Do Foreign Yield Curves Predict U.S. Recessions and GDP Growth?*

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Abstract

This paper shows that foreign term spreads constructed from bond yields of non-U.S. G-7 constituents predict future U.S. recessions and that foreign term spreads are stronger predictors of U.S. recessions occurring within the next year than U.S. term spreads. U.S. and foreign term spreads are both informative of the U.S. economy but over different horizons and for different components of economic activity. Smaller U.S. term spreads lead to smaller foreign term spreads and U.S. Dollar appreciation. Smaller foreign term spreads do not lead to significant U.S. Dollar depreciation but do lead to persistent declines in U.S. exports and FDI flows into the United States. These findings are consistent with the proposition that foreign term spreads embed growth spillovers from the U.S. and the resulting Dollar strength and slowdown abroad spill back to the United States.

Keywords: Globalization, Interest rates, Leading indicator, Spillovers
JEL Classifications: E32; E43; E44; F3; G1

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1 Introduction

The propagation of economic and financial shocks originating in the United States is a central issue in open economy macroeconomics and finance. Meanwhile, 'spillbacks' where the subsequent impact abroad has knock-on effects for the U.S. are relatively under-studied. This paper examines both spillovers and spillbacks by documenting that non-U.S. yield curves, measured as the 10-year minus 3-month sovereign yield differential or *term spread*, contain information that is distinct from the U.S. yield curve about future U.S. recessions and economic activity. It is already well documented by both academics and practitioners that U.S. yield curve inversions led each of the last 8 recessions, but whether and to what extent foreign term spreads signal future U.S. recession risk remains an open question.

Using quarterly data from 1979-2021, a foreign term spread constructed as the average term spread over G-7 constituents Canada, Germany, Japan, and the U.K., is included alongside the U.S. term spread in regressions of future U.S. recession risk and U.S. real GDP growth. Like the U.S. term spread, U.S. recession risk significantly rises and real GDP growth slows as foreign term spreads narrow. However, the U.S. and foreign term spread are informative with respect to future U.S. recession risk at different horizons, across different sources of GDP growth, and suggest different implications for the U.S. Dollar. While both term spreads lead U.S. recessions, the U.S. term spread leads the foreign yield term spread, consistent with U.S. spillovers transmitting via the global financial cycle [Miranda-Agrippino and Rey, 2020]. In addition, foreign term spreads lead underlying components of U.S. economic activity differently than the U.S. term spread. For instance, smaller foreign term spreads lead persistent declines in U.S. exports and rest of the world FDI in the U.S., but the same is not true of U.S. term spreads. The U.S. and foreign term spreads also have asymmetric implications for the exchange rate. A decrease in the U.S. term spread significantly appreciates the Dollar, while a similar decrease in the foreign term spread does not result in a statistically significant depreciation of the Dollar. That a decrease in the foreign term spread does not lead to a significant Dollar depreciation is consistent the observed reduction in U.S. exports and FDI inflows that also follow a decrease in the foreign term spread. These patterns when taken together suggest that foreign term spreads embed growth spillovers from the U.S. and the resulting slowdowns abroad amid a stronger Dollar spill back to the U.S. in the form of weaker foreign demand.

That the U.S. yield curve leads economic activity in the United States is well established.[1] Bordo and Haubrich [2008a] and Bordo and Haubrich [2008b] find that the predictive power

[1]Prominent early studies include Harvey [1988], Harvey [1989], Stock and Watson [1989] Estrella and Hardouvelis [1991], and Estrella and Mishkin [1998].

of the yield curve dates back to the 19th century while Chauvet and Potter [2002] and Giacomini and Rossi [2006] show that the relationship between the yield curve and economic activity varies over time. Rudebusch and Williams [2009] find that simple yield curve models outperform professional forecasters. Several explanations have been put forth to account for this stylized fact. For example, the yield curve may predict economic activity by compressing bank interest margins and risk-taking [Adrian et al., 2019], or by reflecting monetary policy expectations embedded in the term structure of interest rates [Wright, 2006]. For instance, short-term rates rise in the face of inflation but long-term rates fall as markets anticipate that the Fed will reverse course as tighter monetary policy eventually reigns in prices or slows economic activity. The yield curve might predict economic activity through term premium fluctuations caused by cyclical inflation variability [Hamilton and Kim, 2002], or because it reflects expectations over consumption growth [Harvey, 1988; de Lint and Stolin, 2003].

A growing literature, including Bernard and Gerlach [1998], Chinn and Kucko [2015], Bordo and Haubrich [2022] and Hasse and Lajaunie [2022] examine whether yield curve predictability holds across countries. However, these studies restrict themselves to testing within-country predictability, or the predictive content of the domestic yield curve on domestic economic activity. Bernard and Gerlach [1998] and Mehl [2009] test whether U.S. and European term spreads predict recessions in other countries and find that they do. Christiansen [2013] finds that U.S. and German term spreads predict simultaneously occurring recessions across countries. But these studies do not consider whether or how foreign term spreads predict U.S. economic conditions.

We extend the literature by documenting that non-U.S. yield curves contain distinct information about U.S. recessions. The contribution of this paper is therefore most closely related to Plosser and Rouwenhorst [1994], which finds that a global term spread predicts industrial production in a number of advanced economies including the United States. We build on these findings along several dimensions. First, by compiling a quarterly data set that considers a rich set of indicators found to lead recessions alongside the U.S. yield curve, we show that foreign yield curves predict U.S. recessions both in-sample and out-of-sample. Moreover, the foreign term spread is a better predictor of U.S. recessions occurring within the next year than the U.S term spread which better signals U.S. recessions over longer horizons. The predictive content of the foreign term spread persists after controlling for other leading recession indicators including the U.S. term spread, the Federal Funds Rate, near-term spreads, stock market returns and volatility, crude oil prices, and aggregate financial conditions. we also provide an application of the modeling framework to easily produce real-time forecasts or nowcasts of current U.S. recession probabilities.

Why do foreign yield curves predict U.S. recessions? Harvey [1991], Plosser and Rouwenhorst [1994] and others suggest that U.S. and foreign yield curves are governed by a global common factor, or world interest rate, which captures common financial and business cycle fluctuations across countries. Miranda-Agrippino and Rey [2020] further argues that the U.S. is the driving force behind these global common fluctuations. Consistent with this explanation, we find that the U.S. term spread significantly leads the foreign term spread. A smaller U.S. term spread also leads to future U.S. Dollar appreciation that can put further pressure on foreign economies through both trade and financial channels [Avdjiev et al., 2019; Bruno and Shin, 2021]. By contrast, a smaller foreign term spread does *not* induce a significant U.S. Dollar depreciation. Moreover, we present evidence of spillbacks to the U.S., thereby extending this logic. Using local projection methods [Jordà, 2005], both U.S. and foreign term spreads are found to significantly lead U.S. real GDP growth. However, they lead the underlying components of U.S. GDP in starkly different ways. Smaller foreign term spreads predict significant, persistent contractions in U.S. real exports and wider trade deficits while smaller U.S. term spreads predict a temporary expansion of exports. Foreign term spreads do not have a significant relationship with U.S. consumption while U.S. term spreads do. Both U.S. and foreign term spreads significantly lead domestic U.S. investment. By contrast, only smaller foreign term spreads lead to significantly lower foreign direct investment to the U.S. from the rest of the world, which is then linked to fixed investment [Desai et al., 2005]. These patterns across underlying sources of U.S. economic activity suggest that foreign term spreads help predict U.S. recessions not only due to global common factors, but also through cross-border spillbacks. Foreign yield curves are affected by U.S. conditions but also spill back to the U.S. as growth slows abroad, which in conjunction with a stronger Dollar, curtails foreign demand. That said, the aggregate level of the data does limit the degree of causal interpretation that can be drawn on the mechanisms at play.

The rest the paper is structured as follows. Section 2 discusses construction of U.S. and foreign term spreads. Section 3 covers the data, empirical methodology, and main results on recession predictability. Section 4 inspects the mechanisms behind the predictive nature of foreign term spreads for U.S. recession risk. Section 5 concludes.

2 U.S. and Foreign Yield Curves

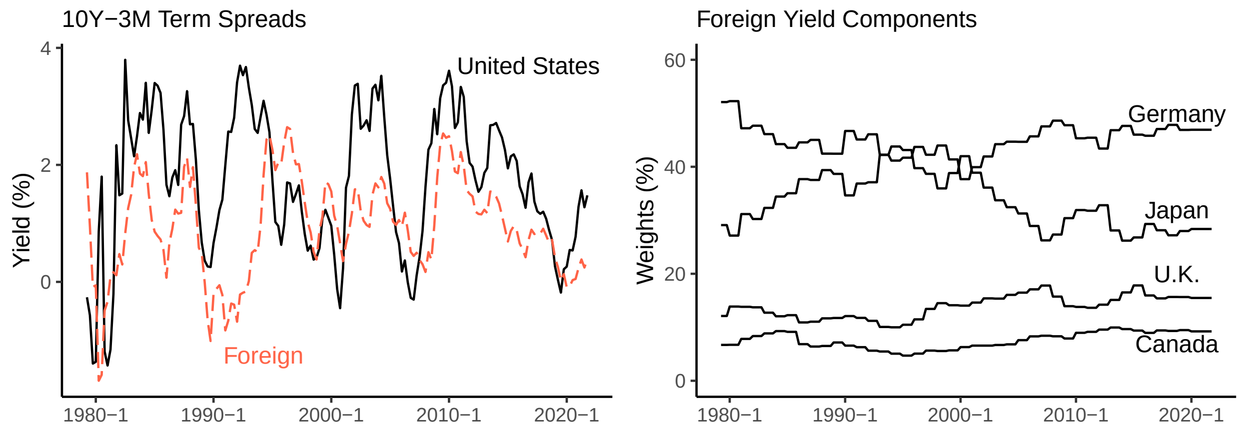
To measure the slope of sovereign yield curves, we construct a standard term spread for several countries. The U.S. term spread (USTS) is calculated by taking the difference between the 10-year Treasury yield and 3-month Treasury yield.[2] The foreign term spread (FTS) is

[2] Bauer et al. [2018] among others document the superior predictive content of term spreads constructed using the 3-month yield.

defined as:

$$FTS_t = \mathcal{Y}_t^{10Y} - \mathcal{Y}_t^{3M}, \text{ where } \mathcal{Y}_t^{\tau} = \sum_{k=1}^{K} w_k y_{k,t}^{\tau}, \tag{1}$$

Figure 1: U.S. and Foreign 10-year-3-month Term Spreads



Left-panel: United States term spread (solid) and foreign term spread (dashed). Foreign term spread is computed as in Equation 1. Right-panel: GDP-based weights across non-U.S. G7 constituents assigned to each foreign yield component of the foreign term spread. The weight assigned to the German term spread is the sum of Germany, France, and Italy GDP. Date range: 1979Q2 to 2021Q4.

where $y_{k,t}^{\tau}$ is the maturity $\tau \in \{3M, 10Y\}$ bond yield of country k. In our setting, $K = 4$ countries representing non-U.S. constituents of the G-7: Canada, Germany, Japan, and the U.K. We do not include yields of France and Italy to ensure the term spread is devoid of credit risk. Instead, German yields are used to represent the three Euro Area constituents. As a result, the FTS is the GDP-weighted average term spread over these four non-U.S. countries dependent on weights w_k which sum to 1. GDP-weights vary over time and the weight on German yields incorporate Italy and France GDP to account for all three Euro Area G-7 constituents.[3] Figure 1 left-panel plots the USTS and the FTS, respectively. The two series are positively correlated (0.38, t-stat of 5.38), consistent with a common factor driving interest rates globally. The right-panel plots the weights assigned to each foreign term spread. The weights are time-varying but persistent over the 40-year sample period, with German and Japanese yields always receiving the greatest weight and Canada receiving

[3]GDP data is in U.S. Dollar terms and annual frequency, converted to quarterly frequency by forward-filling the previous annual value. For robustness, export-based weights are also considered and results are nearly unchanged. We also consider constructing the FTS using Principal Components Analysis which suggests roughly equal weights across non-U.S. term spreads and results in similarly significant but slightly smaller effects on recession probabilities and GDP growth than those from the GDP-weighted FTS.

the smallest.

3 Data, Methodology, and Baseline Results

3.1 Data and Methodology

Probit regressions are used to estimate the relationship between U.S. and foreign yield curves and NBER dated U.S. recessions from 1979Q2-2021Q4. The dependent variable is a binary indicator which takes a value of 1 if an NBER defined recession occurs at some point during quarters t through $t+3$. Intuitively, the model asks whether the USTS or the FTS have been historically predictive of a U.S. recession occurring at any point within the current and next three quarters, i.e., the following year.[4] The probit regression follows that of Wright [2006]:

$$P(NBER_{t,t+3} = 1) = \Phi(\alpha_0 + \beta_1 USTS_{t-1} + \beta_2 FTS_{t-1} + \boldsymbol{X}_{t-1}\boldsymbol{\beta_3}), \tag{2}$$

where $NBER_{t,t+3}$ is the U.S. recession indicator variable, $USTS_{t-1}$ is the U.S. term spread, FTS_{t-1} is the foreign term spread, $\boldsymbol{X}_{t-1}$ includes additional indicators predictive of U.S. recessions: the Federal Funds Rate (FFR), the U.S. near-term spread measured as the difference between the 2-year and 3-month U.S. Treasury yield, S&P 500 stock market returns, the quarterly realized volatility of daily S&P 500 returns, Brent crude oil returns, and the Chicago Fed National Financial Conditions Index. The FFR and the near-term spread, reflecting the stance of monetary policy, have been shown to predict recessions [Ang et al., 2006; Wright, 2006; Engstrom and Sharpe, 2019; Cooper et al., 2020], while stock market volatility is associated with forward-looking sentiment and uncertainty [Karnizova and Li, 2014; Bluedorn et al., 2016]. Tighter financial conditions also lead recessions [Favara et al., 2016; Borio et al., 2020]. All regressors are lagged by one quarter and all data are publicly available, summarized in Table 1.[5]

[4] This approach differs from studies which estimate the probability at exactly quarter $t+h$. We present the corresponding results in Table A.1. In general, the finding that the FTS is an important predictor of U.S. recessions is sustained.

[5] Quarterly data on U.S. real GDP and bond yields from 1979-2019 are from the GVAR data base [Mohaddes and Raissi, 2020] and updated through 2021 using data from FRED. All other data including NBER recession dates are taken from FRED, with S&P 500 stock market data taken from Yahoo! Finance. Quarterly realized volatility of S&P 500 returns is estimated as the standard deviation of daily returns within each quarter.

Table 1: Data Summary

Variable	T	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
U.S. Term Spread	171	1.714	1.201	−1.430	0.865	2.685	3.797
Foreign Term Spread	171	0.941	0.848	−1.690	0.386	1.556	2.645
Fed Funds Rate	171	4.583	4.123	0.060	1.000	6.657	17.780
Near-term Spread	171	0.758	0.648	−0.823	0.304	1.048	3.313
S&P 500 Returns	171	2.251	8.012	−26.431	−0.976	7.375	18.952
S&P 500 Volatility	171	15.627	8.708	5.550	10.515	17.516	67.326
Brent Oil Returns	171	0.940	15.351	−70.374	−5.560	9.555	39.252
Financial Conditions	171	−0.116	0.888	−1.026	−0.636	−0.006	3.322

The U.S. term spread is the 10-year Treasury yield minus 3-month Treasury yield. The Foreign term spread is the GDP-weighted average 10-year minus 3-month yield of non-U.S. G-7 constituents described in Equation 1. Near-term spread is the 2-year Treasury yield minus the 3-month Treasury yield. S&P 500 and Brent oil returns are computed as quarterly log-differences. Quarterly realized volatility of S&P 500 returns is estimated as the standard deviation of daily returns within each quarter. Financial conditions refer to the Chicago Fed NFCI. All variables are in units of percentage points except financial conditions.

3.2 In-Sample Results

Table 2 reports estimates from alternative probit regression specifications. The significant negative coefficient on $USTS_{t-1}$ implies that a steeper (flatter or inverted) U.S. yield curve is associated with lower (higher) recession risk. The FTS is also found to be a statistically significant predictor of U.S. recessions and its inclusion increases the McFadden R^2 from 8% to about 16% (columns 1 and 3). Like the U.S. yield curve, the negative coefficient on FTS_{t-1} implies that U.S. recession risk rises as foreign yield curves flatten.

Columns 3 and 4 of Table 2 show that when the FTS enters directly, the coefficient on the USTS falls substantially. When both the USTS and FTS are included, the FTS is a stronger predictor of U.S. recessions occurring within the next year than the USTS. In the fully specified model (column 4), the U.S. term spread is no longer a significant predictor of recessions while the FTS remains statistically and economically significant.

These results hold when predicting whether a recession occurs in the exact quarter $t+h$ instead of within the period between quarter t to $t+h$. We present these results using an alternative recession indicator out to 8 quarters ahead in Table A.1 of the Appendix. Table A.2 presents additional results from including multiple lags of the USTS, FTS, and other regressors. It's worth noting that the strength of the USTS as a recession predictor appears to increase with the prediction horizon while the FTS is strongest over shorter horizons.

To compare model performance, Figure 2 presents receiving operating characteristic (ROC) curves of the models in columns 1, 3 and 4 of Table 2: the univariate USTS model (M1), the model with the USTS and FTS (M2), and the model with the USTS, FTS, and

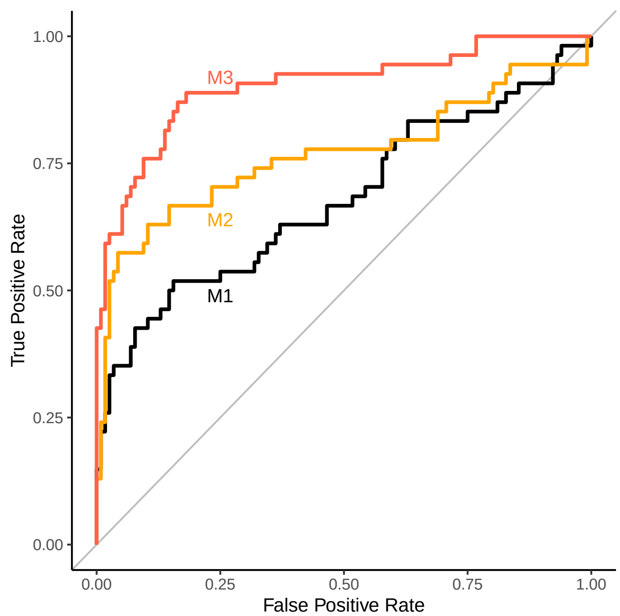
Table 2: Probit Regressions of NBER Recessions

	Dependent variable:			
	NBER Recession within 4 Quarters $[t, t+3]$			
	(1)	(2)	(3)	(4)
Constant	0.115	0.097	0.363	0.694
	(0.209)	(0.200)	(0.249)	(0.705)
U.S. Term Spread $(t-1)$	-0.362^{***}		-0.224^{*}	-0.014
	(0.119)		(0.126)	(0.250)
Foreign Term Spread $(t-1)$		-0.666^{***}	-0.546^{***}	-0.595^{**}
		(0.208)	(0.200)	(0.241)
Fed Funds Rate $(t-1)$				-0.007
				(0.100)
Near-Term Spread $(t-1)$				-0.699
				(0.670)
S&P 500 Returns $(t-1)$				-0.007
				(0.019)
S&P 500 Volatility $(t-1)$				0.016
				(0.019)
Brent Oil Returns $(t-1)$				0.008
				(0.008)
Financial Conditions $(t-1)$				1.849^{***}
				(0.449)
Observations	170	170	170	170
Log Likelihood	-97.285	-92.318	-89.456	-58.070
Akaike Inf. Crit.	198.569	188.636	184.911	134.140
McFadden R^2	0.085	0.131	0.158	0.453

Estimates from the probit regression specified in Equation 2. NBER recession indicator takes a value of 1 if a recession occurs at any point within the $[t, t+3]$ quarterly interval, inclusive. U.S. term spread is the 10-year-3-month spread and the foreign term spread is computed as in Equation 1. McFadden R^2 computed as $1 - \frac{\text{residual deviance}}{\text{null deviance}}$. Newey-West standard errors with one lag reported with '*','**','***' corresponding to 10%, 5%, and 1% significance, respectively. Sample period from 1979Q2-2021Q4.

additional indicators (M3). Compared to M1, M2 has meaningfully higher true positive rates when false positive rates are 15-50% and lower false positive rates when true positive rates are 30-75%. That is, the model which includes both the USTS and FTS (M2) tends to perform better than the USTS-only model (M1) in many instances by eliminating some false positives that might arise when just one yield curve flattens or inverts. M3 dominates both M1 and M2, unsurprisingly.

Figure 2: ROC Curves



Receiving operating characteristic (ROC) curves for models (1), (3), and (4) denoted M1, M2, and M3, respectively from Table 2. The 45-degree line represents a random or non-diagnostic prediction.

3.3 Out-of-Sample Performance

In addition to the in-sample analysis, a pseudo out-of-sample analysis is performed in order to further guard against spurious results arising from over-fitting. The sample is split into a training period and testing period following Christiansen et al. [2014] and others. One advantage of using directly observed financial and commodity market variables as recession predictors is that they are typically sampled in real-time with minimal revisions. However, it should be noted that NBER recession dating is typically done retroactively, and some of the variables are routinely revised and hence this exercise is *pseudo* out-of-sample.[6] Three

[6] While this exercise helps guard against over-fitting, it is not a true out-of-sample exercise because data is revised over time and therefore the estimation of the model may still be based on information that would not otherwise be available to the econometrician by the end of the training period.

different training periods are chosen to vary the number of observations used to estimate the model, starting from 1979Q1 and ending in either: 1991Q3, 1996Q3, or 2004Q1. This allows the model to be estimated on 50, 70, and 100 observations, respectively while keeping the latest three NBER recessions in the testing period which goes from the end of the training period through 2021Q4.

Three models are compared. The benchmark model is the simple univariate probit regression of NBER recessions on the USTS (column 1 of Table 2). The second model is a univariate probit regression of NBER recessions on the FTS (column 2 of Table 2). The third model is a probit regression of NBER recessions on both the USTS and FTS (column 3 of Table 2). Term spread variables are lagged one quarter. Forecast accuracy is based on two standard metrics. The first is the area under the ROC curve (AUC) which measures the ability of a binary classifier to distinguish between classes, where values range between 0.50 and 1, with 0.50 indicating non-informative/random predictions and 1 indicating perfect predictive ability. The second metric is the root mean square error metric (RMSE) defined as:

$$RMSE = \sqrt{\frac{\sum_{t=1}^{T}[P(NBER_{t,t+3} = 1|\omega_{t-1}) - \mathbf{1}_{t,t+3}^{NBER}]^2}{T_{test}}}, \tag{3}$$

which is based on the forecast error given in the numerator calculated as the model-implied recession probability minus the actual realizations of NBER recessions within 4 quarters, i.e. the dependent variable from (2). The term ω_{t-1} refers to the information set based on the right-hand-side of the regression models in (2). A completely naive model which always predicts that the probability of recession equals 0 has RMSEs of 0.498, 0.536, and 0.531 under training periods of 50, 70, and 100 observations, respectively.[7]

The Diebold-Mariano test (DM) for forecast accuracy is used to conduct inference on forecast accuracy of the FTS-only model against the USTS-only model [Diebold and Mariano, 2002]. The alternative hypothesis that is tested is that the forecasts provided by the USTS-only model, which is considered the baseline, are less accurate than the forecasts provided by the FTS-only model. The Clark-West test (CW) is used to examine the forecast accuracy between nested models, namely the USTS+FTS model against the USTS-only model [Clark and West, 2007]. Table 3 reports AUCs, RMSEs and the test statistics from DM and CW tests for varying training period lengths. Not only does including the FTS with the USTS in probit models significantly increase the AUC and reduce the RMSE of recession predictions over the USTS-only model, but a model with *only* the FTS is also significantly more accurate

[7] The RMSE under this "no recession" benchmark can be interpreted as the square root of the proportion of incorrectly predicted quarters where 0 was predicted but the actual value was 1.

Table 3: Pseudo Out-of-Sample Performance Statistics

Training Period	Training T	Test T	$USTS$ AUC	$USTS$ RMSE	$USTS$ –	FTS AUC	FTS RMSE	FTS DM	$USTS+FTS$ AUC	$USTS+FTS$ RMSE	$USTS+FTS$ CW
1979Q2-1991Q3	50	121	0.636	0.494	–	0.701	0.437	2.496***	0.709	0.434	4.379***
1979Q2-1996Q3	70	101	0.616	0.472	–	0.725	0.420	2.665***	0.680	0.436	3.702***
1979Q2-2004Q1	100	71	0.648	0.439	–	0.765	0.413	1.871**	0.729	0.416	2.199***

Pseudo out-of-sample area-under-the-ROC-curve (AUC) statistics and root mean square errors (RMSE) reported, along with Diebold-Mariano test statistics (DM) [Diebold and Mariano, 2002] testing the alternative hypothesis that the FTS model is more accurate than the $USTS$ model. Clark-West test statistics adjusted for heteroskedasticity and autocorrelation (CW) [Clark and West, 2007] are reported for testing the alternative hypothesis that the $USTS + FTS$ model is more accurate than the $USTS$ model. Term spread variables are lagged one quarter. '*','**','***' correspond to an improvement in forecast accuracy over the $USTS$ model at 10%, 5% and 1% significance, respectively.

at forecasting U.S. recessions than the USTS-only model. This matches the in-sample results finding that the FTS has a larger and more significant coefficient than the USTS in probit regressions of U.S. recessions using the full sample reported previously. Moreover, models with the FTS significantly outperform the USTS-only model regardless of the training period length. The RMSE reductions are also sizable. As the training set increases, the percentage RMSE reduction under the USTS+FTS model, compared to the USTS-only model, is -12.2%, -7.7%, and -5.2%, respectively. The percentage RMSE reduction under the FTS-only model, compared to the USTS-only model, is -11.5%, -11%, and -6%, respectively.

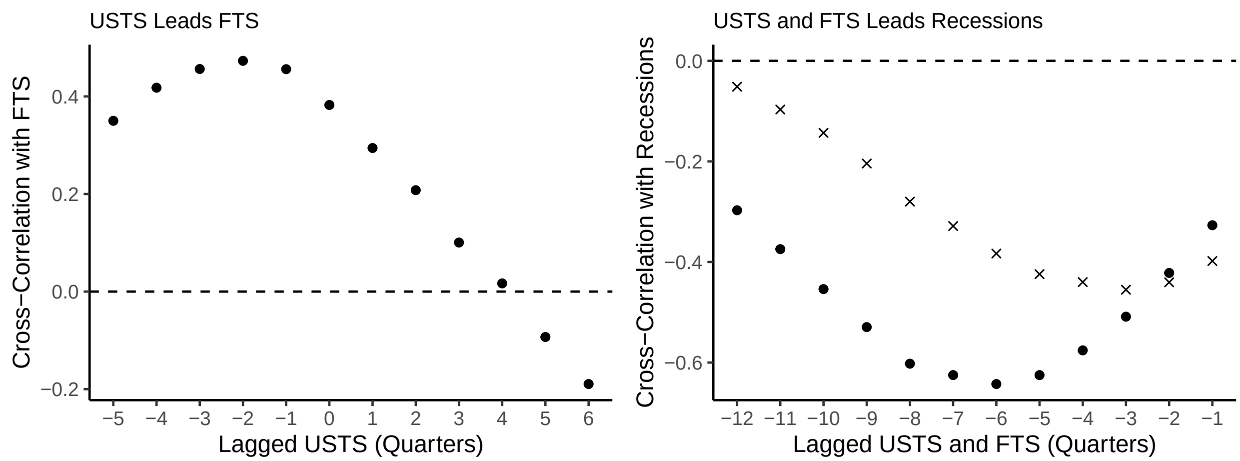
4 Why Do Foreign Yield Curves Predict U.S. Recessions?

Foreign yield curves might predict U.S. recessions through cross-border spillovers, or because they contain information common to but asynchronous with the U.S. yield curve. Plosser and Rouwenhorst [1994], for instance, argued for the latter explanation as the existence of a world yield curve would capture the correlated component of business cycle fluctuations across countries in a forward-looking manner. As a result, foreign and U.S. yield curves could jointly predict U.S. recessions because their predictive power is maximized at varying lags, despite containing the same information. The global financial cycle originating in the U.S. as argued by Miranda-Agrippino and Rey [2020] would suggest that the U.S. term spread leads the foreign term spread, for example. Alternatively, it may also be the case that foreign yield curves predict U.S. recessions because they predict recessions in their respective countries which then spill back to the United States through economic linkages. Both the 'common factor' and 'cross-border spillover' hypotheses are explored in this section.

4.1 Spillovers: U.S. Yield Curves Lead Foreign Yield Curves

The statistically significant correlation between the USTS and FTS reported in Figure 1 provides some cursory evidence of a common factor driving U.S. and foreign term spreads. In addition, the probit regression coefficient on USTS weakens from -0.362 to -0.224 after including the FTS in the baseline regressions shown in Table 2, again suggesting the presence of significant co-movement between U.S. and foreign term spreads.

Figure 3: Cross-Correlation Coefficients



The left-panel shows the cross-correlation function of lags/leads of the U.S. term spread with the foreign term spread. The right-panel shows the cross-correlation functions of lags/leads of the U.S. term spread (circles) and the foreign term spread (crosses) with U.S. recessions occurring within four quarters.

Figure 3 displays the cross-correlation coefficients summarizing the relationship between the USTS and FTS across different lags. The left panel shows that the USTS leads the FTS by up to two quarters. In other words, $USTS_{t-2}$ and FTS_t share the highest correlation, suggesting that information in the USTS may spill over to the FTS. Specifically, the USTS spills over to the FTS but not *vice versa*. The right-panel of Figure 3 shows that both term spreads are negatively correlated with future U.S. recessions, but the strength of the correlation varies with the lag length. The USTS starts signaling future recessions much earlier than the FTS, roughly six quarters ahead. By contrast, the FTS has a stronger negative correlation with U.S. recessions within the next year with just a one to two quarter lag. Therefore, information about U.S. recessions appears to be embedded in the USTS first, and then the FTS with a lag.

To examine these similar yet asynchronous effects of term spreads more precisely, we estimate local projection regressions [Jordà, 2005] for real U.S. GDP growth of the form:

$$\ln RGDP_{t+h} - \ln RGDP_t = \tilde{\alpha}_0^h + \tilde{\beta}_1^h USTS_t + \tilde{\beta}_2^h FTS_t + \boldsymbol{X}_t \tilde{\boldsymbol{\beta}}_{\boldsymbol{3}}^{\boldsymbol{h}} + \epsilon_{t+h}, \tag{4}$$

for $h = 1, ..., 12$ quarters. It is worth noting that the probit models for recession prediction have a 4-quarter or 1-year horizon because that is the horizon at which term spreads are typically most predictive and at which the forecasts are practically useful.[8] That said, we extend the horizon of the local projections beyond 1 year to better differentiate across explanations for why the FTS has predictive power. The right-hand-side variables are the same as in (2), and $\ln RGDP_{t+h} - \ln RGDP_t$ denotes logged U.S. real GDP growth over the interval $[t, t+h]$.[9] Due to the large real GDP growth realizations observed during the 2020 COVID-19 pandemic, the baseline model is estimated on data from 1972-2019 to reduce the influence of outliers on the standard errors. Point estimates are also reported for the entire sample period through 2021, and they are nearly unchanged. We study the response of GDP growth to term spreads because of the close link between GDP growth and recessionary conditions. The latter is often, though not always, partially determined by the observation of contracting real GDP growth, though this information is a single input taken alongside the status of several other economic measures when determining NBER-defined recessions.

We consider local projections over the VAR approach considered by Harvey [1991] and others for several reasons. First, the local projection specification closely resembles the linear analogue to the probit specification used to the previous sections to analyze recession predictability. Local projections and VARs produce asymptotically equivalent IRFs [Plagborg-Møller and Wolf, 2021], however, local projections more easily allow for non-linear specifications and they do not impose restrictions on the shape of the IRF in finite samples. Third, the flexibility of the local projections approach allows for a middle ground that lets us include several other leading indicators while using quarterly time series data without running into overparameterization problems that would arise from a VAR estimated on all of the variables under consideration. However, the local projections approach does not provide any particular advantage over VARs and traditional Granger-causality tests for adducing temporal precedence.[10]

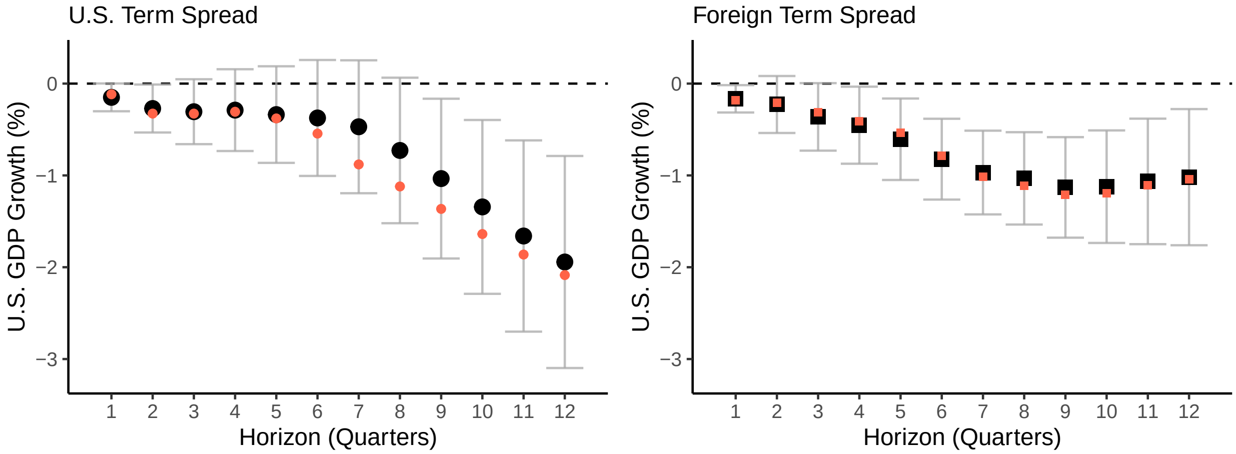
Figure 4 traces the local projection estimates of a 1 percentage point decrease of the USTS and FTS on real GDP growth, i.e. the sequence of $-\tilde{\beta}_1^h$ and $-\tilde{\beta}_2^h$ respectively along with 95% confidence bands. The larger points refer to point estimates over 1979-2019 and the smaller

[8]Most results in the literature tend to be concentrated around a 1-year recession forecast horizon.

[9]This specification is akin to a more traditional local projection where the lagged dependent variable ($\ln RGDP_t$) is on the right-hand side of the equation with its coefficient is restricted to equal 1.

[10]Granger-causality can be inferred from local projections in a similar fashion to a standard VAR setup. Under a VAR(1), x_t Granger causes y_t if x_t is significantly associated with y_{t+1} conditional on y_t. Our local projection setup resembles the stylistic VAR approach with two differences. First, instead of estimating a single VAR, regressions are estimated for each horizon (e.g., $y_{t+1}, y_{t+2}, ..., y_{t+h}$). Second, under local projections, the coefficient on y_t is restricted to equal 1 in order to study growth rates of the dependent variable. The local projection produces H estimates of $\beta(h)$. If these are significant, they imply that x_t Granger causes y_{t+h} at horizon h subject to the restriction that the coefficient on y_t equals 1.

Figure 4: Local Projection Response of Real GDP to a U.S. Term Spread (left) and Foreign Term Spread (right) Decrease of 1 Percentage Point



Estimates $\tilde{\beta}_1^h$ and $\tilde{\beta}_2^h$, $h = 1, ..., 12$ quarters respectively from Equation 4. U.S. term spread is the 10-year-3-month spread and the foreign term spread is computed as in Equation 1. 95% Newey-West standard errors computed with one lag. Point estimates and error bands based on sample period 1979-2019 to remove influence of COVID-19 related outliers on standard errors. Smaller points refer to estimates based on full sample from 1979-2021.

points refer to estimates over 1979-2021. The left-panel shows that a U.S. term spread decrease of 1 percentage point is associated with 0.28% slower real GDP growth over a 4-quarter horizon and a 1.94% slower growth over a 12-quarter horizon. The right panel shows that a 1 percentage point smaller FTS is associated with 0.45% slower real U.S. GDP growth over a 4-quarter horizon and 1.01% slower growth over a 12-quarter horizon. Consistent with the cross-correlation functions in Table 3, the FTS has a statistically significant impact earlier, while the USTS has a statistically significant, and much larger, impact at around 10-11 quarters.

If the FTS predicts U.S. recessions solely due to containing information about U.S. recessions previously embedded in the USTS, then including additional lags of USTS in (2) might attenuate the probit regression coefficient on FTS_{t-1}. However, after augmenting the specification in column 3 of Table 2 which includes $USTS_{t-1}$ and FTS_{t-1} with additional lags of USTS: $USTS_{t-2}$ and $USTS_{t-3}$, the coefficient on FTS_{t-1} remains significant and negative.[11] While the USTS spills over to the FTS, the FTS still exhibits distinctive predictive power over U.S. recessions. One explanation may be that U.S. recessions following a flatter foreign yield curve and flatter U.S. yield curve may be compositionally different than U.S. recessions followed by a flat U.S. yield curve alone, an issue we explore in Section 4.3.

[11] The coefficient on FTS_{t-1} is -0.43, significant at the 10% level with Newey-West standard errors.

4.2 Yield Curves and the Dollar Exchange Rate

Recent findings suggest that the U.S. Dollar (USD) may mediate the international transmission of shocks via both financial and trade channels [Avdjiev et al., 2019; Bruno and Shin, 2021]. Chen and Tsang [2013] document that yield curves are significant predictors of currency returns above and beyond short-term interest rate differentials. To better understand the channels behind the recession signals in the USTS and FTS, this section studies the evolution of the USD exchange rate in response to the two term spreads. We set up a similar, parsimonious local projection specification for the nominal U.S. Dollar:

$$\ln USD_{t+h} - \ln USD_t = \tilde{\alpha}_0^h + \tilde{\beta}_1^h USTS_t + \tilde{\beta}_2^h FTS_t + \tilde{\beta}_3^h \ln USD_{t-1} + \epsilon_{t+h}, \tag{5}$$

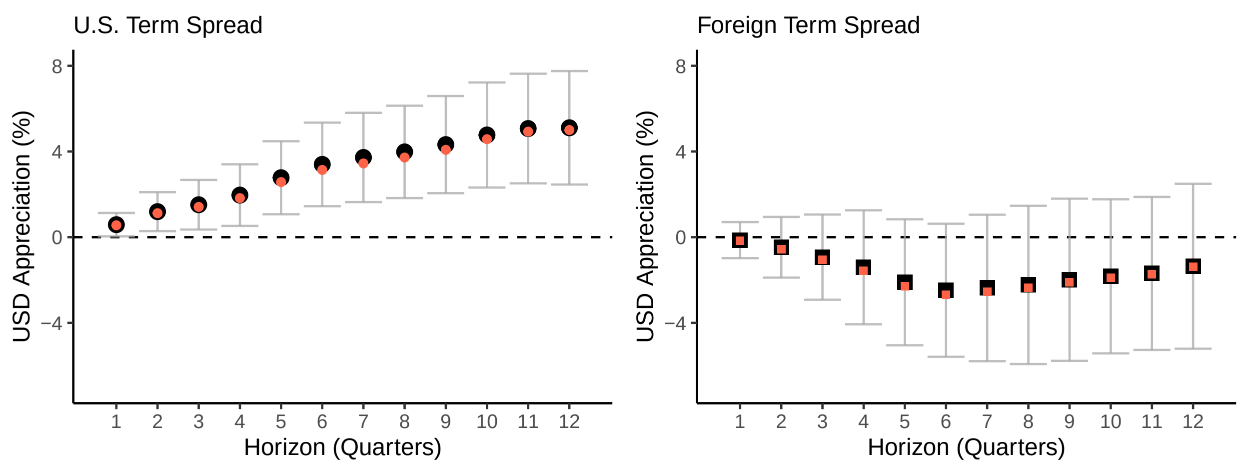
where the logged USD return from t to $t+h$ is regressed on the U.S. and foreign term spread variables. Like the construction of the FTS, the USD exchange rate is measured as the Dollar vis-a-vis a GDP-weighted basket of non-U.S. G7 constituent currencies. According to uncovered interest rate parity (UIP), a widening of the U.S.-foreign interest rate differential should lead to future USD depreciation. However, empirically we tend to observe the failure of UIP and often the opposite result: higher U.S. interest rates lead to USD appreciation. Moreover, the response of exchange rates to interest rate differentials vary by bond maturity [Chinn and Meredith, 2005]. Therefore *ex ante*, it is unclear what the impact on the Dollar might be. Smaller term spreads that lead recessions tend to be driven by the rising short-term rate leg. As a result, flatter yield curves may reflect rising short-term rates and possibly wider U.S.-foreign short-term yield differentials.

Figure 5 left panel shows that a 1 percentage point smaller U.S. term spread is associated with significant future USD appreciation. A smaller foreign term spread is, however, associated with statistically insignificant future USD depreciation (right panel) which in absolute terms is quantitatively smaller than the effect following a change in the U.S. term spread. Since smaller term spreads are largely a function of higher short-term rates, it follows that higher short-term U.S. rates associated with flatter U.S. yield curves may lead to further USD appreciation, which is consistent with the vast literature on UIP violations. However, the right panel of Figure 5 shows that flatter foreign yield curves (holding U.S. yields fixed) do *not* lead to a commensurate depreciation of the Dollar.

The effects of U.S. and foreign yields on the Dollar are therefore asymmetric. Smaller U.S. term spreads foreshadow a stronger Dollar, but smaller foreign term spreads do not lead to a significantly weaker Dollar. Taken together with our other findings, it appears that a flatter U.S. yield curve foreshadows a U.S. growth slowdown and significant Dollar appreciation.[12] This U.S. growth slowdown spills over internationally with a lag in the form of a flatter foreign yield curve but without a symmetric Dollar depreciation. The stronger Dollar, as a result, may add further pressure to foreign growth prospects by reducing dollar-invoiced import demand of foreign countries, which can spill back to the U.S. via trade and investment channels as we show in the following section. Such asymmetric strength of the Dollar may be a consequence of its global reserve currency status [Jiang et al., 2021].

For robustness, we follow Bussiere et al. [2022] and control for global risk appetite using S&P 500 realized volatility, reported in Figure A.2, finding that local projection estimates are nearly unchanged whether financial volatility is controlled for or not. Figure A.3 replaces the nominal U.S. Dollar with the trade-weighted real effective Dollar exchange rate and shows that the results hold beyond the G-7 constituents and in real terms. Finally, the results are qualitatively similar and strengthen further if we include short-term U.S. and foreign interest rates as additional controls.

Figure 5: U.S. Dollar Response to U.S. Term Spread (left) and Foreign Term Spread (right) Decrease of 1 Percentage Point



Estimates $\tilde{\beta}_1^h$ and $\tilde{\beta}_2^h$, $h = 1, ..., 12$ quarters respectively from Equation 5. U.S. term spread is the 10-year-3-month spread and the foreign term spread is computed as in Equation 1. 95% Newey-West standard errors computed with one lag. Point estimates and error bands based on sample period 1979-2019 to remove influence of COVID-19 related outliers on standard errors. Smaller points refer to estimates based on full sample from 1979-2021.

[12]This argument does not rule out other sources of asymmetry. For instance, Engel and Wu [2018] argue that government bonds exhibit different levels of liquidity that might explain sources of strength separate from interest rates alone.

4.3 Yield Curves and Underlying GDP Components

The USTS leads the FTS, but the FTS continues to inform U.S. recessions above and beyond the USTS. One potential explanation may lie in how foreign economic conditions spill back to the United States. For instance, if foreign yield curves inform foreign economic conditions that affect U.S. recession risk because the U.S. 'imports' recessions from foreign countries via economic linkages, then foreign yield curves may affect the underling components of U.S. GDP in different ways than the U.S. yield curve does. For example, flatter foreign yield curves may be more informative of future export growth in the United States, while a flatter U.S. yield curve may be a better predictor of domestic consumption.

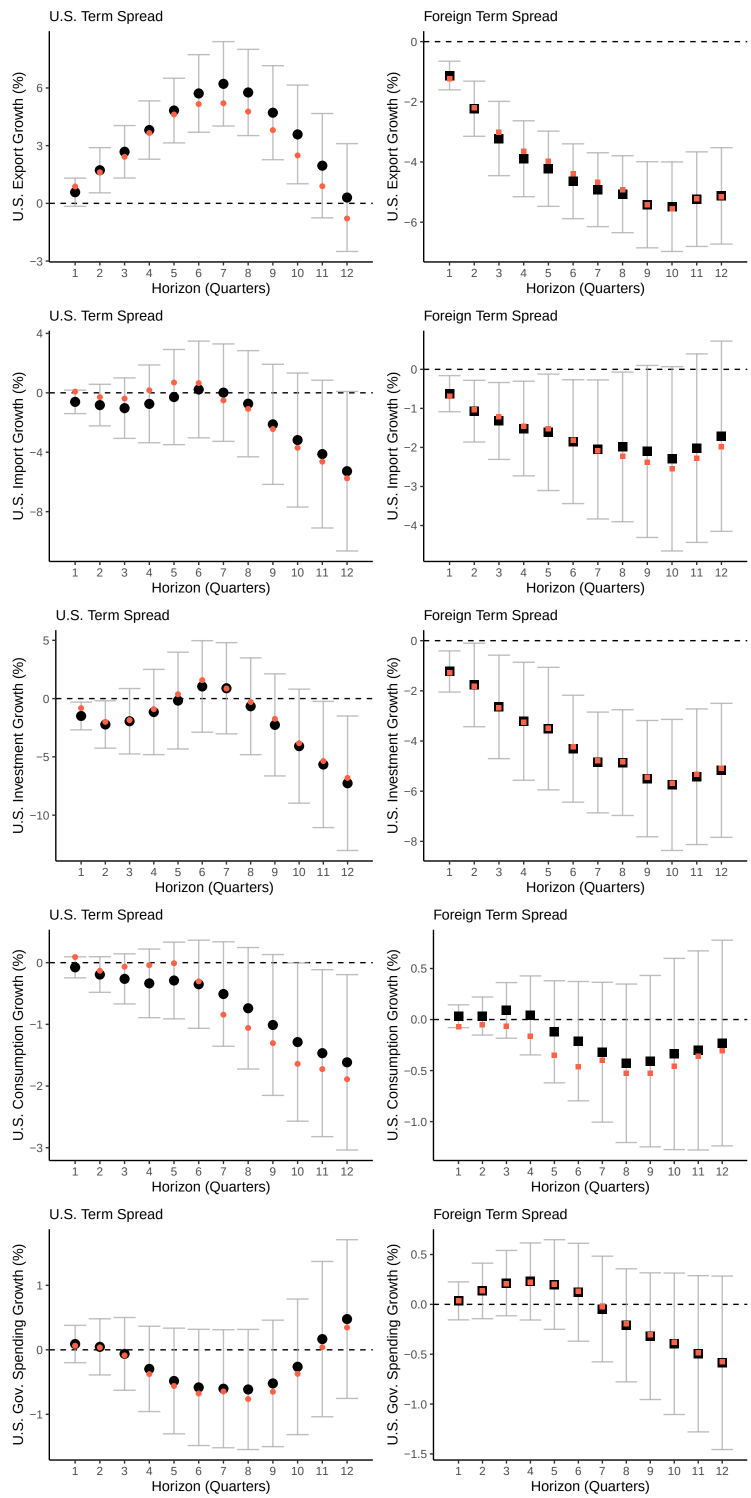
In this section, we extend our analysis to examine how the USTS and FTS affect future growth of the underlying GDP components broken down into the following categories: exports, imports, investment, consumption, and government spending:

$$\ln Y_{t+h} - \ln Y_t = \tilde{\alpha}_0^h + \tilde{\beta}_1^h USTS_t + \tilde{\beta}_2^h FTS_t + \boldsymbol{X}_t \boldsymbol{\tilde{\beta}_3^h} + \boldsymbol{Y_t}^{-} \boldsymbol{\tilde{\beta}_4^h} + \epsilon_{t+h}, \tag{6}$$

where Y_t denotes a GDP component. The specification in (6) is the same as that in (4) except on the right-hand side we additionally condition on the GDP components of GDP that is not the dependent variable, denoted $\boldsymbol{Y_t}^{-}$. All GDP components are logged and measured in real terms. Predicting GDP components using the term spreads may help shed light on potential underlying mechanisms at play because recessions are often, but not always, partially defined by whether U.S. real GDP growth is contracting. In the simplest case, the relationship between terms spreads and underlying GDP components is informative since these components feed into top-line GDP growth in an additive manner. However reality is more complex as general equilibrium effects, interactions, and interdependencies make the true relationship between the underlying GDP components and GDP growth (and thus recession risk) difficult to identify in a clean way. That said, studying the response of GDP growth and its underlying components still serves a useful purpose by allowing some degree of discernment between possible mechanisms through which the FTS and USTS lead U.S. recessions.

Figure 6 reports the local projections following a 1 percentage point decrease in the term spread on the underlying real GDP components. The differential impact on real exports is most striking. A smaller USTS is associated with temporarily increased real exports (a 3.8% increase after 4 quarters, 0.30% increase after 12 quarters) and a reduction in the U.S. trade deficit as the response of real imports is flat or decreasing but to a lesser degree. The response of exports is transitory as the estimate is statistically insignificant by quarter 12. By contrast, a smaller FTS is associated with a significant drop in real exports (a 3.9% decrease

Figure 6: Local Projection Estimates for GDP Components: U.S. Term Spread (left) and Foreign Term Spread (right) Flattening of 1 Percentage Point



Estimates $\tilde{\beta}_1^h$ and $\tilde{\beta}_2^h$, $h = 1, ..., 12$ quarters respectively from Equation 6. U.S. term spread is the 10-year-3-month spread and the foreign term spread is computed as in Equation 1. 95% Newey-West standard errors computed with one lag. Point estimates and error bands based on sample period 1979-2019 to remove influence of COVID-19 related outliers on standard errors. Smaller points refer to estimates based on full sample from 1979-2021.

after 4 quarters, 5.2% decrease after 12 quarters) and an expansion of the U.S. trade deficit as it is also associated with decreasing real imports but to a lesser degree than the impact on exports. Unlike the transitory response of real U.S. exports to a smaller USTS, the response of real exports to a smaller FTS is persistent.

The USTS has a stronger relationship with future real investment (a change in investment of 7.32% after 12 quarters per 1 percentage point change in the USTS), leading it by roughly 6 quarters, while the FTS has a significant although relatively weaker relationship with investment (a change in investment of 5.16% after 12 quarters per 1 percentage point change in the FTS), and the lead time is substantially shorter. These results align well with the asynchronous lead-lag relationships reported earlier between U.S. and foreign term spreads with U.S. aggregate GDP growth. A flatter U.S. yield curve is associated with significantly lower real consumption several quarters ahead (a change in consumption of 1.62% after 12 quarters per 1 percentage point change in the USTS), while the relationship between the FTS and U.S. consumption is statistically insignificant. The responses of government spending to the term spreads are quantitatively smaller and generally statistically insignificant.

The sharp contraction in exports following a smaller FTS which does not occur amid a smaller USTS is consistent with a growth slowdown abroad reflected by foreign term spreads in a forward-looking manner. A growth slowdown abroad that constrains foreign imports could reduce U.S. exports and widen the U.S. trade deficit. This result is also consistent with the insignificant U.S. Dollar depreciation realized following a smaller FTS which can add further downward pressure on U.S. exports. This distinct international channel through which the FTS impacts U.S. economic activity suggests, though not causally, that cross-border spillbacks to the U.S. play an important role in explaining the predictive power of the FTS for U.S. recession risk.

While consumption and investment are well known drivers of U.S. business cycles, its worth examining whether net exports contribute meaningfully to real GDP growth in light of this relationship between foreign term spreads and net exports. Table A.3 reports the mean and volatility of quarterly real GDP growth along with the mean and volatility of the percentage point contribution of net exports to real GDP growth. Over the 1979-2019 period, the standard deviation of net exports contribution to real GDP growth was 1.02 percentage points (annualized). This is quite substantial given that the standard deviation of overall real GDP growth over the same period was equal to 2.79%. The role of net exports as a contributor to overall GDP growth is even larger around recessions. The standard deviation of the contribution of net exports to real GDP growth increases to 1.72 percentage points during recessions, and is equal to 0.86 percentage points during non-recessions. A time-series decomposition of real GDP growth into consumption, investment, net exports, and government expenditures is shown in Figure A.1 where it can be seen visually that net exports often meaningfully contribute to business cycle volatility at the margin, especially during the two recessionary periods preceding the COVID-19 pandemic.[13]

We also run local projections examining whether the relationship between the FTS and select components of GDP, namely exports, imports and investment, vary over recessionary and non-recessionary periods. To this end, we augment (6) with two additional terms: interactions of both the USTS and FTS with a binary indicator that equals 1 in quarters within four quarters of an NBER defined recession, and 0 otherwise. The goal of this exercise is to see if the predictive nature of the FTS on underlying GDP components maps to recession risk, as we assume to some extent that innovations in underlying GDP components feed into top-line GDP growth and thus recession risk. Figure A.4 reports these local projections, finding that a flattening FTS predicts even stronger downturns in U.S. exports, imports, and investment around recessions. The FTS does remain a significant leading indicator during non-recessionary periods for U.S. exports and investment, but not for imports. This suggests that sharper contractions in these underlying GDP components predicted by the foreign term spread may be more closely linked to U.S. recessions, and that foreign term spreads boost U.S. recession probabilities beyond what may be expected from GDP growth predictions alone.

4.4 Yield Curves and Foreign Investment Flows to the U.S.

Theory predicts that foreign capital flows to high interest rate countries, so foreign yield curves may potentially impact U.S. economic activity through shaping foreign investment flows. Moreover, the way foreign yield curves influence the U.S. Dollar may also factor into foreign investment decisions by altering the cost of investment for foreigners, similarly to how the Dollar influences international trade costs. While multiple mechanisms may be at play, foreign investment into the U.S. may slow if foreign economic activity slows, if the Dollar strengthens and makes foreign investment in the U.S. more expensive, or if expected returns on U.S. investments decrease relative to investments elsewhere. Shifts in U.S. and foreign yield curves may impact foreign investment in the U.S. and therefore U.S. economic activity and recession risk through each or any of these channels.

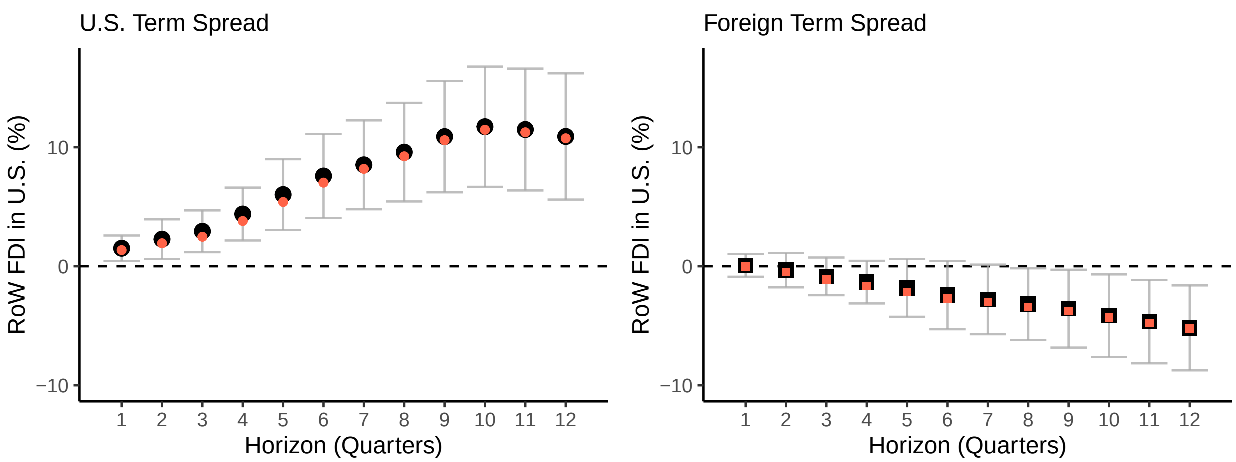
We specify the following local projection specification to analyze the response of foreign investment in the U.S. to changing term spreads:

[13] See, for example, Contessi [2008]

$$\ln FDI_{t+h} - \ln FDI_t = \tilde{\alpha}_0^h + \tilde{\beta}_1^h USTS_t + \tilde{\beta}_2^h FTS_t + \boldsymbol{X}_t \boldsymbol{\tilde{\beta}_3^h} + \tilde{\beta}_4^h \ln RGDP_t + \epsilon_{t+h}, \quad (7)$$

where FDI_t denotes rest of the world foreign direct investment (FDI) to the United States. FDI is particularly relevant form of capital flow as it involves taking a direct ownership stake in an investment and is also typically a longer-lived asset, making long-term interest rates (and hence the yield curve) more likely to enter the rest of the world's decision to invest in the United States. The specification in (7) is the same as that in (4) except the dependent variable is now FDI and on the right-hand side we additionally control for real U.S. GDP.

Figure 7: FDI Response to U.S. Term Spread (left) and Foreign Term Spread (right) Decrease of 1 Percentage Point



Estimates $\tilde{\beta}_1^h$ and $\tilde{\beta}_2^h$, $h = 1, ..., 12$ quarters respectively from Equation 7. U.S. term spread is the 10-year-3-month spread and the foreign term spread is computed as in Equation 1. 95% Newey-West standard errors computed with one lag. Point estimates and error bands based on sample period 1979-2019 to remove influence of COVID-19 related outliers on standard errors. Smaller points refer to estimates based on full sample from 1979-2021.

Figure 7 traces out the local projection response of FDI from the rest of the world to the United States following a 1 percentage point decrease in the U.S. term spread (left panel) and foreign term spread (right panel), respectively. The response of FDI differs substantially in that a smaller USTS predicts significant growth of FDI into the U.S. while a smaller FTS predicts a significant decrease in FDI into the United States. A smaller term spread often results from higher short-term rates leading to higher average interest rates across the term structure. While higher average U.S. interest rates might attract capital to the U.S. (or reflect higher expected returns in the U.S. as the economy is expected to slow), higher average foreign interest rates may make investing in the United States less attractive to foreigners for similar reasons. The results mirror the response of exports, whereby a smaller FTS leads to a contraction in U.S. exports. Both weaker U.S. export growth and FDI from the rest of the world are conducive to a slowdown in U.S. economic activity, all else fixed. In addition, that the USD does not significantly weaken following a smaller FTS also goes hand-in-hand with a smaller FTS predicting less FDI in the U.S. from the rest of the world as Dollar-denominated investments become more expensive.

5 Concluding Remarks

This paper documents that a foreign term spread, constructed from government bond yields of non-U.S. G7 constituents, predicts U.S. recessions after controlling for the U.S. term spread and several other predictive indicators. The foreign term spread is also a stronger predictor of U.S. recessions than the U.S. term spread over short horizons. The U.S. and foreign term spread predict U.S. recessions at different horizons and impact underlying sources of U.S. economic activity differently. Smaller U.S. term spreads lead foreign term spreads and lead to significant U.S. Dollar appreciation, suggesting spillovers from the U.S. to other countries. Smaller foreign term spreads also lead U.S. recessions but result in substantially less U.S. Dollar depreciation. U.S. and foreign term spreads also predict the underlying GDP components in markedly different ways that are consistent with the asymmetric response of the U.S Dollar. Smaller foreign term spreads lead to significant, persistent declines in U.S. exports that U.S. term spreads are not associated with. Smaller foreign term spreads also lead to significant reductions in FDI from the rest of the world to the U.S., while smaller U.S. term spreads do not. Taken together, these results suggests that U.S. term spreads spill over to foreign term spreads as U.S. recession risk goes global and the Dollar strengthens, and these growth slowdowns abroad along with a stronger Dollar spill back to the U.S. by weakening foreign demand for U.S. exports and investment.

An Application

The model relies on key market indicators to predict recessions and as such, a useful application of the model is up-to-date recession forecasting as several of the indicators are observed at high (daily or weekly) frequencies. The year 2022 saw the Federal Reserve begin to aggressively tighten monetary policy as inflation hit its highest levels in over four decades. This backdrop re-invigorated debate over recession risk over the coming years, providing ideal conditions to apply the model in real-time to recover an implied recession probability.

This exercise was conducted on August 15, 2022 using the most recent data at the time. GDP-weights used to construct the FTS are those from 2021Q4. Table 4 reports current values for the model inputs.

Table 4: Indicator Data as of August 15, 2022

USTS	FTS	FFR	Near-term Spread	S&P 500 Return	S&P 500 Volatility	Brent Oil Return	NFCI
0.25	0.551	2.33	0.61	6.57	25.16	-3.05	-0.246

All values are in units of percent except the National Financial Conditions Index (NFCI). For S&P 500 returns, S&P 500 volatility, and Brent oil returns, the quarterly period considered is May 15 to August 15, 2022.

Parameter estimates from the full model (column 4 from Table 2) estimated over the 1979-2021 period are considered to produce a recession forecast for the year ahead as of August 15, 2022. The model predicts a 42.5% probability of a recession occurring within the following year. For context, the median recession probability was 16.7% over the 1979-2021 period and even lower after excluding recession periods. A reading as high as 42.5% had a false positive rate of 6.8 percent and a true positive rate of 70.4 percent between 1979-2021. Meaning, the model-implied probability of a recession occurring in the following year is likelier than not.

The USTS is approaching inversion, currently sitting at 0.25 percent as of August 15, 2022, compared to a historical average of 1.71 percent. Relative to the average USTS reading, the relatively small USTS adds 0.7 percentage points to the recession probability. The FTS of 0.55 percent is also relatively small compared to its historical average of 0.94. The FTS value as of August 15, unlike the USTS, appears to play a major role in driving U.S. recession risk. If the FTS was sitting at its average of 0.94, the model-implied recession probability would equal 33.7%, nearly 9 percentage points lower than the current prediction of 42.5%.

Table A.1: Probit Regressions of NBER Recessions based on Exact Recession Quarters

	Dependent variable:							
	NBER Recession Occuring in Quarter $t+h$							
	$NBER_t$	$NBER_{t+1}$	$NBER_{t+2}$	$NBER_{t+3}$	$NBER_{t+4}$	$NBER_{t+5}$	$NBER_{t+6}$	$NBER_{t+7}$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Constant	.156	0.736	0.907	−0.259	−0.674	−0.591	−0.368	0.229
	(1.067)	(1.234)	(0.815)	(0.725)	(0.832)	(1.110)	(1.053)	(0.816)
U.S. Term Spread ($t-1$)	−0.247	−0.561	−0.531*	−0.511	−0.660	−1.146**	−1.742***	−2.082***
	(0.354)	(0.410)	(0.294)	(0.391)	(0.591)	(0.571)	(0.491)	(0.393)
Foreign Term Spread ($t-1$)	−1.038***	−0.641**	−0.480**	−0.218	−0.423*	−0.639**	−0.647*	−0.689**
	(0.283)	(0.282)	(0.210)	(0.211)	(0.252)	(0.281)	(0.333)	(0.331)
Fed Funds Rate ($t-1$)	−0.242*	−0.131	−0.084	0.007	0.074	0.012	−0.037	−0.099
	(0.124)	(0.119)	(0.079)	(0.080)	(0.078)	(0.102)	(0.105)	(0.101)
Near-Term Spread ($t-1$)	0.604	0.469	0.008	−0.229	−0.062	0.891	1.885**	2.540***
	(0.577)	(0.684)	(0.578)	(0.696)	(1.043)	(0.992)	(0.811)	(0.587)
S&P 500 Returns ($t-1$)	−0.080**	−0.095**	−0.087***	−0.027	−0.018	0.033	0.057**	0.043*
	(0.031)	(0.044)	(0.030)	(0.021)	(0.023)	(0.035)	(0.027)	(0.024)
S&P 500 Volatility ($t-1$)	0.008	−0.031	−0.047**	−0.008	0.005	0.016	0.006	−0.010
	(0.028)	(0.036)	(0.023)	(0.017)	(0.031)	(0.035)	(0.035)	(0.036)
Brent Oil Returns ($t-1$)	0.014	0.005	0.008	0.016	−0.00001	0.011	0.033**	0.037***
	(0.011)	(0.010)	(0.014)	(0.011)	(0.011)	(0.014)	(0.014)	(0.013)
Financial Conditions ($t-1$)	1.293***	0.762**	0.587	0.241	−0.268	−0.345	−0.385	−0.327
	(0.406)	(0.351)	(0.357)	(0.427)	(0.358)	(0.342)	(0.394)	(0.406)
Observations	170	169	168	167	166	165	164	163
Log Likelihood	−27.590	−35.038	−36.390	−37.671	−37.081	−36.284	−33.967	−34.048
Akaike Inf. Crit.	73.179	88.075	90.780	93.342	92.162	90.568	85.933	86.096
McFadden R^2	0.552	0.430	0.407	0.384	0.372	0.362	0.401	0.399

Estimates from the probit regression specified in Equation 2 but with an alternative dependent variable for recessions. The NBER recession indicator now takes a value of 1 only in quarters classified as recessions by the NBER, and 0 otherwise. U.S. term spread is the 10-year-3-month spread and the foreign term spread is computed as in Equation 1. McFadden R^2 computed as $1-\frac{\text{residual deviance}}{\text{null deviance}}$. Newey-West standard errors with one lag reported with '*','**','***' corresponding to 10%, 5%, and 1% significance, respectively. Sample period from 1979Q2-2021Q4.

Table A.2: Probit Regressions of NBER Recessions with Additional Lags of Covariates

	MLE			LASSO			
	4 Lags	4 Lags	4 Lags	2 Lags	4 Lags	6 Lags	8 Lags
Sum of Coefficients	(1a)	(2a)	(3a)	(1b)	(2b)	(3b)	(4b)
U.S. Term Spread	-0.767^{***}		-0.726^{***}	-0.282	-1.311	-4.063	-2.448
	(0.295)		(0.223)				
Foreign Term Spread		-0.945^{***}	-0.577^{*}	-0.539	-0.455	-2.597	-0.873
		(0.127)	(0.337)				
Fed Funds Rate				–	–	-0.125	–
Near-Term Spread				-0.528	-0.077	-2.704	-0.902
S&P 500 Returns				-0.027	-0.142	-0.856	-0.311
S&P 500 Volatility				0.032	0.023	0.183	0.028
Brent Oil Returns				–	-0.015	0.008	0.064
Financial Conditions				1.541	1.760	7.545	3.647
Observations	167	167	167	169	167	165	163

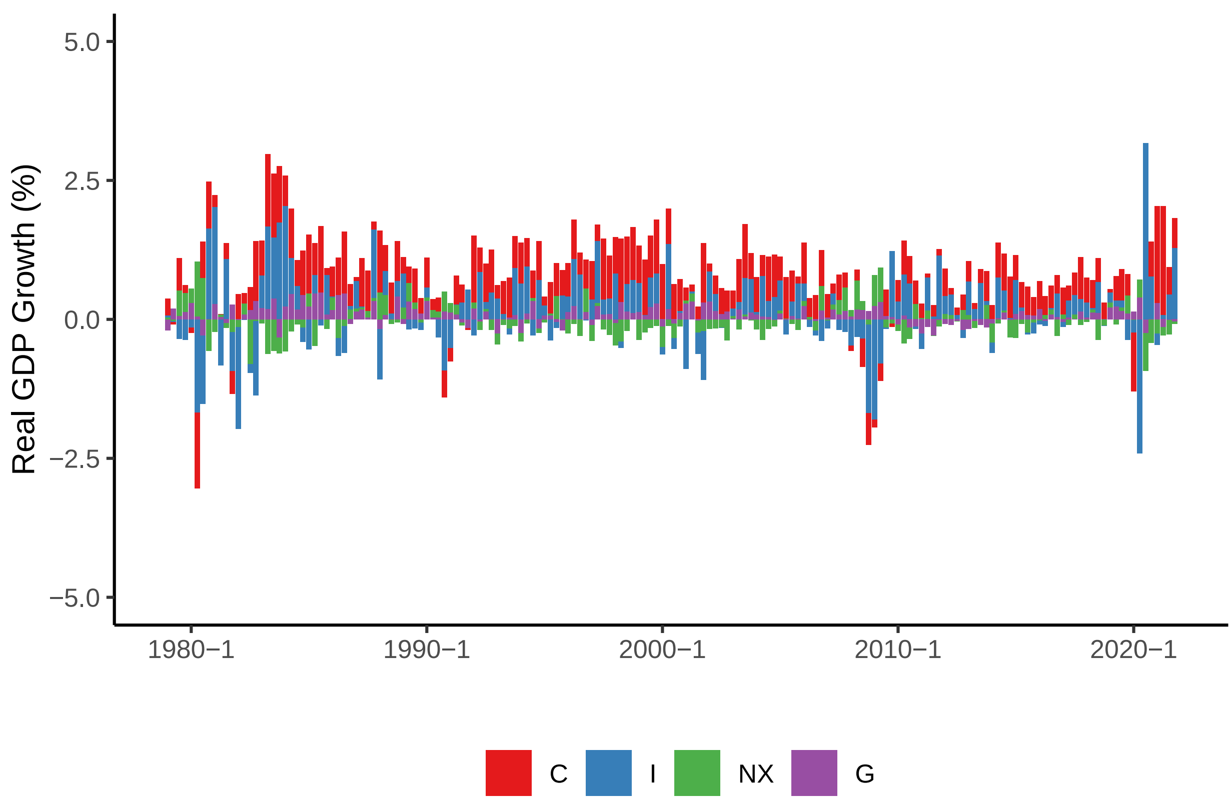
Estimates from the probit regression specified in Equation 2 with an increased number of lags for all covariates. Columns 1a, 2a, an 3a are estimated via MLE, Newey-West standard errors with one lag reported with '*','**','***' corresponding to 10%, 5%, and 1% significance, respectively. Columns 1b, 2b, 3b, and 4b correspond to regressions fit over the full sample using LASSO regularization with penalization parameter chosen to minimize out-of-sample mean absolute error based on an in-sample training period of 1979Q2-2004Q1 and out-of-sample period of 2004Q2-2021Q4. Reported estimates are the sum of coefficients on all lags of corresponding covariates. When no estimate is reported, it indicates that regularization set coefficients on all lags of that covariate to zero. NBER recession indicator takes a value of 1 if a recession occurs at any point within the $[t, t+3]$ quarterly interval, inclusive. U.S. term spread is the 10-year-3-month spread and the foreign term spread is computed as in Equation 1. Sample period from 1979Q2-2021Q4.

Table A.3: Contribution of Net Exports to Real GDP Growth

	Real GDP Growth (%)	Net Exports Contribution to Real GDP Growth (%)
All Periods ($T = 172$)		
Mean	2.62	-0.11
Standard Deviation	2.79	1.02
12M Within Recession ($T = 49$)		
Mean	1.11	0.19
Standard Deviation	3.78	1.37
Recessions Only ($T = 18$)		
Mean	-2.06	0.66
Standard Deviation	3.27	1.72
Non-Recessions ($T = 146$)		
Mean	3.20	-0.21
Standard Deviation	2.10	0.86

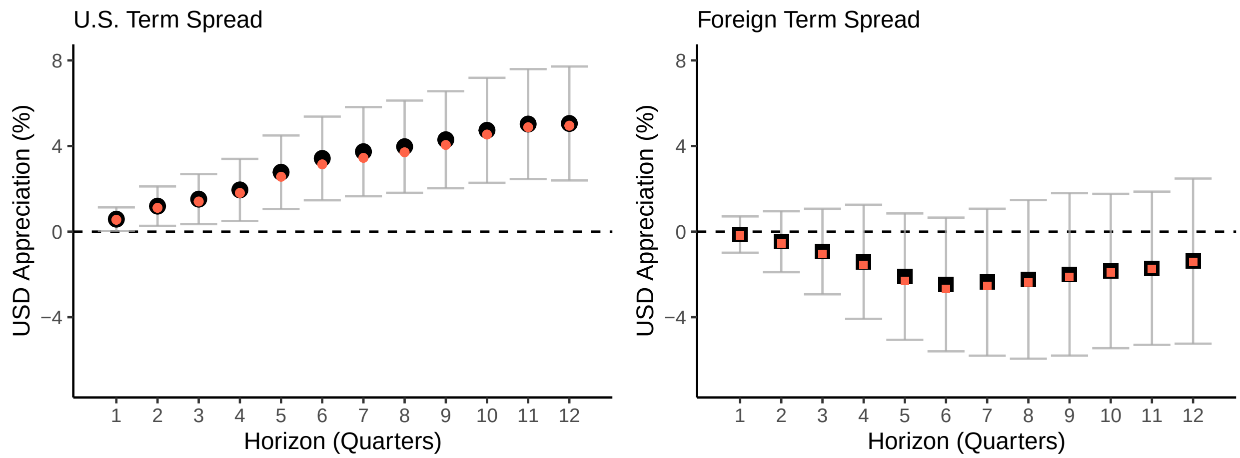
Based on quarterly Real GDP growth and underlying component contributions from 1979Q1-2019Q4, excluding the 2020 pandemic period. GDP Growth and contribution of net exports are reported on an annualized basis. Contribution of net exports are in percentage points of real GDP growth. Source: Bureau of Economic Analysis.

Figure A.1: Decomposition of Quarterly Real GDP Growth



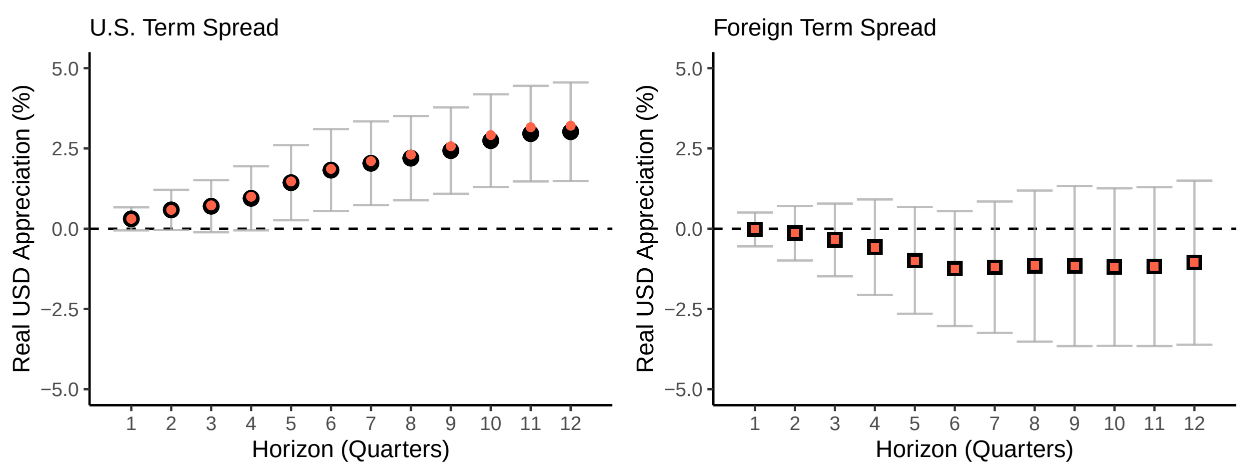
Based on quarterly real GDP growth and underlying components (consumption, investment, net exports, and government expenditures) from 1979Q1-2021Q4. Quarterly growth reported on an annualized basis and 2020Q2 and 2020Q3 are omitted to remove extreme observations during COVID-19. Source: Bureau of Economic Analysis.

Figure A.2: U.S. Dollar Response to U.S. Term Spread (left) and Foreign Term Spread (right) Flattening of 1 Percentage Point (Controlling for Stock Market Volatility)



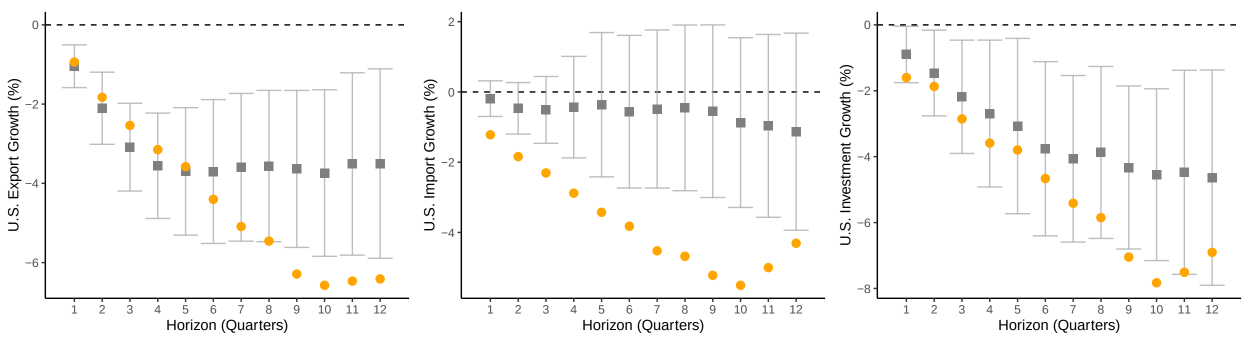
Estimates $\tilde{\beta}_1^h$ and $\tilde{\beta}_2^h$, $h = 1, ..., 12$ quarters respectively from Equation 5 but also controlling for realized S&P 500 stock market volatility. U.S. term spread is the 10-year-3-month spread and the foreign term spread is computed as in Equation 1. 95% Newey-West standard errors computed with one lag. Point estimates and error bands based on sample period 1979-2019 to remove influence of COVID-19 related outliers on standard errors. Smaller points refer to estimates based on full sample from 1979-2021.

Figure A.3: Real Effective U.S. Dollar Response to U.S. Term Spread (left) and Foreign Term Spread (right) Flattening of 1 Percentage Point



Estimates $\tilde{\beta}_1^h$ and $\tilde{\beta}_2^h$, $h = 1, ..., 12$ quarters respectively from Equation 5 but with the trade-weighted real U.S. effective exchange rate as the dependent variable. U.S. term spread is the 10-year-3-month spread and the foreign term spread is computed as in Equation 1. 95% Newey-West standard errors computed with one lag. Point estimates and error bands based on sample period 1979-2019 to remove influence of COVID-19 related outliers on standard errors. Smaller points refer to estimates based on full sample from 1979-2021.

Figure A.4: Local Projection Estimates for Select GDP Components following a Foreign Term Spread Flattening of 1 Percentage Point during Recessionary (Orange) and non-Recessionary (Gray) Periods



Estimates $\tilde{\beta}_1^h$ and $\tilde{\beta}_2^h$, $h = 1, ..., 12$ quarters respectively from Equation 6 augmented with both the USTS and FTS interacted with an indicator variable equal to 1 if a recession occurs at any point within the [t, t + 3] quarterly interval, inclusive. The orange circles trace out the local projection during recessionary periods and the gray squares trace out the local projection response during non-recessionary periods. The U.S. term spread is the 10-year-3-month spread and the foreign term spread is computed as in Equation 1. 95% Newey-West standard errors computed with one lag. Point estimates and error bands based on sample period 1979-2019 to remove influence of COVID-19 related outliers on standard errors.

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