Reuniting r and g: New Evidence from 61 Countries on Real Rates and Growth

Basil Halperin
Stanford

J. Zachary Mazlish
Oxford and GPI

January 31, 2025*

Abstract

We reexamine the relationship between long-term real interest rates (r) and expected growth rates (g). We use survey data on 10-year inflation expectations from up to 61 countries since 1990 to construct ex ante real interest rates. Challenging a recent revisionist literature, we demonstrate a robust positive link between long-term aggregate growth expectations and real rates. Our analysis emphasizes the importance of measuring real interest rates carefully: we decompose our differences with existing literature in a simple step-by-step comparison, including (1) properly measuring inflation expectations, (2) focusing on longer-term rates to avoid business cycle effects, and (3) adjusting for sovereign credit risk. Our results support standard models in which growth and real rates are positively linked through consumption-smoothing behavior: the aggregate Euler equation works.

*Email: basilh@stanford.edu, john.mazlish@chch.ox.ac.uk
We are grateful for generous financial support to the George and Obie Shultz Fund at MIT and to the Institute for Humane Studies under grant number 017435.

1 Introduction

What is the relationship between real interest rates (r) and the growth rate of a country (g)? Standard theory offers a sharp prediction: when GDP growth is expected to be high, then (assuming high GDP growth feeds into high consumption growth) the real interest rate should be high as well. This aggregate, macroeconomic prediction follows from the microeconomic logic of consumption smoothing. When households expect to be able to consume more in the future than they do today, then they would be better off saving less or borrowing today to smooth consumption over time, which pushes up real interest rates. This is the celebrated Euler equation logic of Friedman (1957) and Hall (1978). Empirically verifying a relationship between real interest rates and growth, however, has remained elusive (Hansen and Singleton 1982; Hall 1988). Recent reduced form work has gone as far as claiming that growth and real rates are unrelated (Rogoff, Rossi, and Schmelzing 2024; Lunsford and West 2019).

This paper demonstrates that long-term real interest rates and expected growth rates are positively linked across countries and over time, once real rates are measured carefully. We construct real interest rates from nominal interest rates using high-quality survey data on 10-year inflation expectations from up to 61 countries since 1990, and we document their strong correlation with long-term growth expectations. Our analysis resolves the apparent disconnect between theory and data highlighted by recent work, while emphasizing the critical importance of measurement.

Figure 1 presents one simple, raw cut of the data. The figure plots 10-year real interest rates versus 10-year output growth expectations across the 61 countries from 1990-2023, where both have been demeaned by country. The slope is strongly statistically distinguishable from zero: the point estimate for the slope coefficient is 0.89, with $p < 0.001$ (calculated with Driscoll-Kray standard errors). Real interest rates are calculated simply as benchmark 10-year nominal interest rates from the OECD, minus 10-year expected inflation. Expected inflation comes from the Consensus Economics biannual survey of local professional forecasters; expected output growth rates come from the same source. The raw data strongly show that when long-term growth expectations within a country are higher than the historical average, long-term real interest rates are higher as well.

The rest of the paper expands on this simple figure in two ways. First, we develop our preferred specification, which adjusts this raw data in a few ways, and we demonstrate its robustness along a number of dimensions. Second, we systematically demonstrate why our measurement choices matter by decomposing, step by step, how our results differ from the existing literature that finds no relationship between r and g.

1. Measuring expected inflation. Our empirical approach improves on the existing literature in three key ways, starting with the use of a credible measure of expected inflation in constructing real rates.

A crucial challenge when studying real interest rates is that typically only *nominal* interest rate data are available; and so construction of real interest rates requires a measure

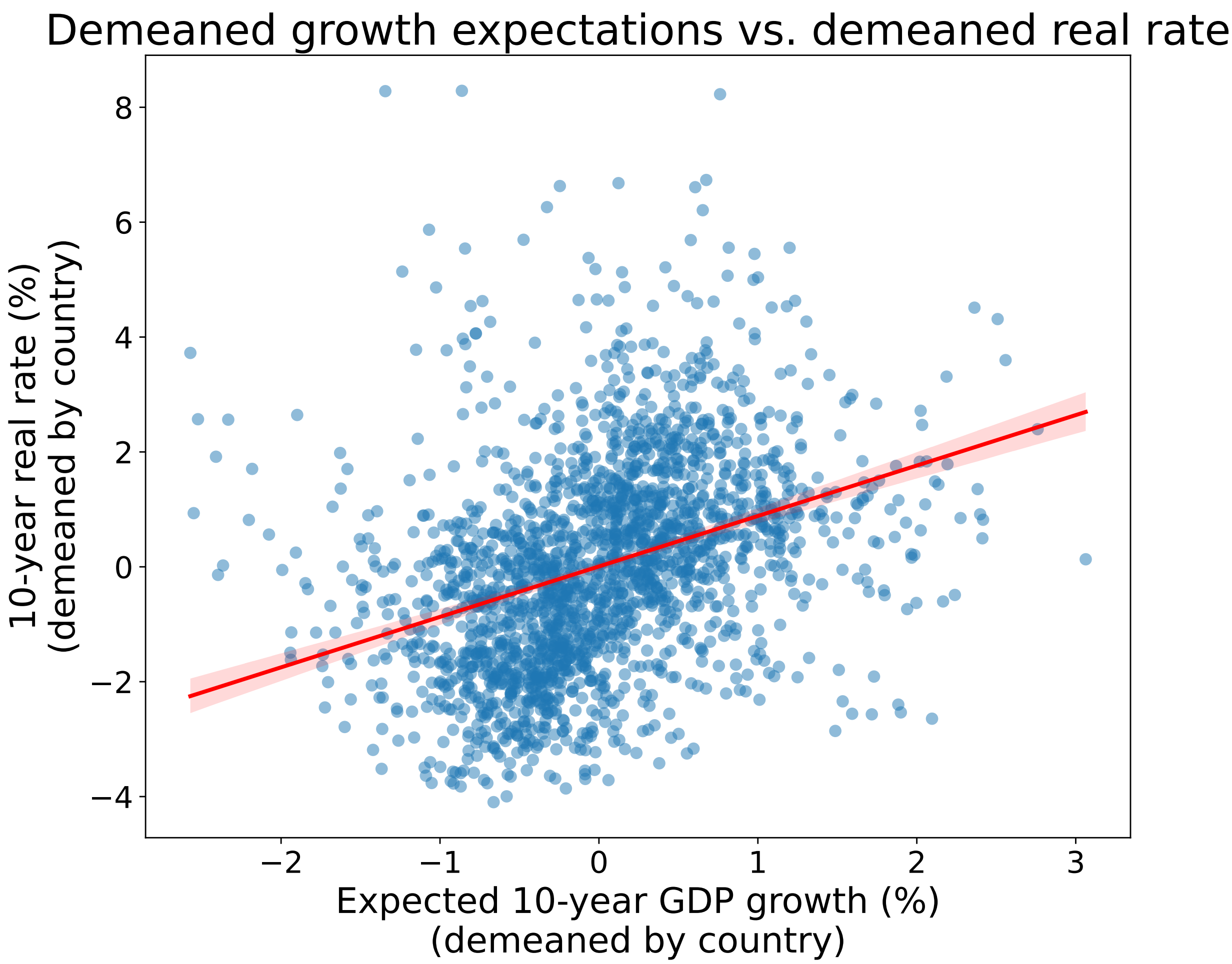

Figure 1: Ex ante real interest rates versus expected GDP growth, both at 10-year horizons and both demeaned by country sample average. Real interest rates are measured using benchmark 10-year nominal interest rates minus 10-year inflation forecasts from professional forecasters collected by Consensus Economics biannually. Expected GDP growth is also from Consensus Economics. More details on data construction are given in the text.

of expected inflation to subtract from the nominal rates. Existing literature typically uses ex post realized inflation, or simply a backward-looking statistical model. For example, the analyses of Lunsford and West (2019), Borio et al. (2022), and Hamilton et al. (2016) use rolling AR(1) forecasts based on past inflation as their measure of expected inflation.

However, these approaches are inherently backward-looking and fail to capture the forward-looking nature of inflation expectations. For example, consider the case of the US at the start of 2023, when inflation was falling rapidly from its highs of the previous year. Under the backward-looking statistical approach used in Rogoff, Rossi, and Schmelzing (2024), 10-year expected inflation would be calculated as 4.2%.[1] This backward-looking approach is quite high, because the 2022 CPI inflation rate was atypically high at 6.4%. However, more direct measurements of inflation expectations at the start of 2023 showed substantially lower inflation expectations: for example, the Survey of Professional Forecasters showed a consensus inflation forecast of 2.4% for the subsequent 10 years.

We instead use, as noted, surveys professional forecasters around the world on 10-year inflation expectations from Consensus Economics. The global data available in this dataset has been largely untapped in academic economic research. A partial exception is Engel and Rogers (2009), who study the same question as this paper, but limited to the G7 countries and with 15 fewer years of data.[2]

2. *Long-term* real interest rates. The second key feature of our empirical approach is the focus on *long-term* real interest rates, to avoid the effects of short-run business cycles.

In modern macroeconomic models, as we have emphasized, higher growth causes higher real interest rates. But simultaneously, real interest rates which are "too" high *cause* lower growth due to nominal rigidities. In the long-run, these nominal rigidities ease; but use of *short-horizon* real rates risks conflating these two mechanisms and distorting the analysis, under time aggregation.

For example, the Volcker Federal Reserve raised policy interest rates in 1979. This plausibly exogenous shock to real interest rates lowered the *level* of output – consistent with New Keynesian theories of nominal rigidities – but raised the *expected growth rate*, consistent with the Euler equation that we study in this paper. An analyst working with non-continuous, *time-aggregated* data on real rates and growth expectations may conflate this jump down in the *level* and jump up in the *expected growth rate* of output.

In figure 1, we use long-term – ten-year – variables to help avoid this problem. This contrasts with parts of the existing literature. For instance, Lunsford and West (2019) use yields on three-month Treasury bills for much of their analysis; Hamilton et al. (2016) uses an overnight interest rate.

Our preferred specification, which we develop in the body of the paper, goes further and uses five-year-five-year forward rates to compare with five-year-five-year forward growth expectations. This goes even further to strip out the effect of short-run business

[1] This approach uses a seven-year weighted average of lagged inflation, with declining weights.

[2] In the asset pricing literature, Asness, Moskowitz, and Pedersen (2013) is an exception in making extensive use of the full global range of this data.

cycle dynamics, to the extent that nominal rigidities dissipate after five years.

3. Adjusting for credit risk. The third key feature of our empirical approach is adjusting our real interest rates for credit risk. That is, we construct *risk-free*, long-term real interest rates. The real interest rate data is based on yields from government bonds, and these yields – and especially *changes* in these yields – can reflect sovereign default risk.

Adjusting for credit risk is especially important given our wide panel of 61 countries. The downside is that clean data on credit risk – that is, data from credit default swaps (CDS) – is only available for a limited set of countries for a limited number of years. As figure 1 shows, adjusting for credit risk is not *necessary* to measure the relationship between r and g in the data, but we show that it helps clarify it.

Our data only goes back as far as 1990, but for other papers in the literature that use longer samples with historical data, failing to adjust for sovereign bond risk may be especially important. This is plausibly relevant, for example, in the long-run historical trends estimated by Schmelzing (2019). He estimates a steady long-run decline in real rates using historical sovereign nominal bonds. Besides also finding an explanation in declining time preference (Clark 2007; Stefanski and Trew 2022), this plausibly reflects a long-run decline in credit risk.

For example, the estimates of Schmelzing (2019) show a sharp rise in real rates during the Napoleonic Wars. The estimates for this period come from the yields of British perpetuities, and the United Kingdom is termed a "safe asset provider". It seems natural to suspect that the measured jump in real rates during this period this reflects, at least in part, heightened credit risk during the conflict, rather than a true increase in risk-free real interest rates.[3] This interpretation is consistent with the post-war normalization of real rate estimates.

Decomposing our empirical approach step-by-step. In section 5 of the paper, we decompose the importance of the various steps of our methodology by re-analyzing our results one step at a time.

(i) Step 1: We start as with much of the older literature: we exclusively consider US data at a one-year horizon. We start by comparing one-year realized growth versus 1-year nominal interest rates adjusted for ex post realized inflation.

(ii) Step 2: Instead of using one-year horizons, use a 10-year horizon.

(iii) Step 3: Expand the data analysis to include all 61 countries in our sample.

(iv) Step 4: As in later literature, use an AR(1) inflation adjustment to proxy for expected inflation, rather than using realized inflation, to convert nominal yields to real yields.

(v) Step 5: Use credible survey measures of 10-year expected inflation to construct real interest rates, instead of using the backward-looking statistical measure.

[3] As well as measurement error in inflation expectations following suspension of the gold standard.

(vi) Step 6: Use survey measures of 10-year expected growth, instead of using ex post realized growth.

(vii) Step 7: Use a five-year-five-year forward horizon, rather than 10-year horizon, to better strip out the effect of business cycles.

(viii) Step 8: Stripping out credit risk using CDS data.

We illustrate this decomposition both graphically and via regression.

Robustness. We also conduct a wide range of robustness exercises and find similar or even stronger results. We use consumption growth expectations, rather than GDP growth expectations, though this survey data is more limited in availability. We always adjust our statistical tests to account for overlapping data, cross-sectional correlation, and timeseries autocorrelation; but we also consider exclusively analyzing non-overlapping samples. We rerun the analyses weighting countries by GDP. We rerun the decomposition analysis with a fully-consistent data sample (i.e., dropping any country that doesn't have data available at every step). We cut the data by advanced versus developing countries.[4]

We also spend a considerable portion of the paper doing the same analysis *in differences*. That is: when expected growth *was revised up*, do real interest rates *increase*? While these analyses are somewhat noisier than our main specification in levels – reflecting that variation in growth rates is not responsible for the majority of variation in real rates – we find a consistently strong relationship in differences as well.

Outline. The paper proceeds as follows. We first offer a review of the literature testing the aggregate Euler equation, with a focus on recent reduced form analyses. Section 2 reviews our data sources. Section 3 offers a brief discussion of theory, and uses this theory to explain our methodology for constructing real interest rates. Section 4 presents the main results: our preferred specification of r versus g, in simple figures and regressions. Section 5 decomposes each step in our methodology to illustrate the implications for the relationship between real rates and growth. Section 6 concludes and discusses implications for monetary policy.

[4]See Chow, Halperin, and Mazlish (2024) for a similar analysis also considering inflation-linked bond yields, when available, as another robustness exercise.

4 Main results: r vs. g

4.1 The five-year-five-year forward horizon

Figure 2 shows five-year-five-year forward rates and growth expectations, without adjusting for credit risk, for any other controls, or by taking out country fixed effects.

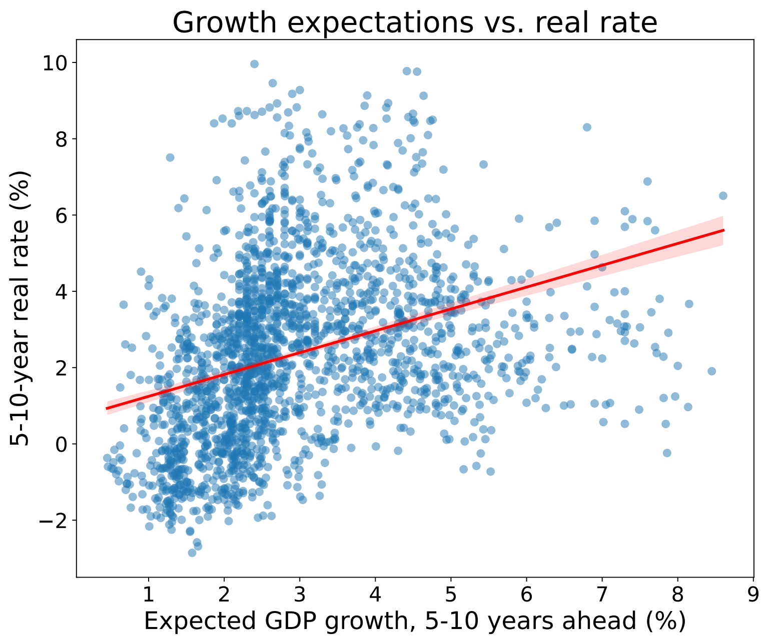

Figure 2: Ex ante real interest rates versus expected GDP growth, both at the five-year-five-year forward horizon.

Figure 3 shows the same, but demeaned by country. Figure 4 shows the constant that was differenced out by demeaning: what is the average growth rate by country versus the average real rate, at the five-year-five-year horizon?

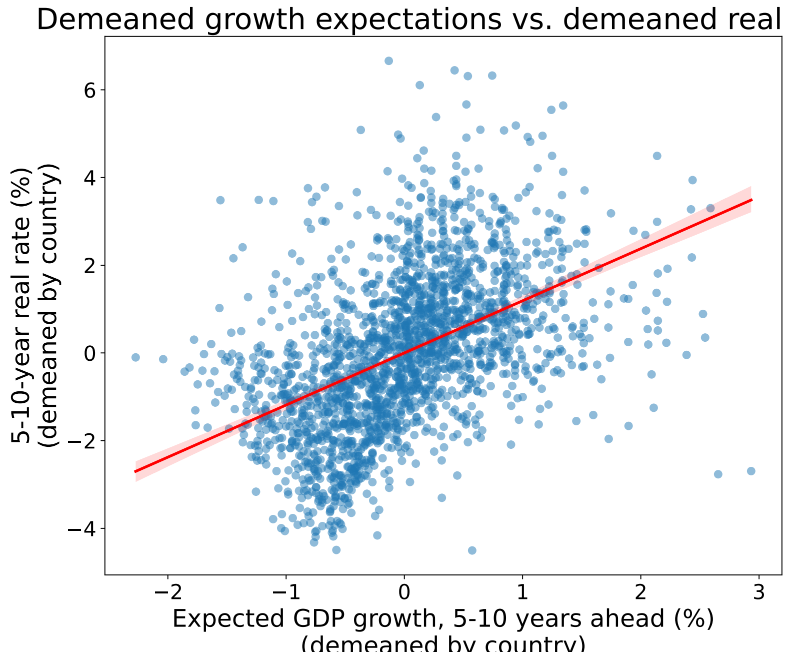

Figure 3: Ex ante real interest rates versus expected GDP growth, both at the five-year-five-year forward horizon. Demeaned by country.

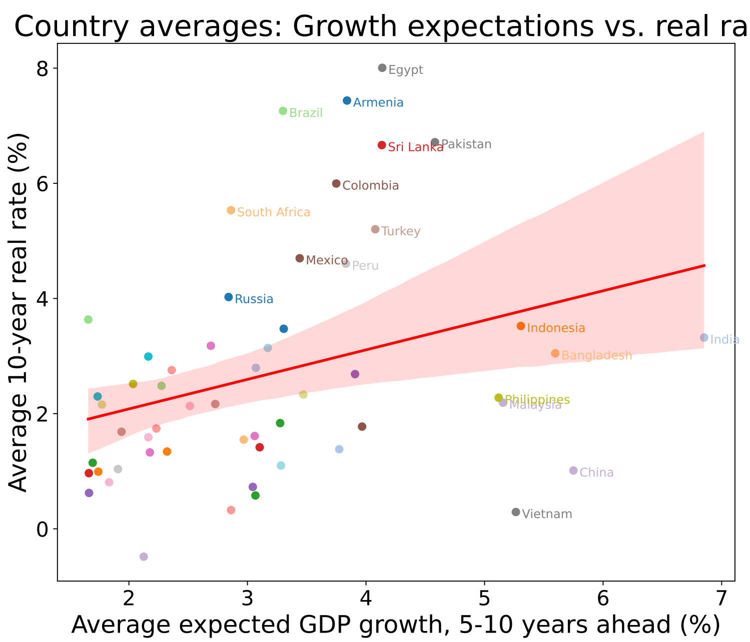

Figure 4: Ex ante real interest rates versus expected GDP growth, both at the five-year-five-year forward horizon, averaged over country sample.

4.2 Regression analysis and adjusting for credit risk

We can also consider regressions with a vector of controls X and country fixed effects:

$$r_{i,t} = \alpha_i + \beta_1 \mathbb{E}_t(g_{i,[t+5,t+10]}) + \beta_2 X_{i,t} + \eta_{i,t} \tag{4.1}$$

In particular, this also allows us to adjust for credit risk.

We consider up to three control variables in our regressions, motivated by the discussion in sections **??** and **??**:

(i) Credit default swap (CDS) rates on the country's ten-year debt. Using CDS rates allows us to control for country default risk, an important issue even for advanced economies like the US, as shown by Chernov, Schmid, and Schneider (2020), which many other papers in the literature have neglected. CDS rates come from either Bloomberg or Longstaff et al. (2011).

(ii) The standard deviation of the Consensus five-to-ten-year-ahead growth forecast. Controlling for dispersion across forecasts, within a given country, is motivated by equation (**??**) and the discussion of the term premium.

(iii) Average expected growth from zero to five years. Controlling for the short-run expected growth is motivated by business cycle considerations discussed above and in section **??**.

Table 2 shows the results of the regressions comparing the level of real interest rates versus the expected growth rate. Column 1 shows the relationship absent any controls or fixed effects, while the rest of the table adds these. We control for CDS spreads to adjust for credit risk; and we control for the standard deviation of expected growth rates across forecasters to control for risk premia.

The primary result is that the coefficient on long-term growth expectations is uniformly positive and highly significant, with a magnitude greater than one in all specifications with controls or fixed effects. A coefficient of one would imply that when long-term GDP growth is expected to be one percentage point higher, real rates are correspondingly one percentage point higher.

All controls are also highly significant. The sign of the coefficient on the standard deviation of the long-term growth forecast matches the prediction of the model in equation (**??**), where higher expected consumption volatility pushes down real rates. The coefficient on 0-5 year growth expectations is negative, likely due to short-run monetary factors, as previously discussed. Finally, the coefficient on CDS represents that an 100 basis point higher CDS rate implies a 50-70 basis point higher ex-ante real rate; an economically large relationship.

The R^2 values are also meaningfully large. Note that in column (3) we do not use any country fixed effects, but still explain more than a third (0.38) of the variation in ex-ante real rates, across over 60 countries.

In appendix A4, we run country-by-country regressions rather than estimating as a panel. In the specification with controls, the median coefficient (across 61 countries) on

Table 1: Expected growth vs. real rate

	Dependent variable: 5-10-year real rate			
	(1)	(2)	(3)	(4)
5-10-year GDP growth forecast	0.57***	1.19***	1.62***	1.37***
	(0.17)	(0.22)	(0.25)	(0.30)
SD(5-10-year GDP growth forecast)			-0.10	-0.35**
			(0.50)	(0.17)
5-year GDP growth forecast			-1.01***	-0.57*
			(0.27)	(0.30)
CDS spread			0.322**	0.194**
			(0.125)	(0.094)
Observations	2072	2072	1301	1301
Overall R^2	0.12	n/a	0.38	n/a
Country FE	No	Yes	No	Yes
Note:	$^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$			

long-term growth is 1.48, with 75% of individual country regression coefficients being positive. Many individual country samples are quite small, so we do not expect perfectly consistent results. Appendix A4 presents more details on these results.

4.3 Analysis in differences

We also consider a first-differenced version of the same regression:

$$\Delta r_{i,t} = \beta_1 \Delta \mathbb{E}_t(g_{i,[t+5,t+10]}) + \beta_2 X_{i,t} + \epsilon_{i,t} \tag{4.2}$$

We use Δ to denote the change in a variable's value across Consensus survey dates and present results below using one-, three-, and five-year changes.[5]

One potential advantage of estimating in changes is that it avoids stationarity concerns. The issue with estimating in changes is that it reduces our sample size and is potentially biased by other sources of noise. For example, short-term liquidity issues in the bond markets during times of crisis could cause measured real rates to rise while growth expectations are falling.

There are also tradeoffs to choosing between one-, three-, or five-year windows for differencing. An advantage of differencing with a shorter horizon is a larger sample size. An advantage of looking at longer horizon changes is that such a window is more likely to purge the short-term noise issues just mentioned.

[5] As a misspecification test, we could run the regression (4.2) without imposing an intercept of 0. Across all specifications shown in table **??**, the intercept is statistically indistinguishable from zero.

Table 2 below presents the results. The first column of the above table presents results where independent variables are one-year changes; the second column with three-year changes; and the third column with five-year changes.

Table 2: Expected growth vs. real rate

	Dependent variable: 5-10-year real rate			
	(1)	(2)	(3)	(4)
5-10-year GDP growth forecast	0.57***	1.19***	1.62***	1.37***
	(0.17)	(0.22)	(0.25)	(0.30)
SD(5-10-year GDP growth forecast)			-0.10	-0.35**
			(0.50)	(0.17)
5-year GDP growth forecast			-1.01***	-0.57*
			(0.27)	(0.30)
CDS spread			0.322**	0.194**
			(0.125)	(0.094)
Observations	2072	2072	1301	1301
Overall R^2	0.12	-0.02	0.38	0.33
Country FE	No	Yes	No	Yes
Note:	$^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$			

Once again, the coefficient on long-term growth expectations is always positive and almost always significant – the one-year horizon change coefficient has a p-value of 0.09. The coefficient's magnitude is noticeably smaller, but increasing in horizon. Both the three- and five-year change specifications include a point estimate of $\beta_1 = 1$ in their 95% confidence interval.

The coefficient on the change in the standard deviation of long-term growth forecasts is significant at longer horizons and is consistently less than or equal to 0, consistent with theory. We should note that our results only shed light on the relationship between *aggregate* risk and real rates. Idiosyncratic risk may have a much stronger negative relationship with real rates, as incomplete markets models would suggest.

The coefficient on the change in 0-to-5-year growth expectations is again negative and mostly significant, also consistent with theory. We view our results as a potential explanation of the "puzzle" in Duffee (2023) where upward changes in one-year US GDP forecasts (from the Fed's Greenbook) are associated with downward changes in interest rates. Monetary factors account for this short-term inverse relationship, while traditional consumption smoothing logic dominates on longer-horizons. Appendix A3 presents further results in this vein, showing that in both levels and changes real rates are more strongly positively associated with 5-10yr growth expectations than 0-5yr or 0-10yr growth expectations.[6] The coefficient on CDS also remains highly significant, though of smaller

[6]In fact, in five-year changes, the positive relationship is only observed between 5-10 year growth ex-

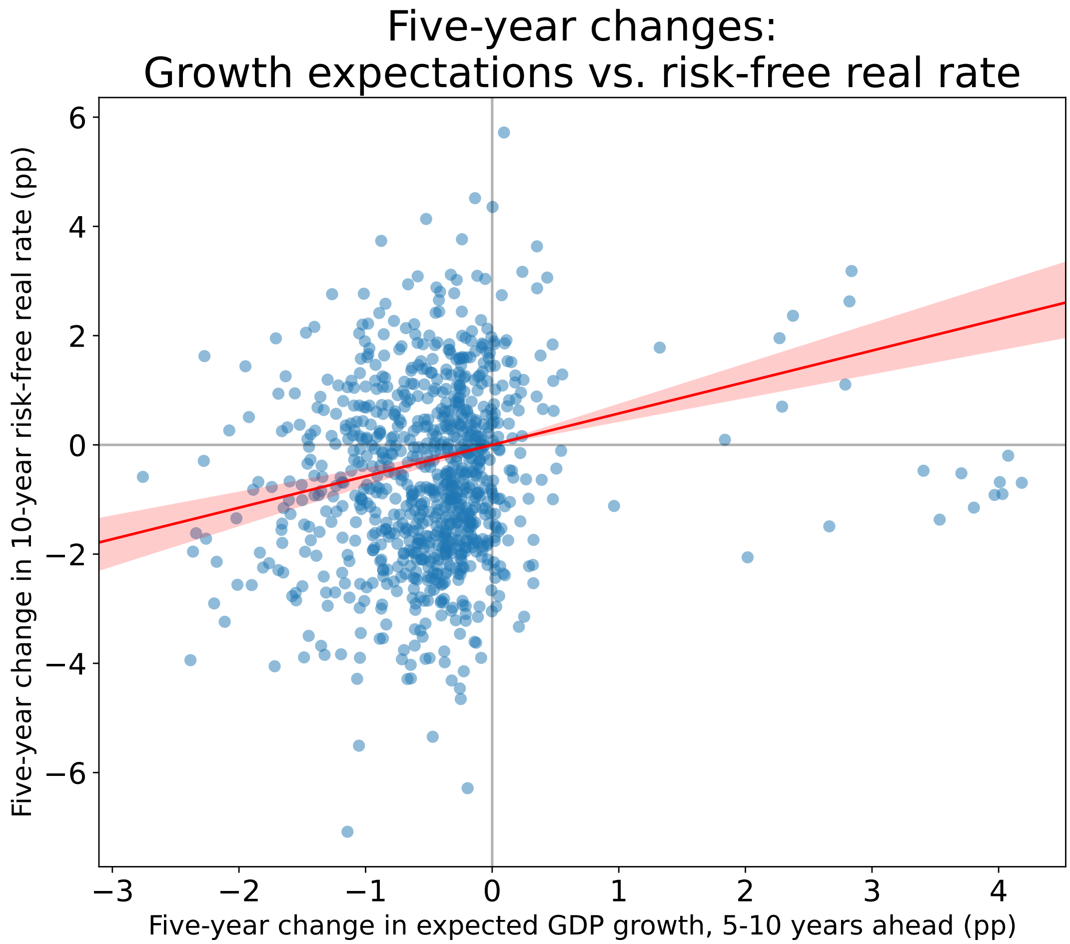

Figure 5: Ex ante *risk-free* real interest rates versus expected GDP growth, both at 10-year horizons. Risk-free real interest rates are measured using inflation-linked bonds when available, otherwise using benchmark nominal interest rates minus expected inflation. For either measure, we subtract the CDS rate to get the risk-free rate. Expected inflation is measured using the consensus of professional forecasters from Consensus Economics. Expected GDP growth is also the consensus of professional forecasters. More details on data construction are given in the text.

magnitude than the regression in levels. Since we are regressing in changes, we do not use country fixed effects, but still achieve meaningfully large R^2 values.

Appendix A5 shows that all results above about the sign and magnitude of the β_1 coefficient are robust to only looking at G7 countries. The coefficient on the regression in changes loses significance, however, which is plausibly due to the smaller sample.

Altogether, our results show a clear and reliable connection between higher long-term growth expectations and higher long-term real rates. We do not believe such a robust relationship has been shown before, and we see our wide cross-country sample as the best available evidence on this foundational macroeconomic relationship.

pectations and real rates; the relationship is significantly negative for the two other horizon growth expectations.

References

Asness, Clifford S, Tobias J Moskowitz, and Lasse Heje Pedersen (2013). "Value and momentum everywhere". In: *The journal of finance* 68.3, pp. 929–985.

Borio, Claudio et al. (2022). "Why so low for so long? A long-term view of real interest rates". In: *International Journal of Central Banking* 18.3, pp. 47–87.

Chernov, Mikhail, Lukas Schmid, and Andres Schneider (2020). "A macrofinance view of US sovereign CDS premiums". In: *The Journal of Finance* 75.5, pp. 2809–2844.

Chow, Trevor, Basil Halperin, and J Zachary Mazlish (2024). "Transformative AI, existential risk, and real interest rates". In.

Clark, Gregory (2007). *A Farewell to Alms: A brief economic history of the world*. Princeton University Press.

Duffee, Gregory R (2023). "Macroeconomic news in asset pricing and reality". In: *The Journal of Finance* 78.3, pp. 1499–1543.

Engel, Charles and John H Rogers (2009). "Expected consumption growth from cross-country surveys: implications for assessing international capital markets". In: *IMF Staff Papers* 56.3, pp. 543–573.

Friedman, Milton (1957). "A Theory of the Consumption Function". In: *NBER Books*.

Hall, Robert E (1978). "Stochastic implications of the life cycle-permanent income hypothesis: theory and evidence". In: *Journal of political economy* 86.6, pp. 971–987.

— (1988). "Intertemporal substitution in consumption". In: *Journal of political economy* 96.2, pp. 339–357.

Hamilton, James D et al. (2016). "The equilibrium real funds rate: Past, present, and future". In: *IMF Economic Review* 64, pp. 660–707.

Hansen, Lars Peter and Kenneth J Singleton (1982). "Generalized instrumental variables estimation of nonlinear rational expectations models". In: *Econometrica: Journal of the Econometric Society*, pp. 1269–1286.

Longstaff, Francis A et al. (2011). "How sovereign is sovereign credit risk?" In: *American Economic Journal: Macroeconomics* 3.2, pp. 75–103.

Lunsford, Kurt G and Kenneth D West (2019). "Some evidence on secular drivers of US safe real rates". In: *American Economic Journal: Macroeconomics* 11.4, pp. 113–139.

Rogoff, Kenneth S, Barbara Rossi, and Paul Schmelzing (2024). "Long-run trends in long-maturity real rates, 1311–2022". In: *American Economic Review* 114.8, pp. 2271–2307.

Schmelzing, Paul (2019). "Eight centuries of global real interest rates, RG, and the 'suprasecular'decline, 1311–2018". In: *RG, and the 'Suprasecular'Decline*, pp. 1311–2018.

Stefanski, Radoslaw and Alex Trew (2022). *Selection, Patience, and the Interest Rate*. Adam Smith Business School.