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The impact of term spread volatility on economic activity

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ABSTRACT

We examine the impact of the volatility of the US Treasury yield curve slope (term spread volatility) on US economic activity within a VAR framework. Our findings show that a positive shock to term spread volatility leads to a persistent decline in US industrial production. Moreover, our econometric results are the first to demonstrate that term spread volatility absorbs the macroeconomic predictive information contained in the level of the term spread. Finally, the negative effect of term spread volatility remains robust in alternative VAR models, as well when including popular uncertainty proxies such as the VIX and the EPU indexes.

1. Introduction

The slope of the term structure of interest rates, broadly defined as the spread between long and short maturity US Treasury yields, is one of the most well-established predictors of economic activity (Ahmed and Chinn, 2024; Estrella and Hardouvelis, 1991; Estrella and Mishkin, 1998; Mody and Taylor, 2004; among others). Separately, there is extensive literature demonstrating the recessionary effects of macroeconomic and financial uncertainty on economic activity (Bloom, 2009; Caldara et al., 2016; among others).

Motivated by the findings of these two distinct strands of macroeconomic literature, this paper empirically examines the macroeconomic impact of yield curve uncertainty shocks, proxied by an unexpected increase in the volatility of the term spread of the US Treasury yield curve. Since the term spread reflects expectations regarding the future level of interest rates and the outlook of the US economy, we presume that a sudden increase in the volatility of the term spread will be associated with an increased dispersion of market expectations regarding the future state of the economy, hence it can be treated as a market-oriented uncertainty shock. To the best of our knowledge, this is the first study showing that the second moment shock in the term spread has a stronger impact on US economic activity as compared to the level of the term spread.

Our econometric analysis, using a structural VAR framework, shows that the term spread volatility shock results in a persistent decline in US economic activity (as proxied by the growth rate of US industrial production) and that it absorbs the predictive information content of the level of the term spread. In addition, we show that the recessionary effect of the term spread remains robust to the inclusion of well-known uncertainty proxies like the VIX and the EPU indexes. In this way, we additionally demonstrate that the macroeconomic predictive information content of term spread volatility contains statistically and economically differentiated information when compared to that of financial and macroeconomic uncertainty. Finally, our main findings remain robust to both non-linear and stochastic volatility VAR model specifications.

2. Methodology and data

2.1. Data

We obtain daily and monthly data for the 3-month maturity US-Treasury bill rate and the 10-year US-government bond yield series. We additionally utilize the monthly series of the federal funds rate, the

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Table 1
Descriptive Statistics and Unit Root Tests This table reports the descriptive statistics and unit root tests for our set of variables included in the VAR analysis. SLOPE and SLOPERV are the term spread and its volatility, INFL is the inflation rate defined as the growth rate of the CPI index, IPI is the growth rate of the industrial production, FFR is the federal funds rate, VIX is the level of the VIX index and EPU is the log-level of the economic policy uncertainty index. The last row reports the *t*-statistics of the Augmented-Dickey Fuller (ADF) unit root test based on the Akaike criterion. With *, ** and *** we reject the null hypothesis of a unit root with 10%, 5% and 1% confidence level.

	SLOPE	SLOPERV	INFL	IPI	FFR	VIX	EPU
Mean	0.0159	0.0004	0.0023	0.0014	0.0393	19.494	4.5993
Median	0.0164	0.0002	0.0023	0.0021	0.0395	17.685	4.5491
Maximum	0.0414	0.0106	0.0136	0.0637	0.1494	62.670	6.3195
Minimum	−0.0173	0.0008	−0.0178	−0.1420	0.0005	10.130	3.6430
Std.Dev.	0.0123	0.0011	0.0026	0.0098	0.0326	7.5166	0.4161
Skewness	−0.3560	6.3089	−0.8260	−6.0006	0.6001	2.0105	0.5219
Kurtosis	2.5135	48.753	11.565	95.395	2.8476	9.7471	3.6021
ADF test	−3.195**	−6.372***	−4.034***	−6.066***	−3.286**	−5.031***	−4.922***

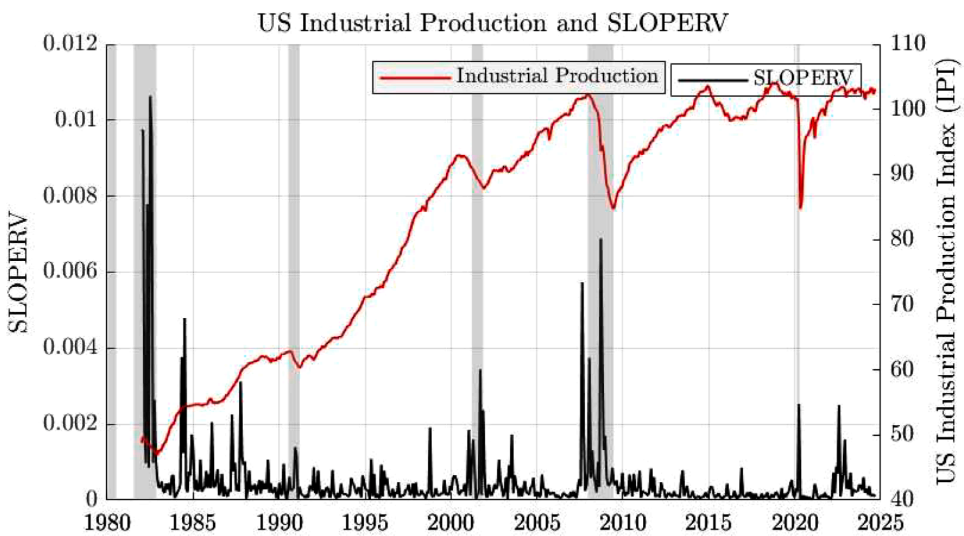

Fig. 1. US Industrial Production and Term Spread Volatility. This graph shows the synchronous variation of the US industrial production index, and the term spread volatility series. The shaded grey area represents NBER recessions. The monthly time series cover the period from January 1983 to August 2024.

US industrial production index, the US consumer price index (all items).[1] Finally, we use the monthly VIX (see Bloom, 2009) and EPU (see Baker *et al.*, 2016) indices as financial and macroeconomic uncertainty proxies, respectively. The time series data are downloaded from the FRED database and cover the period from 1st January 1983 to 31st August 2024.

Following Estrella and Hardouvelis (1991), we calculate the daily and monthly slope of the term structure of interest rates by taking the difference between the daily 10-year US government bond yield and the 3-month US Treasury bill rate. In this regard, the term spread (SLOPE) is defined as the monthly difference between the 10-year and 3-month maturity US government bond yields. The term spread volatility (SLOPERV) is estimated as the monthly realized variance of the daily slope of the US Treasury curve for each monthly period.

2.2. SVAR model

To evaluate the impact of the term spread volatility on US economic activity, we estimate a standard small-scale SVAR model similar to that of Bloom (2009) and Caggiano *et al.* (2014). Following Bloom (2009) and Caggiano et al. (2014), we place financial variables first and macroeconomic variables last in the VAR to capture the slower moving behavior of macro vis-a-vis financial variables. We, thus, estimate a 5-variable VAR model with the following ordering:

$$X_t = [SLOPE_t \;\; SLOPERV_t \; INFL_t \;\; IPI_t \;\; FFR_t] \quad (1)$$

Where SLOPE and SLOPERV are the term spread and its volatility, INFL is the inflation rate defined as the growth rate of the monthly CPI index, IPI is the growth rate of the monthly US industrial production and FFR is the federal funds rate. We place FFR last in the ordering of variables to capture the fact that monetary policy reacts after observing the dynamic interactions between inflation and output. The SVAR model representation is given in Eq. (2):

$$\mathrm{A}_0 X_t = b + \sum_{i=1}^{h} \mathrm{A}_i X_{t-i} + \varepsilon_t \quad (2)$$

In Eq. (2) ε_t is the vector with orthogonal structural innovations and h is the lag-length of the SVAR model. The number of allowed lags is chosen using the Akaike optimal lag-length criterion.[2] For the recursive structure structural identification of shocks ε_t we follow the Cholesky identification strategy.

[1] Both the industrial production index and the consumer price index are seasonally adjusted to eliminate any seasonal effects from the time series.

[2] The Schwarz and Akaike criteria suggest 4 to 6 lags. To ensure sufficient dynamics for the VAR system, we estimate the SVAR model with 6 lags of endogenous variables (h = 6 in Eq. 2). We additionally estimate our model allowing for less and more lags and our main results and conclusions remain qualitatively the same. These additional SVAR results, with alternative lag lengths, are available upon request.

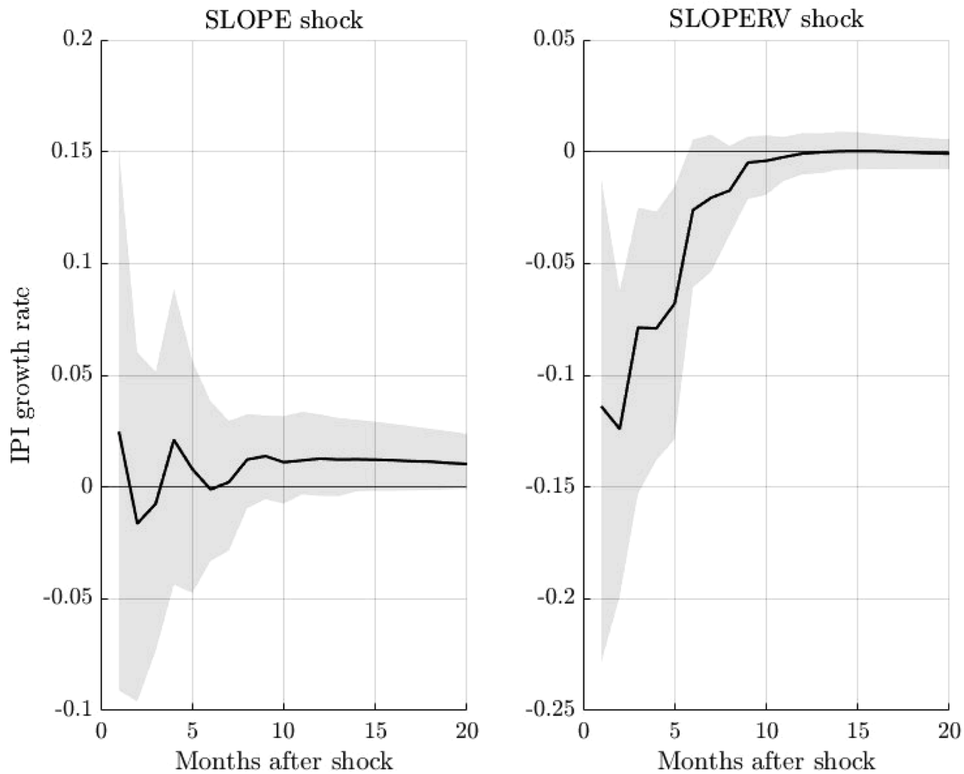

Fig. 2. Impulse Responses of US Industrial Production to Term Spread and Term Spread Volatility Shocks. This plot presents the impulse responses of the US industrial production growth (IPI) to one standard deviation structural shocks in the term spread (SLOPE) and the term spread volatility (SLOPERV). The responses are estimated based on the baseline 5-variable SVAR model (Eq. (1)). The shaded grey area represents the 90% bootstrapped confidence bonds for the IRFs using 10,000 repetitions.

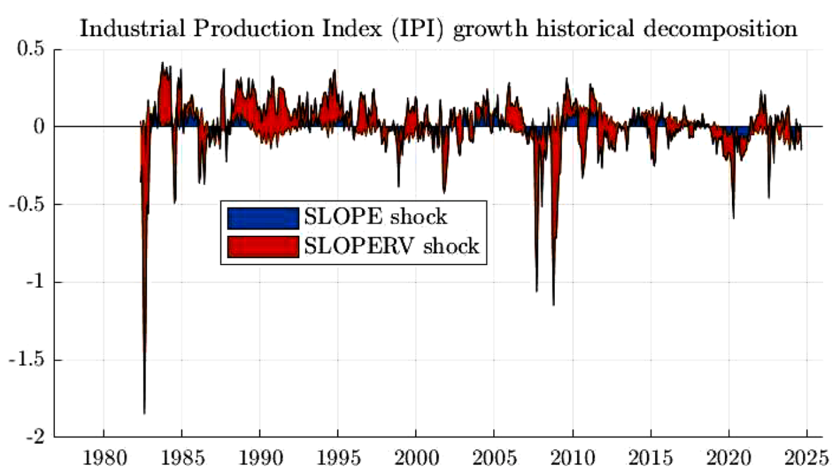

Fig. 3. US Industrial Production Historical Decomposition. This plot presents the historical decomposition (cumulative contribution) of the structural SLOPE and SLOPERV shocks on the US industrial production growth (IPI). The historical decompositions are estimated based on the baseline 5-variable SVAR model.

3. Econometric analysis

We base our analysis on the estimated impulse response functions (IRFs) and the historical decompositions of SLOPE and SLOPERV shocks. Before proceeding to the econometric results, we provide a table with the descriptive statistics and unit root tests for the set of variables used in the SVAR analysis.

As is evident from Table 1, we reject the hypothesis of a unit root for all our time series with at least 5% confidence level. This ensures the fact that all the variables entering theVAR model are in stationary form. Moreover, in Fig. 1 we present the plot of the time series for SLOPERV along with the US industrial production index.

From Fig. 1 it is evident that the spikes in SLOPERV are being followed by severe troughs in US industrial production and with US economic recessions. For instance, the spike in SLOPERV in early 2020 is followed by the COVID-19 recessionary period.

Next, we present and discuss our empirical findings of the SVAR model. Specifically, we present the IRFs of our baseline VAR model in Fig. 2.

Our econometric analysis shows that a positive SLOPERV shock has a higher (in magnitude and persistence) impact on US economic activity when compared to that of a SLOPE shock. In more detail, a positive

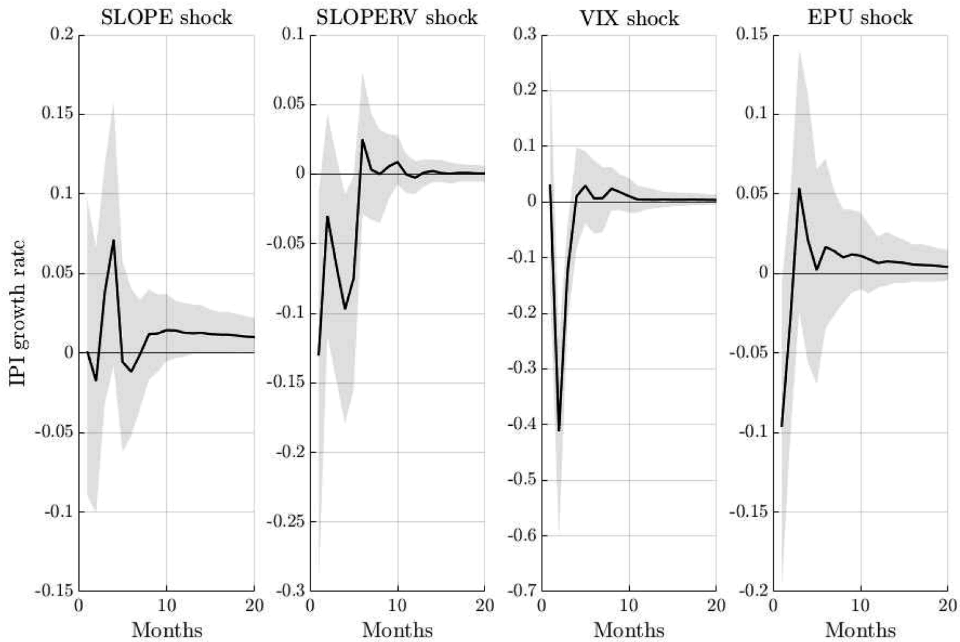

Fig. 4. Impulse Responses of US Industrial Production to Structural Shocks (Extended VAR Model). This plot presents the impulse responses of the US industrial production growth (IPI) to one standard deviation structural shocks in the term spread (SLOPE), the term spread volatility (SLOPERV), the VIX index and the EPU index, respectively. The responses are estimated based on the extended 7-variable SVAR model (Eq. (3)). The shaded grey area represents the 90% bootstrapped confidence bonds for the IRFs using 10,000 repetitions.

SLOPERV shock results to an almost 15 basis points decline in US IPI growth in about 2 months after the initial shock, with the effect remaining negative and significant for 6 months after the shock. On the contrary, the response of US IPI growth to unexpected changes in the SLOPE has a transitory and statistically insignificant effect on US IPI growth.

Furthermore, to examine the time-varying cumulative effect of SLOPE and SLOPERV on US economic activity, we estimate the historical decomposition of the structural SLOPE and SLOPERV shocks to assess their contribution on the time variation of the US IPI growth over the study period, as shown in Fig. 3.

From Fig. 3, we observe that most of the time variation in US IPI growth is not explained by the SLOPE shocks, but rather by the SLOPERV shocks. Interestingly, most of US economic recessions (including the 2007–2008 crisis) are explained solely by SLOPERV shocks.

We also provide further robustness to our empirical results by estimating IRFs of SVAR models with alternative orderings of the variables in the baseline model, as well as by including additional variables in the baseline VAR model.[3] Specifically, we employ an extended VAR model that includes additional proxies for uncertainty, such as the VIX index and the EPU index of Baker et al. (2016). This robustness check ensures that the proposed volatility component of the term spread has a distinct effect on US industrial production, independent of well-known proxies of financial and macroeconomic uncertainty. The ordering of this extended 7-variable VAR model is given in Eq. (3):

$$Z_t = [VIX_t \; EPU_t \; SLOPE_t \;\; SLOPERV_t \; INFL_t \;\; IPI_t \;\; FFR_t] \tag{3}$$

Where VIX is the level of the VIX index and EPU is the log-level of the economic policy uncertainty index. We present the estimated IRFs of this SVAR model in Fig. 4.

Fig. 4 verifies that the inclusion of the VIX and EPU indices in the SVAR model does not significantly alter the findings of our baseline model regarding the impact of the SLOPERV on US IPI growth. Interestingly, we find that the recessionary effect of the SLOPERV shocks is more long-lasting compared to that of VIX and EPU shocks. Lastly, we conduct a battery of robustness checks to our SVAR model to ensure that our results are robust to the change in the identification of structural shocks.[4]

4. Robustness

In this section we show some additional VAR results which provide robustness to the findings of our baseline SVAR model. More specifically, to allow for the fact of possible non-linearities in the relationship between our set of endogenous variables included in the VAR, we estimate a non-linear (regime-switching) SVAR similar to that of Nyberg (2018) with the same VAR ordering and identifying assumptions of our baseline SVAR model (see SubSection 2.2). In our regime-switching SVAR model we allow for two regimes, which are identified as the expansion (positive IPI growth) and the contraction (negative IPI growth) phase of the US economy. The respective responses of our non-linear SVAR model to one standard deviation shocks in SLOPERV and SLOPE are shown in Fig. 5:

The estimated IRFs reported in Fig. 5 show that when allowing for non-linear effects of the yield curve shocks we can observe some additional interesting findings. Specifically, we provide robustness to our baseline SVAR results by showing that the impact of SLOPERV shocks remains negative and statistically significant during expansions and

[3] In addition to the models discussed in this section, we also estimate a structural VAR model in which we replace the FFR with the shadow policy rate proposed by Wu and Xia (2016), as it is a better proxy for monetary policy during the zero-lower-bound period. The results are almost identical and available upon request.

[4] Moreover, to ensure the robustness of our argument, we estimate our baseline VAR model with different orderings of the variables. By altering the order of the variables, we verify that our results are not dependent on a specific ordering and that the impact of SLOPERV on US industrial production remains consistent. The results of these additional estimations of our baseline model, using alternative orderings in the VAR specification as well as with alternative identification of structural shocks, are available upon request.

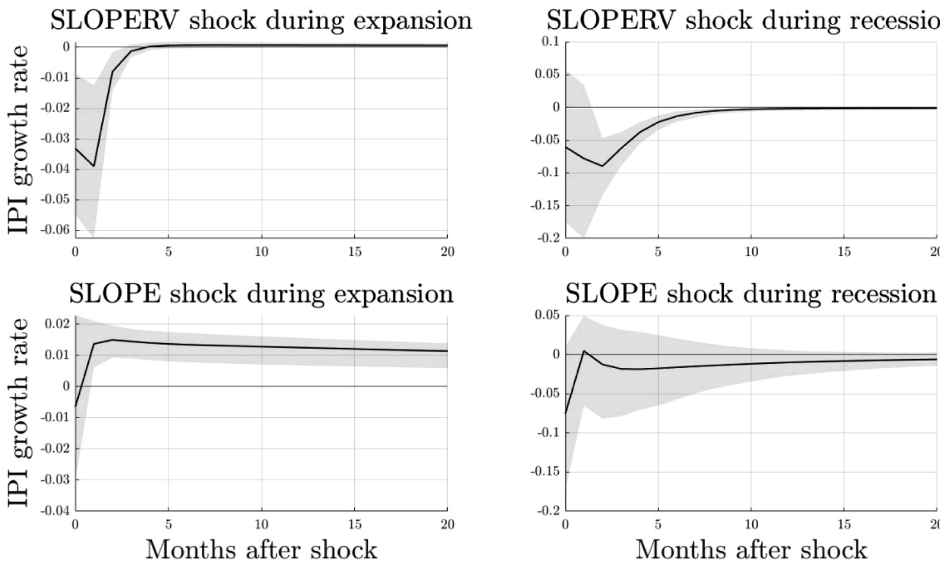

Fig. 5. Impulse Responses of US Industrial Production to Term Spread and Term Spread volatility Shocks During Expansionary and Recessionary Periods. This plot presents the impulse responses of the US industrial production growth (IPI) to one standard deviation structural shocks in the term spread (SLOPE) and the term spread volatility (SLOPERV). The responses are estimated based on a regime-switching 5-variable SVAR model with the same VAR ordering as the baseline model (Eq. (1)). The shaded grey area represents the 90% bootstrapped confidence bonds for the IRFs using 10,000 repetitions.

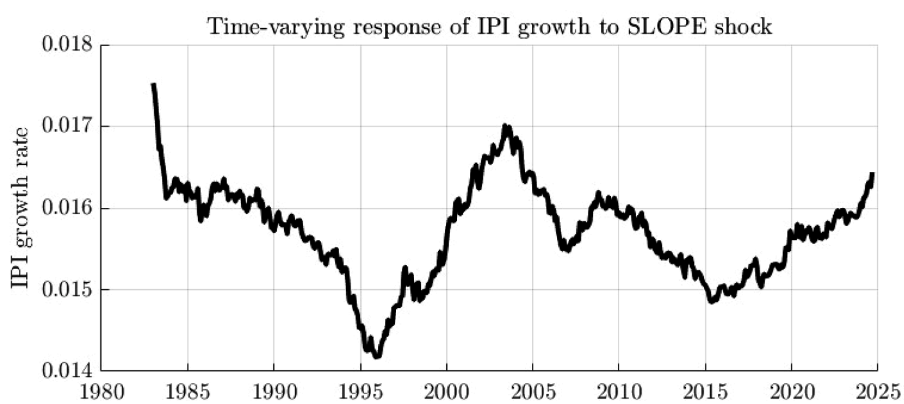

Fig. 6. Time-Varying Impulse Responses of US Industrial Production to Term Spread Shocks. This plot presents the impulse responses of the US industrial production growth (IPI) to time-varying one standard deviation structural shocks in the term spread (SLOPE). The responses are estimated based on a 4-variable stochastic volatility SVAR model with the same VAR ordering as the baseline model (Eq. (1)) in which we have excluded the SLOPERV series and have allowed for stochastic volatility in the innovations.

recessions, but it is more pronounced during recessionary periods. The reverse occurs in the case of the SLOPE shocks, which have a significant positive effect on IPI growth only during expansionary periods. These results, in addition to supporting our main findings, provide new insights by showing that term spread volatility (SLOPERV) is the only yield-curve related variable that significantly affects economic activity when the economy is heading toward a recession.

We finally estimate a 4-variable SVAR model with stochastic volatility (Cogley and Sargent, 2005) in which we exclude the SLOPERV from our set of endogenous variables. In this way, we examine whether the time-varying impact of SLOPE on economic activity increases in times of increased (stochastic) volatility in the disturbances of the term spread shocks. The time-varying (one-step ahead) response of IPI growth to SLOPE shocks is shown in Fig. 6.

It is evident from Fig. 6, that the impact of SLOPE shocks to IPI growth is higher during times of heightened uncertainty in the slope of the yield curve, including the early 1983–1984 period, the 2008–2009 global financial crisis and the recent COVID-19 period.

5. Conclusions

We estimate the recessionary effect of the volatility in the term spread of the US Treasury yield curve. Our contribution to the literature is that we demonstrate that term spread volatility shocks have significant recessionary effects on the US economy, with US industrial production decreasing from the first to the sixth month following the term spread volatility shock. Additionally, we show that the macroeconomic effect of the term spread on economic activity becomes insignificant once we control for the term spread volatility in the model. The policy implication of our results is that monetary authorities should monitor closely not only the level but also the volatility of the slope of the term structure of interest rates when anticipating and projecting future output growth.

Data availability

Data will be made available on request.

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