

Is a recession imminent? The signal of the yield curve

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Introduction

Few stylised facts are currently receiving more attention in the media than the predictive power of the yield curve regarding future economic activity: the yield curve inverted about one year before all nine US recessions identified since 1955. As the US yield curve has recently flattened and occasionally inverted, the question resurfaces: is a recession imminent?

Experience shows that commentators tend to downplay the signals given by the yield curve. In fact, when asked the question in 2007, 2000, 1990 and on earlier occasions, most economists indicated that “this time is different”, meaning that “this time”, the yield curve inversion will not be followed by a recession. Yet, a recession occurred every time.

Central banks also often contribute to downplaying the signals of the yield curve. Regarding the forecasts made by central banks and the yield curve, we note an interesting analogy. While central banks are sometimes compared to the Delphic oracle – for instance, when communication related to monetary policy “reveals expectations of future events” (Praet, 2013) –, the yield curve can be compared to Cassandra, the princess who was given the gift to see into the future but was cursed to never be believed.

However, given that the yield curve is influenced by numerous factors, this article shows that there are good reasons to be cautious when interpreting the signal of the yield curve. Some of these factors are related to the economic cycle and thus give the yield curve predictive power, while others are not and may therefore blur the signal. As the relative importance of these factors in driving yield curve dynamics may vary over time, the predictive power of the yield curve may not be constant.

The article focuses on the US since the debate about how to interpret the signal of the yield curve is most prominent there: the US yield curve is currently suggesting that the country is quite likely to enter a recession in about a year (probability of up to 45 % according to some models).

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The remainder of the article is structured as follows. Section 1 presents the relationship between the yield curve and recessions. Based on theoretical foundations for this relationship (section 2) and empirical regularities observed in the past (section 3), we aim to determine whether the forecasting power of the yield curve is still relevant (section 4).

1. A modern Cassandra

1.1 First look at the data

Chart 1 illustrates the good track record of the yield curve in predicting recessions. In the US (left-hand panel), the slope of the sovereign yield curve – measured as the difference between the ten-year and the one-year yields – turned negative about one year before the latest nine recessions identified by the National Bureau of Economic Research (NBER). Using other yield maturities results in highly correlated slope measures, although the slope might not turn negative before every recession. Besides, in over sixty years, the US yield curve gave only one false alarm¹. Regarding the current context, with the slope of the US yield curve close to zero, a simple rule of thumb would imply that the risk of a US recession is relatively high.

In the euro area, the performance of the yield curve in forecasting recessions is similar (right-hand panel in chart 1). The curve drawn by overnight indexed swap (OIS) rates was flat before the latest financial crisis, and German data before 1999 corroborate the stylised fact. However, the yield curve did not invert before the sovereign debt crisis (a recession started in 2011 according to the Centre for Economic Policy Research, CEPR). Currently, the slope of the yield curve is still significantly positive in the euro area – indicating that the recession probability derived from that slope remains low – which is why the article focuses on the United States.

A decomposition of the changes in the slope of the yield curve into contributions from changes in the short- and long-term yields displayed in chart 2 allows us to make two observations that will be investigated further in the rest of the article. First, each yield curve flattening preceding American or European recessions was accompanied by significant increases



Like Cassandra, the princess of Troy who predicted the fall of her city, the yield curve has always been right but never taken seriously.

Source: The De Morgan Foundation (“Cassandra”, 1898).

¹ It inverted in 1966 but the NBER did not identify any recession at that time. Nevertheless, the US economy slowed down significantly in 1967 and could arguably have entered a recession had the Fed not decided to change the course of its monetary policy stance by resuming money supply expansion (Friedman, 1968, 1970).

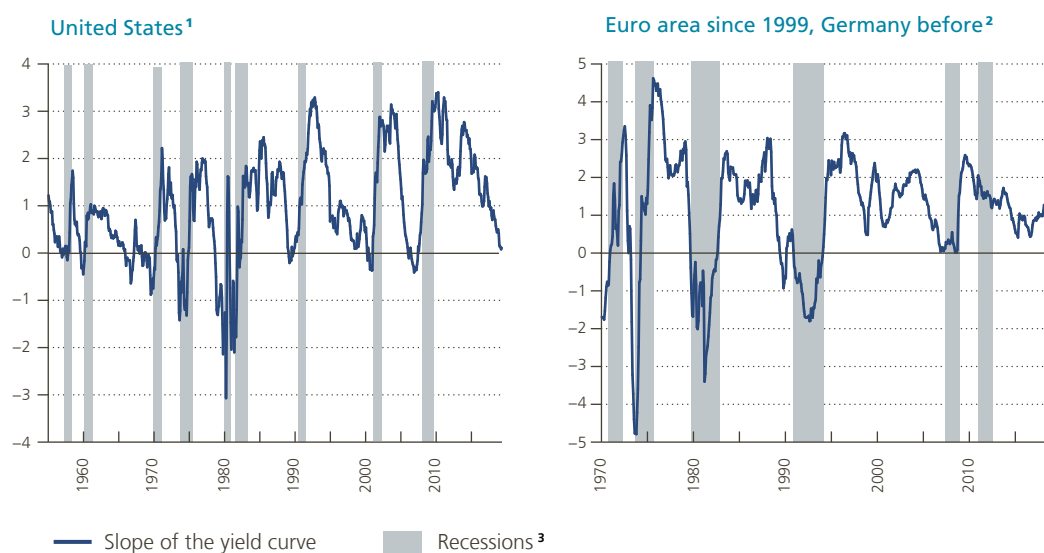
in the short-term yield, whereas the change in long-term yields was smaller. This observation is often used as grounds to emphasise the role of monetary policy.

Second, it appears that the behaviour of long-term yields has changed since the mid-1980s. Before that time, long-term yields tended to increase along with short-term yields ahead of recessions, hence dampening the flattening of the yield curve. Thereafter, long-term yields have tended to decrease slightly ahead of recessions, thus reinforcing the flattening of the yield curve. In this respect, some researchers have found a structural break in the mid-1980s in the relationship between the yield curve and economic activity, which could be due to the greater focus of central banks on the control of inflation.

Chart 1

In the US and euro area, the yield curve inverted before recessions

(slope of the yield curve in %)



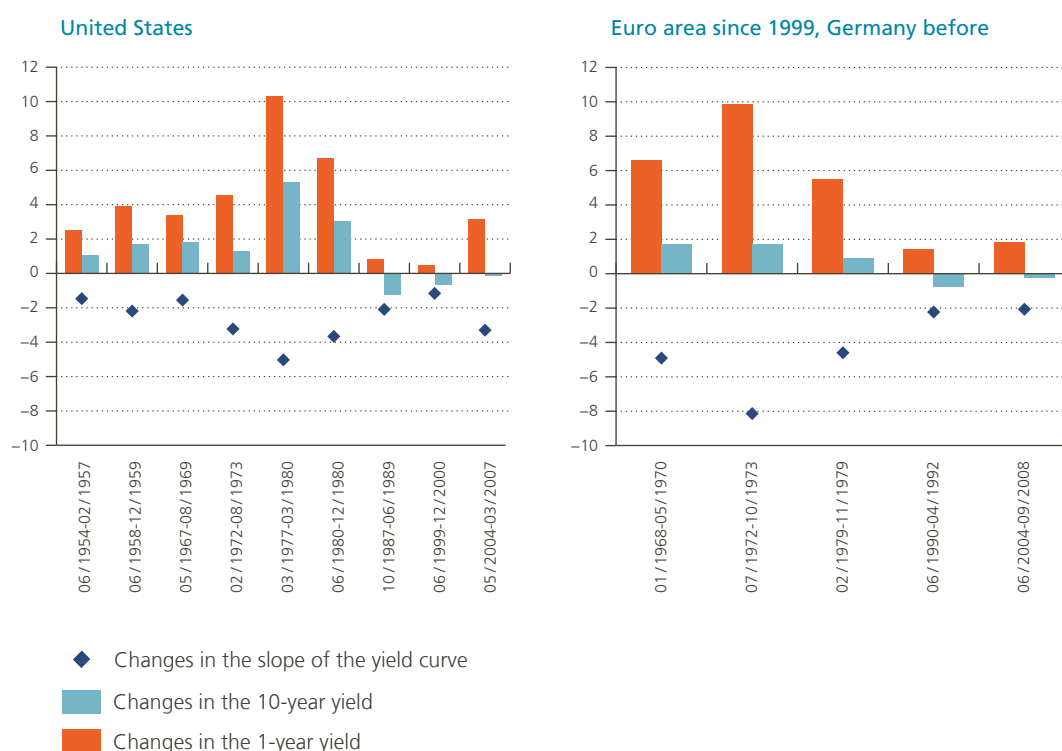
Sources: CEPR, Board of Governors of the Federal Reserve System (H15), NBER, OECD, Thomson Reuters.

- 1 Market spread between US Treasury securities at 10-year and 1-year, constant maturity.
- 2 Spread between 10-year and 1-year OIS yields since 2005. The 10-year OIS yield is retroplated back to 1970 using the 10-year swap rate on Euribor 6-month. The spread is retroplated back to 1970 with German data. German data on long-term yields refer to the yield on outstanding listed federal securities with residual maturities of over 9 to 10 years traded on the secondary market. German data on short-term yields are usually either the three-month interbank offered rate applicable to loans between banks, or the rate associated with Treasury bills, Certificates of Deposit or comparable instruments of three-month maturity in each case. German data refer to unified Germany from July 1990 and West Germany prior to this date.
- 3 US, euro area and German recessions were identified respectively by the NBER, CEPR and Economic Cycle Research Institute (ECRI), with the exception of the German recession at the beginning of the 1970s which is identified by the OECD composite leading indicators. German recession dates determined by ECRI are similar to those determined by the CEPR for the euro area since 1970.

Chart 2

Short- and long-term yield movements during flattening of the curve ahead of recessions¹

(percentage points)



Sources: Board of Governors of the Federal Reserve System (H15), OECD, Thomson Reuters.

¹ See footnotes in chart 1 for details.

1.2 The “this time is different” state of mind

The yield curve did not only earn its reputation as Cassandra from its remarkable past performance at forecasting recessions. It also owes it to the many reassuring statements made by most commentators who hinted that the signals given by the yield curve were not reliable anymore.

Examples of reassuring statements are so numerous that it would be impossible to list them all. However, these statements were also made by the most prominent and influential economists. Focusing on the ones made shortly before the most recent financial crisis, Alan Greenspan notoriously declared in 2005 before the US Senate Banking Committee that “the evidence very clearly indicates that [the yield curve’s] efficacy as a forecasting tool has diminished very dramatically [...]” (as reported in the Financial Times, 4 April 2019). In 2006, Ben Bernanke declared “[...] I would not interpret the currently very flat yield curve as indicating a significant economic slowdown to come [...]”. In 2007, Charles Goodhart wrote that the yield curve has appeared to have good predictive power for future output growth at times in the past, but that “this may now have largely disappeared”.

The situation was best summarised by Rudebusch and Williams (2009) who wrote: “[...] it is interesting to note that many times during the past 20 years forecasters have acknowledged the formidable past performance of the yield curve in predicting expansions and recessions but argued that this past performance did not apply in the current situation”.

Also, in the current environment, “this time is different” arguments are put forward. Most members of the Fed’s Federal Open Market Committee (FOMC) made clear that they would agree with the vice chairman John Williams who recently stated that “There’s a lot of reasons to think that it has been a recession predictor for reasons in the past that kind of don’t apply today” (Bloomberg, 29 March 2019).

However, two members of the FOMC voiced different points of view. Neel Kashkari, president of the Fed of Minneapolis, wrote in mid-2018: “This time is different. I consider those the four most dangerous words in economics. [...] there is little reason to raise rates much further, invert the yield curve, put the brakes on the economy and risk that it does, in fact, trigger a recession”. At the same time, James Bullard, president of the Fed of St. Louis, wrote: “Some argue that this time is different when it comes to the yield curve. I recall similar comments relative to the yield curve inversions in the early 2000s and the mid-2000s – both of which were followed by recessions”.

In summing up the FOMC’s position, Federal Reserve Chairman Jerome Powell showed some consideration for the yield curve by declaring in mid-2018 that “If you raise short-term rates higher than long-term rates, then maybe your policy is tighter than you think. Or it’s tight, anyway” (Bloomberg, 17 July 2018).

To be sure, the arguments made by economists who have tended to discard the yield curve as a reliable predictor of recessions were often convincing and some of them might actually play a role in the present case, as will be shown later in the article. But the repeated act of discarding the yield curve calls for other explanations. An alternative interpretation could be that the yield curve model was deemed “too simple” for forecasting recessions: one single index beat the most sophisticated macroeconomic models and the most extensive surveys of professional forecasters.

Whether or not the yield curve is still a reliable indicator, it has been the best predictor of recessions so far, and this stylised fact calls for explanations. The next section briefly presents theories that could explain the link between the yield curve and recessions.

2. Why does the yield curve predict recessions?

While many empirical studies establish the ability of the yield curve to predict recessions (see section 3 for an overview), theoretical foundations for this relation are relatively scarce and no theory has been generally accepted. As Benati and Goodhart (2008) put it, the predictive content of the yield curve remains “a stylised fact in search of a theory”.

Theoretical investigations largely rely on consumption-based asset-pricing models (Harvey, 1988; Roma and Torous, 1997; Rendu de Lint and Stolin, 2003) or more general macrofinancial models with rational expectations (Estrella, 2005). Most explanations are based on the notion that the yield curve captures changes in monetary policy and the views of the market regarding future economic conditions. According to these theories, the yield curve can *reflect* a future recession, but it is not the *cause* of recessions. Other explanations point to a more active role of the yield curve, either via a negative impact on banks’ profitability or a self-fulfilling prophecy. In this section, we describe these mechanisms and link them with the different building blocks of the slope of the yield curve.

2.1 Monetary policy (short-term rate) and the slope of the yield curve

Monetary policy can influence the slope of the yield curve since it almost entirely determines short-term yields. A tightening of monetary policy usually results in a rise in the short-term rate and thus has a dampening effect on the slope if the increase in long-term yields is smaller. Estrella (2005) and Estrella and Mishkin (1997)

show that this is usually the case and that monetary policy is an important determinant of the slope of the yield curve, particularly when the tightening is credible. A restrictive monetary policy is likely to slow down the economy and inflation, which dampens expectations regarding the real rate of return and future inflation, the two factors driving long-term yields.

The importance of monetary policy for the flattening of the yield curve ahead of recessions seems corroborated by the empirical observation that these episodes in the US were predominantly due to an increase in the short-term rates (as illustrated in chart 2). Note that in this case the yield curve could be seen as an indicator of the monetary stance, either expansionary, neutral or contractionary in case of a steep, flat or negative yield curve. In fact, the findings of Adrian and Estrella (2008) suggest that the monetary policy stance is better captured by the slope of the yield curve than by the level of interest rates.

2.2 Recession expectations affect the slope of the yield curve

Another reason why the yield curve might flatten is the expectation of a recession. The theory put forward by Harvey (1988) can explain an increased demand for assets that mature when a recession is expected. The central assumption in Harvey's model is that consumers prefer a stable level of income rather than high income during expansions and low income during slowdowns. In his simple model where a default-free bond is the only financial instrument available, if investors expect a reduction in their consumption – a recession – they prefer to save by buying long-term bonds in order to get pay-outs in the slowdown. By doing so, they increase the demand for long-term bonds, which decreases the corresponding yield. In addition, to finance the purchase of the long-term bonds, investors may sell short-term bonds whose yields will increase. As a result, when a recession is expected, the yield curve flattens or inverts.

Besides Harvey's general intuition, more recent theories which focus on the decomposition of long-term yields into an expectations component and a term premium help to explain why the slope of the yield curve tends to fall in the case of recession expectations.

Recession expectations dampen the expectations component

When market participants expect a downturn, they likely also anticipate that the central bank will cut the policy rate at some time in the future to provide monetary accommodation. According to the expectations hypothesis of the term structure of interest rates, the expected lower short-term yields imply a decline in the long-term yield.

As a reminder, the expectations hypothesis states that long-term yields are equal to the average of expected short-term yields over a given investment horizon, or that these two quantities differ by a constant term premium. However, abundant empirical evidence shows that the term premium varied widely over time (Fama, 1986; Dai and Singleton, 2002; Joslin *et al.*, 2014). Consequently, the expectations hypothesis is in itself not sufficient to explain yield curve dynamics: the role of the (time-varying) term premium should also be considered.

... and possibly also compress the term premium

To understand the time variation in the term premium, we first need to understand exactly what the term premium is. As formulated by Cohen *et al.* (2018), the term premium represents “the compensation or risk premium that risk-averse investors demand for holding long-term bonds. This compensation arises because the return earned over the short term from holding a long-term bond is risky, whereas it is certain in the short term for a bond that matures over the same short investment horizon”. The term premium can thus be seen as the compensation required by investors who buy long-term bonds to bear the risk that short-term yields do not move as they expect over their investment horizon. Hence, time variation in the term

premium might be due to changes in risk aversion and/or perceptions of potential changes in short-term interest rates.

Being influenced by many factors, the term premium might also contain information regarding future recessions, as suggested by some empirical studies (Hamilton and Kim, 2002; Favero *et al.*, 2005; Wright, 2006; Estrella and Wu, 2008; Dewachter *et al.*, 2014; Bauer and Mertens, 2018a,b). This could be true, for instance, in the event of a “flight-to-safety” (towards government bonds), combined with a preference for long maturities (i.e. ‘preferred habitat’ as explained in Modigliani and Sutch, 1966, and Vayanos and Vila, 2009).

Section 4 discusses other factors (such as asset purchases by central banks) that could disturb the link between the term premium (and thus the slope of the yield curve) and recessions.

2.3 Can the yield curve cause a recession? Bank profits and self-fulfilling prophecy

Up until now, both the explanations zooming in on the effect of monetary policy and recession expectations imply a passive role for the yield curve. The following theories see a more active role.

The yield curve and bank profits

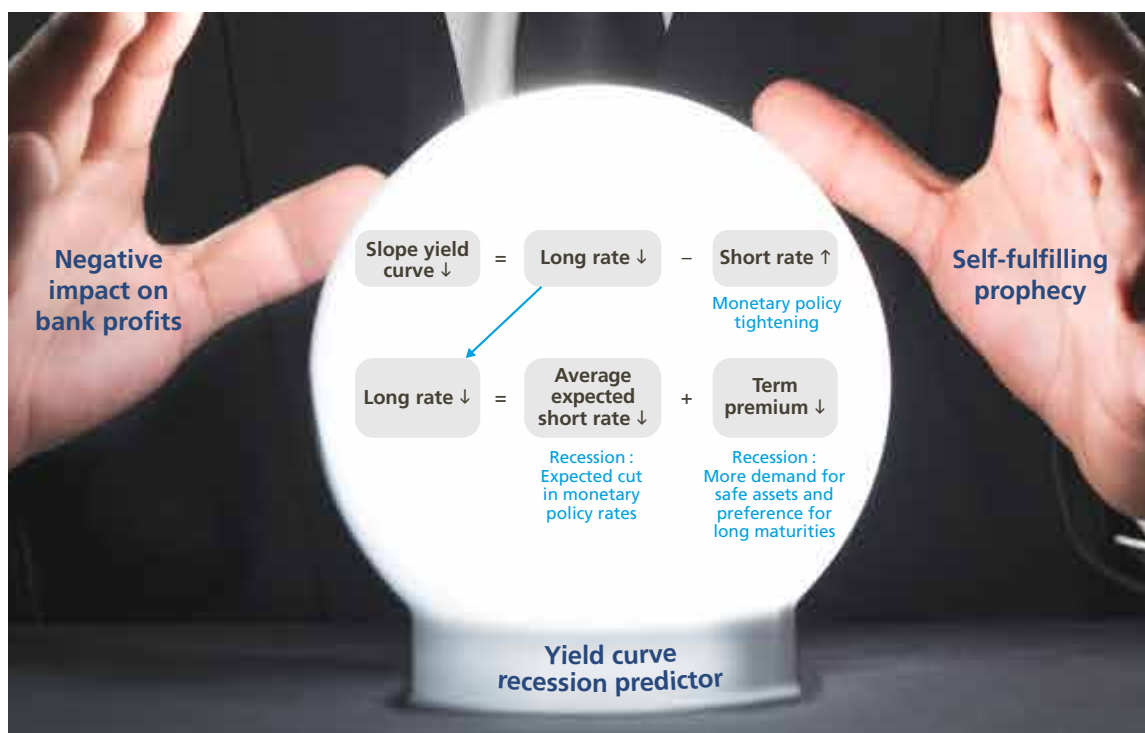
A flatter or negative curve tends to hurt banks’ profitability. Banks are engaged in maturity transformation and thus benefit from the gap between the yield they receive on their long-term assets (mostly loans) and the rate they pay on their short-term liabilities (mostly deposits). *Ceteris paribus*, their net interest margin falls (rises) when the yield curve flattens (steepens). When banks’ margins are squeezed, banks might become involved in a “search for yield” (i.e. invest in riskier assets promising a higher return), making the banking sector and the economy more prone to macrofinancial shocks. If the margin turns negative, and lending is no longer profitable, banks might even stop lending or tighten their credit conditions to compensate for the loss. This in turn reduces the pace of credit growth and economic activity.

The literature on this channel (Alessandri and Nelson, 2015; Borio *et al.*, 2017; Claessens *et al.*, 2018; English *et al.*, 2018; Kapinos and Musatov, 2018; Ampudia and Van den Heuvel, 2018) shows a strong heterogeneity in the findings, depending on the balance sheet characteristics of the banks and the rest of the economy. The profitability explanation for the relationship between the yield curve and economic activity depends on i) the degree to which interest rate risk is hedged by banks, ii) the importance of non-interest-bearing assets, iii) the interest rate pass-through of the different financial instruments, and iv) the effect of bank capital on lending. Furthermore, Borio *et al.* (2017) and Claessens *et al.* (2018) find that the effects of the slope of the yield curve on bank profits tend to be greater at lower levels of interest rates.

Self-fulfilling prophecy

Finally, there might be self-fulfilling mechanisms at play. To the extent that an inverted yield curve is perceived by financial markets as an early warning indicator, this might give rise to greater risk aversion which negatively affects the economy. In the quarterly survey of senior loan officers (FED, October 2018), some banks said they would tighten lending standards if the yield curve were to invert, as it would signal “a less favourable or more uncertain economic outlook”. This combines self-fulfilling elements with an active bank channel, illustrating the potential of the yield curve to cause a recession when its inversion is not disregarded (in contrast with the still predominant “this time is different” state of mind).

Why does the yield curve predict recessions?



Source: NBB.

3. Empirical evidence

3.1 Review of the empirical literature

Early studies such as Kessel (1965) and Fama (1986) already reported the phenomenon of the flattening of the US yield curve before a recession or a slowdown. But the empirical literature really started to develop at the end of the 1980s when the US yield curve flattened again. Harvey (1988, 1989) and Laurent (1988, 1989) showed that the yield curve was a better predictor of recessions than other indicators. In the same vein, Stock and Watson (1989) suggested adding a measure of the slope of the yield curve to the list of leading indicators of the US Department of Commerce. Eventually, the seminal works of Estrella and Hardouvelis (1991) and Chen (1991) considered the link between a flatter yield curve and lower future economic growth as a stylised fact.

Studies carried out in subsequent decades focused on three main questions to which we now turn.

Is the yield curve a better predictor of economic activity than other indicators?

Many studies conclude that the yield curve is the best leading indicator in the US (or one of the best) and that it generally obtains better results than surveys of professional forecasters or indices of leading indicators (Estrella and Mishkin, 1996, 1998; Stock and Watson, 2003b; Rudebusch and Williams, 2009; Berge, 2015). Some studies emphasise that the yield curve is not systematically the best predictor for very short horizons (up to three or six months) but that it performs better than other indicators for medium horizons. Berge and Jordà (2011) estimate at precisely 18 months the horizon at which the yield curve gives the most reliable signals regarding a possible turning point in the business cycle.

Is the relation between the yield curve and economic activity also observed elsewhere than in the United States?

The relation between the yield curve and economic activity has been established in many countries (Harvey, 1991, 1997; Plosser and Rouwenhorst, 1994; Bonser-Neal and Morley, 1997; Estrella and Mishkin, 1997; Bernard and Gerlach, 1998; Ivanova *et al.*, 2000; Moneta, 2005). However, the forecasting power of the yield curve varies across countries. The most convincing results were found in the United States, Germany and Canada, whereas the relation is less pronounced in Belgium, Ireland, Italy, the Netherlands and Spain, for instance.

Without detailing (possibly numerous) country-specific explanations, it appears that the three countries in which the relation is the strongest (the United States, Germany and Canada) are large economies – which implies that they are less subject to idiosyncratic shocks – and that their public debt has been considered risk-free over the past few decades – hence, no credit risk premium on sovereign bond yields can blur the signals of the yield curve.

Has the relation been stable through time?

Empirical results are almost unanimous regarding the existence of a structural break in the mid-1980s resulting in a decrease in the sensitivity of GDP growth to the slope of the yield curve (Chauvet and Potter, 2002; Peel and Ioannidis, 2003; Venetis *et al.*, 2003; Feroli, 2004; Duarte *et al.*, 2005; Galvão, 2006; Schrimpf and Wang, 2010; Aguiar-Conraria *et al.*, 2012). Some studies even suggested that the forecasting ability of the yield curve had vanished (Haubrich and Dombrosky, 1996; Dotsey, 1998; Jardet, 2004), before recent recessions following yield curve flattening questioned that result. Indeed, despite the consensus on the diminished ability of the yield curve to forecast *GDP growth*, models show that it has retained its ability to forecast *recessions* (Dueker, 1997; Ahrens, 2002; Estrella *et al.*, 2003; Rudebusch and Williams, 2009).

The reason underlying the structural break between the yield curve and GDP growth in the mid-1980s is still being investigated. This point will be further discussed in the next sub-section in light of new empirical evidence.

3.2 New empirical evidence

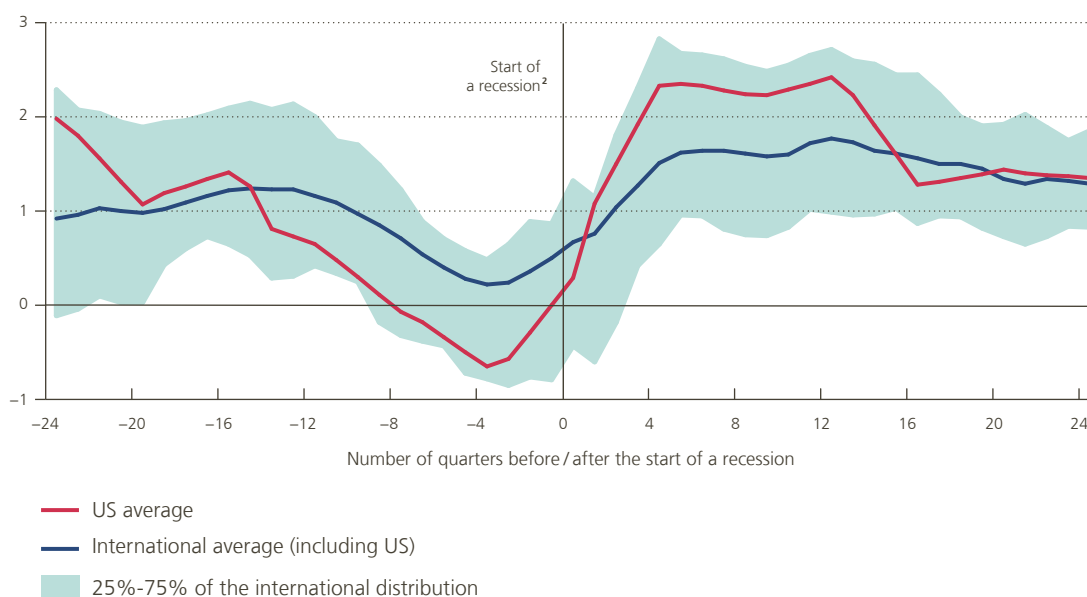
We use the “macrohistory” database of Jordà *et al.* (2017) to provide new evidence of the forecasting power of the yield curve. There are three main advantages in using this database: (1) data go back to 1870 and so cover various historical periods characterised by different macroeconomic regimes; (2) it covers 17 advanced economies (AU, BE, CA, CH, DE, DK, ES, FI, FR, IT, JP, NL, NO, PT, SE, UK, US); (3) it contains several macrofinancial variables that can be used as alternatives for the yield curve to forecast economic activity. To the best of our knowledge, this is the first time that this database has been used to investigate the relation between the yield curve and economic activity.

Chart 3 shows that the database clearly captures the stylised fact of a flattening of the yield curve before recessions since WWII (the most studied period). The slope of the yield curve is computed as the difference between the long-term yield made available in the dataset (usually five-year tenor) and the short-term yield (usually three-month). Recession years are defined as years associated with a fall in real GDP. More specifically, the chart shows that the flattening is clear not only in the United States but also in other countries. It also shows that the yield curve tends to invert in the US before recessions, but that seems to be less the case internationally (note however that the distribution around the international average also goes into negative territory).

Chart 3

The slope of the yield curve around recessions: international evidence¹

(in %, 1953-2016 averages)



Sources: Jordà *et al.* (2017), NBB.

1 All annual series are transformed into quarterly observations through linear interpolation.

2 The start of a recession corresponds to the quarter in which the year-on-year growth of real GDP turns negative.

In addition to reproducing the stylised fact of the yield curve flattening before recessions, the database of Jordà *et al.* (2017) permits an econometric analysis of the relation between the yield curve and real GDP growth. We estimate the following simple regression:

$$real\ GDP\ growth_t = c + \alpha X_{t-1} + \beta real\ GDP\ growth_{t-1} + \epsilon_t,$$

where X_{t-1} is any potential leading indicator of economic activity lagged by one year, c is a constant, and ϵ_t is an error term¹.

Table 1 displays the results of the estimations with different variables used in X_{t-1} , including the slope of the yield curve. Columns in the table show results for the United States, Germany, a panel composed of the United States, Germany and Canada, and a panel composed of the rest of the countries. The sample is split into four sub-periods: the Classical Gold Standard (1880-1913), the interwar period (1919-1938), the “pre-Volcker” period (1953-1978) and the “post-Volcker” period (1985-2016)². The latter two periods are defined so as to account for the change in macroeconomic dynamics, especially regarding inflation, that could relate to the forecasting ability of the yield curve.

The results displayed help to answer the three questions asked in the previous sub-section.

1 We assume that X_{t-1} is predetermined. Post-estimation checks show that residuals are largely free of any serial correlation.

2 The Classical Gold Standard period is defined as starting in 1880 since the convertibility of the greenback paper money was restored in 1879. The pre-Volcker period starts in 1953 to account for the Federal Reserve-Treasury Accord of 1951 which resulted in the formal abandonment of the policy of pegging government bond prices in 1953 (Friedman, 1968).

First, the yield curve is one of the best predictors of economic activity. This is assessed by the relatively high R^2 of the regressions on the slope of the yield curve and the significance of the α estimates¹.

Second, the yield curve helps to forecast real GDP growth not only for the panel of “risk-free” countries but also for the panel of “other countries” (significant α estimates). For those other countries, we note however that α estimates are smaller, which indicates that real GDP growth is less sensitive to changes in the slope of the yield curve which could be affected by changes in the credit risk premium (confirming earlier findings in the empirical literature).

Third, and most importantly, the sensitivity of real GDP growth to the slope of the yield curve declined between the pre- and post-Volcker periods. Focusing on the panel US-DE-CA, estimates show that real GDP growth would fall by 0.95 percentage point if the slope of the yield curve dropped by 1 percentage point in the pre-Volcker period (*ceteris paribus*), whereas it would fall by only 0.50 percentage point in the post-Volcker period².

It is important to understand the underlying reasons for this decrease in sensitivity as it contributes to the “this time is different” state of mind. The increased focus of central banks on the control of inflation is often cited as the main explanation. In the US, since the early 1980s when the Fed – then chaired by Paul Volcker – tightened monetary policy to rein in soaring prices, inflation has been relatively stable at lower levels. Bordo and Haubrich (2004) put forward a theoretical argument that is often used in this context. According to them, an increase in inflation in a credible monetary policy regime could blur the picture concerning the yield curve and economic activity. The argument assumes that a positive inflation shock would be deemed to have temporary effects in a credible monetary policy regime (low inflation persistence) and hence would only raise short- but not long-term yields. This could result in a yield curve inversion but no recession if the underlying shock is purely nominal.

However, empirical research does not favour this theory. It is best tested by studying the Classical Gold Standard period, i.e. the text-book example of a period of price stability (zero expected inflation). Whereas the argument (assuming that it would prevail over other theories) suggests that the coefficient of the slope of the yield curve would not be significant during that period, our estimates displayed in the table show that it is. As such, our results corroborate those of Bordo and Haubrich (2008a,b), Benati and Goodhart (2008) and Gerlach and Stuart (2018). Note that our results are particularly interesting in the case of the US since the country did not have a formal central bank at the time, which suggests that monetary policy is not the only factor explaining the forecasting power of the yield curve.

Overall, Bordo and Haubrich’s (2004) theory could partly explain the diminished forecasting ability of the yield curve since the mid-1980s, as there is empirical evidence of a decrease in inflation persistence (Benati and Goodhart, 2008), but the evidence of the yield curve’s forecasting power during the Classical Gold Standard period makes it a less attractive explanation. The next section presents an alternative explanation – related to the term premium – and shows its implications when assessing current recession probabilities.

1 The good forecasting accuracy of real stock returns in the US during the pre- and post-Volcker periods is also remarkable. However, focusing on the panel of large economies with “risk-free” sovereign yields (US-DE-CA), the coefficient of real stock returns loses its significance for the post-Volcker period whereas the one for the slope of the yield curve remains significant. Therefore, our results corroborate Stock and Watson’s (2003a) conclusion: “[...] no single asset price is a reliable predictor of output growth across countries over multiple decades. The term spread perhaps comes closest to achieving this goal [...]”.

2 Some of these results are corroborated by additional evidence and robustness tests presented in the annex.

Table 1

Forecasting performance for real GDP growth (one-year ahead)¹

| X_{t-1} | $real\ GDP\ growth_t = c + \alpha X_{t-1} + \beta real\ GDP\ growth_{t-1} + \varepsilon_t$ | | | | | | Panel other countries ⁵ | |
|---|--|----------|--------------------|----------|-------------------------------|----------|------------------------------------|----------|
| | US ² | | DE ^{2,3} | | Panel US-DE-CA ^{2,4} | | | |
| | R ² (%) | α | R ² (%) | α | R ² (%) | α | R ² (%) | α |
| Slope of the yield curve | | | | | | | | |
| Classical Gold Standard | 20 | 1.00** | 15 | 0.95* | 16 | 0.99*** | 1 | 0.19*** |
| Interwar period | 23 | 1.08 | 20 | 1.46** | 23 | 1.25** | 4 | 0.55** |
| Pre-Volcker | 40 | 1.23*** | 40 | 0.93*** | 22 | 0.95*** | 10 | 0.15* |
| Post-Volcker | 30 | 0.43** | 2 | 0.52 | 6 | 0.50** | 25 | 0.11* |
| Short-term yield | | | | | | | | |
| Classical Gold Standard | 26 | -1.28*** | 17 | -0.95* | 21 | -1.20** | 1 | -0.55** |
| Interwar period | 22 | -0.75 | 37 | -1.45** | 27 | -1.08 | 1 | -0.11 |
| Pre-Volcker | 18 | -0.45*** | 57 | -0.80*** | 19 | -0.44** | 11 | -0.28*** |
| Post-Volcker | 20 | -0.33 | 9 | 0.60 | 3 | 0.09 | 24 | 0.00 |
| Inflation | | | | | | | | |
| Classical Gold Standard | 14 | -0.44 | 16 | -0.45** | 13 | -0.37** | 2 | 0.03 |
| Interwar period | 21 | -0.27* | 23 | 0.01** | 21 | 0.01** | 7 | -0.12** |
| Pre-Volcker | 8 | -0.25* | 48 | -0.86*** | 12 | -0.29** | 14 | -0.21*** |
| Post-Volcker | 33 | -0.53** | 1 | 0.03 | 4 | -0.31* | 24 | -0.13* |
| Credit-to-GDP gap | | | | | | | | |
| Classical Gold Standard | 13 | -0.18 | 7 | 0.11 | 8 | 0.05 | 3 | -0.07** |
| Interwar period | 16 | -0.03 | – | – | 17 | 0.02 | 1 | 0.00 |
| Pre-Volcker | 2 | 0.10 | 25 | 0.19* | 3 | 0.01 | 15 | 0.03* |
| Post-Volcker | 23 | -0.04 | 3 | 0.08* | 3 | 0.00 | 27 | -0.03*** |
| Real broad money growth | | | | | | | | |
| Classical Gold Standard | 33 | 0.71*** | 15 | 0.24** | 24 | 0.46 | 4 | 0.05** |
| Interwar period | 22 | 0.54 | 30 | 0.07* | 24 | 0.08* | 2 | 0.06* |
| Pre-Volcker | 48 | 0.68*** | 47 | 0.42*** | 23 | 0.29* | 26 | 0.16*** |
| Post-Volcker | 22 | 0.08 | 6 | 0.38 | 3 | 0.05 | 24 | 0.03 |
| Real stock returns | | | | | | | | |
| Classical Gold Standard | 57 | 0.21*** | 8 | 0.05 | 41 | 0.17 | 4 | 0.03** |
| Interwar period | 66 | 0.19*** | 47 | -0.01*** | 33 | -0.01** | 9 | 0.05* |
| Pre-Volcker | 49 | 0.09*** | 70 | 0.07*** | 44 | 0.08*** | 17 | 0.03*** |
| Post-Volcker | 56 | 0.06*** | 1 | 0.00 | 4 | 0.02 | 34 | 0.03*** |
| ΔPublic debt / GDP | | | | | | | | |
| Classical Gold Standard | 11 | -0.44 | 4 | 0.05 | 8 | -0.10 | 3 | -0.03 |
| Interwar period | 19 | 0.28 | – | – | 38 | 0.46 | 2 | 0.04** |
| Pre-Volcker | 32 | 0.88*** | 33 | 0.53** | 10 | 0.26* | 15 | 0.03 |
| Post-Volcker | 25 | 0.13 | 5 | 0.32** | 3 | 0.06 | 24 | 0.03 |
| ΔCurrent account / GDP | | | | | | | | |
| Classical Gold Standard | 10 | 0.27 | 7 | -0.54* | 8 | -0.18 | 2 | -0.01 |
| Interwar period | 16 | -0.52 | – | – | 32 | -0.44 | 1 | 0.05 |
| Pre-Volcker | 5 | -1.04 | 25 | -0.44 | 4 | 0.05 | 17 | 0.23** |
| Post-Volcker | 22 | 0.50 | 6 | -0.97 | 5 | -0.51 | 25 | 0.10** |
| All variables together (α = coefficient of the slope of the yield curve) | | | | | | | | |
| Classical Gold Standard | 74 | -3.36 | 38 | -0.45 | 51 | -2.85* | 7 | -0.10 |
| Interwar period | 81 | 2.90 | – | – | 65 | -0.71* | 10 | 0.94** |
| Pre-Volcker | 77 | 1.71*** | 81 | -0.49 | 61 | -0.07 | 29 | -0.06 |
| Post-Volcker | 75 | 0.95*** | 27 | 1.95 | 19 | 1.27* | 39 | 0.25** |

Sources: Jordà *et al.* (2017), NBB.

- 1 The standard errors for all regressions are robust to heteroskedasticity and cluster-robust for panel regressions. Panel regressions include fixed effects. Asterisks *, ** and *** indicate significance at the 1, 5 and 10 %-level (unilateral tests in function of the sign of the coefficients).
- 2 As credit-to-GDP gaps series are available only since 1888 according to our computational methodology, the series are excluded from the regressions with all variables over the period of the Classical Gold Standard. Credit-to-GDP gaps are computed as the deviation of the credit-to-GDP ratios from their long-term trends. The latter are estimated by applying Hamilton's (2017) method, i.e. five-year direct forecasts based on an AR(4) model.
- 3 Some estimations regarding Germany during the interwar period could not be carried out due to a lack of data.
- 4 No data for Canada for the first two periods (Classical Gold Standard and interwar period).
- 5 Some data are missing for some countries and periods (mainly around the two world wars).

4. Is the yield curve still a reliable indicator?

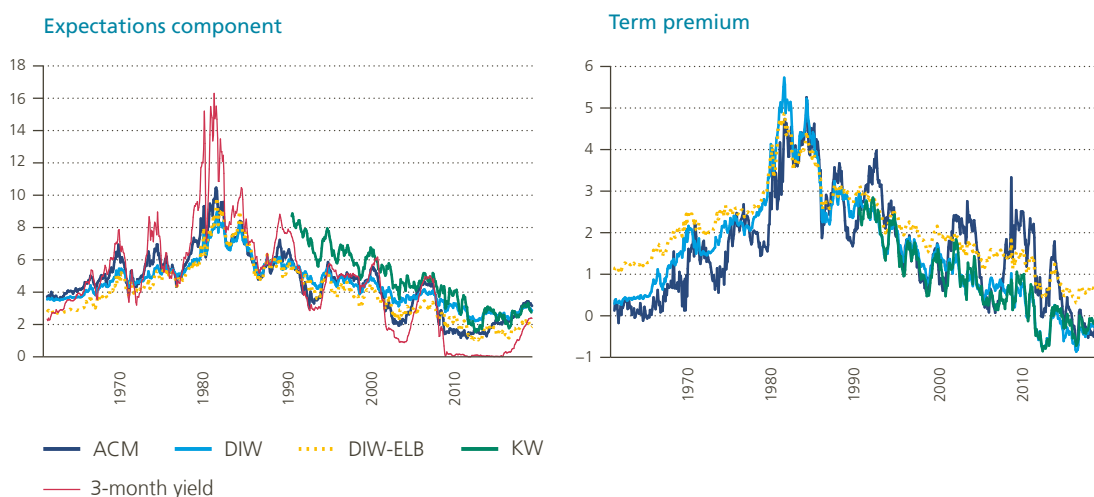
While the previous section showed that the forecasting power of the yield curve has decreased since the mid-1980s, this section further investigates the reasons for that decline and, using more detailed US data, attempts to determine whether the yield curve is still a reliable indicator. In particular, the section draws attention to the prominent role played by structural and policy factors in shaping the long end of the yield curve.

Decomposing long-term US sovereign yields into short-term rate expectations and a term premium helps to shed light on the structural and policy forces that have been influencing the yield curve. Since these two components are unobservable, they have to be estimated, which can be done using various models. Chart 4 displays estimates of these components for the ten-year US sovereign yield derived from four different models: one proposed by Adrian *et al.* (2013, henceforth ACM), one proposed by Kim and Wright (2005, KW) and two proposed by Dewachter *et al.* (2016)¹. The latter two models differ, as one accounts for the effective lower bound (DIW-ELB) whereas the other does not (DIW). The goal is not to discuss all the model specificities, but rather to highlight two observations. First, model uncertainty (in addition to estimation uncertainty) seems sufficiently important to conclude that it is impossible to precisely pin down the value of the two components. However, and this is the second observation, the low-frequency dynamics of the two components are similar across models. Specifically, all models show that the two components maintained an upward trend between the mid-1960s and the beginning of the 1980s, and subsequently followed a downward trend. In the past couple of years, short-term yield expectations have edged upwards, mainly reflecting better economic prospects and consequently (expectations of) monetary policy normalisation, while term premium estimates have remained at low levels.

Chart 4

Decomposition of 10-year US sovereign yields according to different models

(in %)



Sources: Board of Governors of the Federal Reserve System (H15), NBB.

¹ Both specifications proposed by Dewachter *et al.* (2016) are similar to the model of Christensen and Rudebusch (2012), with the level factor of the yield curve restricted to follow a random walk.

These low-frequency dynamics are important as they can help us to understand the changing relation between the yield curve and economic activity. In that respect, note that the trend decline in average expected short-term yields observed since the mid-1980s has not fundamentally altered the slope of the yield curve, since a similar decline can be observed in short-term yields (represented by the three-month sovereign yield on the chart). However, the trend decline in term premiums has altered the slope (considering that the term premium in the three-month yield is negligible). Therefore, the next sub-section takes a closer look at the factors behind the structural and continued decline in the term premium. In contrast to the factors mentioned in section 2, these drivers are unrelated to market expectations of looming recession risks.

4.1 Structural and policy factors behind the fall in the term premium

First of all, note that the nominal term premium can be further decomposed into a real interest rate premium and an inflation risk premium. The trend decline in the term premium over the last decades reflects declines in both of its components.

The trend decline can in part be explained by a shift in the monetary policy regime (Wright, 2011; Vlieghe, 2018). Since the mid-1980s, central banks in advanced economies have focused on bringing inflation down, stabilising it at a low level of about 2% and anchoring inflation expectations at a similar level. In parallel with the inflation conquest, term premiums, and in particular the inflation risk premiums, have come down. With inflation low and rather predictable, the risk of inflation surprises has been reduced, with investors accepting lower compensation for bearing this risk. In addition, the inflation risk premium also dropped as the correlation between inflation and consumption growth became more positive: when consumption growth is weak, inflation tends to surprise on the downside, making bonds, due to their fixed nominal returns, more attractive. Since the global financial crisis in 2008, safe long-term bonds have become more attractive and, with inflation falling short of its target, the inflation risk premium fell even lower. It may currently be close to zero or even negative in the United States (Hördahl and Tristani, 2014; Camba-Mendez and Werner, 2017; Cohen *et al.*, 2018).

Besides the inflation risk premium, the real interest rate premium has also declined steadily in the US. An important factor exerting downward pressure on the latter has been the imbalance between the reduced supply of safe assets and the increased demand for them at global level over the past decades (Caballero *et al.*, 2017; Del Negro *et al.*, 2017). Before the crisis, higher demand for safe, longer US Treasuries can be explained by emerging economies turning to safe US assets to invest their savings, which were expanding as a result of population ageing and central banks building international reserves for precautionary reasons after the Asian financial crisis of the late 1990s (Bernanke, 2005). The global financial crisis exacerbated the supply-demand imbalance in safe assets. The global supply of safe assets fell as government bonds in certain jurisdictions were no longer characterised as safe, while worldwide demand for safe assets was boosted, e.g. by regulatory requirements for pension funds (De Backer and Wauters, 2017). This higher demand for safe longer-term US Treasuries further compressed term premiums, and, in particular, the real interest rate premiums. In addition, the Fed's asset purchases under its quantitative easing programme also lowered term premia on longer-term Treasuries. D'Amico and King (2013) and Bonis *et al.* (2017) find that the large stock of assets on the Fed's balance sheet might still be holding down term premiums. This could explain why, despite the Fed no longer buying long-term assets, term premiums remain depressed today.

In today's situation, to the extent that the low level of term premiums mainly reflects forces unrelated to recession expectations, a flat or inverted yield curve need not necessarily signal that a recession is imminent.

Given that the term premium may distort the signal given by the yield curve, would it not be better to exclude it from the slope altogether to improve its predictive power? The following sub-section investigates this question.

4.2 Should the slope of the yield curve be adjusted for the term premium?

While section 3 assesses the yield curve’s ability to predict future GDP growth, this section focuses on analysing the yield curve’s ability to predict future recessions.

In order to relate the yield curve to the probability of a recession, probit models of the following form are estimated:

$$P(\text{recession}_{t+12, t+18} = 1|X_t) = \Phi(\beta_0 + \beta_1 X_t),$$

where $\text{recession}_{t+12, t+18}$ is a 0/1 indicator that equals 1 if there is an NBER-dated recession at some point between 12 and 18 months ahead, $\Phi(\dots)$ denotes the standard normal cumulative distribution function and X_t is one of the following three explanatory variables:

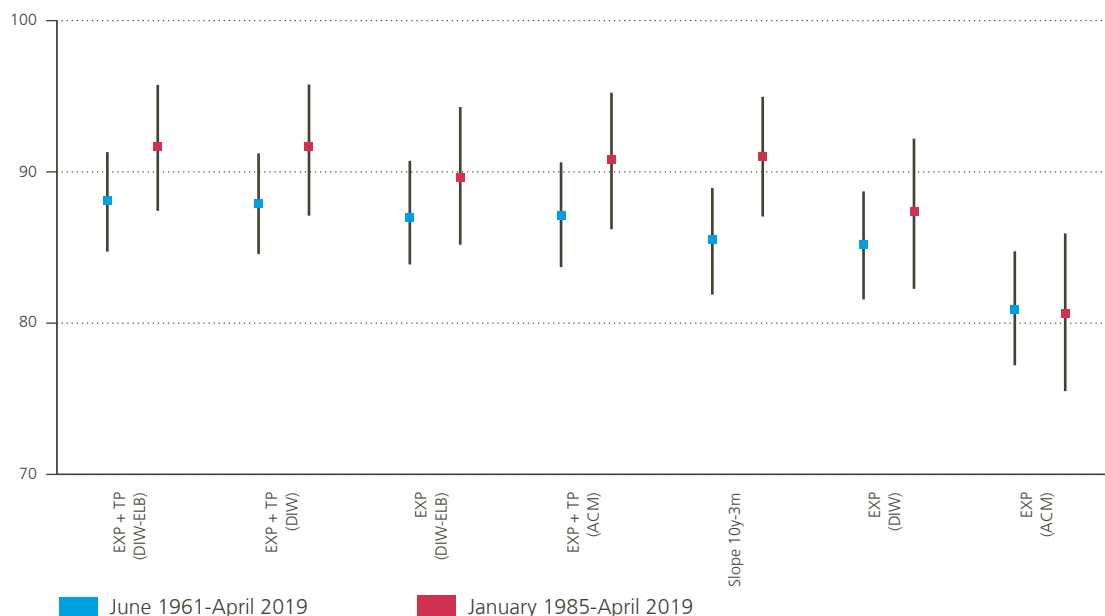
- the slope of the yield curve, defined as the difference between ten-year and three-month US sovereign yields;
- the expectations (EXP) component of the slope of the yield curve (i.e. excluding the term premium);
- the expectations component and the term premium included separately (EXP + TP);

To compare the forecasting accuracy of the three measures, we calculate the “area under the curve” (AUC) for each of them. This measure roughly captures the probability of correct prediction, with 100 % corresponding to perfect prediction and 50 % to no predictive power (equivalent to tossing a coin). We use three different models to decompose the slope of the yield curve since 1961: ACM, DIW-ELB and DIW. We also compute AUCs for an estimation period starting in 1985 to test the stability of the results (taking into account a potential structural break in the mid-1980s).

Chart 5

Predictive power of the slope of the US yield curve and its components

(AUC in %, confidence intervals of 95 %)



Sources: Board of Governors of the Federal Reserve System (H15), NBB.

Note: The predictive power of the expectations and term premium component derived from the KW model are not shown in the chart as they are not comparable with the AUCs depicted. For one thing, KW data are only available as of 1991. Second, KW uses different data for the ten-year yield on US Treasuries. However, AUCs based on KW data lead to similar conclusions to AUCs based on ACM and DIW data.

Chart 5 reports the AUCs obtained for the different models over the two estimation periods. AUCs are rather similar across the two periods (even if the predictive power in the shorter sample is slightly higher overall), confirming the finding in the empirical literature on the stability of the relationship between the yield curve and recessions (as opposed to GDP growth). The slope and its components all seem to have good, and rather similar, predictive power. Explicitly including the term premium component seems to slightly improve the predictive accuracy, suggesting that the term premium does contain some useful information about future recessions. However, the relatively high predictive power of the expectations component suggests that the recession signal embedded in the slope of the yield curve stems mostly from this component¹.

With the confidence intervals of the predictive abilities overlapping, we cannot, at first sight, conclude that the differences between AUCs are statistically significant. However, if we perform a Wald test, we reject the hypothesis that all AUCs are equal (at the 1 % significance level). More specifically, in the full sample, we cannot reject the hypothesis that AUCs are equal only for the first three specifications in the chart, i.e. we can think of these three models as performing equally well. This implies that the predictive power of the expectations component based on DIW-ELB estimates is similar to that of the two components included separately according to DIW-ELB and DIW estimates. Consequently, empirical evidence remains inconclusive on whether the term premium generally has additional explanatory power for predicting recessions, and thus whether the slope generally needs to be adjusted for it. In the smaller sample, we cannot reject the hypothesis that AUCs are equal only for the simple slope specification and the DIW and DIW-ELB specifications which include an expectations component and a term premium separately. This further shows that empirical evidence is inconclusive about the additional explanatory power of the term premium compared to a simple slope measure.

In addition to computing the slope of the yield curve as before, we also look at the predictive power of a “short-term slope”. Given the relatively small size of term premia in short yields, a short-term slope should be a purer measure of market expectations for the trajectory of conventional near-term monetary policy. Like the expectations component, it thus tries to filter out the impact of the term premium from the recession signal in the slope of the yield curve. In this respect, Engstrom and Sharpe (2018) propose to look at a “near-term forward spread”, which is the difference between the implied three-month forward yield on US Treasury bills six quarters from now and the yield on a three-month Treasury bill. The AUCs for this near-term forward spread calculated over the full sample and the sub-sample are respectively 82 % and 86 %. The near-term forward spread thus also has high predictive power but it doesn’t outperform the measures reported in chart 7. Rather, it is in line with the results of the models that use the expectations component only.

4.3 What does the current slope of the yield curve tell us about recession risks?

Since empirical results are rather inconclusive on the relevance of the term premium for forecasting recessions, chart 6 shows estimated recession probabilities according to each of the four specifications mentioned above. More specifically, the chart shows recession probabilities between 12 and 18 months ahead for the ACM, DIW-ELB, DIW, and the near-term forward spread models using data back to 1961. Results obtained with a sample period starting in 1985 send a similar message as those estimated over the full sample.

Overall, the recession probabilities derived from the different specifications tend to behave rather similarly, clearly peaking before the start of a US recession (grey bars). However, at specific points in time, like in the past few years, probabilities derived from the yield curve slope differ from measures excluding the term premium.

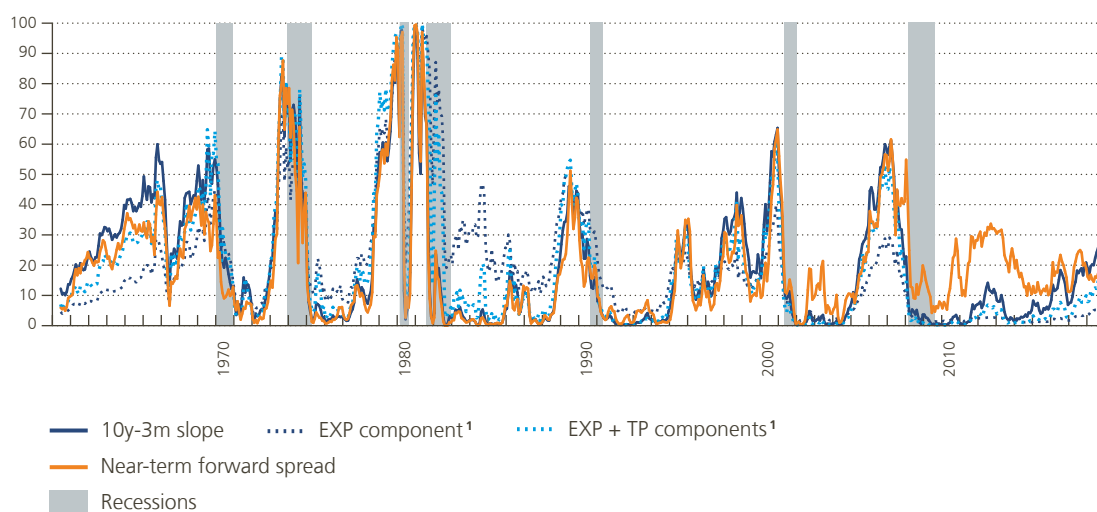
The recession probability derived from the slope of the yield curve has recently risen substantially, standing at around 45 % by April 2019, which is significantly above the unconditional probability of around 20 % (historical probability at any point in time of being in a recession between 12 and 18 months ahead). The recession

¹ This is in line with the findings of Ang *et al.* (2006) and De Graeve *et al.* (2009).

Chart 6

US recession probabilities between 12 and 18 months ahead

(derived from the slope of the yield curve, in %)



Sources: Board of Governors of the Federal Reserve System (H15), Thomson Reuters, NBER, NBB.

¹ Average of the recession probabilities obtained from the estimates of ACM, DIW and DIW-ELB models.

probability inferred from the decomposed slope (expectations component and term premium separately) has also displayed a clear upward trend. However, to the extent that structural and policy forces are depressing the term premium, these probabilities could be overestimating the recession risk.

Indeed, the recession probability based upon the slope adjusted for the term premium indicates a much lower, even insignificant, recession probability at the moment. The expectations component of the slope of the US yield curve is currently still positive, reflecting expectations of further increases in the short-term yield. In contrast, recession probabilities inferred from the near-term forward spread have risen sharply since late 2018, after being flat for years. Also, note that the Fed has recently become more cautious: in January 2019, it announced that further interest rate rises would be put on hold given tepid inflation, rising risks to global growth and tighter financial conditions. Later on, in March, the Fed stated that it would slow down the policy of scaling down its balance sheet and terminate the policy altogether by the end of September 2019, earlier than the markets expected. This change in tone and policy points to a less optimistic outlook and may have led markets to reassess the expected path of short-term rates.

Which slope measure one ultimately prefers will depend a lot on one's view about what forces are dominant drivers of yield curve dynamics at a certain point in time. Today, this debate is far from settled. Bauer and Mertens (2018a,b) appear to be rather sceptical about the this-time-is-different argument. They favour the traditional rate spread between ten-year and three-month Treasuries (without any adjustment for the term premium) as their research shows it to be the best measure for predicting recessions. On the other hand, Engstrom and Sharpe (2018) want to exclude factors that may degrade the predictive power of the yield curve (e.g. the trend decline in the term premium) and thus propose looking at the near-term forward spread to get a purer measure of market interest rate expectations. Johansson and Meldrum (2018) downplay somewhat the heightened recession risk predicted by the ten-year minus three-month spread, by also looking at slope measures adjusted for the term premium.

Conclusion

The stylised fact concerning the yield curve is most apparent in the United States: the yield curve inverted before all nine recessions identified since 1955. Yet, as the US yield curve essentially became flat at the beginning of 2019, most commentators argue that recession risks remain low. In other words, they argue that “this time is different”.

The most frequently cited arguments explaining why “this time is different” are asset purchases by central banks and reduced fears of inflation. These factors explain why the term premium – i.e. the part of the long-term yield which compensates the bond-holder for uncertainty regarding future interest rate movements – is currently low and, hence, yield curve inversions are more likely and do not necessarily signal upcoming recessions. Indeed, estimates show a significant drop in the term premium since the mid-1980s without any accompanying increase in recession occurrences. As a result, it is argued that the slope of the yield curve should be adjusted for the term premium in order to obtain a better indication of future recessions.

However, there is no decisive empirical evidence showing that the slope of the yield curve should be adjusted for the term premium. In fact, models including the term premium tend to obtain better results at forecasting recessions (in terms of “area under the curve”), although the difference compared to models excluding the term premium is not statistically significant. Hence, it remains possible that cyclical fluctuations in the term premium might contain information regarding future recessions, as for instance in the case of greater demand for long-term safe assets in a context of depressed economic prospects.

Given the indecisive empirical evidence, various estimates of current recession probabilities should be considered. According to the estimations carried out in the article, a model based on the slope of the yield curve gives a risk of about 45 % as of April 2019 that a recession will occur in the United States in between 12 and 18 months. Adjusting the slope of the yield curve for the term premium gives lower recession probabilities that depend on the specific model considered to estimate the term premium. Disregarding model uncertainty, the average probability of the models excluding the term premium is about 10 %, which suggests that recession risks are particularly low given the unconditional probability of 20 %. In general, forecasters will lean towards one of these estimates depending on which factors they believe are driving the term premium.

Overall, there are numerous reasons to assume that the yield curve is no longer as reliable as it has been in the past. However, if this leads one to conclude that recession risks remain negligible in the current context, this actually implies that one believes that “this time is different”. Realising this helps to put things in perspective and probably encourages some analysts to question the reasons put forward to claim that recession risks remain low. The resulting debate has at least the advantage of ensuring that the signal given by the yield curve is not discarded too quickly (and that Cassandra’s prediction would be taken more seriously).

Annex

Additional regression results on the forecasting ability of the slope of the yield curve¹

| X_{t-1} | US | | DE | | Panel US-DE-CA ² | | Panel other countries | |
|---|--------------------|----------|--------------------|----------|-----------------------------|----------|-----------------------|----------|
| | R ² (%) | α | R ² (%) | α | R ² (%) | α | R ² (%) | α |
| 1-year ahead forecasts of real consumption growth | | | | | | | | |
| Classical Gold Standard | 20 | 0.58* | 18 | 1.80* | 12 | 0.85 | 0 | 0.23** |
| Interwar period | 23 | 0.78 | 1 | 0.26 | 7 | 0.53 | 1 | 0.15 |
| Pre-Volcker | 29 | 0.74*** | 35 | 0.46 | 19 | 0.60** | 14 | 0.15* |
| Post-Volcker | 39 | 0.34** | 4 | 0.01 | 6 | 0.27* | 24 | 0.01 |
| 1-year ahead forecasts of real investment growth | | | | | | | | |
| Classical Gold Standard | 1 | -0.03 | 23 | 9.36*** | 3 | 1.86 | 0 | 2.24** |
| Interwar period | 7 | 3.68 | 39 | 4.62** | 11 | 4.08** | 6 | 1.80*** |
| Pre-Volcker | 57 | 3.12*** | 24 | 1.83* | 20 | 2.29** | 8 | 0.31 |
| Post-Volcker | 34 | 1.79*** | 6 | 1.16 | 17 | 1.70*** | 24 | 0.81*** |
| 2-year ahead forecasts of real GDP growth | | | | | | | | |
| Classical Gold Standard | 3 | -0.36 | 17 | 1.73** | 0 | 0.09 | 0 | 0.28** |
| Interwar period | 11 | 1.34* | 11 | 1.54 | 12 | 1.44** | 1 | 0.32* |
| Pre-Volcker | 3 | 0.23 | 6 | 0.44 | 4 | 0.35* | 5 | -0.32 |
| Post-Volcker | 25 | 0.64** | 2 | -0.44 | 2 | 0.35 | 3 | 0.08 |
| 3-year ahead forecasts of real GDP growth | | | | | | | | |
| Classical Gold Standard | 2 | 0.04 | 7 | 0.98* | 1 | 0.24 | 0 | 0.08 |
| Interwar period | 28 | 1.99** | 16 | 2.20** | 19 | 2.10** | 0 | 0.11 |
| Pre-Volcker | 6 | -0.40* | 13 | -0.12 | 2 | -0.31* | 7 | 0.00 |
| Post-Volcker | 6 | 0.33 | 5 | 1.18 | 4 | 0.55* | 1 | 0.04 |
| 1-year ahead forecasts of real GDP growth: robustness tests on alternative sub-periods | | | | | | | | |
| 1953-1964 (before rise in US inflation) | 20 | 1.28 | 21 | -0.54 | 11 | 0.32 | 0 | 0.16 |
| 1953-1971 (Bretton Woods period) | 21 | 1.22** | 27 | 0.60** | 15 | 0.72** | 7 | 0.05 |
| 1953-2016 (post-WWII period) | 16 | 0.27*** | 15 | 0.87*** | 17 | 0.73*** | 29 | 0.10* |

Sources: Jordà *et al.* (2017), NBB.

1 The standard errors for all regressions are robust to heteroskedasticity and cluster-robust for panel regressions. Panel regressions include fixed effects. Asterisks *, ** and *** indicate significance at the 1, 5 and 10 %-level (unilateral tests in function of the sign of the coefficients).

2 No data for Canada for the first two periods (Classical Gold Standard and interwar period).

Bibliography

- Adrian T., R. Crump and E. Moench (2013), "Pricing the term structure with linear regressions", *Journal of Financial Economics*, 110(1), 110-138.
- Aguiar-Conraria L., M. M. F. Martins and M. J. Soares (2012), "The yield curve and the macro-economy across time and frequencies", *Journal of Economic Dynamics & Control*, 36, 1950-1970.
- Alessandri P. and B. D. Nelson (2015), "Simple banking: profitability and the yield curve", *Journal of Money, Credit and Banking*, 47(1), 143-175.
- Ampudia M. and S. Van den Heuvel (2018), *Monetary policy and bank equity values in a time of low interest rates*, ECB, Working Paper 2199.
- Ang A., M. Piazzesi and M. Wei (2006), "What does the slope of the yield curve tell us about GDP growth?", *Journal of Econometrics*, 131(1-2), 539-403.
- Arhens R. (2002), "Predicting recessions with interest rate spreads: a multicountry regime-switching analysis," *Journal of International Money and Finance*, 21, 519-537.
- Bauer M. D. and T. M. Mertens (2018a), *Economic forecasts with the yield curve*, Federal Reserve Bank of San Francisco, Economic Letter 2018-07.
- Bauer M. D. and T. M. Mertens (2018b), *Information in the yield curve about future recessions*, Federal Reserve Bank of San Francisco, Economic Letter 2018-20.
- Benati L. and C. Goodhart (2008), "Investigating time-variation in the marginal predictive power of the yield spread," *Journal of Economic Dynamics & Control*, 32, 1236-1272.
- Bernanke B. S. (2005), *The Global Saving Glut and the U.S. Current Account Deficit*, Remarks at the Sandridge Lecture, Virginia Association of Economics, Richmond, Virginia, Federal Reserve Board, 10 March.
- Bernanke B. S. (2006), *Reflections on the yield curve and monetary policy*, Speech before the Economic Club of New York, New York, 20 March.
- Bernard H. and S. Gerlach (1998), "Does the term structure predict recessions? The international evidence", *International Journal of Finance and Economics*, 3, 195-215.
- Berge T. J. (2015), "Predicting recessions with leading indicators: model averaging and selection over the business cycle", *Journal of Forecasting*, 34, 455-471.
- Berge T. J. and Ò. Jordà (2011), "Evaluating the classification of economic activity into recessions and expansions," *American Economic Journal: Macroeconomics*, 3(2), 246-277.
- Bonis B., J. Ihrig and M. Wei (2017), *The effect of the Federal Reserve's securities holdings on longer-term interest rates*, Federal Reserve Board of Governors, FEDS Notes, April 20.
- Bordo M. D. and J. G. Haubrich (2004), *The yield curve, recessions and the credibility of the monetary regime: long-run evidence 1875-1997*, NBER, Working Paper 10431.

- Bordo M. D. and J. G. Haubrich (2008a), "Forecasting with the yield curve; level, slope, and output 1875-1997", *Economics Letters*, 99, 48-50.
- Bordo M. D. and J. G. Haubrich (2008a), "The yield curve as predictor of growth: long-run evidence, 1875-1997", *The Review of Economics and Statistics*, 90(1), 182-185.
- Borio C., L. Gambacorta and B. Hofmann (2017), "The influence of monetary policy on bank profitability", *International Finance*, 20, 48-63.
- Bloomberg (17 July 2018), "Jerome Powell hints at a little trouble with the curve".
- Bloomberg (29 March 2019), "John Williams downplays recession fears, stresses flexible Fed policy".
- Bonser-Neal C. and T. R. Morley (1997), *Does the yield spread predict real economic activity? A multicountry analysis*, Federal Reserve Bank of Kansas City, Economic Review, Third Quarter, 37-53.
- Bry G. and C. Boschan (1971), *Cyclical analysis of time series: selected procedures and computer programs*, NBER, New York.
- Bullard J. (2018), "The risk of yield curve inversion – and how to avoid it", Federal Reserve Bank of St. Louis, Regional Economist, Third Quarter.
- Caballero R. J., E. Farhi, and P.-O. Gourinchas (2017), "The safe assets shortage conundrum", *Journal of Economic Perspectives*, 31(3), 29-46.
- Camba-Mendez G. and T. Werner (2017), *The inflation risk premium in the post-Lehman period*, ECB, Working Paper 2033.
- Chauvet M. and S. Potter (2002), "Predicting a recession: evidence from the yield curve in the presence of structural breaks", *Economics Letters*, 77, 245-253.
- Chen N.-F. (1991), "Financial investment opportunities and the macroeconomy", *The Journal of Finance*, 46(2), 529-554.
- Christensen J. H. E. and G. D. Rudebusch (2012), "The response of interest rates to US and UK quantitative easing", *The Economic Journal*, 122, F385-F414.
- Claessens S., N. Coleman and M. Donnelly (2018), "Low-for-long interest rates and banks' interest margins and profitability: cross-country evidence", *Journal of Financial Intermediation*, 35, 1-16.
- Cohen B. H., P. Hördahl and D. Xia (2018), "Term premia: models and some stylised facts", BIS Quarterly Review, September.
- Dai Q. and K. J. Singleton (2002), "Expectations puzzles, time-varying risk premia, and affine models of the term structure", *Journal of Financial Economics*, 63, 415-441.
- D'Amico S. and T. B. King (2013), "Flow and stock effects of large-scale treasury purchases: evidence on the importance of local supply", *Journal of Financial Economics*, 108(2), 425-448.
- De Backer B. and J. Wauters (2017), "The cyclical and structural determinants of the low interest rate environment", National Bank of Belgium, Economic Review, September, 69-86.

- De Graeve F., M. Emiris and R. Wouters (2009), "A structural decomposition of the US yield curve", *Journal of Monetary Economics*, 56(4), 545-559.
- Del Negro M., M. P. Giannoni, D. Giannone and A. Tambalotti (2017), "Safety, liquidity, and the natural rate of interest", *Brookings Papers on Economic Activity*, Washington DC, 235-294.
- Dewachter H., L. Iania and M. Lyrio (2014), "Information in the yield curve: a macro-finance approach", *Journal of Applied Econometrics*, 29, 42-64.
- Dewachter H., L. Iania and J.-C. Wijnandts (2016), "The response of euro area sovereign spreads to the ECB unconventional monetary policies", NBB, Working Paper 309.
- Dotsey M. (1998), "The predictive content of the interest rate term spread for future economic growth", Federal Reserve Bank of Richmond, *Economic Quarterly*, 84(3), 31-51.
- Duarte A., I. A. Venetis and I. Paya (2005), "Predicting real growth and the probability of recession in the euro area using the yield spread", *International Journal of Forecasting*, 21, 261-277.
- Dueker M. J. (1997), "Strengthening the case for the yield curve as a predictor of U.S. recessions", Federal Reserve Bank of St. Louis, *Review*, March/April, 41-51.
- English W. B., S. Van den Heuvel and E. Zakrajšek (2018), "Interest rate risk and bank equity valuations", *Journal of Monetary Economics*, 98, 80-97.
- Engstrom E. and S. Sharpe (2018), "The near-term forward yield spread as a leading indicator: A less distorted mirror", Board of Governors of the Federal Reserve System, Finance and Economics Discussion Paper 2018-055.
- Estrella A. and G. A. Hardouvelis (1991), "The term structure as a predictor of real economic activity", *The Journal of Finance*, 46(2), 555-576.
- Estrella A. and F. S. Mishkin (1996), "The yield curve as a predictor of U.S. recessions", Federal Reserve Bank of New York, *Current Issues in Economics and Finance*, 2(7).
- Estrella A. and F. S. Mishkin (1997), "The predictive power of the term structure of interest rates in Europe and the United States: implications for the European Central Bank", *European Economic Review*, 41, 1375-1401.
- Estrella A. and F. S. Mishkin (1998), "Predicting U.S. recessions: financial variables as leading indicators", *The Review of Economics and Statistics*, 80(1), 45-61.
- Estrella A., A. R. Rodrigues and S. Schich (2003), "How stable is the predictive power of the yield curve? Evidence from Germany and the United States", *The Review of Economics and Statistics*, 85(3), 629-644.
- Estrella A. and H. Wu (2008), "Term premiums and the predictability of recessions", mimeo.
- Fama E. F. (1986), "Term premiums and default premiums in money markets", *Journal of Financial Economics*, 17(1), 175-196.
- Favero C. A., I. Kaminska and U. Söderström (2005), *The predictive power of the yield spread: further evidence and a structural interpretation*, CEPR, Discussion Paper 4910.

FED, October 2018 Senior loan officer opinion survey on bank lending practices.
<https://www.federalreserve.gov/data/sloos/sloos-201810.htm>.

Feroli M. (2004), "Monetary policy and the information content of the yield spread", *The B.E. Journal of Macroeconomics*, 4(1), 1-17.

Financial Times (4 April 2019), "Has the yield curve predicted the next US downturn?"

Friedman M. (1968), "The role of monetary policy", *The American Economic Review*, 58(1), 1-17.

Friedman M. (1970), "Controls on interest rates paid by banks", *Journal of Money, Credit and Banking*, 2(1), 15-32.

Galvão A. B. C. (2006), "Structural break threshold VARs for predicting US recessions using the spread", *Journal of Applied Econometrics*, 21, 463-487.

Gerlach S. and R. Stuart (2018), "The slope of the term structure and recessions: the pre-Fed evidence, 1857-1913", CEPR, Discussion Paper 13013.

Goodhart C. (2007), "Does a downward-sloping yield curve predict a recession?", VoxEU.org on 24 September.

Hamilton J. D. and D. H. Kim (2002), "A reexamination of the predictability of economic activity using the yield spread", *Journal of Money, Credit and Banking*, 34(2), 340-360.

Harvey C. R. (1988), "The real term structure and consumption growth", *Journal of Financial Economics*, 22(2), 305-333.

Harvey C. R. (1989), "Forecasts of economic growth from the bond and stock markets", *Financial Analysts Journal*, September/October, 38-45.

Harvey C. R. (1991), "The term structure and world economic growth", *The Journal of Fixed Income*, 1, 4-17.

Harvey C. R. (1997), "The relation between the term structure of interest rates and Canadian economic growth", *The Canadian Journal of Economics*, 30(1), 169-193.

Haubrich J. G. and A. M. Dombrosky (1996), "Predicting real growth using the yield curve", Federal Reserve Bank of Cleveland, Economic Review, First Quarter, 26-35.

Hördahl P. and O. Tristani (2014), "Inflation Risk Premia in the Euro Area and the United States", *International Journal of Central Banking*, 10(3), 1-47.

Ivanova D., K. Lahiri and F. Seitz (2000), "Interest rate spreads as predictors of German inflation and business cycles", *International Journal of Forecasting*, 16, 39-58.

Jardet C. (2004), "Why did the term structure of interest rates lose its predictive power?", *Economic Modelling*, 21, 509-524.

Johansson P. and A. Meldrum (2018), "Predicting recession probabilities using the slope of the yield curve", Board of Governors of the Federal Reserve System, *FEDS Notes*.

Jordà Ò., M. Schularick and A. M. Taylor (2017), *Macrofinancial history and the new business cycle facts*, NBER Macroeconomics Annual 2016, volume 31, edited by M. Eichenbaum and J. A. Parker. Chicago: University of Chicago Press.

Joslin S., M. Priebsch and K. J. Singleton (2014), "Risk premiums in dynamic term structure models with unspanned macro risks", *The Journal of Finance*, 69(3), 1197-1233.

Kapinos P. and A. Musatov (2018), "Smaller banks less able to withstand flattening yield curve", Federal Reserve Bank of Dallas, Economic Letter, 13(8).

Kashkari N. (2018), "The flattening yield curve", Federal Reserve Bank of Minneapolis, Message on 16 July.

Kessel R. A. (1965), "The cyclical behavior of the term structure of interest rates", NBER, Occasional Paper 91.

Kim W. and J. Wright (2005), "An arbitrage-free-three-factor term structure model and the recent behaviour of long-term yields and distant-horizon forward rates", Board of Governors of the Federal Reserve System, Finance and Economics Discussion Paper 2005-33.

Laurent R. D. (1988), "An interest rate-based indicator of monetary policy", Federal Reserve Bank of Chicago, Economic Perspectives, January/February, 3-14.

Laurent R. D. (1989), "Testing the 'spread'", Federal Reserve Bank of Chicago, Economic Perspectives, July, 22-34.

Modigliani F. and R. Sutch (1966), "Innovations in interest rate policy", *The American Economic Review*, 56 (1/2), 178-197.

Moneta F. (2005), "Does the yield spread predict recessions in the euro area?" *International Finance*, 8(2), 263-301.

Peel D. A. and Ch. Ioannidis (2003), "Empirical evidence on the relationship between the term structure of interest rates and future real output changes when there are changes in policy regimes", *Economics Letters*, 78, 147-152.

Plosser C. I. and K. G. Rouwenhorst (1994), "International term structures and real economic growth", *Journal of Monetary Economics*, 33, 133-155.

Praet P. (2013), *Forward guidance and the ECB*, column published in VoxEU.org on 6 August.

Rendu de Lint C. and D. Stolin (2003), "The predictive power of the yield curve: a theoretical assessment", *Journal of Monetary Economics*, 50(7), 1603-1622.

Roma A. and W. Torous (1997), "The cyclical behavior of interest rates", *The Journal of Finance*, 52(4), 1519-1542.

Rudebusch G. D. and J. C. Williams (2009), "Forecasting recessions: the puzzle of the enduring power of the yield curve", *Journal of Business & Economic Statistics*, 27(4), 492-503.

Schrimpf A. and Q. Wang (2010), "A reappraisal of the leading indicator properties of the yield curve under structural instability", *International Journal of Forecasting*, 26, 836-857.

Stock J.H. and M. W. Watson (1989), "New indexes of coincident and leading economic indicators," in *NBER Macroeconomics Annual*. O. J. Blanchard and S. Fischer, eds., 351-394.

Stock J.H. and M. W. Watson (2003a), "Forecasting output and inflation: the role of asset prices", *Journal of Economic Literature*, 41, 788-829.

Stock J.H. and M. W. Watson (2003b), "How did leading indicator forecasts perform during the 2001 recession?", *Federal Reserve Bank of Richmond, Economic Quarterly*, 89(3), 71-90.

Vayanos D. and J.-L. Vila (2009), *A preferred habitat model of the term structure of interest rates*, NBER, Working Papers 15487.

Venetis I. A., I. Paya and D. A. Peel (2003), "Re-examination of the predictability of economic activity using the yield spread: a nonlinear approach", *International Review of Economics and Finance*, 12, 187-206.

Vlieghe G. (2018), "The yield curve and QE", speech given at the Imperial College Business School, Bank of England, 25 September.

Wright J. (2006), "The yield curve and predicting recessions", *Federal Reserve Board, Finance and Economics Discussion Paper No. 2006-07*.

Wright J. (2011), "Term Premia and Inflation Uncertainty: Empirical Evidence from an International Panel Dataset", *American Economic Review*, 101(4), 1514-1534.