendix A). We remove inflation rates in excess of 25 percent in absolute value from the estimation (an assumption that extreme inflation rates are not useful for inferences about inflation dynamics). The autoregressive coefficient is capped at 0.9, to limit the impact of extreme inflation (e.g., during the wars or hyperinflation episodes) on the long-term forecast. With this assumption, the half-life for deviations between actual and expected inflation is at most 6.5 years. When the cap is binding, the constant term is reestimated.

Figure 1. Real Interest Rates



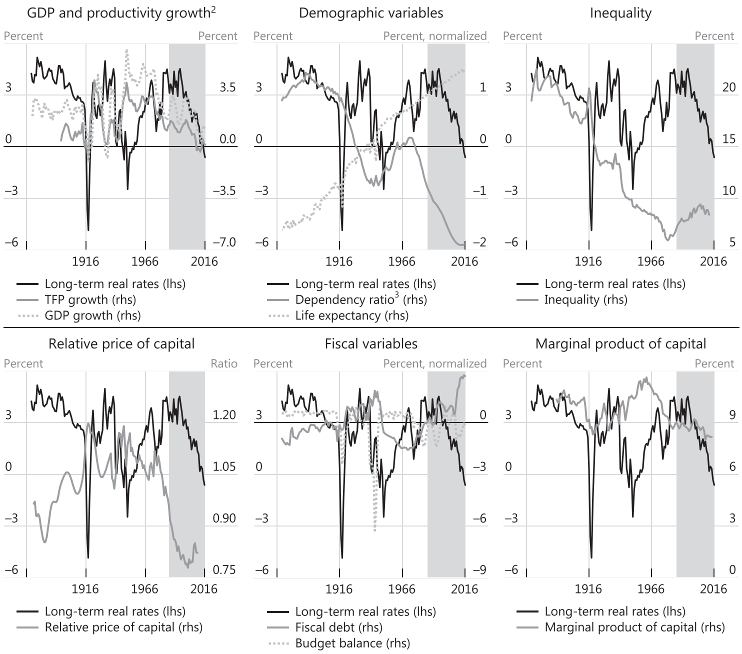
Source: Authors' calculations.

real rates drop, sometimes deeply into negative territory, one can discern four distinct phases. Up to World War I—mostly the classical gold standard—real rates were comparatively high and stable. In the interwar years, after recovering quickly from World War I, they started to fall markedly in the wake of the Great Depression. Real rates then rose much more gradually starting in the early 1950s and, after a new big dip during the Great Inflation, peaked in the early to mid-1980s, reaching levels broadly similar to those seen in the early part of the sample. Finally, real rates have been declining since then, to historically low levels, wars excepted.

Figure 2 plots the long-term real interest rates against the standard factors singled out as potential drivers, all in terms of cross-country medians. Two observations stand out. First, over the latest phase starting in the early 1980s, most of the standard factors are correlated with the decline in real interest rates with signs that accord with the saving-investment framework. This impression is formally confirmed in Table 2, which summarizes the correlation between the median real interest rate and the median of each factor (correctly signed correlations are in bold).

Second, once we extend the sample to cover preceding periods, almost all of the correctly signed correlations disappear. Only life expectancy is consistently correlated with real interest rates and with the right sign. Even then, Figure 2 suggests that this may reflect strong correlations over certain subsamples, since life expectancy trends up throughout. Even the marginal product of capital, which according to theory should be a summary statistic for

Figure 2. Cross-Country Median of Saving-Investment Determinants[1]



Source: Bergeaud, Cette, and Lecat (2016); Costa (1998); Eichengreen (2015); Roine and Waldenström (2015); Chartbook of Economic Inequality; International Historical Statistics; World Wealth & Income Database; OECD; United Nations, Human Mortality Database; national data; authors' calculations.
[1]Cross-country median of long-term real interest rates and various saving-investment factors. [2]Five-year moving averages. [3]Include large emerging markets after 1990.
Note: Shaded area indicates the last 30 years.

the net saving-investment balance, is hardly correlated with the real interest rate over the full sample.

Thus strong subsample trends in the real interest rate that occasionally coincide with similar trends in the saving-investment factors may lead to "spurious" subsample correlation. Indeed, in panel bivariate regressions in which we add a linear time trend, none of the factors have the correct sign in the post-Volcker period. This suggests caution in interpreting analysis based on only the recent history.

Table 2. Correlation between Median Real Interest Rates and Saving-Investment Factors[1]

Factor	Expected Relationship	1985–2016	1870–2016
Marginal Product of Capital	+	**0.65*****	–0.16
GDP Growth	+	**0.37****	*–0.27****
TFP Growth	+	**0.49*****	*–0.34****
Dependency Ratio	+	–0.02	**0.41*****
Broad Dependency[2]	+	**0.87*****	NA
Life Expectancy	–	**–0.87*****	**–0.45*****
Relative Price of Capital	+	**0.36***	*–0.43****
Inequality	–	**–0.53*****	*0.45****
Public Debt	+	*–0.80****	*–0.22****
Fiscal Balance	–	–0.11	0.11

Source: Authors' calculations.
[1]***/**/* denotes results significant at the 1/5/10 percent level. Significant correlation with signs consistent with saving-investment theory is shown in bold, while incorrectly signed significant correlation is shown in italics. War years are excluded.
[2]Broad dependency ratio covers emerging market economies' demographic information. Since the series is only available from 1960 onwards, only the correlation over the recent sample is reported.

3.4 Main Results

To test more formally the long-run relationship between real rates and their posited determinants, we estimate panel regressions that exploit both time and cross-country heterogeneity for identification. As explained in Section 3.1, we can estimate the steady-state parameters both directly using a static panel, provided that both the real interest rate and the saving-investment factors are non-stationary (see Figure 2), and indirectly from a dynamic specification.

We first estimate the steady-state parameters from a static panel specification with country fixed effects,

$$r_{i,t} = \beta_0 + \beta_{0,i} + \beta_1 X_{i,t} + \varepsilon_{i,t}, \tag{4}$$

where $r_{i,t}$ is the 10-year real interest rate, and $X_{i,t}$ are the saving-investment factors (GDP growth, population growth, dependency ratio, life expectancy, the relative price of capital, income inequality, public debt, and fiscal balance) in country i at time t. For parsimony, we leave out TFP and the marginal product of capital, which should be redundant after the inclusion of GDP growth and other saving-investment determinants (we will reconsider TFP and other independent variables in robustness tests). Because the different variables have different coverage, the sample drops to 11 countries, starting in 1870 at the earliest. If we exclude income inequality and life expectancy, we are able to extend the analysis to cover 17 countries. The results turn out to be similar and are reported in online Appendix B.1 (available at http://www.ijcb.org).

In addition to considering the full sample, we also test the relationship in various subsamples identified on the basis of the previous visual data inspection. These correspond to the metallic standards (mostly the classical gold standard),[10] interwar and postwar phases. We further subdivide the postwar subsample into the pre- and post-Volcker-tightening eras. The latter subsample has been extensively used in studies of the secular decline in interest rates.

The results are presented in Table 3 and confirm the indications in Figure 2. For the full sample, none of the factors turn out significant with the right sign. For population growth, which has an ambiguous predicted sign, the estimate is significant, but this is not so in most of the subsamples. For all variables, there is substantial coefficient instability across subsamples in terms of both sign and size. This is also true when we run rolling regressions on various sample windows. Even for the most recent 30-year window, the only variables that significantly obtain the expected sign are public debt and life expectancy, the latter being a variable that has trended up throughout the whole sample.

One possibility is that the weak results in Table 3 are due to some omitted global trend—for instance, from increased demand for safe assets. Such a trend might bias our estimates and obscure possible relations between real interest rates and the saving-investment factors. We check for this possibility by adding time fixed effects to the specification, and the results do not change materially (second column of Table 4) compared with specification without time fixed effects (reproduced in column 1). In fact, adding time fixed effect

[10]In what follows, we often use the shorthand "gold standard" or "classical gold standard" to refer to the metallic standards more generally. This is because the classical gold standard covers most of the period and, in the estimation, we do not distinguish the two types of regime.

Table 3. Static Panel Specification

	Full Sample (1)	Gold Standard (2)	Interwar (3)	Postwar (4)	Pre-Volcker (5)	Post-Volcker (6)
GDP Growth (+)	*–0.13******	–0.00	–0.07	0.07	0.07	0.07
	(0.04)	(0.01)	(0.05)	(0.06)	(0.06)	(0.05)
Population Growth (+/–)	–0.98**	–0.60	0.48	–0.66*	0.10	–0.25
	(0.31)	(0.42)	(0.38)	(0.26)	(0.23)	(0.53)
Dependency Ratio (+)	0.00	0.02	–0.05	0.02	**0.14*****	–0.07
	(0.02)	(0.03)	(0.10)	(0.02)	(0.03)	(0.05)
Life Expectancy (–)	0.02	**–0.18*****	0.44	*0.25******	*0.59******	**–0.33*****
	(0.03)	(0.05)	(0.31)	(0.07)	(0.13)	(0.10)
Relative Price of Capital (+)	0.01	**0.10****	*–0.08**	–0.00	–0.04	0.03
	(0.01)	(0.04)	(0.04)	(0.02)	(0.03)	(0.03)
Income Inequality (–)	0.09	0.03	0.04	*–0.25******	0.03	–0.06
	(0.06)	(0.05)	(0.37)	(0.07)	(0.23)	(0.14)
Public Debt (+)	*–0.01******	*–0.03**	–0.03	*–0.01******	–0.01	**0.02***
	(0.00)	(0.01)	(0.04)	(0.00)	(0.01)	(0.01)
Fiscal Balance (–)	0.00	0.09	–0.09	–0.04	*0.19****	–0.08
	(0.04)	(0.11)	(0.17)	(0.05)	(0.07)	(0.06)
Constant	1.41	9.95*	–17.47	–14.61**	–52.15***	33.07***
	(2.85)	(4.27)	(25.41)	(6.13)	(12.79)	(10.23)
Adjusted R^2	0.10	0.58	0.23	0.24	0.38	0.35
No. of Observations	1,059	186	198	635	296	339
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes

Source: Authors' calculations.
Note: Standard errors in parentheses based on a robust weighting matrix; ***/**/* denotes results significant at the 1/5/10 percent level. Negative adjusted R-squared values not reported. Full sample: 1870–2016; gold (metallic) standard: 1870–1913; interwar: 1920–1938; postwar: 1950–2016; pre-Volcker-tightening: 1950–1979; post-Volcker-tightening: 1980–2016.

Table 4. Static Panel—Controlling Trends and Cyclicality

	Baseline (1)	Time Fixed Effects (2)	5Y Averages (3)	10Y Averages (4)	HP Trends (5)	HLW Real Rate (6)
GDP Growth (+)	*–0.13****	*–0.09***	*–0.25****	–0.08	*–0.28****	0.12
	(0.04)	(0.04)	(0.07)	(0.07)	(0.07)	(0.07)
Population Growth (+/–)	–0.98**	–0.19	–1.72***	–2.09***	–1.80**	–0.21
	(0.31)	(0.28)	(0.45)	(0.50)	(0.60)	(0.04)
Dependency Ratio (+)	0.00	0.02	–0.01	–0.02	0.01	*–0.03*
	(0.02)	(0.01)	(0.02)	(0.02)	(0.02)	(0.01)
Life Expectancy (–)	0.02	0.05	–0.04	–0.06	0.02	0.03*
	(0.03)	(0.06)	(0.03)	(0.04)	(0.02)	(0.00)
Relative Price of Capital (+)	0.01	0.02	0.01	0.01	0.02	*0.03*
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)
Income Inequality (–)	0.09	0.07	0.05	0.05	0.08	*0.11****
	(0.06)	(0.04)	(0.07)	(0.06)	(0.05)	(0.00)
Public Debt (+)	*–0.01****	–0.00	*–0.01***	*–0.01***	*–0.01***	*–0.01****
	(0.00)	(0.01)	(0.00)	(0.00)	(0.01)	(0.00)
Fiscal Balance (–)	0.00	0.05	–0.05	–0.07	–0.02	0.02
	(0.04)	(0.05)	(0.04)	(0.04)	(0.03)	(0.06)
Constant	1.41	–3.67	8.56**	10.17*	1.98	0.61
	(2.85)	(3.07)	(3.23)	(5.16)	(2.75)	(0.78)
Adjusted R^2	0.10	0.06	0.28	0.27	0.14	0.42
No. of Observations	1,059	1,059	215	98	1,105	196

Source: Authors' calculations.
Note: Standard errors in parentheses based on a robust weighting matrix; ***/**/* denotes results significant at the 1/5/10 percent level. Negative adjusted R-squared values not reported. Estimated over 1870–2016; country fixed effects included in all specifications.

where relevant to all specifications and subsamples below leads to the same conclusion.

Another possibility is that cyclical components in the variables dominate the long-run variation and, hence, lead to imprecise estimates of the steady-state coefficients. To address this concern, we pre-filter the variables to obtain estimates closer to the notion of long-run relationship. We undertake three specific exercises. The first is to run regressions on 5-year and 10-year non-overlapping time averages, in effect smoothing out short-term temporal fluctuations (Table 4, columns 3–4). Second, we isolate low-frequency components for each variable directly and then analyze their relationships. To do so, we pre-filter all variables by the HP filter with a smoothing parameter of 100, which yields long-run components with cyclicality of roughly eight years or more (Table 4, column 5). Finally, we use a measure of the equilibrium real rate constructed as in Holston, Laubach, and Williams (2017) as the dependent variable. We filter the natural rates starting from 1861 for the United States and the United Kingdom, and estimate a two-country panel estimation. As shown in Table 4, none of these specifications change the conclusions compared with the baseline in column 1.

We next estimate the steady-state coefficients in a dynamic fixed-effects panel specification of the form

$$r_{i,t} = \mu_0 + \mu_{0,i} + \sum_{l=1}^{K} a_l r_{i,t-l} + \sum_{l=0}^{K} b_l X_{i,t-l} + \varepsilon_{it}, \quad (5)$$

where $X_{i,t}$ again consists of the same variables as before. It is well known that the standard ordinary least squares (OLS) estimator is biased for dynamic panels with fixed effects, such as (5), when the time dimension is small (the Nickell 1981 bias). However, we continue to use the standard estimator, since we have a long panel and the Nickell bias is likely to be small except possibly for certain subsamples. We revisit this issue below where we also apply the system GMM estimator (see Arellano and Bover 1995 and Blundell and Bond 1998) to address the bias and possible endogeneity issues involving the real interest rate and some of the saving-investment factors. The steady-state coefficients and the adjustment coefficient are transformations of the parameters in (5) and can be calculated by the formulas in Section 3.1.

Table 5. Dynamic Panel Specification

	Full Sample (1)	Gold Standard (2)	Interwar (3)	Postwar (4)	Pre-Volcker (5)	Post-Volcker (6)
Long-Run Coefficients						
GDP Growth (+)	–0.11	0.04	–0.07	–0.08	0.11	–0.07
	(0.12)	(0.24)	(0.07)	(0.08)	(0.11)	(0.11)
Population Growth (+/–)	–0.50	–1.18**	–0.01	–0.62*	–0.57	–0.85
	(0.56)	(0.49)	(0.59)	(0.37)	(0.57)	(0.83)
Dependency Ratio (+)	0.01	–0.04	*–0.15***	0.03	**0.17*****	–0.04
	(0.03)	(0.06)	(0.07)	(0.02)	(0.03)	(0.08)
Life Expectancy (–)	**–0.05****	**–0.21****	*0.24***	*0.10****	*0.48***	**–0.34***
	(0.03)	(0.09)	(0.12)	(0.04)	(0.20)	(0.18)
Relative Price of Capital (+)	0.01	**0.16*****	–0.03	0.00	*–0.05**	0.03
	(0.01)	(0.04)	(0.03)	(0.02)	(0.03)	(0.02)
Income Inequality (–)	–0.04	*0.19****	0.01	**–0.22****	0.18	–0.07
	(0.05)	(0.05)	(0.18)	(0.09)	(0.30)	(0.17)
Public Debt (+)	–0.00	–0.00	–0.04	–0.01	**0.01****	0.00
	(0.00)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)
Fiscal Balance (–)	–0.03	0.11	**–0.24***	0.08	*0.30****	–0.03
	(0.05)	(0.11)	(0.14)	(0.05)	(0.09)	(0.06)
Short-Run Coefficients						
Adjustment Parameter	–0.42***	–0.25**	–0.89***	–0.36***	–0.58***	–0.43***
	(0.05)	(0.04)	(0.11)	(0.05)	(0.08)	(0.06)
Constant	3.36	3.01	4.25	–1.52	–27.70**	14.32**
	(2.16)	(2.33)	(10.21)	(1.53)	(13.08)	(5.30)
Adjusted R^2	0.36	0.30	0.70	0.28	0.42	0.30
No. of Observations	990	171	184	620	283	337
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
No. of Lags	2	2	2	2	2	2

Source: Authors' calculations.
Note: Robust standard errors in parentheses based on country clusters; ***/**/* denotes results significant at the 1/5/10 percent level. Full sample: 1870–2016; gold (metallic) standard: 1870–1913; interwar: 1920–1938; postwar: 1950–2016; pre-Volcker-tightening: 1950–1979; post-Volcker-tightening: 1980–2016. Differences: lagged differences from t to t–2 of all variables included in the regressions.

Estimates from the dynamic specification (with $K = 3$) again fail to establish robust relationships between real rates and saving-investment determinants (Table 5). For the full sample, life expectancy now has the correct sign and is statistically significant. But this relationship, as well as those for the other variables, is not robust across subsamples. Indeed, life expectancy is a variable that trends up throughout the sample. We note that these results do not depend on the specific lag length assumed.

4. The Global Dimension and Robustness

Given the high co-movement of interest rates across countries, many studies have emphasized the role of global factors. Jordà and Taylor (2019) and Kiley (2019), for example, document the large global component in real interest rates. Narratives that focus on the global saving glut (Bernanke 2005) and global safe asset shortage (Caballero, Farhi, and Gourinchas 2008) also emphasize the role of global factors. More generally, to the extent that the saving-investment factors have a common component, they could have a material influence on real interest rates. This section explores this possibility. It also outlines the numerous robustness tests that we perform.

4.1 The Role of Global Factors

We explore the potential role of global factors by constructing global counterparts to the posited determinants and estimate their impact alongside the respective country-specific variables, defined in terms of deviations from the global trend. The specification is the following:

$$r_{i,t} = \beta_0 + \beta_{0,i} + \beta_1^G X_t^G + \beta_1^C \left(X_{i,t} - X_t^G \right) + \varepsilon_{i,t},$$

where X_t^G is a measure of the global components in the determinants.[11] We measure the global components as the weighted averages

[11] This parameterization allows us to directly compare the size of β_1^G and β_1^C. For instance, if $\beta_1^G = \beta_1^C$, the global and country-specific components have the same effect on the real interest rate. The connection between the coefficients from this parameterization and an alternative parameterization given by

of each variable based on real GDP at purchasing power parity. This specification allows for the common global components to have different effects on real interest rates from the country-specific ones. Country fixed effects are included.

For the most part, the global variables represent some improvement on the domestic ones, with the country-specific components being mostly insignificant (Table 6). Nevertheless, the instability generally persists. GDP growth and income inequality perform well over the last three subsamples but not the full sample. The dependency ratio is significant and correctly signed in some subsamples, but again not significant over the full sample. However, in all other cases, the co-movements between the common trends in real interest rates and the saving-investment variables are highly unstable. The coefficients on the global components fluctuate over the different subsamples, sometimes changing signs or losing statistical significance. This suggests that these relationships may be coincidental.

It might be argued that the global saving-investment factors exert uneven influence over time, being stronger in periods of higher financial integration. We can readily use the subsample estimates to test this proposition. Economic historians typically judge the gold standard and the last 30 years or so as the two episodes of heightened financial globalization (e.g., Obstfeld and Taylor 2003, Bank for International Settlements 2017). One should then expect the global saving-investment determinants to be significant in both of these periods, and weaker otherwise. But as Table 6 shows, this pattern hardly emerges.

As before, controlling for the possible confounding effects coming from cyclical components by pre-filtering the data does not change the overall conclusion (Table 7).[12] The country-specific components still perform poorly, while for the global components we see some improvements in the specification with time averages.

$r_{i,t} = \beta_0 + \beta_{0,i} + \acute{\beta}_1^G X_t^G + \acute{\beta}_1^C X_{i,t} + \varepsilon_{i,t}$ is $\acute{\beta}_1^G = \beta_1^G - \beta_1^C$ and $\acute{\beta}_1^C = \beta_1^C$. Hence, in the alternative parameterization, $\acute{\beta}_1^G$ reflects the difference in the real interest rate response to changes in the global saving-investment components and those in their idiosyncratic counterparts. If, for instance, the global and country-specific components have the same effect on the real interest rate, then $\acute{\beta}_1^G = 0$.

[12]In contrast to Table 4 in Section 3.4, we cannot add time fixed effects to the baseline specification in this section, as these would subsume all variation from the global factors.

Table 6. Static Global Specification

	Full Sample (1)	Gold Standard (2)	Interwar (3)	Postwar (4)	Pre-Volcker (5)	Post-Volcker (6)
Global Component						
GDP Growth (+)	0.01	–0.01	–0.06	**0.13****	**0.21*****	**0.15****
	(0.04)	(0.02)	(0.10)	(0.05)	(0.05)	(0.07)
Population Growth (+/–)	–0.73	–0.57	–1.90	0.61**	1.27***	16.83*
	(0.40)	(1.22)	(1.94)	(0.23)	(0.27)	(8.27)
Dependency Ratio (+)	–0.08	**0.42****	**1.28****	0.04	**0.22***	–0.03
	(0.05)	(0.14)	(0.43)	(0.04)	(0.10)	(0.15)
Life Expectancy (–)	**–0.12****	*0.24***	*3.04***	0.18	–0.48	*1.06***
	(0.05)	(0.08)	(1.05)	(0.15)	(0.29)	(0.35)
Relative Price of Capital (+)	*–0.08****	0.02	**0.92***	*–0.15****	–0.08	0.02
	(0.02)	(0.06)	(0.47)	(0.04)	(0.06)	(0.05)
Income Inequality (–)	–0.10	–0.09	1.10	**–0.85*****	**–2.69****	**–1.10*****
	(0.10)	(0.12)	(0.83)	(0.17)	(1.04)	(0.23)
Public Debt (+)	*–0.05***	0.06	–0.13	*–0.02**	–0.01	*–0.03***
	(0.01)	(0.04)	(0.09)	(0.01)	(0.04)	(0.01)
Fiscal Balance (–)	–0.06	**–0.38***	0.11	–0.07	–0.02	0.01
	(0.07)	(0.17)	(0.53)	(0.08)	(0.20)	(0.09)
Country-Specific Component						
GDP Growth (+)	*–0.11***	–0.00	–0.11	0.02	0.02	0.01
	(0.04)	(0.02)	(0.07)	(0.05)	(0.05)	(0.07)
Population Growth (+/–)	–0.08	–0.29	0.33	–0.27	–0.20	0.27
	(0.32)	(0.17)	(0.39)	(0.25)	(0.25)	(0.58)
Dependency Ratio (+)	–0.01	–0.04	0.12	0.03	0.01	0.00
	(0.01)	(0.03)	(0.14)	(0.02)	(0.04)	(0.06)
Life Expectancy (–)	0.03	0.05	*0.21**	0.07	–0.37	0.48
	(0.07)	(0.06)	(0.11)	(0.15)	(0.21)	(0.40)
Relative Price of Capital (+)	0.02	**0.10*****	*–0.07**	0.01	–0.04	0.02
	(0.02)	(0.02)	(0.03)	(0.02)	(0.03)	(0.03)
Income Inequality (–)	0.06	–0.04	0.00	0.07	–0.04	0.11
	(0.06)	(0.03)	(0.31)	(0.08)	(0.13)	(0.12)
Public Debt (+)	–0.00	0.00	–0.05	–0.00	0.00	**0.01****
	(0.01)	(0.00)	(0.03)	(0.01)	(0.01)	(0.01)
Fiscal Balance (–)	0.00	0.05	0.01	0.03	0.09	–0.04
	(0.05)	(0.05)	(0.11)	(0.05)	(0.06)	(0.05)
Constant	20.91**	–47.02**	–279.95**	–5.26	40.40	–73.87**
	(7.03)	(14.50)	(95.41)	(9.90)	(23.75)	(28.42)
Adjusted R^2	0.21	0.78	0.35	0.45	0.54	0.44
No. of Observations	1,059	186	198	635	296	339

Source: Authors' calculations.
Note: Robust standard errors in parentheses based on country clusters; ***/**/* denotes results significant at the 1/5/10 percent level. Full sample: 1870–2016; gold (metallic) standard: 1870–1913; interwar: 1920–1938; postwar: 1950–2016; pre-Volcker-tightening: 1950–1979; post-Volcker-tightening: 1980–2016. Global components calculated as the averages of each variable based on real GDP at purchasing power parity.

Table 7. Static Global—Controlling for Cyclicality

	Baseline (1)	**5Y Averages (2)**	**10Y Averages (3)**	**HP Trends (4)**	**HLW Real Rate (5)**
Long-Run Coefficients (Global)					
GDP Growth (+)	0.01	0.06	**1.24*****	0.14	0.14
	(0.04)	(0.09)	(0.37)	(0.16)	(0.13)
Population Growth (+/–)	–0.73	–1.81	–4.79*	–2.66**	–0.00
	(0.40)	(1.11)	(2.23)	(1.12)	(0.15)
Dependency Ratio (+)	–0.08	0.04	–0.02	–0.14	–0.05
	(0.05)	(0.07)	(0.08)	(0.08)	(0.05)
Life Expectancy (–)	**–0.12****	**–0.18*****	**–0.25*****	**–0.09***	0.01
	(0.05)	(0.05)	(0.05)	(0.05)	(0.10)
Relative Price of Capital (+)	*–0.08****	*–0.09****	*–0.12***	–0.00	0.01
	(0.02)	(0.03)	(0.04)	(0.02)	(0.04)
Income Inequality (–)	–0.10	**–0.23****	–0.12	0.07	0.16
	(0.10)	(0.10)	(0.21)	(0.13)	(0.11)
Public Debt (+)	*–0.05***	–0.01	–0.00	–0.04	–0.02
	(0.01)	(0.03)	(0.03)	(0.03)	(0.01)
Fiscal Balance (–)	–0.06	**–0.55*****	**–0.71****	*0.21**	–0.10
	(0.07)	(0.08)	(0.28)	(0.11)	(0.09)
Long-Run Coefficients (Domestic)					
GDP Growth (+)	*–0.11***	–0.06	0.04	*–0.15****	**0.11***
	(0.04)	(0.09)	(0.08)	(0.03)	(0.01)
Population Growth (+/–)	–0.08	–0.59	–1.40*	–0.54	0.08
	(0.32)	(0.56)	(0.65)	(0.72)	(0.20)
Dependency Ratio (+)	–0.01	–0.02	0.01	–0.02	–0.05
	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)
Life Expectancy (–)	0.03	–0.01	–0.05	0.03	–0.11
	(0.07)	(0.05)	(0.05)	(0.08)	(0.15)
Relative Price of Capital (+)	0.02	0.02	0.01	**0.03***	0.04
	(0.01)	(0.02)	(0.01)	(0.02)	(0.03)
Income Inequality (–)	0.06	0.07	0.11	0.07	0.03
	(0.06)	(0.06)	(0.07)	(0.05)	(0.03)
Public Debt (+)	–0.00	0.00	–0.00	–0.01	–0.00
	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)
Fiscal Balance (–)	0.00	–0.00	0.01	–0.03	0.09
	(0.05)	(0.04)	(0.04)	(0.04)	(0.04)
Constant	20.91***	15.74*	21.76***	22.54***	3.45
	(7.03)	(8.51)	(6.45)	(6.00)	(12.02)
Adjusted R^2	0.21	0.44	0.57	0.45	0.33
No. of Observations	1,059	215	98	1,105	213

Source: Authors' calculations.
Note: Robust standard errors in parentheses based on country clusters; ***/**/* denotes results significant at the 1/5/10 percent level. Estimated over 1870–2016; country fixed effects included in all specifications.

The picture is broadly similar in the dynamic specification (Table 8). The global factors perform better than domestic ones, though significant instability remains. The dependency ratio is significant and correctly signed from the gold standard through the pre-Volcker periods, while life expectancy and income inequality have the correct sign in the full sample but not for much of the subsamples.

Overall, the result above highlights a potentially important role for the global component in the behavior of real interest rates, as emphasized by the recent work of Jordà and Taylor (2019) and Kiley (2019). We find, however, that common variations in saving-investment factors offer at best an incomplete explanation for the common movements of real interest rates across countries. This raises the question: what then determines global real rates, and does so in a globally synchronized way?

To be sure, synchronized movements in the *nominal* interest rates are hardly surprising in a financially integrated world. The country that issues the dominant global currency of the day adjusts its nominal interest rate given its domestic objectives and institutional constraints. International arbitrage then brings interest rates elsewhere in line with that in the anchor country. Could the co-movement of nominal interest rates translate into persistent co-movement in the *real* interest rates, aided perhaps by nominal rigidities or other frictions? This would be consistent with the importance of international financial flows, and a commensurately reduced role of saving-investment factors, in influencing financial conditions in open economies (e.g., Kumhof, Rungcharoenkitkul, and Sokol 2020). We generalize the empirical specification to consider this hypothesis, and compare the relative contributions of common saving-investment factors with those coming from financially dominant anchor countries.

As has been extensively documented, the country acting as global monetary anchor has changed over time. Up to World War I, under the classical gold standard, the United Kingdom played the main anchor role (e.g., Bloomfield 1959 and De Cecco 1974). After World War I the United States started to play a similar role, because of the abundance of its gold holdings and the United Kingdom's struggle to adhere to the old parity. The United States then consolidated its unrivaled role in the post–World War II period, starting with the

Table 8. Dynamic Global Specification

	Full Sample (1)	Gold Standard (2)	Interwar (3)	Postwar (4)	Pre-Volcker (5)	Post-Volcker (6)
Long-Run Coefficients (Global)						
GDP Growth (+)	−0.12	0.01	0.21	*−0.88***	**0.65***	*−1.75***
	(0.13)	(0.10)	(0.23)	(0.40)	(0.36)	(0.80)
Population Growth (+/−)	−0.45	−0.31	0.00	−8.31***	11.13**	−96.48***
	(0.74)	(0.80)	(0.00)	(2.37)	(5.57)	(28.20)
Dependency Ratio (+)	−0.03	**0.64****	**1.44***	**0.36*****	**1.69*****	0.72
	(0.07)	(0.29)	(0.77)	(0.11)	(0.60)	(0.46)
Life Expectancy (−)	**−0.14*****	*0.65***	0.00	**−0.63***	2.49	**−9.29*****
	(0.05)	(0.30)	(0.00)	(0.36)	(1.59)	(2.59)
Relative Price of Capital (+)	−0.03	0.18	−0.61	*−0.23****	**2.48****	−0.19
	(0.03)	(0.17)	(0.52)	(0.07)	(1.00)	(0.19)
Income Inequality (−)	**−0.18****	0.05	0.00	**−0.57***	−7.20	*3.00****
	(0.09)	(0.27)	(0.00)	(0.31)	(5.09)	(0.90)
Public Debt (+)	−0.00	0.12	*−0.08**	**0.11*****	**0.37***	**0.77*****
	(0.02)	(0.12)	(0.05)	(0.04)	(0.20)	(0.28)
Fiscal Balance (−)	−0.05	−1.88	**−4.11****	**−1.38*****	*2.98****	0.04
	(0.16)	(1.35)	(2.06)	(0.35)	(0.74)	(0.59)
Long-Run Coefficients (Domestic)						
GDP Growth (+)	−0.01	0.03	−0.08	−0.03	−0.01	−0.13
	(0.12)	(0.11)	(0.06)	(0.08)	(0.09)	(0.15)
Population Growth (+/−)	−0.04	−0.47	−0.03	−0.10	−0.52	0.23
	(0.54)	(0.42)	(0.62)	(0.65)	(0.49)	(0.60)
Dependency Ratio (+)	−0.00	*−0.11****	−0.12	0.02	−0.01	0.04
	(0.03)	(0.02)	(0.10)	(0.03)	(0.06)	(0.07)
Life Expectancy (−)	−0.02	−0.03	*0.30***	0.16	−0.65	*0.71****
	(0.04)	(0.13)	(0.15)	(0.20)	(0.47)	(0.24)
Relative Price of Capital (+)	0.01	**0.15*****	−0.08	0.02	−0.03	0.02
	(0.01)	(0.02)	(0.05)	(0.02)	(0.03)	(0.03)
Income Inequality (−)	0.01	*0.10****	0.08	0.07	0.25	0.06
	(0.06)	(0.03)	(0.15)	(0.09)	(0.26)	(0.11)
Public Debt (+)	−0.00	**0.03****	*−0.05****	0.00	**0.01***	0.01
	(0.00)	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)
Fiscal Balance (−)	0.03	0.03	−0.12	*0.13***	*0.23****	0.02
	(0.06)	(0.10)	(0.17)	(0.07)	(0.07)	(0.06)
Short-Run Coefficients						
Adjustment Parameter	−0.46***	−0.51***	−0.82***	−0.38***	−0.55***	−0.43***
	(0.06)	(0.13)	(0.11)	(0.05)	(0.12)	(0.05)
Constant	7.87*	−46.76***	−91.42*	12.00	163.31*	283.52***
	(4.67)	(12.45)	(49.82)	(10.66)	(91.25)	(69.35)
Adjusted R^2	0.42	0.49	0.76	0.44	0.60	0.57
No. of Observations	990	171	184	620	283	337

Source: Authors' calculations.
Note: Robust standard errors in parentheses based on country clusters; ***/**/* denotes results significant at the 1/5/10 percent level. Full sample: 1870–2016; gold (metallic) standard: 1870–1913; interwar: 1920–1938; postwar: 1950–2016; pre-Volcker-tightening: 1950–1979; post-Volcker-tightening: 1980–2016. Differences: lagged differences from t to $t-2$ of all variables included in the regressions.

Bretton Woods agreement in 1944. We therefore focus on these two countries.

We proceed in two steps. First, we construct a global monetary anchor variable, which is based on monetary policy of the financially dominant country. Following the previous discussion, we define the global monetary anchor as the U.K. policy rate up to World War I and the U.S. counterpart thereafter. We regress the U.S. and U.K. short-term real interest rates on their respective saving-investment determinants—both country-specific and global components. This helps, to some extent, to control for variations associated with movements in the natural rate. As such, the residuals from these regressions should align more closely with interest rate changes associated with nominal frictions, including those from monetary policy. In the second step, we plug this proxy measure of nominal factors into the baseline panel regressions for the long-term real interest rates for all countries except the United States and the United Kingdom, controlling for both country-specific and global saving-investment determinants. This allows us to test whether the proxy measure of nominal factors retains explanatory power.

The results indicate that the proxy measure matters for long-term real interest rates in the full sample and all the subsamples with one exception—the (mostly) classical gold standard (Table 9). Meanwhile, most of the saving-investment determinants still perform poorly, particularly in the cross-country panel: they have the wrong signs and/or switch signs across subsamples. The observation that short-term real interest rates in anchor countries are systematically correlated with long-term real rates in other countries suggests the presence of some global factor that is correlated with anchor country's monetary policy. Given that we control for global saving-investment determinants, global financial factors, related to monetary policy in major countries, could be at play.[13] This is an important question that we leave for further study.

[13]For a discussion of these issues, see Neely and Rapach (2008). Borio et al. (2017) analyze the potential role of monetary regimes in real interest rate movements.

Table 9. Global Monetary Policy and Real Long-Term Interest Rates in the Rest of the World

	Dependent Variable: Individual Countries' Real Long-Term Interest Rates					
	Full Sample (1)	**Gold Standard (2)**	**Interwar (3)**	**Postwar (4)**	**Pre-Volcker (5)**	**Post-Volcker (6)**
Global Component						
Global Monetary Policy	**0.28*****	0.19	**0.43****	**0.35*****	**0.47*****	**0.21****
	(0.05)	(0.10)	(0.14)	(0.08)	(0.11)	(0.07)
GDP Growth (+)	–0.02	0.02	0.09	–0.03	–0.05	0.12
	(0.04)	(0.02)	(0.12)	(0.04)	(0.07)	(0.08)
Population Growth (+/–)	–1.08	–3.76*	–0.97	0.47	1.12*	20.01*
	(0.66)	(1.75)	(2.45)	(0.41)	(0.49)	(9.27)
Dependency Ratio (+)	–0.04	0.24	0.53	0.08	0.16	0.30
	(0.07)	(0.17)	(0.40)	(0.05)	(0.12)	(0.19)
Life Expectancy (–)	**–0.14***	0.07	1.37	–0.07	0.32	0.34
	(0.07)	(0.13)	(1.00)	(0.24)	(0.33)	(0.35)
Relative Price of Capital (+)	*–0.10****	0.00	0.19	*–0.22****	*–0.18**	*–0.17***
	(0.03)	(0.07)	(0.48)	(0.06)	(0.09)	(0.06)
Income Inequality (–)	–0.13	0.20	–0.78	**–0.58***	–0.98	**–0.69****
	(0.15)	(0.26)	(0.86)	(0.25)	(1.36)	(0.23)
Public Debt (+)	*–0.04**	**0.22*****	*–0.24**	*–0.05****	–0.06	*–0.05****
	(0.02)	(0.04)	(0.11)	(0.01)	(0.06)	(0.01)
Fiscal Balance (–)	–0.14	–0.36	–0.59	**–0.25***	–0.22	**–0.28***
	(0.08)	(0.23)	(0.60)	(0.12)	(0.27)	(0.12)
Country-Specific Component						
GDP Growth (+)	*–0.12***	–0.01	–0.11	0.03	0.03	0.01
	(0.04)	(0.01)	(0.07)	(0.05)	(0.05)	(0.07)
Population Growth (+/–)	–0.38	–0.44*	0.05	–0.44	0.22	0.09
	(0.49)	(0.18)	(0.43)	(0.35)	(0.31)	(0.72)
Dependency Ratio (+)	*–0.03**	0.12	0.16	0.04	**0.09***	0.01
	(0.01)	(0.07)	(0.15)	(0.04)	(0.05)	(0.05)
Life Expectancy (–)	–0.00	0.11	0.19	0.09	0.02	0.47
	(0.08)	(0.07)	(0.14)	(0.21)	(0.14)	(0.49)
Relative Price of Capital (+)	0.02	**0.11*****	*–0.06***	0.01	*–0.05**	0.01
	(0.02)	(0.01)	(0.03)	(0.02)	(0.03)	(0.03)

(*continued*)

Table 9. (Continued)

	Dependent Variable: Individual Countries' Real Long-Term Interest Rates					
	Full Sample (1)	**Gold Standard (2)**	**Interwar (3)**	**Postwar (4)**	**Pre-Volcker (5)**	**Post-Volcker (6)**
Income Inequality (–)	0.08	–0.06	–0.14	0.13	–0.00	0.08
	(0.11)	(0.04)	(0.47)	(0.11)	(0.14)	(0.15)
Public Debt (+)	–0.01	**0.01****	*–0.07***	–0.01	*–0.06**	**0.02****
	(0.01)	(0.00)	(0.02)	(0.01)	(0.03)	(0.01)
Fiscal Balance (–)	–0.03	0.05	0.07	0.02	0.06	–0.01
	(0.05)	(0.05)	(0.16)	(0.06)	(0.04)	(0.08)
Constant	19.93*	–33.85	–89.58	9.51	–23.26	–49.26
	(9.67)	(21.02)	(81.68)	(14.26)	(27.05)	(30.96)
Adjusted R^2	0.27	0.86	0.42	0.52	0.56	0.48
No. of Observations	846	143	160	513	236	277

Source: Authors' calculations.

Note: Standard errors in parentheses; *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$. Horse race between three potential determinants of real long-term interest rates: (i) global monetary policy (set in the center countries, the United States and United Kingdom); (ii) global aggregates of saving-investment factors; and (iii) country-specific component of the saving-investment factors. Global saving-investment factors calculated as the weighted cross-country averages of each factor based on real GDP at purchasing power parity. Full sample: 1870–2016; gold (metallic) standard: 1870–1913; interwar: 1920–1938; postwar: 1950–2016; pre-Volcker-tightening: 1950–1979; post-Volcker-tightening: 1980–2016. Global components calculated as the averages of each variable based on real GDP at purchasing power parity.

4.2 Robustness Tests and Econometric Concerns

The key results hold up well against a wide range of additional robustness tests beyond alternative sample coverage and smoothed variables discussed previously (see the online appendix for a full report). These tests include using short-term interest rates as the dependent variables, potentially more robust to any mismeasurement problem in expected inflation (online Appendix B.2). We also use real interest rates based on alternative measures of ex ante inflation expectations, including one more sensitive to short-term inflation shocks, one based on rationally formed inflation expectations (via GMM estimation), and ex post inflation—see online Appendix B.3. In all cases, systematic relationships between real rates and saving-investment factors continue to be elusive.

Our findings are also robust to a wide range of alternative independent variables. Productivity growth does no better than GDP growth in explaining real rates (online Appendix B.4). The "saver ratio" of Lunsford and West (2019) does as poorly as our dependency ratio (online Appendix B.5).[14] For demographic factors, we additionally allow for the potential effect of time-varying retirement age, which means the relevant age thresholds for life-cycle planning could change over time. Interacting the key demographic variables with a proxy for retirement age again does not overturn the findings (online Appendix B.6). We also consider risk premium as a factor in two extensions: first, by including time-varying moments of GDP and inflation—namely their variance, skewness, and kurtosis—as proxies for the degree of macroeconomic risk that could drive secular changes in interest rates over time; second, by including a measure of the U.S. equity risk premium as a proxy for global risk premium, and examining its ability to explain global real interest rates. In neither exercise do we find a systematic relationship with real interest rate trends (online Appendix B.7).

[14] Lunsford and West (2019) find the saver ratio to be the only variable that can reasonably explain secular movement in real interest rate. The different findings could be explained by at least two factors. First, our empirical analysis draws on cross-country evidence, while Lunsford and West (2019) examine only the United States. Second, we allow all saving-investment real factors to jointly affect real interest rates, whereas they only consider bilateral relationships.

We also report subsamples results where we replace real interest rates and explanatory variables with their 5-year and 10-year non-overlapping averages. Moreover, while our baseline regressions already exclude the war periods, we also try dropping five years immediately after the two world wars to ensure that the reconstruction periods do not unduly affect the results (online Appendix B.8). None of these affects our key findings.

Another possible concern is that the real interest rate may influence some of the saving-investment factors, so that the latter are in fact endogenous. In particular, we allow for the possibility that real GDP growth, the relative price of capital, and income inequality are endogenous, while we continue to treat demographic variables as exogenous. To estimate the relationship under these assumptions, we use the system GMM approach (Blundell and Bond 1998) in which the endogenous variables are instrumented by their own lags and the exogenous variables. One additional benefit is that this estimator also resolves the dynamic panel bias (Nickell bias), even if this bias is likely to be small in a long panel like ours. The details of the implementation and the results are provided in online Appendix B.9. This extension too does not change our conclusion.

It is also unlikely that an attenuation bias due to possible measurement errors drives the results: this would just lead to statistically insignificant results. Instead, most of the coefficients flip sign—for example, from significantly positive to significantly negative over different subsamples. Similarly, collinearity between the saving-investment factors is probably not the culprit either, as the same conclusion emerges from the bivariate specifications. In terms of the role of global factors, Kiley (2019) has pointed out that common global trends may result in multicollinearity in regressions where both domestic and global factors are included. To check for this, we ran regressions including the global factors only. We find that the results are generally robust to this (see online Appendix B.10).

Overall, the results point in the same direction: no single real factor, or combination of such factors, can consistently explain the long-term evolution of real interest rates. This holds at both the domestic and global levels. It suggests that the observed correlation between the saving-investment factors and the real interest rate in the latest sample is largely coincidental, mostly driven by temporary but unrelated trends in the variables.

5. Conclusion

The prevailing view among academics and policymakers is that the decline in real interest rates since the early 1980s to historically low peacetime levels reflects a decline in the natural (equilibrium) interest rate. In this view, changes in (ex ante) saving-investment balances have pushed down the real interest rate consistent with full employment (output at potential). The empirical evidence for this hypothesis has so far relied primarily on two approaches. One approach is based on the assumption that observed real interest rates roughly track, on average and over long periods, natural rates; it then links their observed decline to potential underlying determinants of saving-investment balances mainly through informal inspection or calibrated models. Another approach filters out the natural rate from market rates based on critical assumptions, including the hypothesis that inflation responds stably and systematically to domestic economic slack and that the real interest rate is a key factor influencing aggregate demand.

In this paper, we have argued that the role of maintained hypotheses in this type of evidence is uncomfortably strong. Accordingly, we have adopted a more data-driven approach, which links *observable* proxies for the underlying determinants of saving-investment balances to real interest rates, both market rates and traditional estimates of natural rates. Importantly, we examine the corresponding relationships also beyond the standard recent sample (from the early 1980s), in order to limit the risk of finding spurious relationships. To do so, we go back in history, all the way to the late 1800s, for as many as 19 countries.

Our results cast doubt on the traditional interpretation. While there is a reasonable bivariate link between some of the posited underlying saving-investment determinants and the real interest rate in the most recent reference period, the link does not survive beyond the standard sample nor when considered jointly in a multivariate context. This suggests caution in interpreting analysis based on only the recent history or those that consider only a subset of the factors in isolation. More generally, it raises questions about the prevailing paradigm of real interest rate determination. The saving-investment framework may not serve as a reliable guide for understanding real interest rate developments.

There are two ways in which this result, *taken at face value*, could be interpreted. One is to suggest that the information content of the proxies for the saving-investment determinants may have changed over time for structural reasons. While no doubt possible, it is not immediately obvious why certain saving-investment factors should be more important at one time than another. Indeed, the unsystematic nature of the instability in the individual saving-investment coefficients would suggest otherwise. In any case, if structural breaks were driving our results, one may ask to what extent these factors could be counted on to reliably predict future trends of real interest rates.

Another interpretation is that the maintained hypotheses deserve further investigation. The long-term evolution of real interest rates may be influenced importantly by other factors that may not necessarily fall within the traditional real saving-investment framework. In particular, the roles of financial and balance sheet variables could exert a more persistent effect on real interest rates than typically assumed in traditional macroeconomic models. Recent research has for example emphasized the role of debt overhang in pushing down the equilibrium real interest rate, leading to a "liquidity trap" (Eggertsson and Krugman 2012). But debt overhang itself could be a consequence of excess borrowing during preceding financial booms, which in turn could be caused by a variety of factors, monetary as well as real (see Rungcharoenkitkul, Borio, and Disyatat 2019 and Mian, Straub, and Sufi 2021). In this case, the "right" natural interest rate concept, namely one consistent with keeping the economy on a stable trajectory, may need to be generalized to encapsulate the notion of the *financial market* equilibrium as well as the goods market equilibrium.

Incidentally, the open-economy macroeconomic literature is already recognizing the distinction between real saving and financing patterns (namely net versus gross flows), and may offer useful insights for the current discussion. Current account deficits, a real saving concept, are long thought of as the relevant metric of global imbalances. Recent research has however highlighted the role of cross-border *gross* flows, a financial/balance sheet concept, which are larger in size, more volatile, and arguably more important for global financial stability (e.g., Borio and Disyatat 2015, Kumhof, Rungcharoenkitkul, and Sokol 2020). In our context, the importance of balance sheet and financial factors may partly explain the weak link between saving-investment determinants and real interest rates, consistent with our findings under the global specifications. These issues deserve further examination, which we leave for future research.

Appendix A. Data Sources and Coverage

Table A.1. Data Sources

Variables	Series	Data Sources
Nominal Interest Rates	Policy interest rates (official policy interest rates, or closest proxies)	BIS and Global Financial Data
	Short-term interest rates (three-month government bill yields, or closest proxies)	Global Financial Data; Jordà, Schularick, and Taylor (2017); Bordo et al. (2001); and national authorities
	Long-term interest rates (10-year government bond yields or closest proxies)	Global Financial Data and national authorities[1]
Macroeconomics	GDP annual growth	National authorities, Global Financial Data, and the Maddison Project (http://www.ggdc.net/maddison/maddison-project/home.htm)
	CPI annual growth	National authorities, Global Financial Data, and Mitchell's International Statistics
Productivity	Total factor productivity, capital share, labor productivity, and capital density	Bergeaud, Cette, and Lecat (2016) (http://www.longtermproductivity.com)
Demographics	Population sizes by age brackets	United Nations, Human Mortality Database (http://www.mortality.org), and Mitchell's International Historical Statistics
	Population growth and life expectancy at birth	Human Mortality Database, Our World in Data (https://ourworldindata.org/), The Human Life-Table Database (http://lifetable.de)
	Labor force participation above age 65	OECD, Costa (1998)
Relative Price of Capital	Investment goods price index divided by consumption price index	Eichengreen (2015)
Inequality	Top 1 percent income share, or closest proxies	Roine and Waldenström (2015) and World Wealth & Income Database (http://wid.world/), supplemented by Lindert (2000) and the Chartbook of Economic Inequality (https://www.chartbookofeconomicinequality.com)
Fiscal Variables	Public debt-to-GDP ratio and budget balance relative to GDP	Jordà, Schularick, and Taylor (2017)
U.S. Equity Risk Premium	Implied equity risk premium from a two-stage augmented dividend discount model	A. Damodaran (http://pages.stern.nyu.edu/~adamodar/)
Monetary Policy Regimes	Dummy of policy regimes	BIS, Benati (2008), Meissner (2005), Eh.net (https://eh.net/)

[1] Our long-term interest rate data are very similar to those of Mauro, Sussman, and Yafeh (2006).

Table A.2. Data Coverage

Countries	Policy Rate	Short Rate	Long Rate	GDP	CPI	Product.	Pop. Age Profile	Life Expect.	Pop. Growth	Labor Force Participation	Relative Price of Capital	Inequality	Public Debt	Budget Balance
Australia	1921–	1872–	1872–	1870–	1870–	1890–	1870–	1885–	1922–	1966–	1872–	1921–	1870–	1902–
Austria	1874–	1874–	1874–	1871–	1870–	NA	1870–	1870–	1948–	1994–	NA	NA	NA	NA
Belgium	1881–	1881–	1881–	1870–	1871–	1890–	1870–	1870–	1870–	1983–	NA	NA	1870–	1870–
Canada	1935–	1934–	1881–	1871–	1871–	1890–	1870–	1870–	1922–	1976–	1872–	1920–	1870–	1870–
Denmark	1870–	1875–	1870–	1870–	1870–	1890–	1870–	1875–	1870–	1983–	1872–	1870–	1871–	1870–
Finland	1911–	1911–	1911–	1870–	1901–	1890–	1870–	1870–	1879–	1963–	1872–	1870–	1914–	1882–
France	1870–	1870–	1870–	1870–	1870–	1890–	1870–	1870–	1870–	1870–	NA	1915–	1880–	1870–
Germany	1870–	1870–	1870–	1870–	1870–	1890–	1871–	1875–	1957–	1870–	1872–	1891–	1871–	1873–
Italy	1872–	1885–	1872–	1870–	1870–	1890–	1870–	1872–	1873–	1970–	1872–	1901–	1870–	1870–
Japan	1882–	1879–	1879–	1871–	1870–	1890–	1884–	1870–	1948–	1968–	1877–	1886–	1875–	1875–
Netherlands	1870–	1870–	1870–	1870–	1870–	1890–	1870–	1870–	1870–	1971–	NA	1914–	1870–	1870–
New Zealand	1923–	1973–	1918–	1871–	1908–	NA	1870–	1901–	1902–	1986–	NA	1921–	NA	NA
Norway	1870–	1870–	1870–	1870–	1870–	1890–	1870–	1870–	1870–	1972–	1872–	1875–	1880–	1870–
Portugal	1941–	1941–	1941–	1870–	1931–	1890–	1870–	1940–	1941–	1974–	NA	1976–	1870–	1870–
Spain	1870–	1880–	1870–	1870–	1870–	1890–	1870–	1882–	1909–	1972–	NA	1981–	1880–	1870–
Sweden	1870–	1870–	1870–	1870–	1870–	1890–	1870–	1870–	1870–	1963–	1872–	1903–	1870–	1870–
Switzerland	1870–	1870–	1893–	1870–	1870–	1890–	1870–	1876–	1877–	1991–	NA	1933–	1880–	1871–
United Kingdom	1870–	1870–	1870–	1870–	1870–	1890–	1870–	1870–	1870–	1870–	1872–	1870–	1870–	1870–
United States	1914–	1870–	1870–	1870–	1870–	1890–	1870–	1880–	1934–	1870–	1872–	1913–	1870–	1870–

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