US Special

Is the next US recession visible in the yield curve?

Financial Markets Research

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Marketing Communication

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Summary

Inversions of the US treasury yield curve are often seen as harbingers of a recession. However, now that shortterm rates are extremely low it has become very difficult for the yield curve to invert. Does this mean that we can no longer use the yield curve as an early warning signal for a US recession? Fortunately, by adjusting the yield spread for low short-term rates we are able to amplify the signal and find that the current yield spread, although it is positive, does indicate an elevated risk of a recession. We also find that the highest risk lies beyond the 12 month horizon that is usually reported by researchers.

Introduction

The disappointing GDP growth rates for Q1 (0.8%) and Q2 (1.2%) have raised questions about the momentum of the US expansion. Is this a slowdown related to the global headwinds that the US economy is facing and are we going to see a reacceleration going forward, or is the inability of the economy to reach escape velocity the first sign of an upcoming recession? Last year we noted in our special Thinking about the next US recession that the expansion had already lasted longer than average. In this special we try to find an early warning signal of the next recession by using the information that is contained in the US treasury yield curve. In the past, US recessions were preceded by an inversion of the yield curve, as is evident in figure 1 where we plot the spread between the 12 month and 10 year US treasury yield and indicate the recessions by the shaded areas. Note that each recession since the 1960s was preceded by a yield curve inversion.

Figure 1: 12m-10y yield spread

Therefore, the yield spread has become a popular tool to forecast recessions. For example, the New York Fed provides regular updates of a recession probability model based on the yield spread between 3m treasury bills and 10y treasury bonds. In July 2016, the probability of a US recession twelve months ahead was 9.8505%. The Cleveland Fed maintains a similar model: the most recent forecast was made in May and indicated an 8.29% probability of a recession in one year. However, we would like to note that with short-term rates at extremely low levels, it has become very difficult for the yield curve to invert. So if we take the yield spread at face value, we will forecast a low probability of a recession as long as money market rates remain very low. One could argue that this is justified, because with extremely loose monetary policy
the risk of a recession should be small. If this is true, the reported probabilities of a recession calculated by the New York Fed and the Cleveland Fed are plausible. However, in this special we explore the possibility that a recession may occur despite the Fed’s extremely loose monetary policy. This also means that we cannot use the yield spread in its raw form, because it only gives a muted signal as it is very difficult for the yield curve to invert if the short-term rate is extremely low. Therefore we make an adjustment to the spread that amplifies the signal that is contained in the yield curve.

By adjusting the spread we implicitly assume that we are in the middle of a structural break in the correlation between the yield spread and recessions. In fact, we will show that this is not the first structural break in that correlation. However, after the earlier break the yield curve was still easily able to invert, which is no longer the case at present.

We also investigate which specific spread has been the most reliable predictor of recessions, as researchers have investigated the spreads between different maturities (see Appendix). We apply our adjustment to the spread that has been the most reliable in the past.

Finally, we question the habit of researchers to focus on the 12 month horizon when forecasting recessions with the yield curve. While economists like to present their forecasts at this horizon, we find that the optimal horizon from an econometric perspective lies beyond that point. This means that the common yield curve based recession forecasts underestimate the probability of a recession because the probability peak that lies further ahead remains unnoticed.

The logit model

The binary nature of being in a recession – the economy is either in recession or it is not – makes the standard linear regression model inadequate. Instead, the logit model is an appropriate model to explain dichotomous data, and also easily interpretable because we can express the probability of a recession as a function of the lagged yield spread and the estimated parameters in closed form. Given the relatively low frequency of economic recessions it makes sense to first consider a large sample in order to estimate the model. Using monthly data for the 12m-10y US treasury yield spread and NBER recession dates from February 1962 to April 2016, we found an optimal lag of 11 months (see endnote 1). The recession probabilities implied by the logit model with the 11 month lag of the yield spread are plotted in figure 2 and seem to match consistently the observed periods of US recession (shaded areas).

Figure 2: Recession probability implied by 12m-10y yield spread (based on 1962-2016 sample)

Source: Rabobank Financial Markets Research


Structural break and re-estimation

While this result confirms the usefulness of the yield spread as a predictor of recessions, the estimated probabilities shown in figure 2 are much lower for the last three US recessions. This suggests the existence of a structural break in the model. The reason becomes more obvious when we take a second look at the behavior of the 12m-10y yield spread in figure 1. Notice that the yield curve inversions were much more modest in the last three recessions. Consequently, estimates based on the entire sample underestimate the probability of recession over the later part of the sample.

The existence of structural change in the large sample suggests that a smaller sample should be considered, taking solely into account data after the breaking point in order to avoid large forecasting errors. Following an analogous procedure as in the previous section, the 17th lag has been selected for this model. So while inversions have become smaller, their optimal forecasting horizon has increased.

The estimated probabilities prior to recession periods are this time much higher than previously which suggests that considering a smaller data sample from 1985 is more appropriate in this specific case. As observable in figure 3, the current probability of entering into a recession in 17 months is relatively low, 2.56% by the end of July 2016. This confirms the results of the New York Fed and the Cleveland Fed.

To get a deeper understanding of the model, the probability of recession can be represented as a function of the number of lags (figure 4) and the value of the spread (figure 5).

First, let’s take a look at recession probability as a function of the number of lags. While researchers usually report the probability of a recession at the 12 month horizon, we have selected the optimal forecasting horizon, which is 17 months. In fact, if we estimate the model for different lags we are able to plot the recession probability at different horizons in figure 4. It is clear that the yield spread is not a very good predictor of recessions at short horizons. The recession probability initially rises as we look further ahead, and the highest probability of recession is obtained at the 17 month horizon. Nevertheless, if we assume that a probability of 50% is a sufficiently high signal of recession, lagged periods of the spread from 13 to 25 months can also be used as adequate predictors. However, the habit of researchers of reporting the recession probability at the 12 month horizon clearly misses the probability peak that lies beyond this point. That is why we prefer to report the probability at the optimal horizon of 17 months.

Now consider recession probability as a function of the yield spread. In figure 5, the probability of being in recession at the optimal 17 month horizon is plotted with respect to different values of the spread. Large positive values of the yield spread imply only a small probability of a recession, while large negative values give a high recession probability. We can think of a 50% probability as a critical point. It turns out...
Is the next US recession visible in the yield curve?

that this is reached when a spread of 0 is observed. So a flat yield curve can be seen as a signal that the probability of a recession is 50%; any inversion indicates a higher probability.

An increasingly noisy signal?
The track record of yield curve inversions as a predictor of recessions is impressive if we look at figure 1. However, some caution is in order in the present circumstances. The unprecedented actions by the Fed have pushed the entire US treasury yield curve so far down that an inversion has become more difficult to achieve than in the past. Since the Fed keeps the policy rates at extremely low levels, short term rates remain extremely low as well. Therefore, it is difficult for long term rates to fall below short term rates. What’s more the slope of the US treasury yield curve does not purely reflect market expectations of the US business cycle and future Fed policy – which is the logic behind the predictive information in the slope of the yield curve –; it is distorted by the Fed’s actions. This means that the signal given by the yield curve is noisier than usual. Nevertheless, history suggests that it is a signal that should not be ignored.

Adjusting the yield spread to amplify recession signals
How can we correct for the increasing difficulty to obtain an inversion of the yield curve due to the extremely low short term rates of recent years? Intuitively we would like to create an adjusted yield spread measure that will exhibit an inversion (or more generally: give a recession signal) before the original yield curve does when the long term rate is decreasing. This correction should work most strongly for low values of the short term rate and less for higher values, where an adjustment is actually not needed. In this way we may bridge the structural break that is caused by extremely low money market rates. The functional form for the transformation that immediately comes to mind is a natural logarithm, as it has a strong curvature for small values and flattens out for higher values. One way to achieve this is to add an affine function of the natural logarithm of the short term rate to the original yield spread: for small values of the short term rates this correction term will subtract an amount from the original spread that increases in magnitude as short term rates get smaller. So as it becomes more difficult to get a negative value for the original spread we make it easier for the adjusted spread to turn negative.

But how much should we subtract from the original spread? We can calibrate the adjustment through regression analysis. Suppose we use an affine function of the natural logarithm of the short term rate STR as a correction for the original spread SP. We can write this as $SP_t = \alpha + \beta \ln(STR_t + 1) + ASP$. So if we run a linear regression of the original spread SP on the natural logarithm of the short term rate, the residuals of the regression can be used as the adjusted spread (ASP). We find the following regression result:

$$SP_t = 2.616 - 0.808 \ln(STR_t + 1) + \epsilon_t$$
Is the next US recession visible in the yield curve?

Note that the original spread $SP$ is a downward sloping function of the natural logarithm of the short term rate, which is consistent with higher policy rates causing curve flattening (see What drives the US treasury yield curve?). We can rewrite the regression equation to obtain the adjusted spread (see endnote 2):

$$ASP_t = \varepsilon_t = SP_t - 2.616 + 0.808 \ln(STR_t + 1)$$

In figure 6 we plot the adjustment $ASP-SP$ as a function of the short term rate. Note that the adjusted spread makes a downward correction to the original spread that increases in size as short term rates get lower. What’s more, these increases get bigger as short term rates get lower. This is what we tried to achieve by using the natural logarithm: as short term rates get closer to zero it becomes increasingly more difficult for the original spread to turn negative, so we have to make an increasingly larger adjustment to generate a recession signal (see endnote 3).

How do we interpret the adjusted yield spread? Note that the ASP, as the residual from the regression, has an average of zero (see figure 7). When ASP is zero, the original spread has a value that is ‘average’ for the value of the short term rate at that moment. When ASP is negative, the spread is low for that short term rate. This means that the risk of a recession is higher (see endnote 4). We can then calculate for which negative value the ASP indicates a 50% probability of a recession at a future date (see figure 10).

The adjusted 12m-10y yield spread is plotted as a function of time in figure 7. Note recent values of the adjusted spread (ASP) are currently much more similar to pre-recession periods than recent values of the original spread. The creation of a level playing field for the recent yield curve reveals that the risk of a recession is much higher than suggested by the original spread.
Is the next US recession visible in the yield curve?

So how large is this recession probability? We translate the adjusted spread into recession probabilities through the logit model. They are plotted in figure 8 (see endnote 5).

Like before, we can get a deeper understanding of the model implications by plotting the recession probability as a function of the number of lags (figure 9) and the value of the yield spread (figure 10). The optimal forecasting horizon is again 17 months, and the adjusted spread has to reach a value of -1.28% in order to get a 50% probability of a recession at the optimal horizon (see endnote 6).
Conclusion

So what is the current yield curve telling us about the probability of a recession in the future? By the end of July the (original) 12m-10y spread was 0.96%, which means that the yield curve is not inverted. Therefore, at first sight, the yield curve is not giving a recession signal. However, the adjusted 12m-10y yield spread was -1.33% by the end of July 2016, which is below the critical value of -1.28% that we established for a 50% recession probability. In fact, we find a 54.17% probability at the 17 month horizon, which is December 2017. At the 12m horizon our recession probability is 39.23%, which is much higher than the New York Fed’s 9.8505%, and the Cleveland’s Fed 8.29%. So the recent flattening of the US treasury yield curve, even though it has not led to an inversion, should be seen as a signal that the risk of a recession has reached an alarming level, especially beyond the 12 month horizon.

References


https://www.newyorkfed.org/research/capital_markets/ycafaq.html


Endnotes

1) We have determined the optimal number of lags $h$ between the yield spread inversion and the recession by looking at the value of the Akaike Information Criterion (AIC).

2) The ASP, as the residual from the regression, has an average of zero. This explains why the ASP subtracts a constant from the original spread, because the latter is positive on average. The constant can be interpreted as the normalization needed to get a zero mean for the distribution of ASP when the short term rate is exactly 0. As the short term rate increases, the adjustment becomes smaller.

3) While we have adjusted for the low level of the yield curve, the other noise caused by the Fed’s distortion of the slope has not been adjusted for. So while we have amplified the signal, without which the yield curve would have lost its use as an early warning for recessions, a substantial amount of noise remains. Nevertheless, it is a signal that we cannot afford to ignore.
4) Since the adjusted spread has an average of zero, the critical value for a recession is a negative number, because the economy is expanding on average. Therefore, we are no longer looking at mere inversions as a signal for a recession, because the ASP is inverted about half of the time (depending on how far the median lies from the mean). We are now looking for a sufficiently large inversion.

5) Note that after adjusting the yield spread for low short term rate levels our model fails to provide a sufficiently strong signal for the recession in 1990-1991. This may be caused by the high short term rate levels in that period. However, the model performs well for the last two recessions. What’s more, excluding the 1990-1991 recession from the sample does not improve the results, perhaps because the amount of recessions in the sample drops to only two. We also tried a linear adjustment instead of a logarithmic, by regressing the original spread on the short term rate directly. However, the logit model based on a linear adjustment to the spread performs worse than the version with the logarithmic adjustment. So our spread adjustment is able to bridge the structural break between the Great Recession and the next recession, but does so at the expense of forcing a structural break between the 1990-1991 recession and the 2001 recession.

6) Note that the probability peak in figure 9 is relatively low because of the poor fit for the 1990-1991 recession, as explained in 5).

Appendix: Alternative spreads

Another sensitivity analysis of the results can be performed by looking at alternative yield spreads. While we have presented our results so far in terms of the spread between the yields on 12 month Treasury bills and 10 year Treasury bonds, several types of term spreads have been explored in the literature on forecasting recessions with the yield curve. In fact, we examined the most common beforehand by comparing the in-sample forecasting accuracy of the 3m-10y, 12m-10y and 2y-10y yield spread. As suggested by Diebold & Rudebusch (1989), we used the probability-forecast analog of the mean squared error, the Quadratic Probability Score (QPS) as a measure of the forecasting accuracy. The QPS ranges from 0 to 2, with lower values indicating better accuracy of the model. As observable in table A.1, the 12m-10y yield spread seems the most appropriate leading indicator of US recession given the lowest QPS measure of 0.11.

<table>
<thead>
<tr>
<th>Table A.1: Forecasting accuracy of alternative yield spreads</th>
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<tbody>
<tr>
<td>Spread</td>
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<tr>
<td>-----------------</td>
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<tr>
<td>3m-10y spread</td>
</tr>
<tr>
<td>12m-10y spread</td>
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<tr>
<td>2y-10y spread</td>
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Source: Rabobank Financial Markets Research
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Is the next US recession visible in the yield curve?

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