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Abstract

The ability of the term structure (specifically the term spread, or the difference between the long and short ends of the yield curve) to predict economic activity is empirically well-established for the US, but less so for small open economies. The literature emphasizes the role of monetary policy for this predictive ability. Between 1972-2018, Ireland experienced three monetary regimes: first, the Irish Pound was fixed to Sterling (1972-1979); second the Pound floated in a band when Ireland was a member of the EMS (1979-1998); and third, as a member of the euro area (1999-2018). Using dynamic probit models and monthly data, I show that the term spread only had predictive power during the second regime, the only one in which the Central Bank of Ireland had any discretion to set interest rates based on domestic conditions.

Keywords: Ireland, term structure, recessions, monetary regimes.

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1. Introduction

Forecasting the future path of the economy is a challenge for policymakers. One simple and reliable indicator of future economic activity in the US is the term spread of interest rates. However, while this relationship is well understood in the US, the evidence for smaller, more open economies is less well developed. Nonetheless, for policymakers in these economies -- where forecasting economic activity is particularly difficult due to the vulnerability to external shocks -- a simple forecasting tool such as the term spread, which is available in real time and never revised, would be particularly useful.

One reason for the relatively small literature on the predictive relationship between the term spread and economic activity in small open economies is that it is often ascribed to monetary policy. Thus, the slope of the term structure may be less informative in small and highly open economies where central banks tend to fix, or manage heavily, their exchange rates. With interest rates consequently determined, or strongly influenced, by those abroad and investors' expectations as to whether the central bank will be able to adhere to the exchange rate objective, the domestic term structure may reflect only to a limited extent domestic economic conditions.

A question that arises in the context of small open economies is, does the predictive power of the term spread depend on the monetary regime in place? This paper addresses this question by focussing on one small open economy, Ireland, over the period 1972-2018 and asking, what is the role of the monetary regime in determining the predictive power of the term structure of interest rates? Ireland is a particularly interesting case study because, during the sample period, it experienced three distinct monetary regimes. In the period up to March 1979 a rigorously fixed exchange rate regime was in place between the Irish Pound and Sterling. From April 1979 to December 1998, the Irish Pound was part of the European Exchange Rate Mechanism (ERM). In this period, it floated in a band but was subject to significant management. Since January 1999, Ireland has been a member of the euro area.

Consequently, the role for Irish monetary policy was limited throughout much of the sample period. During the period of exchange rate fixity with Sterling, there was little scope to incorporate domestic concerns into the setting of Irish interest rates, and monetary policy was essentially determined in London. Similarly, during the most recent period, monetary policy has been determined by the Governing Council of the ECB whose decisions are taken in the interests of the euro area as a whole. Thus, only in the intermediate period, during ERM, did the Irish Central Bank have some discretion over monetary policy.

In this paper, I study the role of monetary regimes by using dynamic probit models to forecast recessions in Ireland using monthly data for the period 1972-2018. Recessions are measured using the OECD's recession indicator, which takes a value of one from the peak to the trough of the business cycle and zero otherwise. In this sense, it captures 'downturns' and 'upturns' in the business cycle. Although this is different from a recession defined as two consecutive quarters of negative GDP growth, similar indicators are used throughout the literature.[1] I therefore maintain the convention and refer to 'recessions' throughout the paper.

I first consider the predictive power of the term spread for the sample period as a whole, before considering subsamples reflecting the monetary regimes in place during the period. The main findings are as follows. First, over the full sample period, the term spread had no predictive power for recessions in Ireland. Second, sub-sample estimates indicate that the term spread has no predictive power during the periods when the Central Bank had no discretion over monetary policy, specifically during the first monetary policy regime when the exchange

[1] See for instance, Estrella and Hardouvelis (1991), Estrella and Mishkin (1995), Bernard and Gerlach (1996) and Gerlach and Stuart (2018). Goodhart et al., (2019) include a discussion of the issue.

rate with Sterling was fixed, and during the third regime, when Ireland was a member of the euro area. However, during the intermediate period, when the Irish Pound was a member of ERM and the Central Bank had some discretion over monetary policy, the term spread can forecast recessions. Third, during this ERM period the term spread has predictive power for horizons of approximately five quarters ahead, although the predictive power is strongest at short horizons. Fourth, the in- and out-of-sample fit during ERM can be improved at different horizons by selecting alternative measures of the term spread.

The paper is structured as follows. The literature is reviewed in the next section. Section 3 discusses the monetary regimes in place in Ireland over the periods since 1972 in more detail. The data are presented in Section 4. Section 5 sets out the econometric framework and presents the results of the analysis. Section 6 concludes.

2. Literature Review

The predictive power of the slope of the term structure for economic activity is well established in the literature. At least since Kessel (1956), the cyclicality of the term structure has been recognized, while Harvey (1989) undertook an early formal study of the predictive power of the term structure for economic activity. Other studies of the predictive power of the term spread for economic activity were undertaken soon after, including Bernanke (1990), Plosser and Rouwenhorst (1994) and Hamilton and Kim (2002). Estrella and Hardouvelis (1991) were among the first to test the predictive power for a zero-one recession dummy using probit models. A similar technique is employed in this study.[2]

[2] More recently, Bauer and Mertons (2018) argue that neither the low level of interest rates nor the recent decline in the natural real interest rate observed in the post-Global Financial Crisis period have impacted the predictive power of the term spread, while Adrian et al. (2018) identify a bank 'risk-taking channel' through which the term spread may impact the real economy.

Nonetheless, although this relationship has been widely studied in the US, there are relatively few studies for other, smaller and more open economies. Two cross-country studies, both covering sample periods from the early 1970s to the early 1990s, provide some insight. Estrella and Mishkin (1995) find that the term structure predicts recessions reasonably well in the United States and Germany, to a lesser extent in the United Kingdom and Italy, and hardly at all in France. Bernard and Gerlach (1996) show that the term spread has at least some predictive power for recessions in Belgium, Canada, France, Germany, Japan, the Netherlands, the United Kingdom and the United States.

The results in these papers are particularly interesting for the present study. In both cases, ERM was in place for most of the sample periods studied, although the overlap is not perfect. Furthermore, while the Deutschmark played an important role in determining the corridor in ERM, other members were, to varying extents, small open economies. Overall, these studies suggest that it was possible for the term spread to predict recessions in small open economies during ERM.

Why does the term spread have predictive power? This is often attributed to the conduct of monetary policy.[3] In general, it is argued that countercyclical policy rate increases in the upswing of the business cycle do not transmit entirely to the long interest rate, as markets anticipate that central bank actions will slow the economy. As a result, the spread narrows in advance of recessions (see for instance Adrian et al. (2018)). Moreover, Feroli (2004), Estrella (2005), and Estrella and Trubin (2006) argue that when monetary policy is more responsive to changes in the domestic output gap, the predictive power of the term spread increases.

Since the responsiveness of monetary policy to the domestic business cycle can determine the predictive power of the term spread, the monetary regime in

[3] Alternatively, Harvey (1988) and Hu (1993) argue that predictive power of the term structure can arise from the consumption smoothing behaviour of consumers.

place may be important. As the monetary regime can limit the ability of the central bank to respond to the domestic business cycle, it may be that the predictive power of the term spread varies according to the regime in place. In the next section I outline the monetary regimes in Ireland during this period.

3. Monetary regimes in Ireland

There were three distinct monetary regimes in Ireland over the period 1972 to 2018. The first was in place from the establishment of the Irish Free State in 1922 up until 1979. The Currency Act of 1927 introduced the Irish Pound, which was fully backed by Sterling assets, and set up a Currency Commission.[4] Although the Central Bank of Ireland was established in March 1943, the close link to Sterling remained in place until 1979. As a consequence, Irish interest rates closely followed those in Britain and were thus determined with little, if any, direct reference to economic conditions in Ireland.[5]

The close link to sterling was broken in 1979 when Ireland became a founding member of the European Monetary System (EMS). As a result, the Irish Pound joined the exchange rate mechanism (ERM) and floated in a band of 2.25 per cent around its cross-parity with the other currencies in the ERM.[6] The objective of the Central Bank was price stability, which implied monetary policy in Ireland continued to be geared to the requirement of exchange rate stability (occasional devaluations of the Irish pound notwithstanding).[7] Nonetheless, for the first time the Central Bank had some – limited -- discretion over the monetary policy stance. For instance, McCarthy (1979, p. 113) states:

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[4] See Kelly (2003) for a discussion.

[5] Indeed, the balance of payments crisis in the 1950s was shown by Honohan and Ó Gráda (1998) to arise from a deviation of official Irish interest rates from those in the UK.

[6] For a discussion of the operation of ERM, see Central Bank of Ireland (1979a and b).

[7] The band was realigned on several occasions throughout the period, including several Ireland-specific devaluations (see Honohan (2015) for a discussion).

"The fact that we now have margins of fluctuation, in place of the no-margins sterling link, makes a little difference, … but the margins are narrow".

Following the ERM crisis in the winter of 1992-93, the band was widened from 2.25 per cent to 15 per cent, a much freer float than previously.[8] During this period, the Central Bank loosely targeted the effective exchange rate, although there was little information about what exactly this entailed (Honohan (2019, p.62)). Nonetheless, in 1996 the Central Bank *Annual Report* (p. 18) noted that the Bank placed weight, not just on exchange rate movements, but also on developments in:

"money supply and credit and a range of other price indicators in monitoring inflationary pressures [when setting policy]."

Thus, although monetary policy was focused on maintaining the exchange rate, it seems domestic conditions also played some role in the decision-making process.

In January 1999 Ireland became a founding member of the Eurosystem and the Irish money supply was redenominated in euro at a fixed conversion rate. During the period since, policy rates have been determined by the ECB's Governing Council in Frankfurt.[9] The Governor of the Central Bank of Ireland is a member of the Governing Council; however, all members of the Council must take account of developments in the euro area as a whole, rather than narrow national interests, when voting.

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[8] See Chapter 2 of Honohan (2019) for a discussion.

[9] Of course, long-term interest rates embody credit and liquidity risk premiums and therefore at times diverged from those outside of Ireland.

4. Data

The term spread is calculated as the long-term government bond yield[10] minus the 3-month interbank rate.[11] These are the only long and short rates that I am aware of that are available for the entire sample period.[12] This measure of the spread is used in the baseline estimates below. In Section 5.4 and 5.5 I consider some alternative measures of the spread during the ERM period.

The series on recessions is a dummy variable that takes a value of one from the period after a peak in the business cycle through to the trough.[13] The recession indicator is based on the OECD's composite leading indicator, which is composed of seven series covering domestic demand, exports, producer prices, financial markets and the money supply.[14] There are two advantages of using the recession dating rather than GDP growth to capture the business cycle. First, the recession data are available monthly, whereas the highest frequency that GDP is available is quarterly. While monthly data are likely to be noisier than quarterly data, the number of observations triples. This is likely to lead to better (and, in any case, timelier) estimates. Second, quarterly GDP data for Ireland begin only in 1995. Such a short sample period would prevent an analysis of the predictive power of the term structure across monetary regimes.

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[10] The long-term rate is available from the Federal Reserve Bank of St Louis' Fred database for the period since 1970. The Fred database notes that the rate is obtained from the OECD, who in turn source their data to the Central Statistics Office (CSO) of Ireland. As discussed in footnote 25, the maturity of the long-term bond yield varies somewhat over the sample period.

[11] The 3-month interbank rate is available from the Fred database since 1984. Data for the period prior to this were collected from Central Bank of Ireland *Quarterly Bulletins*. These data are available on a monthly frequency from January 1972.

[12] With the exception of the official central bank rate. However, since official rates moves infrequently, they are rarely used in the literature.

[13] The data are from the OECD, also accessed via the Fred database.

[14] Specifically, the OECD use: exports to Northern Ireland, exports of agri products to other European countries, passenger car registrations, total PPI in mining and quarrying activities, real effective exchange rates, the M2 money supply. The series are chosen based on several criteria, particularly their ability to lead industrial production and GDP cycles, as well as availability and frequency.

The term spread and the recession indicator are presented in Figure 1. Also included are vertical lines marking March 1979 and December 1998, the final months of the monetary regimes. The Figure suggests that the relationship between the term spread and recessions was somewhat erratic during the sample period. The term spread declined in advance of two of the three recessions that occurred during the first monetary regime (fixed exchange rate with Sterling). However, at more than 2%, the level of the spread in advance of recessions was often quite high during this period. During the second monetary regime, the spread was generally lower, and became negative on several occasions. Moreover, the spread was generally, although not uniformly, declining in advance of recessions. The spread reached its minimum value of -29.6% during the ERM crisis in this period (the value is truncated to aid readability of the graph). Since joining the euro, the spread declined in advance of the first three recessions but rose in advance of the final two. Indeed, the spread reached its second highest level immediately in advance of the recession beginning in 2011.

5. Estimation

5.1 Full sample estimates

To consider more formally the relationship between the current term spread and the likelihood of a recession *h* month ahead, I next present preliminary estimates using a probit model and data for the period January 1972 to June 2018.

There are two possible ways to construct multi-period forecasts using such models. The first is the 'direct' method, in which the recession indictor several months ahead is regressed on its current value and lagged values of the explanatory variables. The second is the 'iterated' method, in which a one-period ahead forecast model is estimated and forecasts are computed iteratively for the desired horizon.

Marcellino et al. (2006) study the relative forecasting power of the direct and iterated methods. They do so using univariate autoregressions and bivariate vector autoregressions for 170 US macro time series. They find that iterated forecasts generally have lower MSFEs than direct forecast, particularly at longer forecast horizons, although the improvements are modest.

Kauppi and Saikkonen (2008) note that the ranking in efficiency of the two methods is theoretically ambiguous. Specifically, the iterated method is more efficient than the direct method but may be biased if the one-step ahead model is misspecified. If both models have p lags, but the correct lag length is greater than p, then the MSFE of the direct method cannot be larger than that of the iterated method. If the correct lag specification is less than p, the MSFEs are the same and the iterated method is more efficient (see, for instance, Bhansali (1999), Ing (2003)).

Marcellino et al. (2006, p. 300) argue that because it seems unlikely that typically low-order autoregressive models are correctly specified, the theoretical literature tends to conclude that the robustness of the direct forecast to model misspecification makes it a more attractive procedure than the bias-prone iterated forecast.

As such, the direct method is used here. Indeed, it is much more common in the literature on the forecasting ability of the term spread.[15] In the models estimated below the dependent variable is thus the recession dummy h months ahead.

Following Dueker (1997), I estimate dynamic probit models.[16] The recession indicator has its own autocorrelation structure, which may impact the predicted probabilities from a static probit model that does not include the recession indicator as a regressor. Furthermore, univariate time series modeling of

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[15] See Estrella and Hardouvelis (1991), Estrella and Mishkin (1995), Bernard and Gerlach (1996) among others.

[16] Similar models are considered by Moneta (2005), Gerlach and Stuart (2018) and Kauppi and Saikkonen (2008).

macroeconomic data has demonstrated the importance of a variable's own history in generating forecasts. Dynamic probit models deal with the autocorrelation by conditioning explicitly on the recent history of the recession indicator.[17]

Since short interest rates are determined by policy, it is important that the information included in the prediction equation reflects the information available to policymakers. Referring to the US, Dueker (1997) argues that three months is the minimum reasonable 'recognition lag' for policymakers to be sure that the economy is in a recession and I follow that convention here.[18]

Finally, conventional t-statistics would be biased because the forecast errors are overlapping (see Estrella (1995)). I therefore compute t-statistics assuming MA(h-1) standard errors.

The results for forecast horizon h = 3 months ahead over the full sample period are presented in column (1) of Table 1. Overall, the results indicate that there is no role for the term spread in predicting recessions over this period. In column (2), the period of the ERM crisis from summer 1992 to the end of 1993 is excluded from the estimation in case this might drive the result. However, the coefficient on the term spread is also insignificant in this specification. These results hold at all forecast horizons to 15 months (h = 1 to 15).

As a small open economy, these results may appear unsurprising. However, given the different monetary regimes in place during the period, I next turn to the question of whether the result varies across these regimes.

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[17] Kauppi and Saikkonen (2008) also propose an autoregressive probit model where the lagged value of the estimated probability of a recession is included as an explanatory variable. However, - the authors find that there is little or no improvement in the in- and out-of-sample fit of their models from arising from this specification, Thus, since it is also computationally onerous, it is not considered here.

[18] In practice, throughout much of the sample period considered here, the publication lags on the macro data necessary to judge whether the Irish economy was in recession may well have been longer than three months.

5.2 Sub-sample estimates

As discussed in Section 3, there were three distinct monetary regimes in place in Ireland during this period. I next re-estimate the model – using the same data and specification as above - for each of these sub-sample periods, again for h = 3 months ahead. The results are presented in columns (3), (4a) and (5) of Table 1.

During the first and third monetary regimes (the Sterling peg (1972-1979) and the euro (1998-2018)), when interest rates were largely determined by external conditions, the term spread does not predict recessions (columns (3) and (5)). From column (6), this result holds if we estimate the model across the two sub-samples also (that is, if the model is estimated for the period 1972 to 2018, but the period 1979 to 1999 is dropped).

In contrast, column (4a) shows that the term spread was significant during the period 1979-1999 when the Central Bank of Ireland had greater control over monetary policy. Although this result may be somewhat surprising at first, there is evidence from Bernard and Gerlach (1996) and Estrella and Mishkin (1995) for the predictive power of the term structure in other small open economies involved in ERM. Moreover, the statements from the Central Bank noted in Section 3 suggest that the institution itself recognized that it had some discretionary 'margins' when setting policy.

The sign of the coefficient on the term spread in column (4a) is negative, suggesting that as the spread increases and the term structure becomes steeper, the probability of a recession occurring in three months' time declines. This result also holds when the ERM crisis of 1992-93 is dropped from the sample (column 4b). Overall, it appears that the term spread had predictive power for recessions during this monetary regime.

The results in column (4a) are silent on the relative importance of the short and the long interest rates. In the regression in column (4c), the short and the long interest rates are entered separately. The results show that both are individually significant and with the absolute value of the parameters roughly equal in size. Indeed, a Wald test indicates that the null that the two coefficients are equal in size but oppositely signed cannot be rejected (p-value = 0.65).

Finally, the short rate is included in addition to the spread. While we generally think of the predictive power of the term spread relating to monetary policy, Wright (2006) suggested this specification, which captures whether monetary policy has a predictive power independently of the term spread. From column (4d), the short rate is clearly insignificant. This suggests that the role of monetary policy is fully captured in the movements of the term spread. Thus, it appears that all the information in the two interest rates can be collapsed into the spread.

5.3 Prediction horizons, 1-15 months

The analysis so far has used a 3-month prediction horizon. In this section I extend the analysis to include prediction horizons from 1 to 15 months during the period April 1979 to December 1998.[19] The panels of Figure 2 present the point estimates for the coefficients on the spread, the recession dummy and the constant, along with two standard error bands. Consider Panel (a): the horizontal axis indicates the forecast horizon at which the coefficient on the spread is estimated. For each horizon, the point estimate along with a 2-standard error band is included in the figure. Panel (a) shows that the coefficient on the spread is significant at the 5% level up to h = 14, with the exception of h = 9, when the p-value of the coefficient on the term spread is 0.055. Thus, it appears that the slope of the term structure had predictive power almost 5 quarters ahead during this period.

Turning to the estimated coefficients on the recession dummy, Panel (b) of Figure 2 suggests that the current value of the recession dummy is significant and

[19] All estimation was carried out for horizons up to h = 18, however, in the interests of brevity only h = 1 to 15 are presented here, since the term spread is insignificant thereafter.

positive at very short forecast horizons ($h < 5$), indicating that if the economy is in recession now, it is more likely to be so in a few months' time. The significance declines as the forecast horizon increases: when forecasting 6 months ahead, the current value of the recession indicator is no longer significant. However, at longer horizons (for $h > 10$), the coefficient on the lagged recession dummy is again significant, but it is now negative. Intuitively, this suggests that if the economy is currently in recession, it is likely to emerge from this after 11 months.

Figure 3 shows the predicted probability of being in a recession using the model estimated at $h = 3$ and $h = 12$ months ahead. The data are offset in the chart so that they can be read as the probability of being in recession today, based on data from three months previously and twelve months previously. It is notable that the probability of being in a recession generally rises in advance of recessions and is highest during recessions. This is as one would expect from the model. Exceptions occur at the end of recessions: this is due to the presence of the lagged recession indicator – in the case of the three-month ahead prediction, the probability of being in a recession often falls significantly three months after the end of the recession.

5.4 Alternative measures of the spread during ERM and model fit

The analysis so far has considered just one measure of the term spread. However, it is possible that some segments of the term spread contain more information for predicting recessions than others.[20] Therefore, I next consider alternative measures of the spread during the ERM period.[21]

The Central Bank of Ireland's *Quarterly Bulletins* are an alternative source of bond yield data at various maturities. From these, yields are available for eight

[20] Bauer and Mertons (2018) note that although the academic literature on the US tends to focus on the spread between a 3-month rate and a 10-year rate, financial commentators often use a 2-year rate instead of a 3-month rate.

[21] While there is no consistent alternative measure of the spread available across all subperiods, some alternative measures are available for the pre- and post-ERM subperiods, but these do not materially alter the results and are not reported for brevity.

different maturities for various sample periods (see Table 2). The four series that are available for the entire period from April 1979 to December 1998 are the 1-, 3-, 5- and 15-year yield. These series are presented in Figure 5: it is evident that the four yields move quite similarly, although there are periods of divergence.[22]

Using these four series, along with the 3-month rate used to calculate the baseline spread used previously, it is possible to consider a range of measures of the term spread.[23] In total, seven new measures of the spread are calculated and included separately in the model. The results are presented in Table 3. For brevity, the Table presents the horizons, in months, for which the parameter on the spread is significant at the 5% level. Measures that capture the short end of the yield curve, for instance, the spread between the 1-year and 3-month rates, and the spread between the 3-year and 3-month rates have predictive power at short horizons only. In contrast, the spread between the 15-year yield and the 3-month rate is significant up to 14 months ahead, and the spreads between the 15-year yield and the 1-year yield and the 5-year and the 1-year yields are both significant for the full 15 month horizon considered here.[24]

Which of these models fits best? The measure of the term spread which results in the best fitting model at each horizon both in- and out-of-sample is presented in Figure 4 (solid lines). Here, I am searching for the best fit among the seven newly calculated measures of the spread and the baseline measure used in the earlier analysis.

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[22] A comparison of these yields with the long-term government bond yield used in the baseline specification (and originating from the Irish Central Statistics Office) suggests that prior to January 1985, the CSO long-term yield data are the 15-year yield. It appears that the long-term CSO yield for the period January 1985 to June 1993 may be an interpolation of the 8- and 15-year yields. A 10-year yield is only available from the Central Bank from July 1993.

[23] An exercise was also carried out in which a yield curve was interpolated from the available data. Since there are so few data points, a simple cubic spline was used, and from this a 10-year yield was calculated. However, this did not yield any statistically significant results.

[24] Indeed, the parameter on the spread measured as the 15-year yield and the 1-year yield is significant at the 16-month horizon.

The in-sample fit is calculated using the Akaike Information Criterion (AIC).[25] Overall, the AICs indicate that the fit is generally better at short horizons, however, different models perform better at different horizons. The spread between the 3-year and 3-month rates fits best at short horizons (1 to 4 months). The spread between the 5-year and the 1-year rates fits best for horizons of 6 and 7 months ahead, while the spread between the 15-year and the 1-year rates fits best for most medium term horizons (8 to 14 months ahead). It is notable that the model including the baseline measure of the spread does not fit best at any horizon.

Testing the out-of-sample fit in a historical setting raises a number of issues. Out-of-sample tests generally require that the model is estimated up to a certain date, and the out-of-sample forecast for the remainder of the sample is evaluated against the observed data. Choosing this cut-off is arbitrary, particularly for a historical sample period.

As a result, I use the leave-one-out (LOO) cross validation method to test the out-of-sample fit of these models. This is a special case of the leave-k-out cross validation methods (Bruce and Martin (1989)), which uses model estimates from multiple subsets of the sample for validation. In a dataset with n observations, the model is run on a subsample of (n-1) observations, and then a fitted value for the omitted observation is estimated. The difference between the fitted value and the observed value of the variable – the error – is calculated and then squared.

[25] Alternative measures of in-sample fit - the Bayesian Information Criterion (BIC) and the pseudo r-squared - give exactly the same results in terms of the best fitting model. The AIC is calculated as: $-2L_u + k * 2$, the BIC is calculated as: $-2L_u + k * log\ n$, and the pseudo r-squared is calculated as in Estrella (1998): $1 - \left(\frac{L_u}{L_c}\right)^{-\frac{2}{n}L_c}$, where k is the number of estimated parameters, n is the number of observations, L_u is the log likelihood of the model, and L_c is the likelihood including only a constant as a regressor.

This process is repeated until every observation in the dataset has been excluded once.[26] The squared errors are then averaged across all test cases to obtain a mean square error (MSE) for the model. The MSE can then be compared across models and prediction horizons; the model with the lowest MSE is considered the best fit.

Figure 4 presents the model with the lowest MSE at each horizon from 1 to 15 months (read off the right hand axis). The best fit at horizons of 1 to 4 months is provided by the spread between the 3-year and 3-month rates, while the spread between the 15-year and 1-year rates provide the best fit at medium horizons (7 to 15 months). Again, the model including the baseline measure of the spread does not fit best at any horizon.

Thus, both the in-sample and out-of-sample fits suggest that the model has the greatest predictive power at shorter horizons. Moreover, alternative measures of the term spread can improve both the in- and out-of-sample fit of the model.

5.5 Alternative leading indicators[27]

Next, I ask whether other alternative leading indicators may predict recessions in addition to the term spread during the ERM period. For instance, Nyberg (2010) shows that other financial variables such as asset prices and the term spread in a main trading partner can help predict recessions, while other variables, such as business tendency indicators, may also be predictors.

In selecting alternative leading indicators, one constraint is availability: there are a limited number of series available on a monthly frequency from 1979. A second constraint is avoiding variables used in the calculation of the recession dummy. Thus, although monetary aggregates have been used in other studies to

[26] This method creates two 'groups' of observations either side of the one being left out. The model is run so that there are never less than 20 observations in a group, as per Teh et al., (2010).

[27] I am grateful to a referee for suggesting this exercise.

forecast economic activity, since the M2 money supply is used in the calculation of the recession dummy, it is not considered here.[28]

As a result, I consider eight series: the term spread in the UK and in Germany, the differential of the short rates between the UK and Ireland and between Germany and Ireland[29], annual growth in share prices, two business tendency indicators for manufacturing (current tendency and future tendency) and annual growth in industrial production.[30] The term spread and interest rate differential for the UK and Germany are chosen as the UK was a close trading partner during this period, while the Deutschmark played a central role in the ERM.

Preliminary investigations indicate that, when added to the baseline model, seven of the eight alternative series are rarely, if ever, significant. I therefore focus on the remaining variable – the growth in share prices – in the below analysis.

I next search across the different measures of the spread, which were set out in the previous section, to find the best fitting model including share price growth both in- and out-of-sample.[31] These are presented in Figure 4 (dashed lines). For both in- and out-of-sample fit, a model including share price growth fits better at every horizon (since the AIC and MSEs including share price growth (dashed lines) are both lower than the respective baseline results (solid lines)).[32]

At short horizons the inclusion of share price growth does not have a significant impact on the measure of the term spread selected in the best fitting

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[28] See for instance, Stuart (2020).

[29] This measure is also suggested by Nyberg (2010).

[30] The data are sourced primarily from the OECD's Main Economic Indicators database, with the exception of the UK short rate, which is the rate on 90-day Treasuries, and the long and short German rates which are sourced from Fred.

[31] Not shown here, the parameter on the term spread selected (both for best fitting models both in- and out-of-sample) is significant at the 5% level at horizons of 1 to 15 months, with the exception of month 3 to 5, when the parameter is significant at the 10% level.

[32] The results are the same when the BIC is used instead of AIC. The pseudo r-squared is not comparable across models that contain different numbers of explanatory variables. As before, for out-of-sample fit, I use the LOO method.

model: both in- and out-of-sample the best fit for horizons of 1-4 months is obtained using the spread between with the 3-year and 3-month rates. At longer horizons, including share price growth most often results in the best fitting model including the spread between the 5-year and 1-year rates in- and out-of-sample, although at long horizons in-sample, the spread between the 15-year and 1-year rates fits best.

Overall, the results indicate that the growth in the share price may contain information not included in the term spread which may be useful for forecasting recessions in small open economies.

7. Conclusions

In this paper, I studied the relationship between the term spread and recessions in one small open economy, Ireland, across three different monetary regimes, to understand how control over interest rates can impact the business cycle. During the period 1972-2018, Ireland first had a fixed exchange rate with Sterling (1972-1979). From 1979 to 1998, the Irish Pound was part of the European Exchange Rate Mechanism. Since the Irish currency then floated in a band, the Central Bank had some opportunity to respond to domestic conditions. Finally, since January 1999, Ireland has been a member of the euro area, and interest rates have been determined by the ECB with reference to the euro area economy as a whole.

Using dynamic probit models and monthly data to forecast recessions in Ireland over the period 1972-2018, I show that the term spread has no predictive power over the entire sample period. Moreover, it cannot predict recessions in the first and third regimes. However, in the second regime, during which the Central Bank had some scope to tailor interest rates to the domestic economy, the term spread had predictive power for the domestic business cycle. During this period the term spread helped forecast recessions for horizons of approximately five quarters ahead, although the predictive power is strongest at short horizons. Furthermore, different segments of the yield curve can improve the in- and out-of-sample fit of the model.

The results of the paper suggest that the term spread may prove a simple tool for recession prediction in other small open economies whenever the domestic central bank is not strongly committed to keeping parity with other currencies and can move interest rates freely. As such, several avenues for future research could be pursued. A panel study in which the monetary regime in place is controlled for, could provide cross-country evidence. Alternatively, researchers could consider using an endogenous mechanism for identifying when there is a switch in monetary policy regime and the most appropriate forecasting model. Finally, exploring further the predictive power of share price growth for recessions in small open economies may be a fruitful avenue of future research.

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Table 1: Results for estimated dynamic probit models, 3-month ahead forecast horizon, 1972M1-2017M7

	(1) 1972-2017	**(2) 1972-2017, ex-ERM crisis**	**(3) 1972-1979**	**(4a) 1979-1989**	**(4b) 1979-1989, ex-ERM crisis**	**(4c) 1979-1989**	**(4d) 1979-1989**	**(5) 1999- 2017**	**(6) 1972-1979, 1999- 2017**
Spread	-0.041 (1.114)	-0.033 (0.042)	-0.106 (0.082)	-0.234** (2.314)	-0.233** (2.108)		-0.263** (2.506)	0.021 (0.310)	-0.011 (0.218)
Short rate						0.245** (2.498)	-0.018 (0.458)		
Long rate						-0.263** (0.105)			
Recession (third lag)	1.112*** (6.261)	1.110*** (0.178)	0.597 (0.462)	1.006*** (3.486)	0.920*** (3.111)	0.984 (3.313)	0.984*** (3.313)	1.186*** (4.334)	1.067*** (0.231)
Constant	-0.493*** (3.536)	-0.508 (0.144)	-0.294 (0.383)	-0.541*** (0.208)	-0.542*** (0.209)	-0.333 (0.662)	-0.333 (0.662)	-0.606** (2.344)	-0.457** (0.212)
Pseudo r-squared	0.195	0.188	0.133	0.282	0.238	0.284	0.284	0.199	0.168

Note: t-statistics robust to serial correlation in the residuals in parenthesis. */**/*** indicate significance at the 1% / 2.5% / 5% levels. ERM crisis is assumed to have occurred between July 1992 and December 1993.

Table 2: Bond yield data, availability from Central Bank of Ireland Quarterly Bulletins

	1yr	**2yr**	**3yr**	**5yr**	**8yr**	**10yr**	**15yr**	**20yr**
Start-date	Dec 1976	Jan 1999	Jun 1971*	Dec 1976	Jun 1971*	Jun 1993	Jun 1971	Jun 1993
End-date	Dec 1998	Jun 2010	Dec 1998	Jun 2010	Jul 1993	Jun 2010	Dec 1998	Dec 1998

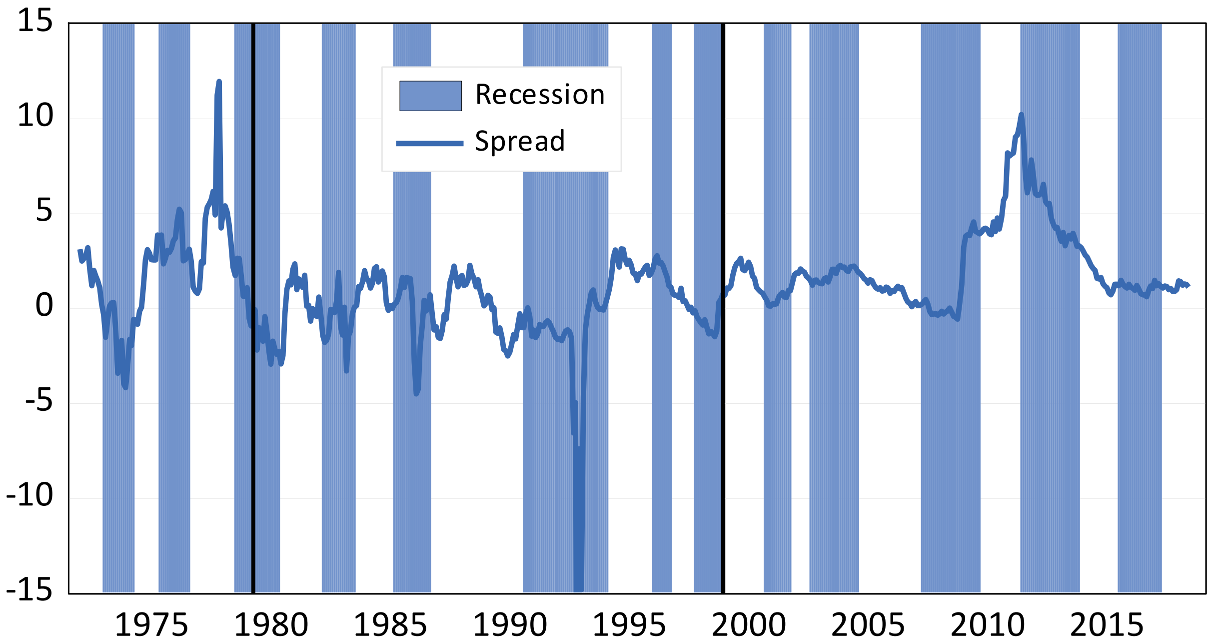
Notes: * Missing data for May 1972.

Table 3: Results for estimated dynamic probit models, using various measures of the term spread, 1979M4-1998M12

Measure of the spread	Horizons at which the spread parameter is significant (5% level, in months)	Horizons at which the third lag of the recession indicator is significant (5% level , in months)
1-year – 3-month	1-4	1-4,
3-year – 3-month	1-6	1-4, 12-14
5-year – 3-month	7, 12-13	1-4, 12-15
15-year – 3-month	1-8, 10-14	1-4, 11-15
5-year – 1-year	1-16	1-4, 11-16
15-year – 1-year	1-16	1-4, 12-17
15-year – 3-year	9-16	1-5, 9-16
Baseline measure	1-14	1-4, 11-15

Note: results for the constant are suppressed in the interests of brevity.

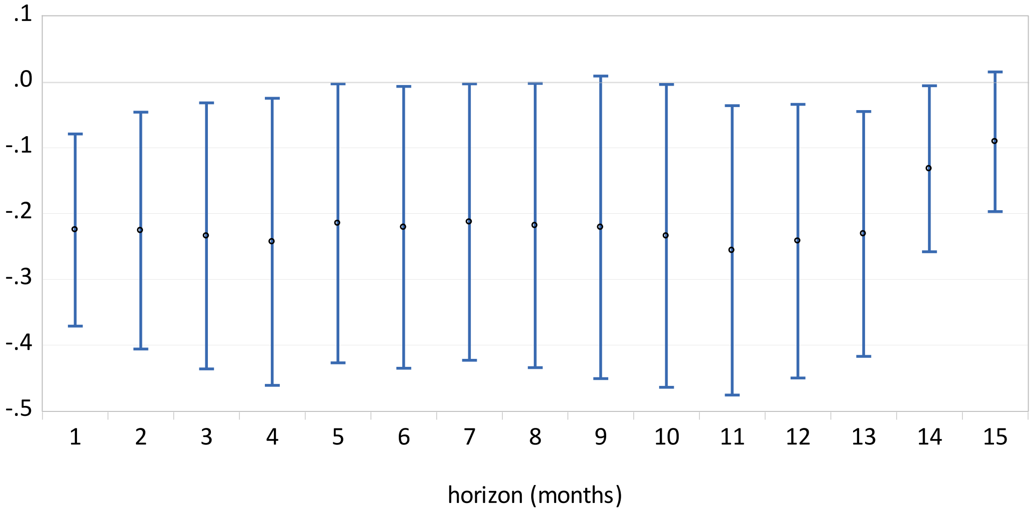
Figure 1: Recessions and term spread, 1972-2018



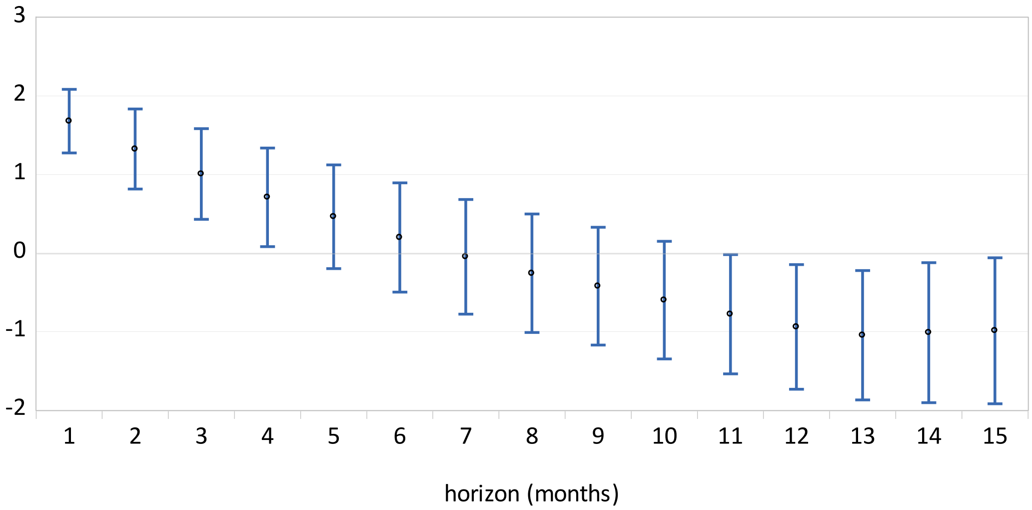
Note: The spread reached -29% in November 2011 (ERM crisis). This is truncated for readability.

Figure 2: Probit model estimates, horizons 1-15months, 1979M4-1998M12

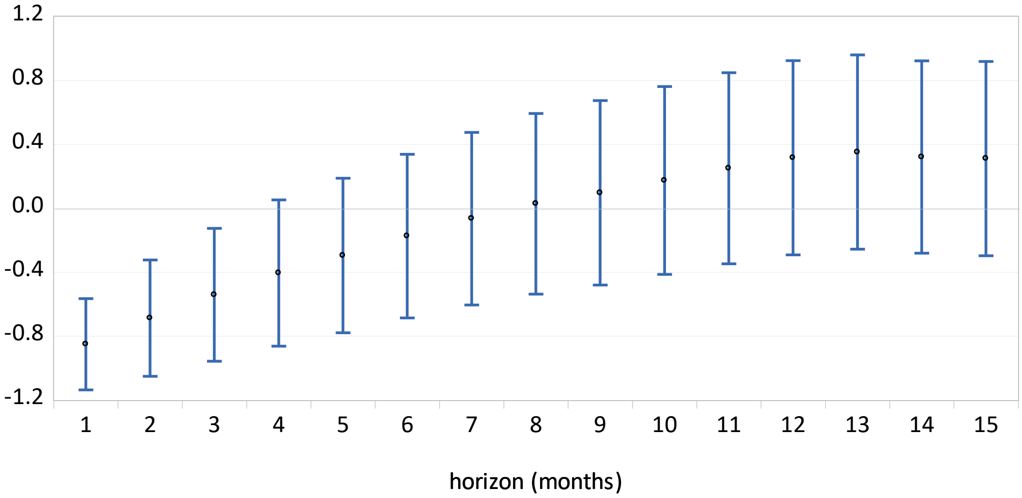
(a) Spread, estimated coefficients



(b) Recession dummy, estimated coefficient

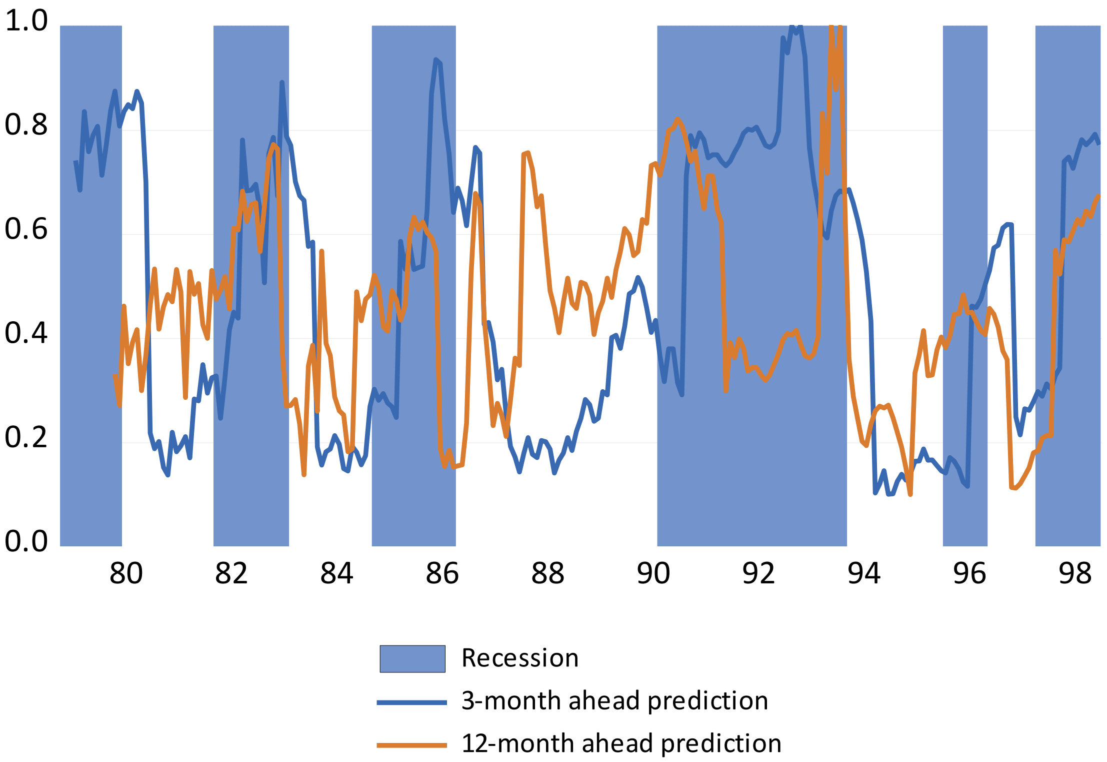


(c) Constant



Note: Charts show estimated parameter and a +/- 2 standard error confidence band.

Figure 3: Predicted recession probabilities for h = 3 and h = 12 months ahead



Note: Data on 3- and 12-month prediction are offset in chart; chart can be read as the probability of being in recession today, based on prediction from 3 months previously and 12 months previously.

Figure 4: In-sample (AIC, LHS) and out-of-sample (MSEs, RHS) fit for h = 1 to 15 months, baseline specification, and model including share price growth, 1979M4-1998M12

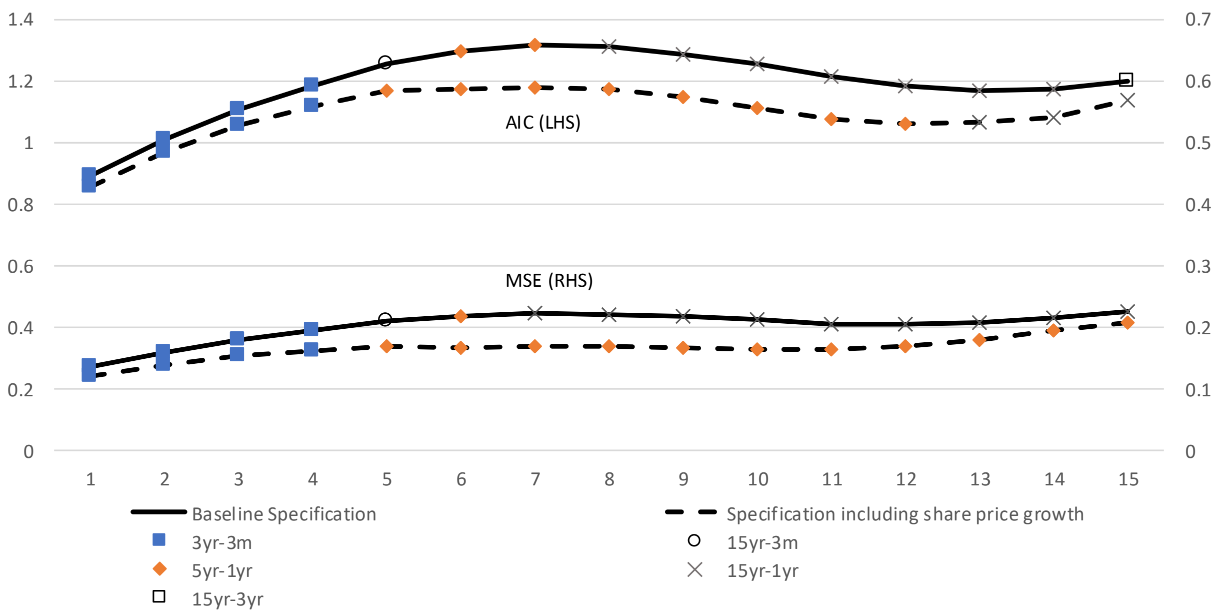


Figure 5: 1-, 3-, 5- and 15-year bond yields, January 1979-December 1998