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Empirical evidence on the stock-bond correlation

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Research

OPEN ACCESS

Empirical Evidence on the Stock-Bond Correlation

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The correlation between stock and bond returns is a cornerstone of asset allocation decisions. History reveals abrupt regime shifts in correlation after long periods of relative stability. We investigate the drivers of the correlation between stocks and bonds and find that inflation, real rates, and government creditworthiness are important explanatory variables. We examine the implications of a shift in the stock–bond correlation and find that increases are associated with higher

Introduction

The correlation between stocks and bonds is an essential driver of any asset allocation decision. It impacts not only the overall risk of a diversified multi-asset class portfolio but also the risk premia one should expect to receive for taking risk in different asset classes. The obstacle one faces when estimating the correlation between stocks and bonds is that it fluctuates extensively across periods. Volatility of asset classes can vary widely inside of a business cycle but remain relatively stable over longer horizons. Correlations between stocks and bonds may persist with the same sign for extended periods, before eventually reversing. For example, the average correlation between stocks and bonds was 0.35 in the United States between 1970 and 1999 and then was –0.29 between 2000 and 2023. The effect of these variations can be seen in

WHO WROTE THIS?

WHY IS THIS TOPIC IMPORTANT?

WHAT DO WE **DO**?

WHAT DO WE **FIND**?

HOW CAN WE USE IT?

WHY **NOT** WRITE THIS PAPER?

Who wrote this? By practitioners for practitioners

> Roderick Molenaar	Robeco
> Edouard Senechal	State of Wisconsin Investment Board
> Laurens Swinkels	Robeco & Erasmus University
> Zhenping Wang	State of Wisconsin Investment Board




Common incentive is that we wanted to understand better what determines the stock-bond correlation

- Until recently, I had only met one of my coauthors in real-life, and still have never met Zhenping
- We didn't start out with the idea to write an article, but shared ideas and results in short presentations for about a year
- We learned so much during this year that we thought others may also benefit from our insights

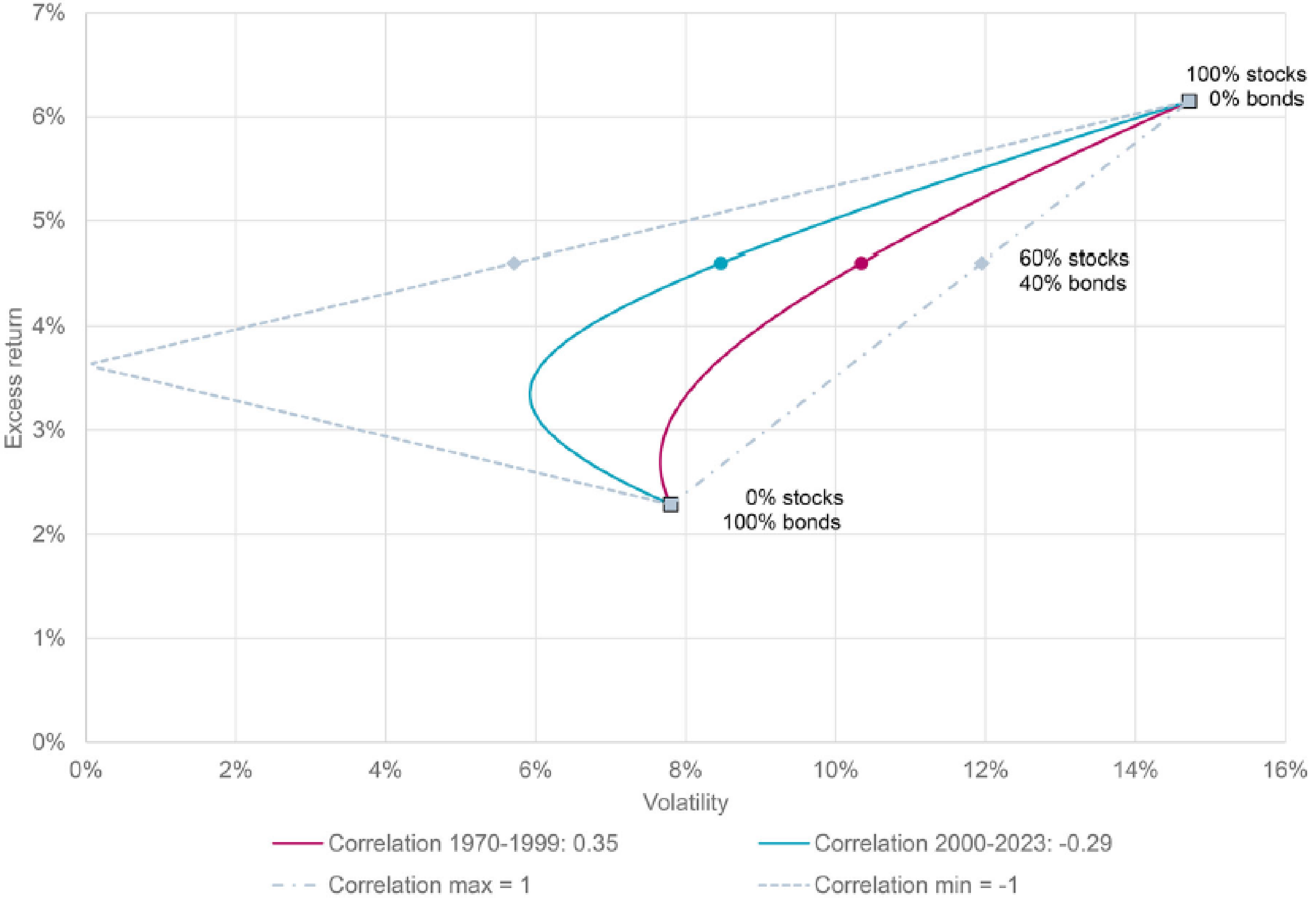
Why is this topic important? (1/2) Portfolio risk

- From my Finance 1 course (Erasmus Universiteit Rotterdam)

$$\sigma_p = \sqrt{w_1^2\sigma_1^2 + w_2^2\sigma_2^2 + 2 w_1 w_2 \rho_{1,2}\sigma_1\sigma_2}$$

- Impact of *only* the stock-bond correlation
  - Volatility 60/40: 8.4% versus 10.5%
  - Increased equity weight: 73/27

Figure 1. Multi-Asset Portfolio Risk and Return for Different Stock–Bond Correlation



Notes: Spearman rank correlation based on monthly returns for the US equity market and government bonds with 10-year maturity.

Why is this topic important? (2/2) Expected return on bonds

> From my Finance 1 course Erasmus Universiteit Rotterdam

$$E(r_i) = r_f + \beta_i \times (E(r_m) - r_f)$$

$$\beta_i = \frac{Cov(r_i, r_m)}{\sigma^2(r_m)}$$

$$\beta_i = \frac{\sigma_{i,M}}{\sigma_M^2} = \frac{\sigma_i \sigma_M \rho_{i,M}}{\sigma_M^2} = \frac{\sigma_i}{\sigma_M} \rho_{i,M}$$

> "Why on earth would investors ever buy bonds when the interest rate is near zero?"

> The expected returns versus cash may still be positive if the correlation with the market (= dominated by equity risk) is positive

> If bonds perform well when the equity market crashes, they should be expensive and have a negative risk premium

> Alternatively: Investors with bond-like liabilities may buy bonds to hedge interest rate risk and not care about their expected return

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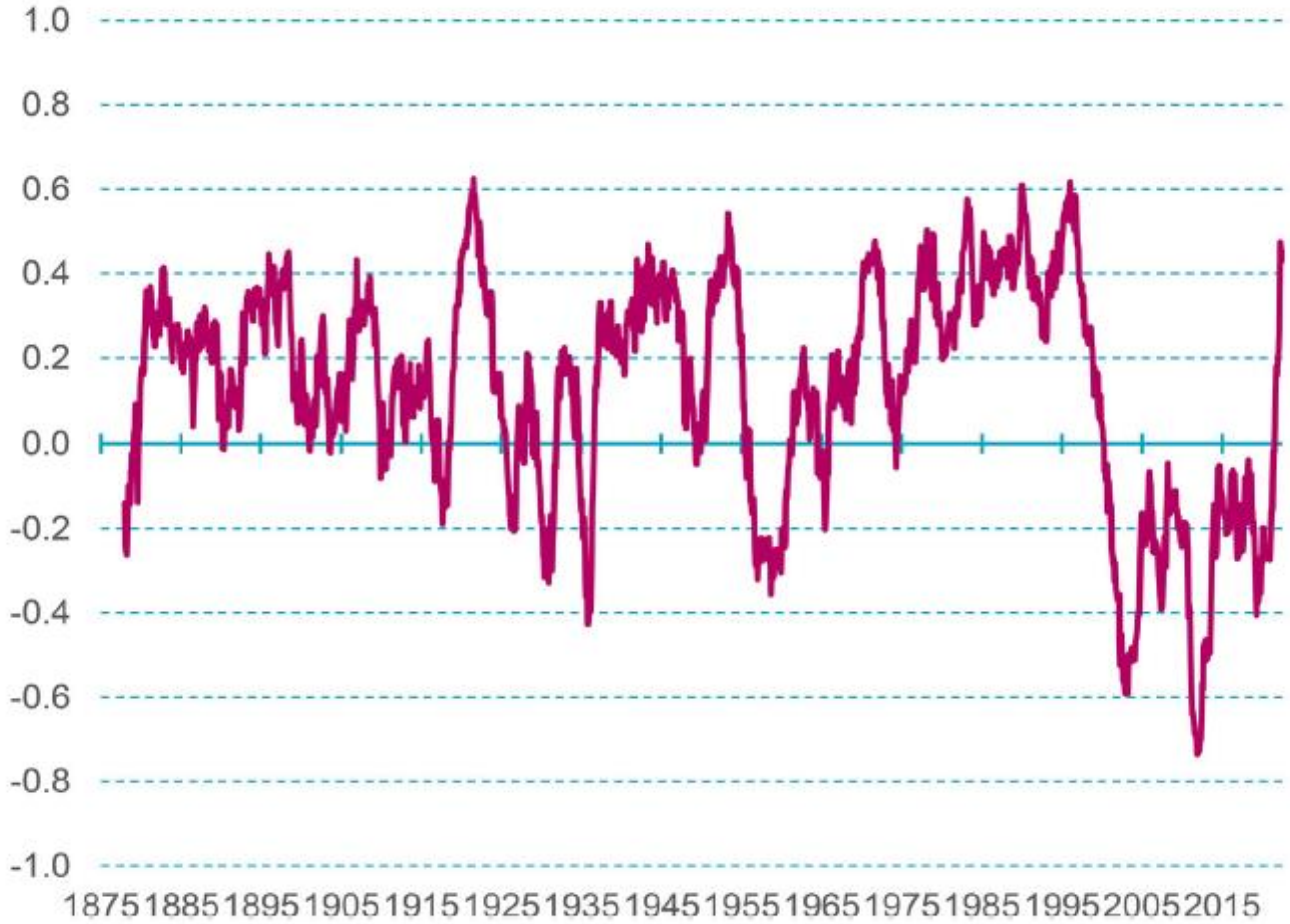
What do we do? (1/2) Calculate the stock-bond correlation over time

Figure 2. Stock–Bond Correlation for the United States



Notes: Spearman rank correlation based on monthly returns for the U.S. equity market and government bonds with 10-year maturity. Rolling window estimation using 36 monthly observations over the period January 1875 to June 2023.

What do we do? (2/2) What can we expect based on **theory**?

- What influences bond returns?

$$r^b_{t+1} \approx \alpha^b - \beta^b_{rr}\Delta_{t+1}rr - \beta^b_{\pi}\Delta_{t+1}\pi - \beta^b_{brp}\Delta_{t+1}brp$$

- What influences stock returns?

$$r^e_{t+1} \approx \alpha^e - \beta^e_{rr}\Delta_{t+1}rr - \beta^e_{\pi}\Delta_{t+1}\pi - \beta^e_{erp}\Delta_{t+1}erp + \beta^e_{g}\Delta_{t+1}g$$

- Write out what this means for the correlation between stocks and bonds:

$$cov\left\{r^b_{t+1}, r^e_{t+1}\right\} = \beta^b_{rr}\beta^e_{rr}\sigma^2_{rr} + \beta^b_{\pi}\beta^e_{\pi}\sigma^2_{\pi} + \left(\beta^b_{rr}\beta^e_{\pi} + \beta^b_{\pi}\beta^e_{rr}\right)\sigma_{rr,\pi} + \ldots$$
$$\ldots + \beta^b_{rr}\beta^e_{erp}\sigma_{rr,erp} - \beta^b_{rr}\beta^e_{g}\sigma_{rr,g} + \beta^b_{\pi}\beta^e_{erp}\sigma_{\pi,erp} - \beta^b_{\pi}\beta^e_{g}\sigma_{\pi,g} + \ldots$$
$$\ldots + \beta^b_{brp}\beta^e_{rr}\sigma_{brp,rr} + \beta^b_{brp}\beta^e_{\pi}\sigma_{brp,\pi} + \beta^b_{brp}\beta^e_{erp}\sigma_{brp,erp} - \beta^b_{brp}\beta^e_{g}\sigma_{brp,g}.$$

- We then estimate this equation for different countries and confront it with a very simple estimation not based on theory

rr = real interest rate
π = inflation
brp = bond risk premium
erp = equity risk premium
g = growth

What we find? (1/3) Inflation and real rate *levels* are important after 1952, but not before

Table 1. Explaining the Stock–Bond Correlation over the Long Term

	United States			United Kingdom			France		
Start	1875	1875	1952	1801	1801	1952	1871	1871	1952
End	2023	1951	2023	2023	1951	2023	2023	1951	2023
Intercept	–0.05	0.15	–0.20	0.27	0.30	–0.06	0.12	0.44	–0.12
t statistic	*–0.77*	***2.12***	***–2.36***	***5.68***	***4.55***	*–0.73*	*1.90*	***4.35***	*–1.57*
Inflation	4.48	0.96	5.66	0.75	2.61	3.80	2.28	–2.80	3.42
t statistic	***4.04***	*0.55*	***3.82***	*1.01*	*1.40*	***3.59***	***2.60***	*–0.95*	***3.53***
Real rate	4.36	0.70	7.35	1.88	2.88	3.70	2.78	–2.02	7.01
t statistic	***3.47***	*0.44*	***4.17***	***2.03***	*1.52*	***2.95***	***3.32***	*–0.69*	***6.06***
Adj R^2	0.19	0.01	0.39	0.05	0.04	0.25	0.09	0.19	0.42
Equality (*p* value)		0.019			0.853			0.004	

Notes: Dependent variable is the 36-month Spearman rank correlation between stock and bond markets over the full sample period (starting dates for United States: January 1875, United Kingdom: January 1801, France: January 1871, same end date: June 2023), over a historical sample until December 1951, and over a modern sample starting in January 1952. Independent variables are measured as averages over the same 36-month period as the dependent variable. The *t* statistics use Newey and West (1987) standard errors with 35 overlapping observations. Bold *t* statistics indicate statistical significance at the 5% level. The bottom row contains the *p* value corresponding to the *F* test for equality of the coefficients for inflation and real rate over the two subsample periods.
Source: Authors.

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What we find? (2/3) Theory and simple model almost as effective in explaining

Table format

Table 2. Explaining the 36-Month Stock–Bond Correlation

	Theoretical		Empirical		Combination	
	Coeff.	*t* statistic	Coeff.	*t* statistic	Coeff.	*t* statistic
ρ (*brp*, *erp*)	0.74	***3.76***	–		0.34	***3.67***
ρ (*brp*, π)	0.08	*0.57*	–		0.03	*0.26*
ρ (*brp*, *rr*)	−0.08	*−0.82*	–		−0.16	*−2.83*
ρ (*brp*, g)	0.56	*2.53*	–		0.25	*2.03*
ρ (π, *erp*)	−0.03	*−0.30*	–		−0.04	*−0.49*
ρ (π, *g*)	−0.18	*−1.49*	–		−0.01	*−0.14*
ρ (*rr*, *erp*)	0.62	***4.65***	–		0.62	***7.05***
ρ (*rr*, π)	0.28	***2.99***	–		0.30	***3.31***
ρ (*rr*, *g*)	0.07	*0.46*	–		−0.24	***−2.22***
σ (π)	−0.47	*−0.66*	–		0.62	*0.96*
σ (*rr*)	0.21	***3.16***	–		−0.18	*−1.84*
μ (π)	–	–	7.72	***4.73***	9.99	***6.28***
μ (*rr*)	–	–	9.39	***5.25***	9.31	***7.85***
Adjusted R^2	0.63		0.52		0.79	

Notes: Dependent variable is the 36-month Spearman rank correlation between U.S. stock and bond markets over the period June 1961 to June 2023. Each component from Equation (3) is shown here, where correlations are indicated with ρ, volatilities with σ, and ex-post averages with μ. The components are as follows: bond risk premium (brp), equity risk premium (erp), real interest rate (rr), growth (g), and inflation (π). The column "Coeff" the estimated coefficients, and the *t* statistics use Newey and West (1987) standard errors with 35 overlapping observations. *t* statistics in bold are significant at the 5% level and of the expected sign.
Source: Authors.

What we find? (2/3) Theory and simple model almost as effective in explaining

Graphical format

Figure 3. Fit of the Explanatory Models for the Stock–Bond Correlation

Notes: Figure shows the stock–bond correlation and the explanatory values based on the theoretically motivated model, the empirically motivated model, and the combination of the two, as well as the U.S. stock–bond correlation, calculated as the Spearman correlation over rolling 36-month periods over the period June 1961 to June 2023.

Source: Authors

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What we find? (3/3) Inflation and real rate tend to be more important for safer bond markets

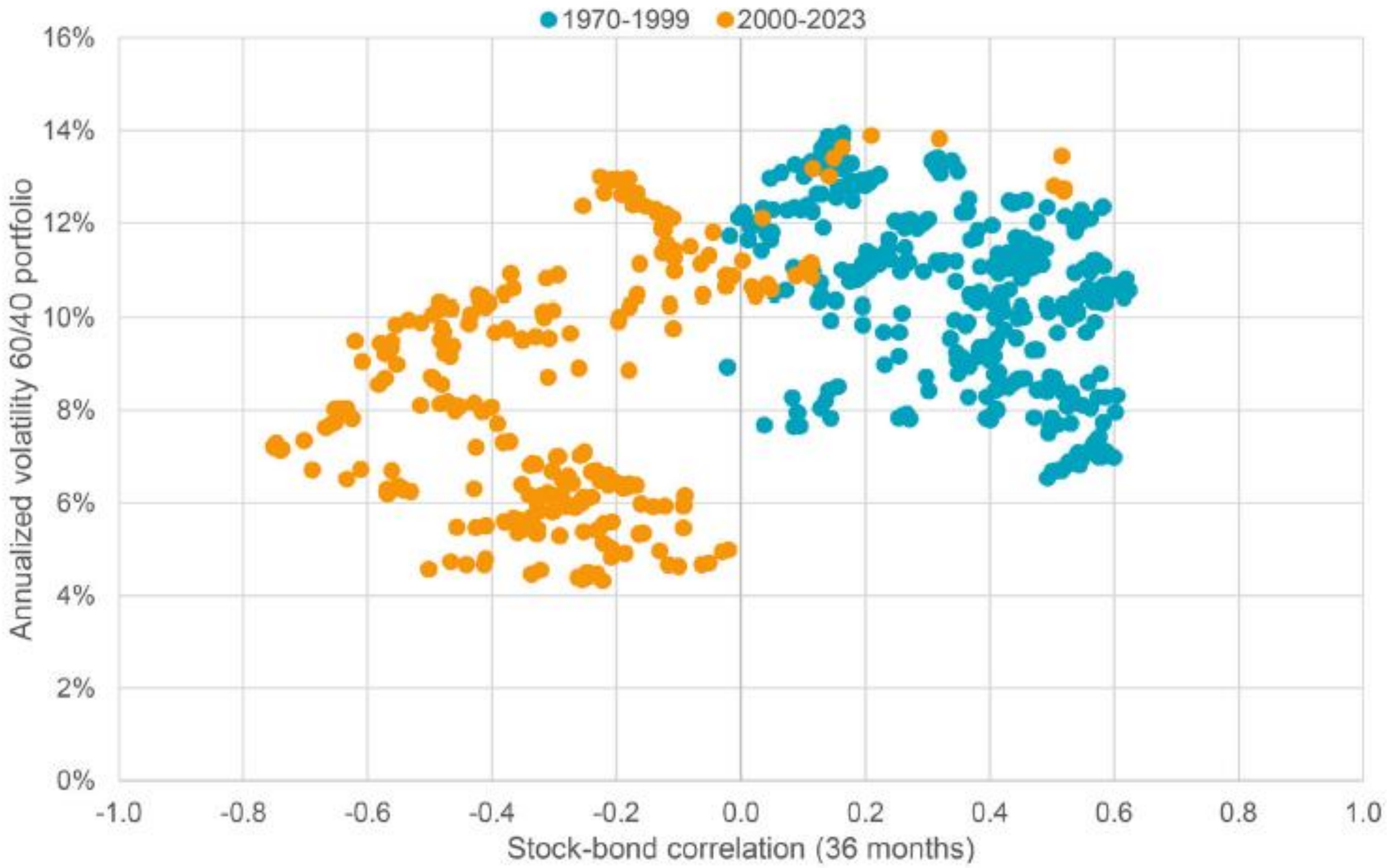
Table 3. Explaining the 36-Month Stock–Bond Correlation: International Evidence

	G7 countries							Emerging markets				
	CA	FR	DE	IT	JP	UK	US	BR	MY	MX	ZA	TH
Inflation	5.51	−2.00	18.87	1.52	14.67	10.92	14.27	−0.60	27.51	8.49	2.90	2.25
t statistic	*0.73*	*−0.14*	***3.61***	*0.42*	***2.49***	***3.48***	***2.77***	*−0.16*	*1.76*	***4.16***	*1.48*	*0.70*
Real rate	11.47	8.62	4.66	3.40	9.96	5.01	8.57	−0.83	23.56	6.51	−0.25	7.46
t statistic	***3.77***	***2.50***	***2.10***	*1.43*	***2.93***	***2.29***	***2.79***	*−0.53*	*1.48*	***4.53***	*−0.12*	*1.56*
Intercept	−0.24	−0.07	−0.48	0.15	−0.35	−0.27	−0.46	0.43	−0.55	−0.21	0.16	−0.02
t statistic	*−1.85*	*−0.38*	*−3.10*	*1.26*	*−6.93*	*−2.18*	*−3.34*	*1.38*	*−1.18*	*−1.98*	*1.27*	*−0.32*
Adjusted R^2	0.60	0.31	0.42	0.12	0.58	0.41	0.40	0.01	0.19	0.43	0.05	0.18
Credit rating	AAA	AAA	AAA	A	AA	AAA	AAA	BB	A	BBB	BBB	BBB
AAA	72	67	100	0	36	78	64	0	0	0	0	0
AA	28	33	0	50	39	22	36	0	0	0	0	0
A	0	0	0	17	25	0	0	0	91	0	0	0
BBB	0	0	0	33	0	0	0	30	9	96	57	100
BB (or lower)	0	0	0	0	0	0	0	61	0	4	43	0

Notes: Dependent variable is the 36-month Spearman rank correlation between stock and bond markets for the G7 over the period January 1988 to June 2023. CA = Canada, FR = France, DE = Germany, JP = Japan, UK = United Kingdom, US = United States. For emerging markets, BR = Brazil (start January 2002), MY = Malaysia (start January 2002), MX = Mexico (start January 2002), ZA = South Africa (start July 1994), TH = Thailand (start = February 2001). Independent variables are measured as averages over the same 36-month period as the dependent variable. The rows with "*t* statistic" contain *t* statistics using Newey and West (1987) standard errors using 35 overlapping observations. Bold indicates statistical significance at the 5% level. Credit rating contains the average S&P credit rating over the sample period. The distribution of credit ratings is displayed in the bottom five rows, in percentages.
Source: Authors.

How can we use it? (1/2) Estimating multi-asset portfolio risk

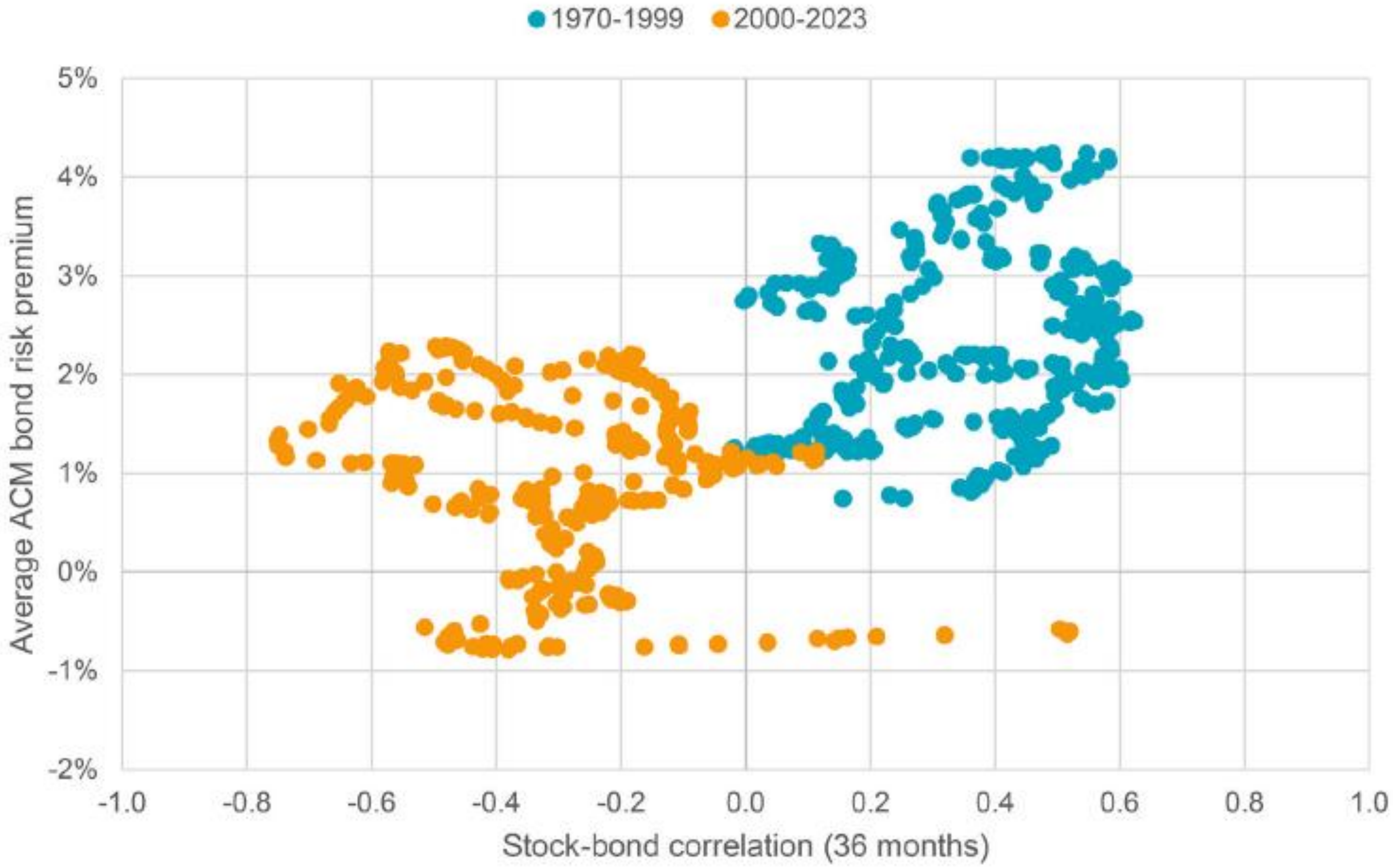
Figure 4. Relation between Stock–Bond Correlation and Portfolio Risk



Notes: Average of standard deviation and Pearson correlation coefficient of monthly returns computed over 36-month rolling windows ending January 1970 to June 2023.
Source: Authors.

How can we use it? (2/2) Estimating the expected returns on bonds

Figure 5. Relation between the Stock–Bond Correlation and the Bond Risk Premium



Notes: Average of Adrian, Crump, and Moench (2013) risk premia, average stock–bond correlation of monthly returns over 36-month overlapping windows ending January 1970 to June 2023.
Source: Authors, Federal Reserve Bank of New York.

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Why **not** write this paper? Before (and sometimes after) publication, there are concerns…

> Concerns on the content: "*You are **not predicting** the stock-bond correlation. Who cares about explaining it?*"

> Concerns about the time spent on the paper: "*Aren't there higher priority projects to work on?*"

> Concerns with regards to compliance: "*Is it legally allowed to write a joint paper together with a potential US client?*"

> Concerns about our intellectual property: "*Why should we make competitors smarter?*"

> Despite all the concerns, I am very happy that I am standing here today to present to you the highlights of our research

Appendix

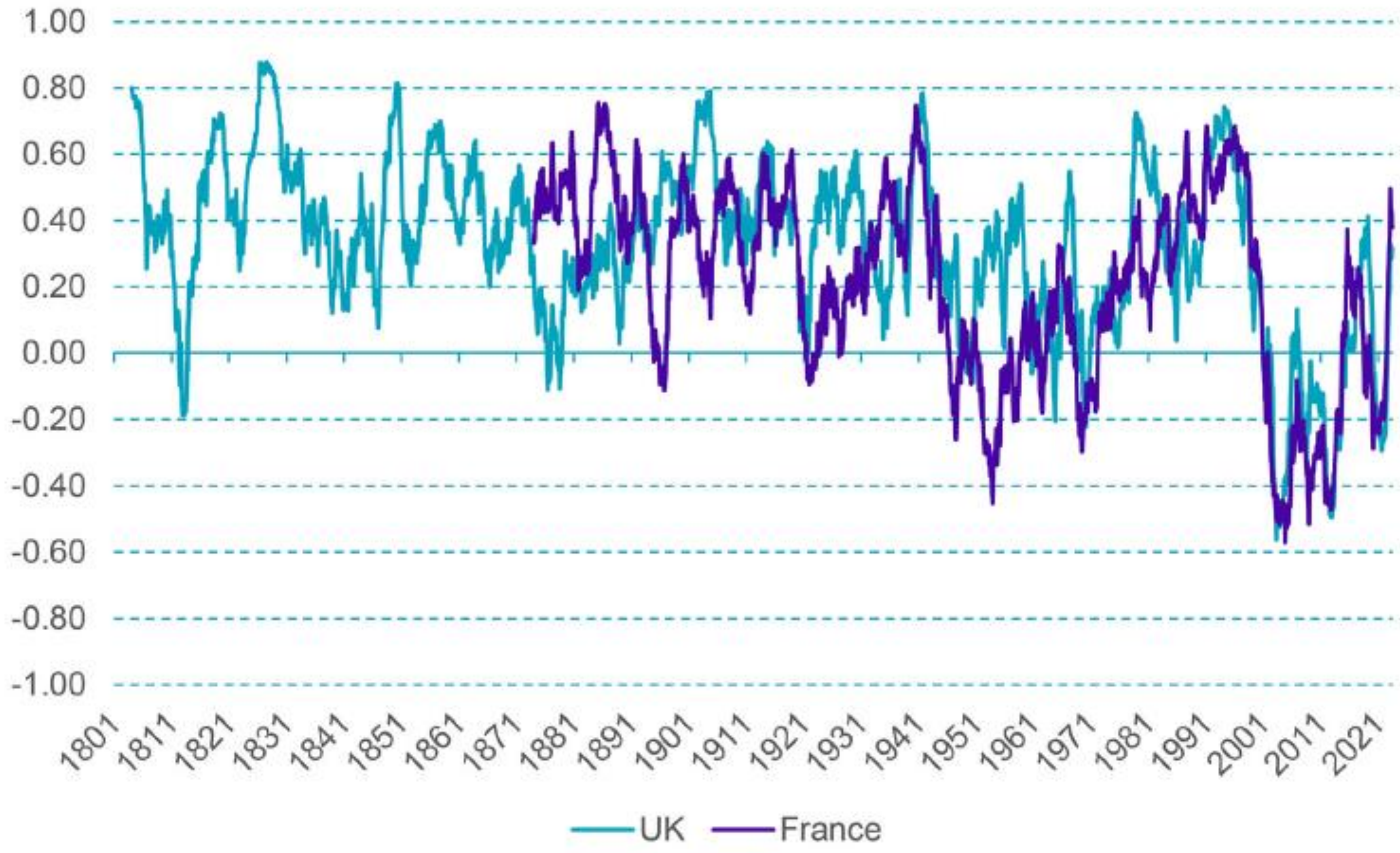
Table 4. Explaining the 36-Month Stock–Bond Correlation with Survey Expectations

	Theoretical		Empirical		Combination	
	Coeff.	*t* statistic	Coeff.	*t* statistic	Coeff.	*t* statistic
ρ (*brp*, *erp*)	0.44	***2.96***			0.25	*1.84*
ρ (*brp*, π)	0.57	***3.46***			0.42	***2.57***
ρ (*brp*, *rr*)	0.23	*1.81*			0.07	*0.60*
ρ (*brp*, g)	0.56	*4.24*			0.40	*2.52*
ρ (π*, *erp*)	0.40	***2.19***			0.40	***2.08***
ρ (π*, *g*)	–0.44	***–2.00***			0.01	*0.02*
ρ (*rr*, *erp*)	0.77	***5.33***			0.95	***6.28***
ρ (*rr*, π)	1.41	***7.35***			0.20	*0.64*
ρ (*rr*, *g*)	–0.63	***–2.76***			–0.37	*–1.73*
σ (π*)	4.76	***2.96***			4.01	***3.55***
σ (*rr*)	0.11	***3.64***			–0.09	*–1.50*
μ (π)			6.33	***2.90***	7.36	***3.28***
μ (*rr*)			10.10	***4.48***	7.63	***4.12***
Adjusted R^2	0.82		0.55		0.88	

Notes: Dependent variable is the 36-month Spearman rank correlation between U.S. stock and bond markets over the period January 1978 to June 2023. Each component from Equation (3) is shown here, where correlations are indicated with ρ, volatilities with σ, and ex-post averages with μ. π* refers to the expected inflation from the Michigan survey, and its volatility is the cross-sectional volatility of the estimates. The column "Coeff." contains the estimated coefficients, and "*t* statistic" contains the corresponding *t* statistics using Newey and West (1987) standard errors using 35 overlapping observations.
Source: Authors.

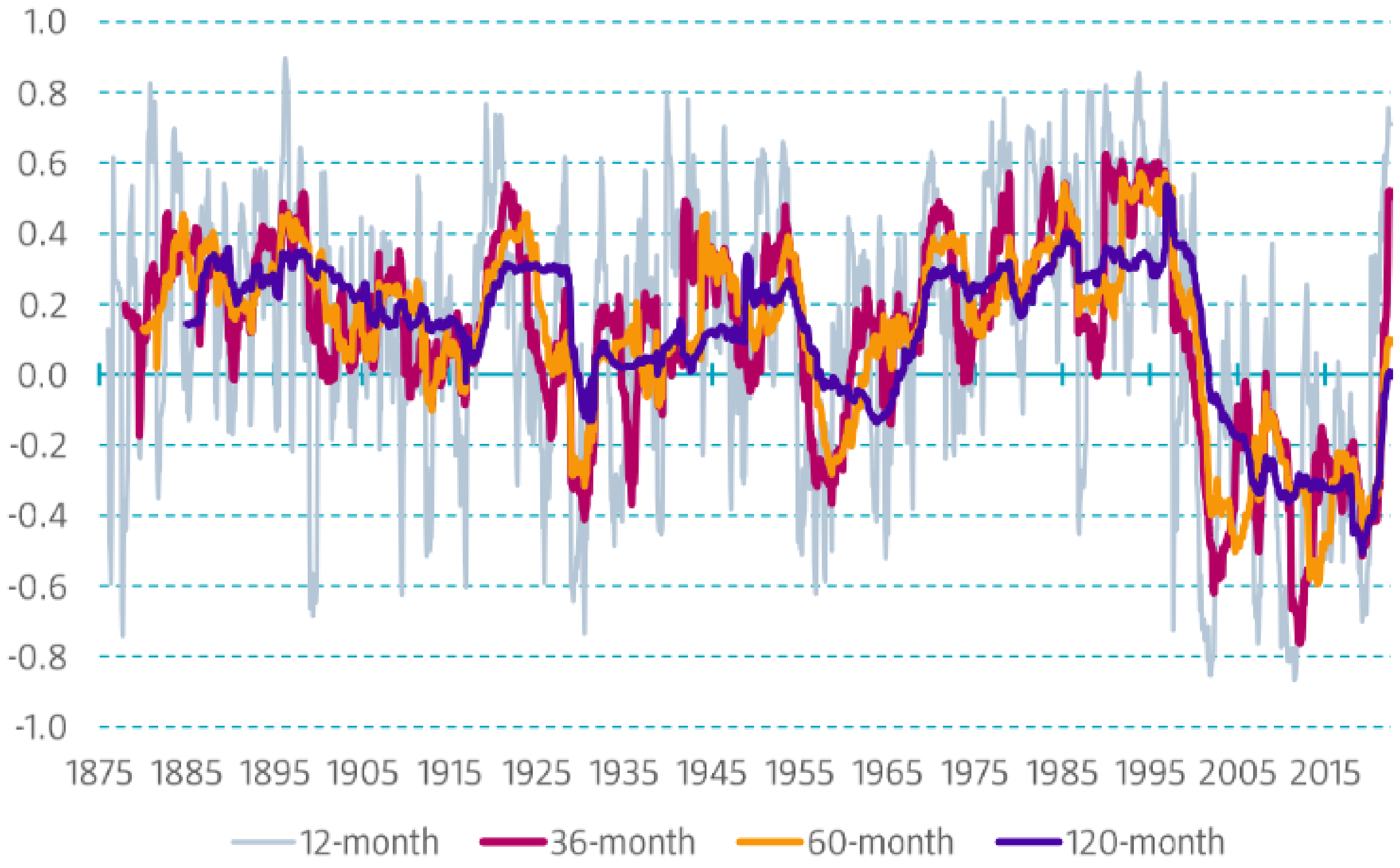
Long-term stock-bond correlation for the United Kingdom and France

Figure A1. Stock–Bond Correlation for the United Kingdom and France



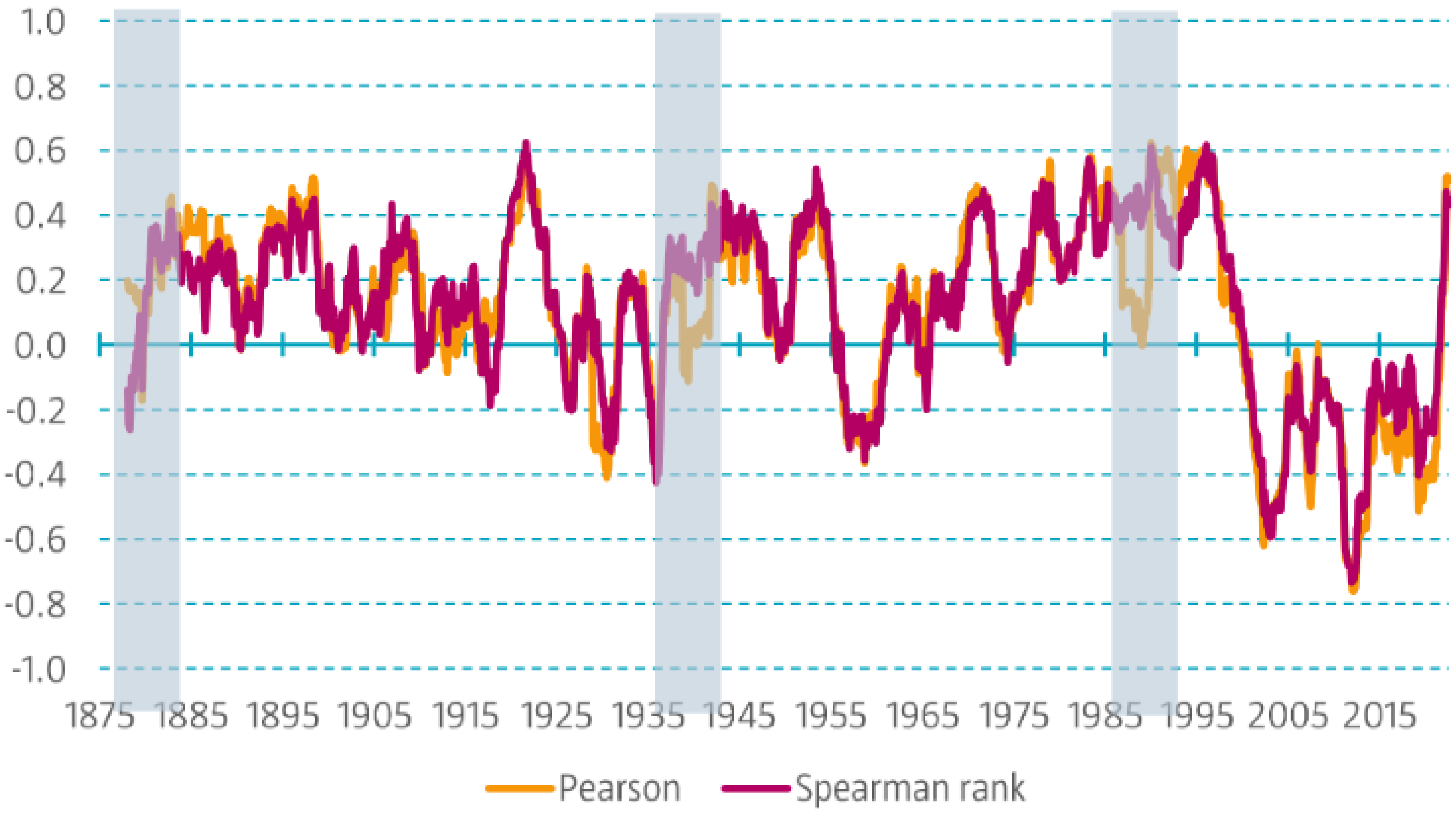
Notes: Spearman rank correlation based on monthly returns for the US equity market and government bonds with 10-year maturity. Rolling-window estimation using 36-month observations.
Source: Authors, Global Financial Data.

Figure OA1: Effect of estimation period on stock-bond correlation estimate



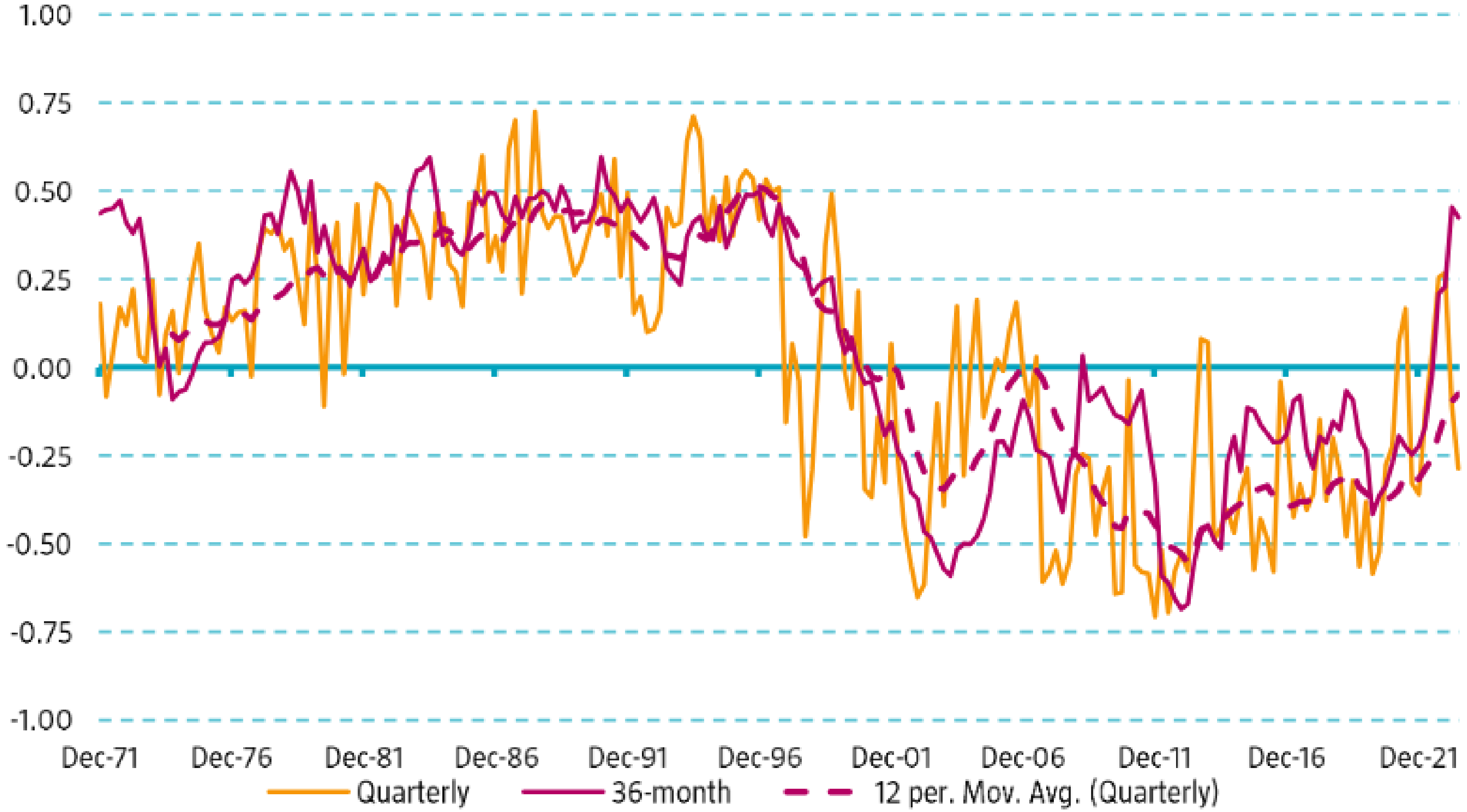
Source: Authors, GFD. Spearman rank correlation based on monthly returns for the US equity market and government bonds with 10-year maturity. Rolling window estimation using 12, 36, 60, and 120 monthly observations.

Figure OA2: Effect of using Pearson and Spearman rank correlation.



Source: Authors, GFD. Pearson correlation and Spearman rank correlation based on monthly returns for the US equity market and government bonds with 10-year maturity. Rolling window estimation 36 monthly observations.

Figure OA3: Effect of using daily and monthly data for the stock-bond correlation.



Source: Authors, FED, Kenneth French. Quarterly stock-bond Spearman rank correlation using ~63 daily observations and Spearman rank correlation based on 36 monthly returns for the US equity market and government zero-coupon bonds with 10-year maturity over the period 1971-Q4 to 2023-Q2.

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