The Yield Spread as a Predictor of Economic Activity in Mexico: The Role of the Term Premium

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Abstract

This paper analyzes whether there exists a relationship between the slope of the yield curve and future economic activity in Mexico for the period 2004–2019. In particular, we evaluate whether such a relationship depends on the term premium. For this purpose, we estimate a threshold model in which the relationship between the yield spread and economic activity, measured as either output growth or the probability of a contraction, depends on whether the term premium is above or below a certain threshold. The main results indicate that the slope of the yield curve seems to anticipate the behavior of economic activity only when the term premium is above a threshold. Our results also suggest that the slope of the yield curve has predictive power over the probability of facing a contraction in the future only when the term premium is above a threshold.

JEL Classification: C53; E32; E37; E43

Keywords: Yield Spread; Economic Activity; Term Premium.

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1 Introduction

The slope of the yield curve, defined as the difference between the long-term and short-term interest rates, has been used by different economic analysts as a leading indicator of economic activity, mainly in the case of the United States and other advanced economies. In particular, the attention of the academic community and participants in financial markets has focused on episodes in which the slope of the yield curve becomes inverted, which in turn could precede periods of lower economic growth and even recessions. In that sense, this paper analyzes whether there exists a relationship between the slope of the yield curve and the future behavior of economic activity in the case of Mexico. In particular, we evaluate whether such a relationship depends on the term premium level.[1] A low term premium is associated with a stronger anchoring of inflation expectations, reducing the impact of inflationary shocks on such expectations and long term rates. As discussed by Bordo and Haubrich (2004), Feroli (2004), and Estrella (2005), these inflation shocks, by affecting only short term rates, reduce the yield spread and have no future real effects, thus weakening the predictive power of the yield spread while the term premium is low.[2] Motivated by these studies, this paper evaluates the role of the term premium on the relationship between the slope of the yield curve and future economic activity using a threshold model.

The main results indicate that the slope of the yield curve seems to anticipate the behavior of economic activity only when the term premium is above a threshold. Similarly, we find that the slope of the yield curve has predictive power over the probability of facing a contraction in the future only when the term premium is above a threshold. The estimated value of such a threshold depends on the forecast horizon and the measure of economic activity. In addition, our results also seem to support the existence of time variation in the term spread-output relationship in Mexico during the period 2001–2019. Although our sample is relatively

[1] The term premium is defined as the compensation that investors demand for maintaining longer-term financial instruments instead of short-term ones. In this sense, long term interest rates are determined by the average of current and future expected short-term interest rates, plus a term premium.

[2] This is relevant in the global context due to the reduction observed in the term premium after the global financial crisis, which is partly associated with unconventional monetary policies adopted by advanced economies (Kim and Wright, 2005; Wright, 2011).

small, the results from a linear model using a rolling window regression approach show that the yield spread-output relationship seems to weaken over time.

This paper is related to the empirical literature on the predictive power of the yield spread to anticipate economic activity.[3] Previous works, including Hamilton and Kim (2002) and Ang et al. (2006), among others, have focused on analyzing the predictive power of the two components of the yield spread, that is, the expectations of short-term interest rates in the future, and the term premium. In general, both components are found to have predictive power for economic activity. Much of the literature has also analyzed the usefulness of the yield spread to predict recessions rather than future output growth.[4] On the other hand, some related empirical works have examined the possible existence of nonlinearities in the yield spread-output relationship. In particular, Galbraith and Tkacz (2000) and Duarte et al. (2005) have shown the existence of time variation in the yield spread-output relationship, resulting from threshold effects that depend on the yield spread and past output growth. This paper is also related to the empirical evidence for emerging economies, which is more limited due to low availability of data. Some exceptions include the work of Mehl (2009), who finds that the yield curve seems to predict future economic activity in emerging economies, although with some differences between them. In the specific case of Mexico, Castellanos and Camero (2003) and Reyna et al. (2009) document some predictive power of the yield curve on economic activity.

This paper contributes to the traditional literature about the relationship between the yield curve and future economic activity in several aspects. First, to the best of our knowledge, this is the first paper that uses a threshold model to examine whether the predictive power of the yield spread depends on whether the term premium is below or above a determined threshold at each particular period.[5] In addition, we also analyze whether the predictive power of the

[3]Some of the early empirical studies of the US and other advanced economies include Harvey (1988, 1989), Estrella and Hardouvelis (1991), Plosser and Rouwenhorst (1994), Estrella and Mishkin (1997), and Estrella et al. (2003), among others. Evgenidis et al. (2020) present a recent review of this literature.

[4]Empirical studies of the US and other advanced economies include Estrella and Hardouvelis (1991), Estrella and Mishkin (1998), Rosenberg and Maurer (2008), and Gerlach and Bernard (1998), among others. In the case of Mexico, Castellanos and Camero (2003) and Reyna et al. (2009) also highlight the usefulness of the term structure to predict economic contractions.

[5]An alternative approach followed by Venetis et al. (2003), for instance, consists of smooth transition nonlinear

slope of the yield curve to anticipate the probability of facing a future contraction depends on the term premium.

Secondly, this is the first study investigating a nonlinear relationship between the yield spread and output growth of Mexico.[6] As will be discussed later in the paper, the association between the yield spread and output in this country has become less clear in recent years, at the same time that the term premium was relatively low (Banco de México, 2019a). This provides motivation to analyze the possibility of nonlinearities in the yield spread-output relationship associated with the term premium level. In addition, this work contributes to the literature by providing recent evidence for the case of a large emerging economy like Mexico, which during the period of analysis experienced a significant development of its financial markets (Sidaoui and Ramos-Francia, 2008).[7] Indeed, our own calculations with data from the International Monetary Fund show that, over the last twenty years, Mexico was the country with the highest investment in government securities by non-residents among emerging economies.[8]

Our analysis is from 2004 to 2019 and thus allows us to analyze a period after the adoption of the inflation targeting regime in 2001. The period of analysis is longer compared to previous studies of Mexico (Castellanos and Camero, 2003; Reyna et al., 2009), which were limited because the 10-year bond has been issued since 2001. According to Gaytán and González García (2007), the monetary policy transmission mechanism seemed to present a structural change after 2001. This is relevant given that, for the US and other advanced economies, Es-

models (STR) that allow for a smooth adjustment between the two states. As a first approximation, however, we use a two regime switching discrete model similar to that of Galbraith and Tkacz (2000) and Duarte et al. (2005). This model can be seen as a particular case of the more general model employed by Venetis et al. (2003), allowing for easier interpretation while still being able to generate rich nonlinear dynamics.

[6] The presence of non-linearities is a recurrent feature of emerging economies (Arango and Melo, 2016). In the case of Mexico, Ibarra (2016) and Jaramillo-Rodríguez et al. (2019) are some recent empirical studies that have examined the existence of nonlinearities in Mexico in the relationship between financial and macroeconomic variables.

[7] According to Cortés et al. (2008), after the adoption of an inflation targeting regime in 2001, the Mexican macroeconomic environment has become more stable owing to a low and stable inflation level. This fact, along with important regulation developments, has allowed the economy to experience a significant development of financial markets, in particular, the primary and secondary markets for public sector debt of different maturities.

[8] Similarly, a survey conducted by the Emerging Markets Traders Association shows that in the last year the trading volume of Mexican debt securities was the highest among emerging markets (Murno, 2019).

trella and Mishkin (1997), Bordo and Haubrich (2004), Feroli (2004), and Estrella (2005) find that the relationship between the yield spread and future economic activity may depend on the credibility of the central bank, the monetary regime, and the degree of aversion of the policymaker to deviations from inflation targets. As discussed by Aguilar-Argaez et al. (2014), Banco de México's commitment to price stability seems to have strengthened the anchoring of medium and long-term inflation expectations. Therefore, it is likely that temporary inflation shocks have tended to add relatively more noise to the spread-output relationship during the last years, by reducing the yield spread (as these shocks only affect short-term rates) and having no future real effects. In this case, the term spread-output relationship becomes weaker while the term premium is low. Regarding the latter and as a motivational exercise, in this paper we also analyze, using a rolling window regression approach, the stability of the predictive power of the yield spread and whether changes in such predictive power are associated with changes in the term premium level. To the best of our knowledge, this is also the first paper that examines the stability of the yield spread-output relationship in an emerging economy.

The remainder of the paper is organized as follows. Section 2 describes the data. Section 3 describes the econometric models used to determine whether the slope of the yield curve has predictive power on economic activity. The estimation results are reported and discussed in Section 4, while concluding remarks are presented in Section 5.

2 The Data

2.1 Data Description

We use aggregate monthly data for the Mexican economy over the period 2004:M1–2019:M12. The dependent variable in the threshold model is the real domestic output (Y_t),[9] and the relevant predictor variable is the yield spread, measured as the difference between the 10-

[9] In particular, we use an aggregate indicator of economic activity (IGAE by its Spanish acronym) provided by INEGI, the statistical authority in Mexico, as the output variable. The correlation between this variable and GDP for Mexico is 0.99.

year government bond yield (i_t^{10y}) and the 3-month interest rate on Mexican Treasury bills, CETES, (i_t^{3m}).[10] The control variables include the real funding rate (r_t), the slope of the US yield curve, measured as the difference between the ten year Treasury bond rate and the three-month Treasury bill rate, ($i_t^{*10y} - i_t^{*3m}$), and lagged output. The control variables were selected following previous studies about the relationship between the yield spread and economic activity, including Estrella and Hardouvelis (1991), Plosser and Rouwenhorst (1994), Estrella and Mishkin (1997), Dotsey (1998), Hamilton and Kim (2002), among others.

Seasonally adjusted IGAE is included as a measure of Mexican economic activity. This indicator employs the methodology and the conceptual framework of the national accounts, in particular, GDP. In addition, IGAE is available on a monthly basis, which allows to have a larger sample size.[11]

Following most of the literature, we measure the yield spread as the difference between the 10-year government bond yield i_t^{10y} and the 3-month interest rate on CETES i_t^{3m}. The yield spread is a valuable forecasting tool, particularly in a context where final output estimates are released with a lag. Considering that IGAE measurements reflect developments over the entire month rather than purely at a point in time, we use the monthly average for the spread rather than a point-in-time value such as end of the month values. In addition, considering that Mexico has issued 10-year bonds since 2001, data for i_t^{10y} are available from 2001:M12, and thus the yield spread can be calculated from this date onwards. This allows us to analyze a period after the adoption of the inflation targeting regime in 2001. Gaytán and González García (2007) find that the monetary policy transmission mechanism seemed to present a structural change after this period. As mentioned above, the role of monetary

[10] CETES are debt issued by the Federal Government through the Ministry of Finance and the Central Bank of Mexico, Banco de México. Following Estrella et al. (2003), Ang et al. (2006), and Mehl (2009), among others, zero coupon interest rates are used for all maturities in order to obtain comparable interest rates, as each bond pays different coupons for each maturity.

[11] This indicator is subject to revisions. According to Orphanides (2001), the effect of monetary policy on output based on real-time data can be different from that obtained with revised data. Nevertheless, although it would be of interest to analyze the yield spread-output relationship using real-time data, this information for Mexican output is not available. Given the unavailability of real-time data and considering that the focus of this paper is on analyzing what actually happens to economic activity, not preliminary announcements of its state, we use revised data in our estimations. In addition, Croushore and Evans (2006) find that the estimated response of output to a monetary policy shock does not seem to depend largely on the use of real-time or ex post revised data in VAR analyses.

policy in explaining the predictive ability of the yield spread has been widely documented. In particular, according to Bordo and Haubrich (2004), regimes with high credibility (low persistence of inflation) tend to have lower predictability of the yield spread.

We use the term premium on a 10-year bond $\hat{\theta}_t$ obtained by Aguilar-Argaez et al. (2020), which in turn is the average from three different methodologies. In particular, the long-term interest rate i_t^n for a nth-month-maturity bond is determined by the average of the expected short-term interest rates over the next n periods, plus a term premium. Thus, these authors use this relationship to estimate the term premium on a 10-year Mexican bond as the difference between the 10-year government bond yield i_t^{10} and the average of the expected 3 month interest rates over the next ten years. Nevertheless, since the expectation of the future short-term interest rate is an unobservable variable, Aguilar-Argaez et al. (2020) use three quantitative approaches in order to estimate it. In particular, they use two affine term structure models, one similar to Adrian et al. (2013) and another to Kim and Wright (2005), as well as the average of swaps of interbank equilibrium interest rate with maturities of 1, 3, 5, 7, and 10 years. A key assumption of the two affine models, henceforth ACM and KW models respectively, is that of no-arbitrage, which is a necessary condition for an equilibrium in financial markets. The differences between the two affine models lie in the factors considered, the estimation approach, the estimation period, and the information included in the model.[12] The ACM model has five observable factors, which are used as a proxy for the level, slope, curvature, implied excess returns, and term premium of the yield curve. This model is estimated through OLS, and principal components from 2004 to 2019 with data on the yields of government bonds with maturities of 1 to 120 months. In contrast, the KW model contains three latent factors, which are correlated with the level, slope, and curvature of the yield curve (Tang and Xia, 2007).[13] This model is estimated through maximum likelihood and the Kalman filter from 2002 to 2019, with data on the yields of government

[12] More details on the term premium, its evolution, and estimation for Mexican bonds are presented in Aguilar-Argaez et al. (2020), Carrillo et al. (2018), and Banco de México (2019b).

[13] As explained by Dewachter and Lyrio (2006), the level factor can represent the long run inflation expectations of investors. In turn, the slope factor captures the current economic outlook, while the curvature factor reflects the stance of monetary policy (Rosenberg and Maurer, 2008).

bonds with maturities of 1, 3, 6, 12, 24, 36, 60, 84, and 120 months. On the other hand, the average of swaps considers the expectations of economic agents on the short-term interest rate at different horizons drawn from financial instruments. Although the dynamics for the average expectation obtained by each of the methodologies varies in level, in general, they present similar trends. According to Carrillo et al. (2018), the level of such average expectation in the affine models may differ because transitory factors seem to affect relatively more the ACM model. Considering that data on bond yields for some maturities are available from 2004:M1, the sample is constrained from this date.

Following Estrella and Hardouvelis (1991), Plosser and Rouwenhorst (1994), Estrella and Mishkin (1997), Dotsey (1998), and Hamilton and Kim (2002), among others, who have investigated whether the yield spread has additional information beyond that contained in monetary policy, we use the ex ante real interbank funding interest rate r_t as an indicator of the stance of monetary policy. It is widely accepted that monetary policy can influence the slope of the yield curve mainly through their effects on the current and expected future short-term interest rates. As explained by Estrella and Mishkin (1997), long-term rates are determined by many other factors, including long-term expectations of inflation and real economic activity. Thus, when a monetary tightening occurs, short-term rates tend to increase more than long-term rates. Because of this, the yield curve tends to flatten. At the same time, the increase in short-term interest rates may eventually be reflected in a reduction in the rate of economic expansion (Estrella and Hardouvelis, 1991; Feroli, 2004).[14] The interbank funding rate is equivalent to the US federal funds rate. In particular, we use the monthly average of the one day interbank funding interest rate. The real rate r_t is calculated as the nominal rate i_t minus the one-year expected rate of inflation. In turn, the expected rate of inflation is obtained from the Survey of Professional Forecasters published by Banco de México.[15]

[14] An alternative mechanism that can generate a relationship between the slope of the yield curve and future economic activity is the relationship between the economic cycle and the risk premium. Regarding this mechanism, in general, when the economy goes through an expansion, the risk premium, an important component of the term premium, tends to decrease, so the long-term rates tend to adjust downward. This tends to flatten the slope of the yield curve, while the evolution of the economic cycle, where expansion phases are usually followed by phases of slower economic growth, would imply a reduction in the rate of economic growth in the future (Ang and Piazzesi, 2003).

[15] Capistran et al. (2010) find that forecasts of inflation taken from Banco de México's survey of professional

Finally, following Plosser and Rouwenhorst (1994), Gerlach and Bernard (1998), and Mehl (2009), among others, we consider the existence of international financial linkages by including the slope of the yield curve in the US. This spread $i_t^{*10y} - i_t^{*3m}$ is measured as the difference between the ten year Treasury bond rate and the three-month Treasury bill rate. According to Mehl (2009), the predictive power of this variable may be attributed to several factors, such as the large size of foreign demand on the part of US or the broad development of the US debt security markets. The series of Y_t, i_t^{10y}, i_t^{3m}, the interbank funding rate, and the interest rates at different maturities are obtained from Banco de México, and i_t^{*10y} and i_t^{*3m} are obtained from the US Federal Reserve Bank.

2.2 Evolution of the Yield Spread and Economic Activity

In this section we analyze the time series of output, the yield spread, measured as the difference between the 10-year government bond yield and the 3-month interest rate on CETES, and the two components of such spread: the term premium and the expectations component. The expectations component is calculated as the difference between the average of the expected 3 month interest rates over the next ten years, as explained in the previous section, and the current 3-month interest rate.[16] Figure 1 shows the historical behavior of these variables for the period 2004–2019.

Figure 1a) depicts the annual growth rate of output. During 2004-2007, the average growth rate of output was 3.19%. As can be observed, Mexican output growth was negative from the end of 2008 to the end of 2009, as a response to the decline in external demand due to the Global Recession. Mexican economic activity started to recover in 2010, but it was again affected by the European sovereign debt crisis and the effects of natural gas shortages in 2013 (Alcaraz and Villalvazo, 2017). Subsequently, from 2014 to 2018 economic

forecasters outperform forecasts from traditional benchmarks such as univariate and multivariate time series models.

[16]Long term interest rates are determined by the average of current and future expected short-term interest rates, plus a term premium. That is, $i_t^n = \frac{1}{n}\sum_{j=0}^{n-1} E_t i_{t+j}^1 + \theta_t$, where i_t^n denotes the long-term interest rate, i_t^1 is the short-term interest rate, and θ_t represents the term premium. Therefore, we can obtain the yield spread as $i_t^n - i_t^1 = \left(\frac{1}{n}\sum_{j=0}^{n-1} E_t i_{t+j}^1 - i_t^1\right) + \theta_t$, where the first term on the right-hand side denotes the expectations component.

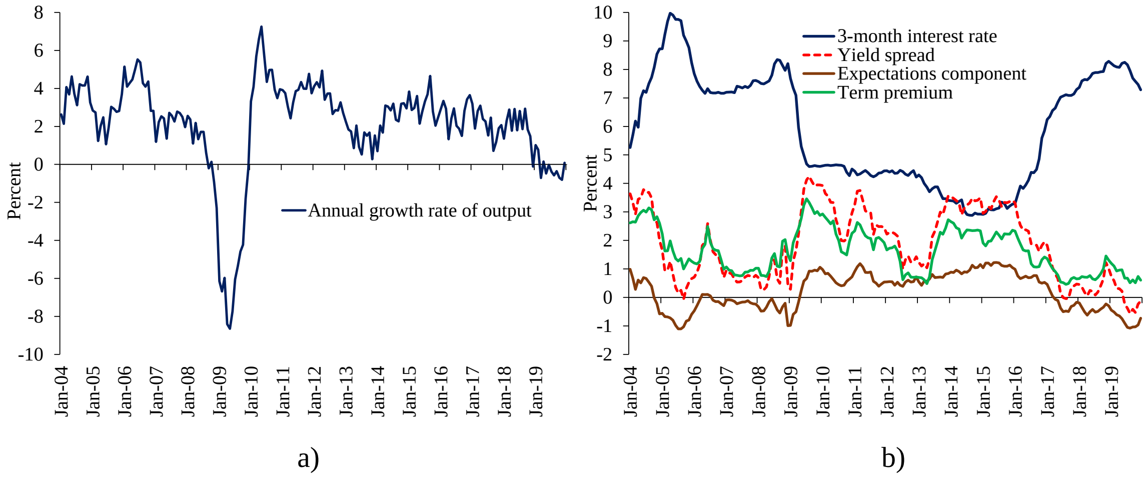


Figure 1: Data Series

Source: Author's estimates using data from Banco de México and INEGI.
Notes: The global economic activity indicator (IGAE by its Spanish acronym) is used as the output variable. The expectations component is estimated as the difference between the average of the expected 3 month interest rates on Mexican Treasury bills, CETES, over the next ten years and the current 3-month interest rate on CETES. The term premium is estimated as the residual between the 10-year government bond yield and the average of the expected 3 month interest rates on CETES over the next ten years. The yield spread is measured as the difference between the 10-year government bond yield and the 3-month interest rate on CETES.

activity presented relative stability due mainly to a higher external demand. The weakness of national economic activity during 2019 reflected both the effects of the lower dynamism of industrial activity in the United States on exports, as well as the effects of external and internal uncertainty on investment and consumption.[17]

Figure 1b) shows the 3-month interest rate, the yield spread between the 10-year government bond yield and the 3-month interest rate on CETES, the expectations component, and the term premium. By construction, the yield spread closely follows the movements of the term premium and the expectations component, which is greatly influenced by the the 3-month interest rate and thus by the stance of monetary policy.[18]

As can be seen in Figure 1b), the term premium reached relatively high levels during the global financial crisis. Subsequently, during the implementation of unconventional monetary

[17] More details on these sources of external and internal uncertainty are presented in Banco de México (2019c).
[18] The monetary policy rate and the 3-month interest rate track each other so closely. Indeed, the correlation between these rates is 0.99.

policies adopted by advanced economies to stimulate the economy, the term premium showed a downward trend, by reaching historical minimum levels in April 2013. During the "Taper Tantrum" episode that started when the Federal Reserve announced in May 2013 a possible early reduction of unconventional monetary policies, the term premium presented an important upward adjustment, mainly associated with the increase in the US term premium, the volatility of the international financial markets that impacted the emerging economies, and the increase in the real compensation in Mexico due to lower capital flows.[19] Finally, the term premium increased in November 2018, which seems to be associated with the cancellation of some infrastructure projects in Mexico and tighter financial conditions (Aguilar-Argaez et al., 2020).

Regarding the other variables, in 2004 and 2005, Banco de México increased the interest rate to face the supply side pressures that impacted prices, while in 2006 the interest rate was reduced given the stable inflation environment. As shown by Figure 1b), the former was associated with a decrease of the expectations component, given an increase of the 3-month interest rate, and thus a flattening of the yield curve, resulting in an inverted curve in September 2005. In turn, the reduction in the monetary policy rate in 2006 was related with an increase of the expectations component and thus an increase of the spread, which peaked in June of the same year.

In turn, in 2007 and 2008, monetary conditions were restricted to deal with the inflationary pressures that resulted from the increase in commodity prices. As can be seen in Figure 1b), while the expectations component seems to show a decreasing trend during this period, the yield spread remains in positive levels. This fact seems to be explained by the behavior of the term premium. In 2009, given the contraction of output, the objective interest rate was reduced to 4.5%. The increase in the term premium associated to the global financial crisis in

[19] According to the literature, the dynamics of the term premium can be mainly explained by a real term premium and an inflation risk premium (Abrahams et al., 2016; Bauer, 2017; Bernanke, 2015). Thus, a fall in the term premium might be driven, for instance, by an improvement in investor uncertainty about long-term productivity or better anchored inflation expectations (Rosenberg and Maurer, 2008). In addition, the US term premium, which can be interpreted as a global risk factor for emerging economies, also seems to be an important determinant of the long-term interest rates is such economies (Albagli et al., 2019) and thus it could explain the dynamics of the term premium in Mexico (Banco de México, 2019b).

part explains the high value of the spread. The interest rate was kept at 4.5% in an environment of stable inflation and improved country risk perception. During this period, the yield curve shows a downward trend. Nevertheless, in 2013 the interest rate was reduced when the economy experienced a slowdown of internal and external demand. The yield spread increased during this period in part as a result of the increase in the term premium during the Taper Tantrum.

Finally, since the end of 2014, the Mexican economy has been affected by several shocks that have significantly impacted inflation. Thus, from December 2015 to December 2018, Banco de México increased the target for the interest rate from 3% to 8.25%. Once again, as shown by Figure 1b), this coincided with a decline in the term premium and a flattening of the yield curve, resulting in an inverted curve from July 2017 to September 2017. Nevertheless, despite gradual increases in the interest rate, the yield spread remains positive from the end of 2017 to mid-2019, even locally peak in November 2018. This fact was again related with the level of the term premium. Finally, during the last months, the yield spread has been negative, while the term premium has remained at low levels.

2.3 Preliminary Analysis

Figure 2 depicts the yield spread, the term premium, and output growth 12 months ahead. This figure seems to illustrate that the slope of the yield curve tracks the future realization of output growth relatively well during some episodes, especially during the period following the Global Recession. Notice, however, that approximately from late 2004 to early 2009 and from 2017 onwards, with some exceptions, the association between the yield spread and output is less clear. At the same time, the term premium was relatively low during an important part of these periods. This fact is in line with the existence of a possible nonlinear relationship between the slope of the yield curve and economic activity. Indeed, as the preliminary analysis suggests, this nonlinear relationship could depend on the term premium level. Regarding this latter point, it is important to highlight that if the term premium is located at low levels, the yield curve can be inverted with a small downward adjustment in the expected short-term

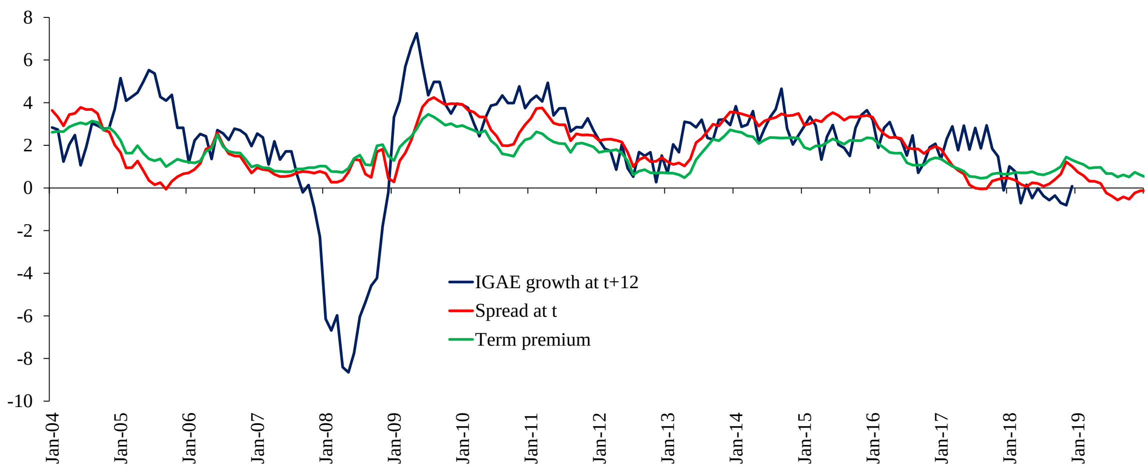


Figure 2: Yield Spread, Term Premium and IGAE Growth 12 Months Ahead

Source: Author's estimates using data from Banco de México and INEGI.
Notes: The yield spread is measured as the difference between the 10-year government bond yield and the 3-month interest rate on CETES. The term premium is estimated as the residual between the 10-year government bond yield and the average of the expected 3 month interest rates on CETES over the next ten years.

interest rates. In this context, in principle, it can be argued that this movement would have less predictive power to anticipate a reduction in economic activity.

Figure 3 depicts the cross correlations between the yield spread $Spread_t$ and the annual growth rate of output Y_{t+j} for a horizon j from 0 to 36 leads-lags. Consistent with the evidence for United States, Germany, and United Kingdom, as shown by Wheelock and Wohar (2009), high levels of the spread today are associated with high values of output in the future. These correlations are statistically significant. The highest correlations occur between the yield spread today and the annual growth rate of output from 8 to 28 months ahead.

Overall, the preliminary analysis seems to indicate that high levels of the yield spread seem to be followed by high levels of output growth. However, as shown by Figure 2, the relationship between the yield spread and output is less clear in some periods, where the term premium is relatively low. Motivated by this issue and the fact that some authors such as Greenspan (2005) and Werner (2006) have argued that the relationship between the slope of the yield curve and economic activity may depend on other variables such as the term premium, we present below a linear model that is used to determine, using a rolling window

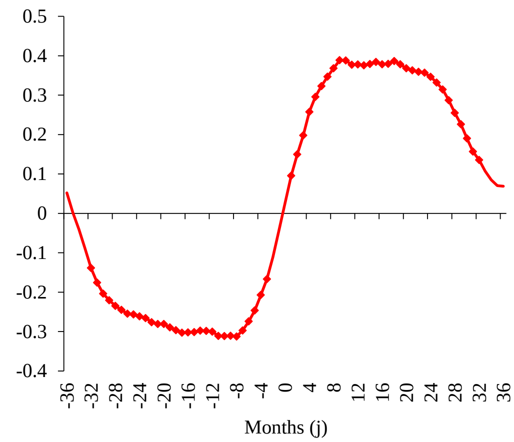


Figure 3: Cross Correlations

Source: Author's estimates using data from Banco de México and INEGI.
Notes: $Spread_t$ represents the yield spread and Y_{t+j} is the annual growth rate of IGAE. Solid squares indicate a significant correlation at the 10% level. The sample period is from 2004:M1 to 2019:M12.

regression approach, whether the predictive power of the slope of the yield curve on economic activity has change over time and also examine whether changes in such predictive power are associated with changes in the term premium level.

2.4 Rolling Windows

In order to analyze the stability of the predictive power of the yield spread over time and also examine whether changes in such predictive power are associated with changes in the term premium level, we initially estimate a linear model for the Mexican economy using a rolling window regression approach. Following the initial specification from previous studies, such as Estrella and Hardouvelis (1991), Estrella and Mishkin (1997), Haubrich and Dombrosky (1996), Bonser-Neal and Morley (1997), Dotsey (1998), and Hamilton and Kim (2002), we use the regression below as a first approximation to examine the predictability of the yield spread for real activity:

$$Y_{t,t+k} = \alpha_0 + \alpha_1 Spread_t + \varepsilon_t \tag{1}$$

where $Y_{t,t+k}$ is the annualized cumulative IGAE growth over the next k months, defined as $Y_{t,t+k} = \left(\frac{1200}{k}\right)\left[\log \frac{y_{t+k}}{y_t}\right]$, where y_t is IGAE at month t, $Spread_t$ represents the slope of the yield curve, defined as the difference between the 10-year government bond yield i_t^{10y} and the 3-month interest rate on CETES i_t^{3m}, and ε_t is an error term.[20] Including contemporaneous values of the term spread $Spread_t$ and future values of real activity $Y_{t,t+k}$ in Eq. (1) helps to address simultaneity concerns among both variables. Throughout a rolling window regression approach, OLS estimation of Eq. (1) is repeated with a 72 month fixed-width window.[21] With the start point and end point moving down one month each time, the fixed-width window regressions would roll from the start point to the end point of the full sample size.[22]

We also use the year-on-year output growth for a horizon k months on the future as an alternative measure of real activity. Thus, the annualized marginal percentage change in output from month $t+k-12$ to future month $t+k$ is defined as $Y_{t+k-12,t+k} = 100\left[\log \frac{y_{t+k}}{y_{t+k-12}}\right]$. Therefore, while the cumulative measure considers the change in output over the entire horizon, that is, from t to $t+k$, the marginal measure focuses on the change in output during the last 12 months of that horizon, that is, from $t+k-12$ to $t+k$. Note that both measures are exactly equal for a horizon 12 months on the future. Although the cumulative growth measure follows most of the literature about the predictability of the yield spread on real activity, it is also of interest as in Estrella and Hardouvelis (1991), Plosser and Rouwenhorst (1994), Kozicki (1997), Dotsey (1998), and Hamilton and Kim (2002) to consider this alternative measure.

The forecasting horizon k is for 6, 12, and 24 months ahead. The overlapping for the dependent variable generates a moving average error that does not affect the consistency of

[20] Although the coefficients α_0 and α_1 depend on the horizon k, they are not indexed to facilitate notation.

[21] A 6-year window allows us to consider about a full economic cycle in Mexico, which has an average length of 60 to 63 months (Antón, 2011). Bordo and Haubrich (2004), for instance, also use this fixed-width window in their analysis. We also estimate the model using a window of 8 years as robustness test. Nevertheless, qualitatively, the results were very similar. The results are reported in Figure A.1 of the Appendix.

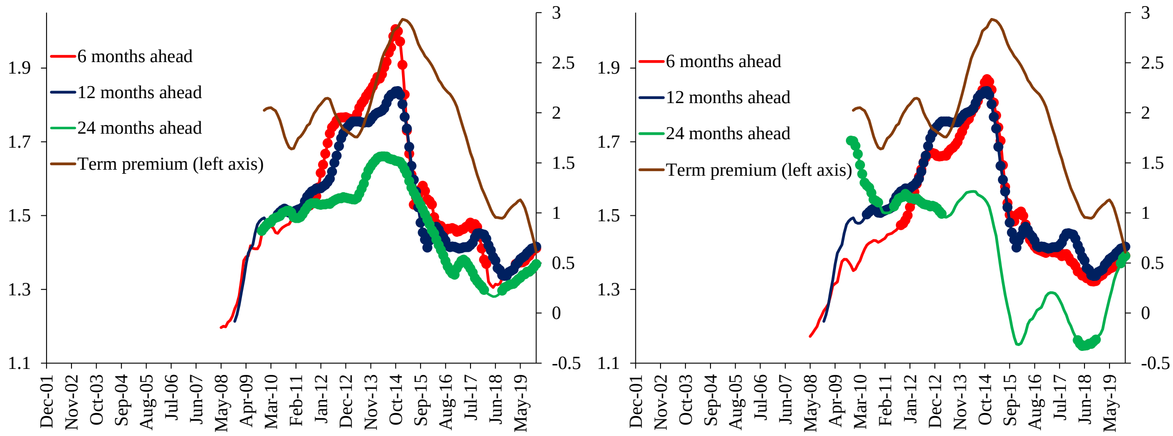
[22] For example, for a horizon of 12 months ahead, the first coefficient is estimated through a regression between the annual variation of IGAE, corresponding to the period from 2002:M12 to 2008:M11, and the slope of the yield curve for the period from 2001:M12 to 2007:M11. The second coefficient is estimated through a regression between the annual variation of the IGAE, for the period of 2003:M1 to 2008:M12, and the slope of the yield curve for the period from 2002:M1 to 2007:M12. This exercise is repeated until obtaining the last coefficient corresponding to a regression between the annual variation of IGAE for the period 2014:M1 to 2019:M12 and the slope of the yield curve for the period 2013:M1 to 2018:M12.

the OLS regression coefficients but does affect the consistency of the OLS standard errors. Therefore, for correct inferences, we use the Newey and West (1987) method to adjust the OLS standard errors. The lag used in order to obtain them is in turn determined by computing: $l = \left\lfloor (4 \times (T/100)^{2/9}) \right\rfloor$, where T denotes the time series length.

Figure 4 shows the coefficient regression between the spread and output for forecasting horizons of 6, 12, and 24 months ahead. As explained before, we use rolling regressions with a window of 6 years. The sample period is from 2001:M12 to 2019:M12 due to the fact that the term premium is not considered into the estimation. This allows us to consider a larger number of windows in the analysis. Figure 4a) depicts the results for the cumulative change, while Figure 4b) illustrates those for the marginal change. Solid lines represent coefficients that are not statistically significant, while those with markers indicate statistically significant coefficients at the 95% confidence level. These figures also show the 6-year moving average for the term premium. As can be seen, the slope of the yield curve seems to have predictive power on economic activity. In particular, a steeper (flatter) slope seems to imply faster (slower) future growth in real output. The predictive power of the yield curve tends to be higher at short term horizons, especially in the cumulative case. This result is in line with many previous studies which highlight a better forecasting ability of the yield spread for short horizons than longer horizons (Evgenidis et al., 2020). Indeed, the reduction in the predictive power of the yield spread seems to coincide with a reduction in the term premium.[23]

Considering the previous finding that the predictive power of the yield spread has the same declining trend as the term premium and motivated by the preliminary analysis in Section 2.3, in next section we use the term premium $\hat{\theta}_t$ as a threshold variable to analyze potential nonlinear effects of the yield spread on future output. A low term premium is associated with the strengthening of the central bank credibility and a stronger anchoring of inflation expectations, reducing the impact of inflationary shocks on such expectations. By affecting

[23] For robustness, we also analyzed the behavior of the standardized (regression) coefficients, also called beta coefficients. The standardized coefficients are the estimates of the regression where the variables are standardized, so that they have unit variance. In this way, the rolling regressions are unaffected by changes in the relative variance between the dependent and the independent variables across time. In general terms, the conclusions are similar to those presented in this paper and are available upon request.



a) Cumulative Change of Output

b) Marginal Change of Output

Figure 4: Coefficients between the Term Spread and Future Output

Source: Author's estimates using data from Banco de México and INEGI.
Notes: Rolling regressions with a window of 6 years. The model is as follows: $Y_{t,t+k} = \alpha_0 + \alpha_1 Spread_t + \varepsilon_t$, where $Y_{t,t+k}$ is the annualized cumulative IGAE growth over the next k months, or $Y_{t+k-12,t+k} = \alpha_0 + \alpha_1 Spread_t + \varepsilon_t$, where $Y_{t+k-12,t+k}$ is the annualized marginal percentage change in output from month $t+k-12$ to future month $t+k$. $Spread_t$ represents the slope of the yield curve and ε_t is an error term. Solid lines represent coefficients that are not statistically significant, while those with markers indicate statistically significant coefficients at the 95% confidence level. The lag used in order to obtain the Newey and West (1987) standard errors turned out to be three. The 6-year moving average for the term premium is shown on the left axis. The sample period is from 2001:M12 to 2019:M12.

only short term rates but not long term rates, these shocks reduce the yield spread and have no future real effects (Bordo and Haubrich, 2004), thus weakening the predictive power of the yield spread while the term premium is low. Therefore, it is important to analyze the role that the term premium level has in this process.[24]

3 Methodology

This section describes the econometric models used to analyze the relationship between economic activity and the yield spread. Section 3.1 describes the threshold model used to examine whether the yield spread-output relationship depends on the term premium. Section

[24] In Section 4.3 we present a detailed discussion about potential explanations for observing a nonlinear relationship between the yield spread and future economic activity.

3.2 describes the probit models used to analyze the usefulness of the yield spread to predict economic contractions, and whether this predictive power depends on the term premium.

3.1 Threshold Model

To investigate whether the relationship between the slope of the yield curve and future economic activity depends on the term premium, we estimate a threshold model following the approach used by Galbraith and Tkacz (2000) and Duarte et al. (2005) to analyze whether this relationship depends on the yield spread or output growth. In particular, we relax the assumption of linearity in parameters to allow the spread coefficient to vary between states. States are defined in terms of the term premium level. As such, the yield spread-output relationship will depend on whether, at each particular period, the term premium is below or above of an estimated threshold.

The threshold model is represented as:

$$Y_{t,t+k} = \alpha_0 + \alpha_1 Spread_t \mathbb{1}(\hat{\theta}_t < \phi) + \alpha_2 Spread_t \mathbb{1}(\hat{\theta}_t \geq \phi) + \sum_{i=3}^{5} \alpha_i x_{it} + \varepsilon_t \tag{2}$$

where the variables $Y_{t,t+k}$ and $Spread_t$ are defined as before. $\mathbb{1}(\cdot)$ is an indicator function that takes the value of 1 if the expression is true and 0 otherwise. The threshold variable that determines the regime of Eq. (2) is the term premium, $\hat{\theta}_t$. Thus, the parameter associated to the spread depends on whether the term premium is below or above a determined threshold ϕ. Therefore, the coefficient associated with the slope of the yield curve is α_1 if $\hat{\theta}_t < \phi$ and α_2 if $\hat{\theta}_t \geq \phi$. The model also includes as control variables x_{it} the lagged growth of IGAE, cumulative or marginal depending on what dependent variable is used, the real interest rate, and the slope of the US yield curve.[25] The lagged growth of IGAE allows capturing the dynamics of economic activity. Galbraith and Tkacz (2000) and Hamilton and Kim (2002), among others, were some of the early empirical studies that include lagged output growth in their studies. In addition, following most of the literature, Estrella and Hardouvelis (1991), Plosser

[25] We also considered the lagged growth of the US industrial production instead of using the lagged growth of IGAE. The results are consistent with our baseline specification.

and Rouwenhorst (1994), Estrella and Mishkin (1997), and Dotsey (1998), among others, the real funding interest rate is included to control for the monetary policy stance, which affects the slope of the yield curve by having a greater impact on the short-term rate than the long-term rate and at the same time by influencing future economic activity. Finally, following Plosser and Rouwenhorst (1994), Gerlach and Bernard (1998), and Mehl (2009), among others, the slope of the US yield curve is included to capture the financial links between Mexico and the United States. Note that the regressors x_{it} do not vary across regimes.

Given the possibility of regime switching, the estimation of Eq. (2) is a little more complex than in the linear case. In particular, following Hansen (2000), we use nonlinear least squares to estimate the parameters of the model. Specifically, if we define the residual sum-of-squares objective function as:

$$S(\alpha,\phi)=\sum_{t=1}^{T}\left(Y_{t,t+k}-\alpha_0-\alpha_1 Spread_t \mathbb{1}(\hat{\theta}_t<\phi)-\alpha_2 Spread_t \mathbb{1}(\hat{\theta}_t\geq\phi)-\sum_{i=3}^{5}\alpha_i x_{it}\right)^2 \quad (3)$$

where $\alpha=(\alpha_0,\alpha_1,\alpha_2,\alpha_3,\alpha_4,\alpha_5)$, then we can take advantage of the fact that for a given, ϕ, say $\tilde{\phi}$, minimization of the objective function $S(\alpha,\phi)$ is a simple least squares problem. Therefore, we can view estimation as finding the threshold value and corresponding OLS coefficient estimates that minimize the sum-of-squares across all possible sets of threshold partitions. Following Andrews (1993), the set of values in which the threshold parameter is allowed to take a particular value is trimmed by 15%, which implies that regimes are restricted to have at least 15% of the observations.[26]

3.2 Probit Model

To estimate the predictive power of the yield spread on the probability of a contraction, we use a probit model following the standard approach of Estrella and Hardouvelis (1991), Estrella

[26] This trimming percentage has been commonly used in the literature (Hansen, 2000; Galbraith and Tkacz, 2000; Duarte et al., 2005). It is worth nothing that small values of this trimming percentage can lead to estimates of coefficients and variances which are based on very few observations. We have also estimated the threshold model by considering a trimming percentage of 20%. The results are similar to those reported in this paper and are reported in Table A.1 of the Appendix.

and Mishkin (1998), Rosenberg and Maurer (2008), and Gerlach and Bernard (1998). First, we represent the state of the economy with a dummy variable equal to 1 if a contraction occurred at time t and 0 otherwise. Following Fair (1993), Moneta (2005), and Duarte et al. (2005), among others, we define economic contractions as two consecutive quarters of declining GDP. Thus, the dummy variable will take the value of 1 in each month during those quarters in economic contraction. Then, we map the level of the term spread at time t to the state of the economy k months later, particularly for 6, 12, 18, and 24 months ahead, by estimating the following model:

$$\Pr[Con_{t+k} = 1] = F(\beta_0 + \beta_1 Spread_t + \beta_2 Spread_t^*) \tag{4}$$

where Pr denotes probability, F is the cumulative normal distribution, and the binary variable Con equals unity during those months considered as contractions. $Spread_t$ is defined as above and $Spread_t^*$ is the yield spread in the US.[27] Note that the last variable is included as an additional regressor to the set of variables included in Eq. (1). As discussed by Gerlach and Bernard (1998), the slope of the yield curve in the US seems to be a strong predictor of recessions in other countries, particularly in the UK and Japan.

We can estimate the parameters of this model using the method of maximum likelihood. The log-likelihood function $l_t(\boldsymbol{\beta})$ for observation t is a function of the parameters $\boldsymbol{\beta}$ and the data. Because F is strictly between zero and one, $l_t(\boldsymbol{\beta})$ is well defined for all values of $\boldsymbol{\beta}$. The log-likelihood for a sample size of T is obtained by summing $l_t(\boldsymbol{\beta})$ across all observations, that is; $\mathscr{L}_t(\boldsymbol{\beta}) = \sum_{t=1}^{T} l_t(\boldsymbol{\beta})$. The maximum likelihood estimation of $\boldsymbol{\beta}$ maximizes this log-likelihood. After estimating the model's coefficients, we can use equation (4) to estimate the probability of an economic contraction k months ahead.

In order to analyze if the predictive power of the yield spread depends on the term pre-

[27] As explained by Estrella and Mishkin (1998), the probit model can be derived from an underlying latent variable model of the form $y_{t+k}^* = \beta_0 + \beta_1 Spread_t + \beta_2 Spread_t^* + \varepsilon_t$ where the dependent variable is an unobservable that determines the occurrence of a contraction at time t, k is the length of the forecast horizon, and ε_t is an error term. The observable binary variable Con_t is related to this model by $Con_t = 1$ if $y_t^* > 0$ and $Con_t = 0$ otherwise. Thus, Eq. (4) is the form of the model to be estimated where F is the cumulative normal distribution function corresponding to $-\varepsilon$.

mium level, we estimate the following model:

$$\Pr[Con_{t+k} = 1] = F(\gamma_0 + \gamma_1 Spread_t \mathbb{1}(\hat{\theta}_t < \phi) + \gamma_2 Spread_t \mathbb{1}(\hat{\theta}_t \geq \phi) + \gamma_3 Spread_t^*) \quad (5)$$

where the threshold variable that determines the regime of Eq. (5) is the term premium, $\hat{\theta}_t$. As before, the indicator function $\mathbb{1}(\cdot)$ takes the value of 1 if the expression is true and 0 otherwise. Thus, the coefficient associated to the spread depends on whether the term premium is below or above a determined threshold ϕ. Therefore, the coefficient associated to the slope of the yield curve is γ_1 if $\hat{\theta}_t < \phi$ and γ_2 if $\hat{\theta}_t \geq \phi$. Note that the regressor $Spread_t^*$ does not vary across regimes. As in the previous model, we can view estimation of Eq. (5) as finding the threshold value and corresponding coefficient estimates that maximize the log-likelihood function across all possible sets of threshold partitions. Consistent with the threshold model presented in the previous subsection, the set of values in which the threshold parameter is allowed to take a particular value is trimmed by 15% on each end of the sample of the term premium variable.[28]

4 The Role of the Term Premium in the Yield Spread-Output Relationship

This section presents the estimation results that illustrate the relationship between the yield spread and economic activity in Mexico. Section 4.1 depicts the results from the threshold model. Section 4.2 analyzes the usefulness of the yield spread to predict economic contractions. Finally, Section 4.3 presents a discussion about potential explanations for observing a nonlinear relationship between the yield spread and future economic activity.

[28] We also estimated the model by considering a trimming percentage of 20%. The results are similar to those reported in this paper and are reported in Table A.7 of the Appendix.

4.1 Analysis of Nonlinear Effects

The previous section shed light about a potential nonlinear relationship between the yield spread and future output. In that sense, Table 1 shows the estimates of the threshold model provided in Eq. (2) for both the cumulative and the marginal change in output as defined above. In particular, we present the coefficient associated with the slope of the yield curve when the term premium is below the threshold $\hat{\alpha}_1$, the corresponding coefficient when the term premium is above the threshold $\hat{\alpha}_2$, and the estimated term premium threshold $\hat{\phi}$. In addition, we also present the rest of the model coefficients: the intercept $\hat{\alpha}_0$ and the coefficients associated with the lagged growth of IGAE $\hat{\alpha}_3$, cumulative or marginal depending on what dependent variable is used, the real funding interest rate $\hat{\alpha}_4$, and the slope of the US yield curve $\hat{\alpha}_5$.[29]

As can be seen in Table 1, in general terms the slope of the yield curve does not seem to have predictive power on the behavior of economic activity in the future when the term premium is below the estimated threshold, as $\hat{\alpha}_1$ is nonsignificant in most of the cases. On the other hand, when the term premium is above the estimated threshold, the yield spread seems to anticipate the behavior of economic activity, as $\hat{\alpha}_2$ is significant in most cases. For the cumulative case, the coefficient is significant at horizons from 3 to 24 months ahead. This result is in line with Dotsey (1998) and Hamilton and Kim (2002), among others, who highlight the ability of the yield spread to predict future economic activity at horizons ranging from one quarter up to two years. By construction, cumulative changes in real output are smoother than marginal changes, particularly for long horizons. Thus, cumulative changes are more predictable than marginal changes, particularly in the long term. The predictive power of the yield spread on marginal changes in real output is significant at horizons from 3 to 18 months ahead. This in turn could explain the fact that the R^2 of the model for the cumulative change of output increases in relation with the forecasting horizon, while that of the model for the marginal change decreases. In addition, the threshold estimate depends on

[29] The results presented in this paper should be interpreted cautiously given the potential measurement error in the estimation of the term premium. As mentioned above, we use the term premium on a 10-year bond $\hat{\theta}_t$ obtained by Aguilar-Argaez et al. (2020), which in turn is the average from three different methodologies.

the forecast horizon and ranges between 0.9 and 2.6 percentage points, in the cumulative case, and between 1.1 and 2.6, in the marginal case. In particular, for 12 months ahead it amounts to 1.54 percentage points. Note also that the threshold estimate seems to decrease over the forecast horizon. This result may be associated with the lagged effect in the transmission of monetary policy to the economy (Friedman, 1961). In other words, monetary policy affects economic conditions after a lag and thus there is a broader range of term premium values for which we can observe a relationship between the slope of the yield curve and future economic activity at long horizons.

Note that the results presented in Table 1 suggest that the yield spread provides additional information beyond that contained in lagged growth rates, current monetary policy, and the slope of the US yield curve. In line with previous studies, the estimated coefficient on the lagged growth of IGAE $\hat{\alpha}_3$ is negative at most horizons, thus reflecting the evolution of the economic cycle, where the expansion periods are usually followed by periods of less economic growth. For marginal changes in real output, however, this coefficient seems to be positive and statistically significant in the short term. This result could be associated with the overlapping between the marginal growth of IGAE and the lagged value of this variable for forecasting horizons lower than 12 months. On the other hand, the coefficient associated with the funding interest rate $\hat{\alpha}_4$ is negative, although not significant at most horizons. That is, a monetary tightening tends to be reflected in a reduction of economic growth in the future.[30] For the marginal case, however, the coefficient associated to the real interest rate is positive in two cases. Finally, in line with Mehl (2009), the slope of the US yield curve is found to contain some information for future economy growth in Mexico. In particular, in long term horizons the estimated coefficient on this variable is positive and statistically significant, as expected, while the Mexican yield spread seems to lose importance. This result reflects the strong international linkages that there exist between Mexico and the US through the financial

[30] For robustness, we also considered the nominal funding rate and the 28-day interbank equilibrium interest rate as alternative indicators of the stance of monetary policy instead of using the real interest rate. In addition, we extend the model to account for other financial variables such as the Mexican Stock Market Index and the Financial Conditions Index (FCI) for Mexico. The results reported in Tables A.2, A.3, A.4, and A.5 of the Appendix are consistent with our baseline specification.

Horizon	Number of	Cumulative Change							
k	observations	$\hat{\alpha}_0$	$\hat{\alpha}_1$	$\hat{\alpha}_2$	$\hat{\alpha}_3$	$\hat{\alpha}_4$	$\hat{\alpha}_5$	$\hat{\phi}$	$\overline{R^2}$
3	189	4.35*	-0.06	1.06**	0.15	-0.57	-1.51	2.09	0.17
		(2.52)	(0.68)	(0.49)	(0.11)	(0.51)	(1.05)		
6	186	4.56*	0.80	1.64***	-0.15	-0.61	-1.71	2.55	0.18
		(2.72)	(0.50)	(0.62)	(0.12)	(0.61)	(1.13)		
9	183	3.19**	-0.04	1.20***	-0.19*	-0.24	-1.20	1.54	0.24
		(1.54)	(0.72)	(0.43)	(0.10)	(0.35)	(0.77)		
12	180	2.33*	0.29	1.16***	-0.19*	-0.11	-0.88	1.54	0.25
		(1.19)	(0.62)	(0.42)	(0.10)	(0.28)	(0.59)		
18	174	0.95	-0.47	0.73**	-0.08	0.01	0.01	1.06	0.31
		(0.83)	(1.13)	(0.30)	(0.12)	(0.20)	(0.39)		
24	168	0.87*	-0.57	0.41*	-0.17**	0.03	0.45	1.07	0.46
		(0.51)	(0.84)	(0.22)	(0.07)	(0.14)	(0.33)		
36	156	1.08*	0.44	-0.03	-0.25*	-0.03	0.79***	0.94	0.65
		(0.64)	(0.40)	(0.21)	(0.13)	(0.11)	(0.23)		

Horizon	Number of	Marginal Change							
k	observations	$\hat{\alpha}_0$	$\hat{\alpha}_1$	$\hat{\alpha}_2$	$\hat{\alpha}_3$	$\hat{\alpha}_4$	$\hat{\alpha}_5$	$\hat{\phi}$	$\overline{R^2}$
3	189	1.58**	0.07	0.70***	0.80***	-0.31	-0.58*	2.59	0.73
		(0.83)	(0.21)	(0.23)	(0.07)	(0.20)	(0.31)		
6	186	2.84**	0.39	1.20***	0.43***	-0.47	-1.11*	2.55	0.45
		(1.48)	(0.34)	(0.39)	(0.10)	(0.34)	(0.57)		
9	183	2.41	1.01**	1.56***	0.07	-0.28	-1.23*	2.55	0.30
		(1.60)	(0.41)	(0.46)	(0.11)	(0.39)	(0.66)		
12	180	2.33**	0.29	1.16***	-0.19*	-0.11	-0.88	1.54	0.25
		(1.19)	(0.62)	(0.42)	(0.10)	(0.27)	(0.59)		
18	174	-2.75**	1.37***	0.91**	-0.06	0.47**	0.90*	2.33	0.29
		(1.32)	(0.49)	(0.43)	(0.07)	(0.21)	(0.48)		
24	168	-3.79**	0.77*	0.08	0.06	0.43**	2.19***	1.99	0.48
		(1.51)	(0.45)	(0.36)	(0.06)	(0.17)	(0.56)		
36	156	0.75	1.86	-0.72	-0.22***	-0.14	1.50**	1.07	0.40
		(1.14)	(1.30)	(0.54)	(0.07)	(0.24)	(0.63)		

Table 1: Threshold Model Estimates

Source: Author's estimates using data from Banco de México, INEGI, and the US Federal Reserve Bank.
Notes: The model is as follows: $Y_{t,t+k} = \alpha_0 + \alpha_1 Spread_t \mathbb{1}(\hat{\theta}_t < \phi) + \alpha_2 Spread_t \mathbb{1}(\hat{\theta}_t \geq \phi) + \sum_{i=3}^{5} \alpha_i x_{it} + \varepsilon_t$, where $Y_{t,t+k}$ is the annualized cumulative IGAE growth over the next k months, or $Y_{t+k-12,t+k} = \alpha_0 + \alpha_1 Spread_t \mathbb{1}(\hat{\theta}_t < \phi) + \alpha_2 Spread_t \mathbb{1}(\hat{\theta}_t \geq \phi) + \sum_{i=3}^{5} \alpha_i x_{it} + \varepsilon_t$, where $Y_{t+k-12,t+k}$ is the annualized marginal percentage change in output from month $t+k-12$ to future month $t+k$. $Spread_t$ represents the slope of the yield curve, $\hat{\theta}_t$ is the term premium, ϕ is the term premium threshold, and $\mathbb{1}(\cdot)$ is an indicator function that takes the value of 1 if the expression is true and 0 otherwise. The model also includes as control variables x_{it} the lagged growth of IGAE, cumulative or marginal depending on what dependent variable is used, the real interest rate, and the slope of the US yield curve. The coefficients associated to these variables are α_3, α_4, and α_5, respectively. ε_t is an error term. In parentheses are Newey and West (1987) heteroskedasticity and autocorrelation consistent standard errors. The lag used in order to obtain them turned out to be four. ***, **, and * denote statistically significant at the 1 percent, 5 percent, and 10 percent levels in two-tailed test respectively. Row k is based on estimation for t=2004:M1 through 2019:M12-k.

markets and the market of goods and services.[31] Note that the coefficient associated to the slope of the US yield curve is, in general, not significant for the cumulative case, while for the marginal case this coefficient is negative and statistically significant, particularly for short horizons. This result could be associated with the fact that, for horizons shorter than 12 months, marginal changes contain not only future but also past information about real activity.

Figure 5 shows the evolution of the yield spread, the term premium, and the annual variation of IGAE 12 months ahead, as well as the estimated term premium threshold for a horizon of 12 months ahead. The shaded areas represent the periods where the term premium was relatively low. As can be seen, the relationship between the yield spread and future economic activity seems to weaken in periods in which the term premium was relatively low. As noted in the preliminary analysis, these periods seem to coincide with a dissociation between the yield spread and the expectations component.

4.2 Analysis for the Probability of a Contraction

Table 2 shows estimations results for the probit specification without threshold, Eq. (4), and the specification with threshold, Eq. (5), for forecasting horizons of 6, 12, 18, and 24 months ahead. Regarding the former, we present the coefficient associated to the slope of the yield curve $\hat{\beta}_1$, while for the latter, we report the coefficient associated with the yield spread when the term premium is below the threshold $\hat{\gamma}_1$, the corresponding coefficient when the term premium is above the threshold $\hat{\gamma}_2$, and the respective term premium threshold $\hat{\phi}$. In addition, we present the rest of the coefficients; the intercept $\hat{\beta}_0$ and $\hat{\gamma}_0$, and the coefficient associated to the slope in the US, $\hat{\beta}_2$ and $\hat{\gamma}_3$, in the specifications without and with threshold, respectively.

As can be seen in Table 2, consistent with much of the literature, including Estrella and Hardouvelis (1991), Estrella and Mishkin (1998), and Rosenberg and Maurer (2008), among others, in the case of the model without threshold, we obtain a negative and highly significant yield spread coefficient for all horizons. That is, as the yield curve becomes steeper, the model

[31] We have also estimated the threshold model excluding for lagged growth, monetary policy, and the US yield curve. The results are similar to those reported in this paper and are reported in Table A.6 of the Appendix.

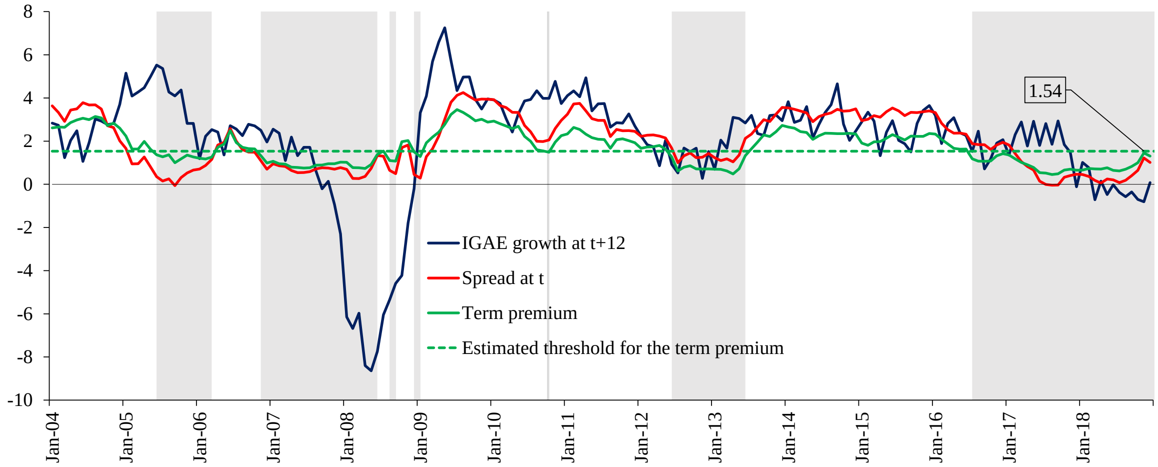


Figure 5: Yield Spread, Term Premium and IGAE Growth 12 Months Ahead

Source: Author's estimates using data from Banco de México, INEGI, and the US Federal Reserve Bank.
Notes: The yield spread is measured as the difference between the 10-year government bond yield and the 3-month interest rate on CETES. The term premium is estimated as the residual between the 10-year government bond yield and the average of the expected 3 month interest rates on CETES over the next ten years. The shaded areas represent the periods where the term premium was below the estimated threshold for a forecasting horizon of 12 months ahead, which is 1.54 percentage points.

predicts a lower probability of a contraction in the future. Nevertheless, when we consider the threshold specification, a flatter yield curve seems to indicate an increase in the probability of a future contraction only when the term premium is above a determined threshold, in line with the results presented in the previous subsection. That is, $\hat{\gamma}_2$ is negative and statistically significant at all horizons, while $\hat{\gamma}_1$ is not significant at any of the horizons.[32] The threshold estimate depends on the forecast horizon and ranges between 0.6 and 0.8 percentage points. Thus, a flattening or inversion of the yield curve will not necessarily be an indicator of fu-

[32]For robustness, we also extended the models to account for more information from the yield curve following Argyropoulos and Tzavalis (2016) and Johansson and Meldrum (2018). In particular, we included in the estimation the level and curvature factors of the term structure of interest rates obtained from the ACM model described in Subsection 2.1. In general terms, the results are consistent to those reported in this paper, although they seem to weaken in longer-term horizons. Likewise, following Johansson and Meldrum (2018), an alternative approach to account for the term premium is to estimate the probit model using the difference between the slope of the yield curve and the term premium, that is, the expectations component of the yield curve as an explanatory variable. We have also estimated that model. However, the specification used in this paper showed a better fit. The results are available upon request. Finally, experimentation with quarterly instead of monthly data produces very similar results, although they also seem to weaken in longer-term horizons. In the same way, excluding the US yield curve from the probit model produces very similar results. The results are reported in Tables A.8 and A.9 of the Appendix.

Forecasting Horizon		Without Threshold					With Threshold						
k Months Ahead	Nobs.	$\hat{\beta}_0$	$\hat{\beta}_1$	$\hat{\beta}_2$	R^2_{McF}	R^2_{Est}	$\hat{\gamma}_0$	$\hat{\gamma}_1$	$\hat{\gamma}_2$	$\hat{\gamma}_3$	$\hat{\phi}$	R^2_{McF}	R^2_{Est}
6	186	-0.51**	-0.94***	0.34*	0.25	0.18	-1.00***	0.44	-0.93***	0.50**	0.75	0.29	0.22
		(0.26)	(0.22)	(0.19)			(0.34)	(0.60)	(0.23)	(0.21)			
12	180	0.01	-1.24***	0.15	0.35	0.27	-0.76*	0.59	-1.24***	0.37	0.80	0.43	0.34
		(0.32)	(0.30)	(0.21)			(0.43)	(0.65)	(0.35)	(0.24)			
18	174	1.39***	-2.22***	-0.60**	0.52	0.42	1.48**	-1.04	-9.85**	-0.68*	0.76	0.70	0.59
		(0.48)	(0.59)	(0.27)			(0.63)	(0.86)	(4.95)	(0.35)			
24	168	0.65**	-0.84***	-0.55***	0.39	0.31	0.30	1.73	-0.68***	-0.51***	0.57	0.44	0.35
		(0.33)	(0.26)	(0.19)			(0.35)	(1.13)	(0.26)	(0.19)			

Table 2: Probit Model Estimates

Source: Author's estimates using data from Banco de México, INEGI, and the US Federal Reserve Bank. Notes: The model without threshold is $\Pr[Con_{t+k} = 1] = F(\beta_0 + \beta_1 Spread_t + \beta_2 Spread^*_t)$, while the model with threshold is $\Pr[Con_{t+k} = 1] = F(\gamma_0 + \gamma_1 Spread_t \mathbb{1}(\hat{\theta}_t < \phi) + \gamma_2 Spread_t \mathbb{1}(\hat{\theta}_t \geq \phi) + \gamma_3 Spread^*_t)$, where Pr denotes probability, F is the cumulative normal distribution, and the binary variable Con equals unity during those months considered as contractions. $Spread_t$ represents the slope of the yield curve, $Spread^*_t$ is the yield spread in the US, $\hat{\theta}_t$ is the term premium, ϕ is the term premium threshold, and $\mathbb{1}(\cdot)$ is an indicator function that takes the value of 1 if the expression is true and 0 otherwise. In parentheses are asymptotic standard errors. ***, **, and * denote statistically significant at the 1 percent, 5 percent, and 10 percent levels in two-tailed test respectively. Row k is based on estimation for t=2004:M1 through 2019:M12-k.

ture contraction, particularly if the term premium is located at low levels. These results are consistent with those of Johansson and Meldrum (2018) for the US. Moreover, the absolute value of the yield spread coefficient seems to be higher at horizons of 12 and 18 months ahead; the same time lapse that monetary policy seems to take to affect inflation and output (Blinder, 1996).[33] Finally, Table 2 also shows the pseudo-R^2 and the alternative measure of fit proposed by Estrella (1998), R^2_{Est}.[34] As can be seen, both fit measures of the model with threshold are higher than those of the model without threshold at all horizons.

Figure 6 plots the estimated probabilities of a recession for both models at a 12-months-ahead horizon. These results, however, should be interpreted with some caution given the reduced number of observations that allows us to consider a maximum of only two full economic cycles in Mexico. The shaded areas denote periods of actual contractions. As can

[33]This result is consistent with the evidence provided by Rudebusch and Williams (2009) for US. Note that because the relation is nonlinear it is difficult to assess the magnitude of the parameters. Thus, following previous literature, we focus on evaluating the estimated probability of a contraction.

[34]We use the pseudo-R^2 suggested by McFadden (1974) and an alternative measure of fit proposed by Estrella (1998), R^2_{Est}, which conforms with classical R^2 in terms of both its range and its relationship with the underlying test. In particular, the last measure performs very well regardless of the relative proportion of values of the binary dependent variable.

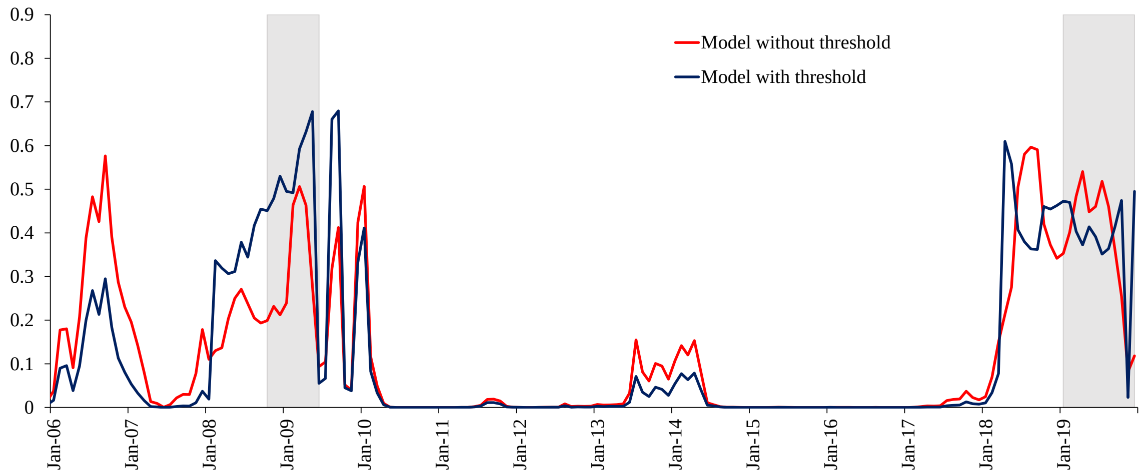


Figure 6: Forecasted Probabilities of Contraction for Current Month Based on the Slope of the Yield Curve 12 Months Earlier

Source: Author's estimates using data from Banco de México and INEGI.
Notes: The shaded areas denote periods of actual contractions, which are defined as two consecutive quarters of declining GDP. The forecasted probabilities of contraction denote the within-sample fit of the probit model without threshold and the probit model with threshold, estimated over the monthly sample period from 2004:M1 through 2019:M12. The model without threshold is $\Pr[Con_{t+k} = 1] = F(\beta_0 + \beta_1 Spread_t + \beta_2 Spread_t^*)$, while the model with threshold is $\Pr[Con_{t+k} = 1] = F(\gamma_0 + \gamma_1 Spread_t \mathbb{1}(\hat{\theta}_t < \phi) + \gamma_2 Spread_t \mathbb{1}(\hat{\theta}_t \geq \phi) + \gamma_3 Spread_t^*)$, where Pr denotes probability, F is the cumulative normal distribution, and the binary variable Con equals unity in each month during those quarters in economic contraction. $Spread_t$ represents the slope of the yield curve, $Spread_t^*$ is the yield spread in the US, $\hat{\theta}_t$ is the term premium, ϕ is the term premium threshold, and $\mathbb{1}(\cdot)$ is an indicator function that takes the value of 1 if the expression is true and 0 otherwise.

be observed, the two forecasts generally track each other closely. Nevertheless, the model with threshold tends to show a better fit. In particular, the estimated probability for the 2008-2009 economic contraction is higher, while the estimated probabilities during other non-contractionary periods tend to be lower compared to those estimates of the model without threshold.

4.3 Discussion

The results presented in this section seem to support the existence of time variation in the term spread-output relationship in Mexico during the period 2001–2019. Indeed, the reduction in the predictive power of the yield spread seems to coincide with a reduction in the term premium. In fact, the inversion of the yield curve has been used in the past as an indicator of possible recessive periods to the extent that it reflected the expectation of a significant reduction in short-term interest rates in the future. That is, although the yield curve provides information on future economic activity, the signal associated with a reduction in longer-term interest rates that, in turn, leads to an inversion of the yield curve, is influenced by the level of the term premium and the expectations for the short-term interest rate. Thus, the higher the term premium, the greater the reduction in short-term interest rate expectations that would be required for the slope of the yield curve to become negative, which in effect would suggest a greater risk of a reduction in economic activity. On the contrary, with low levels of the term premium, the yield curve can be inverted with a small downward adjustment in the expected short-term interest rates. In this context, in principle, it can be argued that such movement could have less predictive power about a reduction in economic activity.

In addition, the relationship between term premium and future output may depend on the types of factors that affect the term premium. According to Bernanke (2006), a fall in the term premium might be a consequence of an increase in the demand for long-term bonds relative to the supply, leading investors to accept smaller excess returns for holding such assets. This in turn could be associated with better anchored inflation expectations, greater liquidity associated with unconventional policies in advanced economies or a recomposition of portfolios by pension funds toward long-term bonds, among other factors (Kim and Wright, 2005). In turn, these factors can also have different implications for the determination of output. Better anchored inflation expectations, for instance, consistent with a stable and low inflation environment, promote more favorable conditions for economic growth, job creation, and real household income. Thus, a fall in the term premium could coincide with an acceleration in future growth at the time that the yield spread becomes flatter, thus making the coefficient regression between the spread and future economic activity more uncertain. Werner (2006) explains that some declines in long-term bond yields in the eurozone have been largely driven by a declining term premium, which could explain why the yield spread-output relationship seems to have weakened during some periods. That is, the declining risk premium coincides with an acceleration in growth, thus making the coefficient regression between the spread and future economic activity weak or even negative.

In addition, as discussed by Bordo and Haubrich (2004), Feroli (2004), and Estrella (1997; 2005), the accuracy of the spread's predictive power could be affected by changes in the credibility of the central bank. In particular, according to Bordo and Haubrich (2004), regimes with high credibility (low persistence of inflation) tend to have lower predictability. This is related with the fact that temporary inflation shocks can differently affect long-term inflation expectations and thus long-term rates depending on the credibility of the central bank. In the case of a regime with high credibility, a temporary inflation shock will increase short rates but will have practically no effect on long-term rates, as it will have minimal impact on long-term inflation expectations. Under these conditions, such shocks tend to add noise to the spread-output relationship, by reducing the yield spread and having no future real effects. On the contrary, in the case of a regime with low credibility (high persistence of inflation), an inflation shock will increase both short rates, just as before, and long rates, as expectations of inflation are permanently higher. An inflation shock thus has minimal effect on the term structure, as both long and short rates move up by the amount of the permanently higher inflation rate. Therefore, the spread-output relationship is not affected by the inflation shock as in the case of the regime with high credibility. In this line, according to Feroli (2004) and Estrella (2005) if monetary policy is essentially reactive to deviations from inflation target, then the yield spread-output relationship may weaken. Intuitively, the more averse the monetary authority is to deviations from inflation targets the smaller the expected changes in inflation by the agents in response, for instance, to temporary inflation shocks. Therefore, these inflation shocks will only affect short rates but not long term rates, thus reducing the yield spread and having no future real effects.

The results observed in this section could also be associated with the adoption, on the part of Banco de México, of an inflation targeting regime as from 2001. According to Chiquiar et al. (2010), inflation in Mexico went from being a non-stationary process to being a stationary process around the end of 2000 or the beginning of 2001. In the same vein, Gaytán and González García (2007) find that monetary policy transmission mechanism seems to have presented a structural change after this period. In particular, the new monetary regime involved a stronger reaction of the central bank rate due to demand pressures and the inflation rate. According to the authors, changes in the monetary policy rate become more effective in changing the trajectory of inflation. Indeed, as discussed by Aguilar-Argaez et al. (2014), Banco de México's commitment to price stability seems to have strengthened the anchoring of medium and long-term inflation expectations. According to the authors, the response from such expectations to supply shocks diminished up to levels approaching zero. Therefore, it is likely that temporary inflation shocks have tended to add relatively more noise to the spread-output relationship during the last years, by reducing the yield spread and having no future real effects.

The anchoring of inflation expectations could not only have affected the predictive power of the yield spread through the effects that supply shocks may have on long-term rates, but also through its effect on the inflation risk premium. The inflation risk premium can be defined as the compensation demanded by investors to hold financial assets that are subject to inflation risks. According to the literature, the dynamics of the term premium can be mainly explained by a real term premium and an inflation risk premium (Abrahams et al., 2016; Bauer, 2017; Bernanke, 2015).[35] Indeed, the behavior of the inflation risk premium, particularly the decreasing trend observed during the last years, is similar to that of the term premium observed in Figure 4. As mentioned above, the adoption of an inflation targeting seems to be a key factor to explain the behavior of such variable. According to Aguilar-Argaez et al. (2016), the gradual reduction registered in the inflation risk premium in the last years is the result of the perception of a lower inflationary risk associated with anchoring inflation expectations and their convergence toward the inflation target.

Overall, the analysis presented in this section seems to suggest that the strengthening of

[35] The yield spread between nominal and inflation-linked bonds, known as the break-even inflation rate, reflects the overall compensation demanded to hold nominal bonds, comprising both, the expected level of inflation and an inflation risk premium. Thus, following Aguilar-Argaez et al. (2016), the inflation risk premium can be estimated as the residual between the break-even-inflation and the long-run inflation expectation. In particular, the break-even-inflation is obtained from the difference between the 10-year nominal bond yield and the real yield associated with an inflation-indexed bond of the same term. On the other hand, the long-run inflation expectation is estimated as the average of the expected inflation over the next ten years by using an affine term structure model of interest rates. Further details about this methodology can be found in Ang et al. (2008), Adrian and Wu (2010) and Aguilar-Argaez et al. (2016), among others. The estimated inflation risk premium is reported in Figure A.2 of the Appendix.

the central bank credibility may have been associated to a reduction of the predictive power of the yield spread. As the inflation risk premium and thus the term premium is lower, the yield curve could be inverted with a small downward adjustment in the expected short-term interest rates. In this context, in principle, it can be argued that such movement could have less predictive power to anticipate a reduction in economic activity. In addition, a high credibility tends to have lower predictability due to temporary inflation shocks increase short rates, but they have practically no effect on long-term rates. Under these conditions, such shocks tend to add noise to the spread-output relationship, by reducing the yield spread and having no future real effects. In this case, the term spread-output relationship becomes weaker while the term premium is low.

5 Conclusion

This paper provides an empirical analysis of the relationship between the term spread and future output in Mexico with a particular emphasis on evaluating whether this relationship depends on the term premium level. Our nonlinear models suggest that the slope of the yield curve seems to anticipate measures of future economic activity, but only when the term premium is above a determined threshold. The estimated value of such a threshold depends on the forecast horizon and the measure of economic activity. One potential explanation is related with the fact that a low level of the term premium is associated with a stronger anchoring of inflation expectations. As discussed by Aguilar-Argaez et al. (2014), the Banco de México's commitment to price stability seems to have strengthened the anchoring of inflation expectations, reducing the impact of inflationary shocks on such expectations and long term rates. By affecting only short term rates, these shocks reduce the yield spread and have no future real effects. At the same time, the term premium is lower due to a reduction in the inflation risk premium. Therefore, in line with Werner (2006), a relatively low term premium that leads to a flattening or possibly an inversion of the yield curve could weaken the coefficient regression between the yield spread and economic activity.

This study has important implications both from the point of view of economic policy and the analysis strategy. From an economic policy perspective, our findings suggest that even though the slope of the yield curve seems to be an important leading indicator of economic activity, it needs to be interpreted carefully. In that sense, the evidence for Mexico suggests that a flattening of the yield curve could not always be an indicator of future economic weakness, particularly, if the term premium is at relatively low levels. Therefore, policy makers' decisions and forecasts should be adapted to consider the possible existence of asymmetry in the yield spread-output relationship. Regarding the analysis strategy, this study shows the relevance of including the term premium when modelling the linkage between yield spread and output. Our results also seem to support the evidence presented by several authors about the role of monetary policy in explaining the predictive ability of the yield spread.

Our results are, of course, specific to the particular empirical models and the sample period used. Future research could examine alternative nonlinearities of the yield spread-output relationship by using other approaches, such as smooth transitions and tree-based methods, or by employing different threshold variables. Following Ang et al. (2006), a dynamic model that allows for endogenous feedback effects between output and the yield spread could also be considered. Finally, future research could also analyze the ability of the probit model to identify business cycle turning point dates in real time.

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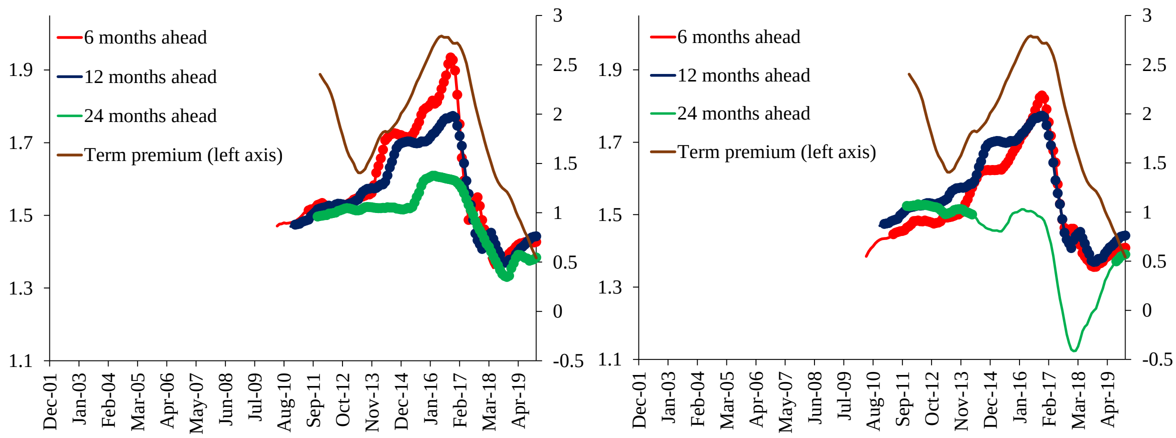
A Appendix: Supplemental Results



a) Cumulative Change of Output

b) Marginal Change of Output

Figure A.1: Coefficients between the Term Spread and Future Output

Source: Author's estimates using data from Banco de México and INEGI.

Notes: Rolling regressions with a window of 8 years. The model is as follows: $Y_{t,t+k} = \alpha_0 + \alpha_1 Spread_t + \varepsilon_t$, where $Y_{t,t+k}$ is the annualized cumulative IGAE growth over the next k months, or $Y_{t+k-12,t+k} = \alpha_0 + \alpha_1 Spread_t + \varepsilon_t$, where $Y_{t+k-12,t+k}$ is the annualized marginal percentage change in output from month $t+k-12$ to future month $t+k$. $Spread_t$ represents the slope of the yield curve and ε_t is an error term. Solid lines represent coefficients that are not statistically significant, while those with markers indicate statistically significant coefficients at the 95% confidence level. The lag used in order to obtain the Newey and West (1987) standard errors turned out to be three. The 8-year moving average for the term premium is shown on the left axis. The sample period is from 2001:M12 to 2019:M12.

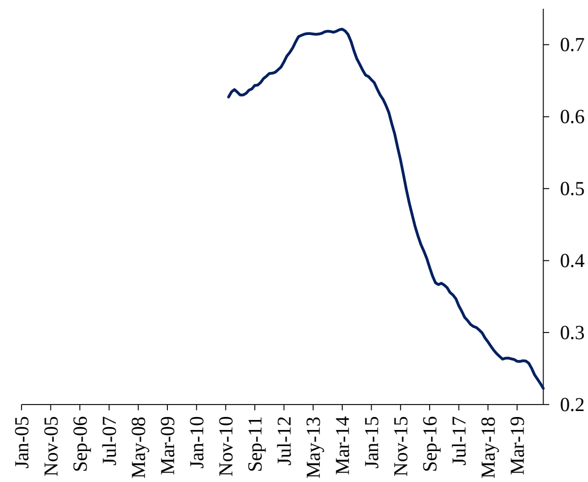


Figure A.2: Inflation Risk Premium (6-Year Moving Average)

Source: Author's estimates using data from Banco de México.
Notes: The inflation risk premium is estimated as the difference between the overall inflation compensation to hold a nominal bond, that is, the break-even-inflation and the long-run inflation expectation (Aguilar-Argaez et al., 2016). The break-even-inflation is obtained from the difference between the 10-year nominal bond yield and the real yield associated with an inflation-indexed bond of the same term. The long-run inflation expectation is estimated as the average of the expected inflation over the next ten years by using an affine term structure model of interest rates. The sample period is from 2005:M1 to 2019:M12.

Horizon	Number of	Cumulative Change							
k	observations	α_0	α_1	α_2	α_3	α_4	α_5	ϕ	$\overline{R^2}$
3	189	4.35*	-0.06	1.06**	0.15	-0.57	-1.51	2.09	0.17
		(2.52)	(0.68)	(0.49)	(0.11)	(0.51)	(1.05)		
6	186	4.12*	0.81	1.52**	-0.13	-0.54	-1.59	2.36	0.17
		(2.48)	(0.51)	(0.59)	(0.11)	(0.56)	(1.08)		
9	183	3.19**	-0.04	1.20***	-0.19*	-0.24	-1.20	1.54	0.24
		(1.54)	(0.72)	(0.43)	(0.10)	(0.35)	(0.77)		
12	180	2.33*	0.29	1.16***	-0.19*	-0.11	-0.88	1.54	0.25
		(1.19)	(0.62)	(0.42)	(0.10)	(0.28)	(0.59)		
18	174	0.95	-0.47	0.73**	-0.08	0.01	0.01	1.06	0.31
		(0.83)	(1.13)	(0.30)	(0.12)	(0.20)	(0.39)		
24	168	0.87*	-0.57	0.41*	-0.17**	0.03	0.45	1.07	0.46
		(0.51)	(0.84)	(0.22)	(0.07)	(0.14)	(0.33)		
36	156	1.78**	-0.46	-0.25	-0.23*	-0.12	0.81***	1.61	0.64
		(0.74)	(0.35)	(0.24)	(0.12)	(0.12)	(0.24)		

Horizon	Number of	Marginal Change							
k	observations	α_0	α_1	α_2	α_3	α_4	α_5	ϕ	$\overline{R^2}$
3	189	1.38**	0.09	0.62***	0.79***	-0.27	-0.55*	2.36	0.71
		(0.83)	(0.21)	(0.22)	(0.08)	(0.19)	(0.32)		
6	186	2.31**	0.47	1.11***	0.43***	-0.37	-1.00*	2.36	0.43
		(1.48)	(0.34)	(0.39)	(0.12)	(0.32)	(0.56)		
9	183	2.36	1.01**	1.50***	0.08	-0.26	-1.18*	2.36	0.30
		(1.60)	(0.42)	(0.45)	(0.11)	(0.38)	(0.65)		
12	180	2.33**	0.29	1.16***	-0.19*	-0.11	-0.88	1.54	0.25
		(1.19)	(0.62)	(0.42)	(0.10)	(0.27)	(0.59)		
18	174	-2.75**	1.37***	0.91**	-0.06	0.47**	0.90*	2.33	0.29
		(1.32)	(0.49)	(0.43)	(0.07)	(0.21)	(0.48)		
24	168	-3.79**	0.77*	0.08	0.06	0.43**	2.19***	1.99	0.48
		(1.51)	(0.45)	(0.36)	(0.06)	(0.17)	(0.56)		
36	156	0.75	1.86	-0.72	-0.22***	-0.14	1.50**	1.07	0.40
		(1.14)	(1.30)	(0.54)	(0.07)	(0.24)	(0.63)		

Table A.1: Threshold Model Estimates (Trimming Percentage=20)

Source: Author's estimates using data from Banco de México, INEGI, and the US Federal Reserve Bank.
Notes: The estimated model is as follows: $Y_{t,t+k} = \alpha_0 + \alpha_1 Spread_t \mathbb{1}(\hat{\theta}_t < \phi) + \alpha_2 Spread_t \mathbb{1}(\hat{\theta}_t \geq \phi) + \sum_{i=3}^{5} \alpha_i x_{it} + \varepsilon_t$, where $Y_{t,t+k}$ is the annualized cumulative IGAE growth over the next k months, or $Y_{t+k-12,t+k} = \alpha_0 + \alpha_1 Spread_t \mathbb{1}(\hat{\theta}_t < \phi) + \alpha_2 Spread_t \mathbb{1}(\hat{\theta}_t \geq \phi) + \sum_{i=3}^{5} \alpha_i x_{it} + \varepsilon_t$, where $Y_{t+k-12,t+k}$ is the annualized marginal percentage change in output from month $t+k-12$ to future month $t+k$. $Spread_t$ represents the slope of the yield curve, $\hat{\theta}_t$ is the term premium, ϕ is the estimated term premium threshold, and $\mathbb{1}(\cdot)$ is an indicator function that takes the value of 1 if the expression is true and 0 otherwise. The model also includes as control variables x_{it} the lagged growth of IGAE, cumulative or marginal depending on what dependent variable is used, the real interest rate, and the slope of the US yield curve. The coefficients associated to these variables are α_3, α_4, and α_5, respectively. ε_t is an error term. In parentheses are Newey and West (1987) heteroskedasticity and autocorrelation consistent standard errors. The lag used in order to obtain them turned out to be four. ***, **, and * denote statistically significant at the 1 percent, 5 percent, and 10 percent levels in two-tailed test respectively. Row k is based on estimation for t=2004:M1 through 2019:M12-k.

Horizon	Number of	Cumulative Change							
k	observations	α_0	α_1	α_2	α_3	α_4	α_5	ϕ	$\overline{R^2}$
3	189	8.60*	0.05	1.22**	0.11	-0.82	-1.49	2.39	0.18
		(5.18)	(0.64)	(0.53)	(0.11)	(0.60)	(1.00)		
6	186	7.45	0.62	1.56***	-0.15	-0.65	-1.58	2.55	0.18
		(5.03)	(0.53)	(0.57)	(0.12)	(0.59)	(1.01)		
9	183	3.91	-0.04	1.19***	-0.18*	-0.21	-1.14	1.54	0.24
		(2.46)	(0.71)	(0.44)	(0.10)	(0.30)	(0.72)		
12	180	2.41	0.36	1.20***	-0.19*	-0.07	-0.86	1.54	0.25
		(1.90)	(0.65)	(0.46)	(0.10)	(0.23)	(0.56)		
18	174	0.97	-0.49	0.72**	-0.08	0.00	0.01	1.06	0.31
		(1.38)	(1.15)	(0.33)	(0.12)	(0.18)	(0.39)		
24	168	1.12	-0.68	0.35	-0.17**	-0.01	0.45	1.07	0.46
		(0.89)	(0.87)	(0.25)	(0.07)	(0.13)	(0.33)		
36	156	1.21	0.43	-0.04	-0.25*	-0.03	0.80***	0.94	0.65
		(0.95)	(0.41)	(0.22)	(0.13)	(0.10)	(0.23)		

Horizon	Number of	Marginal Change							
k	observations	α_0	α_1	α_2	α_3	α_4	α_5	ϕ	$\overline{R^2}$
3	189	2.60*	0.06	0.70***	0.80***	-0.28	-0.51*	2.59	0.73
		(1.48)	(0.22)	(0.24)	(0.07)	(0.18)	(0.28)		
6	186	4.52*	0.34	1.19***	0.43***	-0.44	-1.01*	2.55	0.46
		(2.69)	(0.36)	(0.39)	(0.10)	(0.32)	(0.52)		
9	183	3.54	0.96**	1.54***	0.06	-0.28	-1.17*	2.55	0.30
		(2.90)	(0.43)	(0.45)	(0.11)	(0.36)	(0.61)		
12	180	2.41	0.36	1.20***	-0.19*	-0.07	-0.86	1.54	0.25
		(1.90)	(0.65)	(0.46)	(0.10)	(0.23)	(0.56)		
18	174	-4.62**	1.31***	0.81*	-0.06	0.48**	0.82*	2.63	0.29
		(2.00)	(0.49)	(0.43)	(0.07)	(0.22)	(0.48)		
24	168	-4.27**	0.61	-0.02	0.06	0.28**	2.09***	1.99	0.47
		(1.69)	(0.47)	(0.38)	(0.06)	(0.14)	(0.58)		
36	156	0.55	2.10	-0.61	-0.22***	-0.05	1.52**	1.07	0.40
		(1.55)	(1.31)	(0.54)	(0.07)	(0.21)	(0.67)		

Table A.2: Threshold Model Estimates by using the 28-day Interbank Interest Rate

Source: Author's estimates using data from Banco de México, INEGI, and the US Federal Reserve Bank.
Notes: The estimated model is as follows: $Y_{t,t+k} = \alpha_0 + \alpha_1 Spread_t \mathbb{1}(\hat{\theta}_t < \phi) + \alpha_2 Spread_t \mathbb{1}(\hat{\theta}_t \geq \phi) + \sum_{i=3}^{5} \alpha_i x_{it} + \varepsilon_t$, where $Y_{t,t+k}$ is the annualized cumulative IGAE growth over the next k months, or $Y_{t+k-12,t+k} = \alpha_0 + \alpha_1 Spread_t \mathbb{1}(\hat{\theta}_t < \phi) + \alpha_2 Spread_t \mathbb{1}(\hat{\theta}_t \geq \phi) + \sum_{i=3}^{5} \alpha_i x_{it} + \varepsilon_t$, where $Y_{t+k-12,t+k}$ is the annualized marginal percentage change in output from month $t+k-12$ to future month $t+k$. $Spread_t$ represents the slope of the yield curve, $\hat{\theta}_t$ is the term premium, ϕ is the estimated term premium threshold, and $\mathbb{1}(\cdot)$ is an indicator function that takes the value of 1 if the expression is true and 0 otherwise. The model also includes as control variables x_{it} the lagged growth of IGAE, cumulative or marginal depending on what dependent variable is used, the 28-day interbank interest rate, and the slope of the US yield curve. The coefficients associated to these variables are α_3, α_4, and α_5, respectively. ε_t is an error term. In parentheses are Newey and West (1987) heteroskedasticity and autocorrelation consistent standard errors. The lag used in order to obtain them turned out to be four. ***, **, and * denote statistically significant at the 1 percent, 5 percent, and 10 percent levels in two-tailed test respectively. Row k is based on estimation for t=2004:M1 through 2019:M12-k.

Horizon	Number of	Cumulative Change							
k	observations	α_0	α_1	α_2	α_3	α_4	α_5	ϕ	$\overline{R^2}$
3	189	7.81	0.16	1.28**	0.11	-0.76	-1.50	2.40	0.17
		(4.91)	(0.62)	(0.55)	(0.11)	(0.59)	(1.02)		
6	186	6.83	0.70	1.61***	-0.15	-0.61	-1.59	2.55	0.18
		(4.83)	(0.53)	(0.59)	(0.12)	(0.59)	(1.03)		
9	183	3.59	0.03	1.24***	-0.19*	-0.18	-1.15	1.54	0.23
		(2.38)	(0.71)	(0.45)	(0.10)	(0.31)	(0.73)		
12	180	2.11	0.42	1.24***	-0.19*	-0.04	-0.86	1.54	0.25
		(1.86)	(0.65)	(0.47)	(0.10)	(0.24)	(0.57)		
18	174	0.70	-0.40	0.76**	-0.08	0.03	0.01	1.06	0.31
		(1.32)	(1.14)	(0.33)	(0.12)	(0.18)	(0.39)		
24	168	0.86	-0.59	0.39	-0.17**	0.02	0.45	1.06	0.46
		(0.85)	(0.86)	(0.24)	(0.07)	(0.13)	(0.33)		
36	156	1.08	0.47	-0.02	-0.24*	-0.02	0.80***	0.94	0.65
		(0.93)	(0.40)	(0.22)	(0.13)	(0.10)	(0.23)		

Horizon	Number of	Marginal Change							
k	observations	α_0	α_1	α_2	α_3	α_4	α_5	ϕ	$\overline{R^2}$
3	189	2.41*	0.08	0.71***	0.80***	-0.27	-0.52*	2.59	0.72
		(1.43)	(0.22)	(0.25)	(0.07)	(0.18)	(0.29)		
6	186	4.17	0.39	1.21***	0.42***	-0.41	-1.02*	2.55	0.45
		(2.60)	(0.35)	(0.40)	(0.10)	(0.33)	(0.53)		
9	183	3.12	1.03**	1.57***	0.06	-0.24	-1.17*	2.55	0.30
		(2.81)	(0.44)	(0.47)	(0.11)	(0.36)	(0.62)		
12	180	2.11	0.42	1.24***	-0.19*	-0.04	-0.86	1.54	0.25
		(1.86)	(0.65)	(0.47)	(0.10)	(0.24)	(0.57)		
18	174	-4.75**	1.34***	0.83*	-0.06	0.51**	0.83*	2.63	0.30
		(2.04)	(0.51)	(0.44)	(0.07)	(0.22)	(0.48)		
24	168	-4.46**	0.65	0.01	0.06	0.32**	2.10***	1.99	0.47
		(1.77)	(0.47)	(0.38)	(0.06)	(0.15)	(0.57)		
36	156	0.82	1.98	-0.66	-0.22***	-0.09	1.53**	1.07	0.40
		(1.57)	(1.31)	(0.55)	(0.07)	(0.21)	(0.66)		

Table A.3: Threshold Model Estimates by using the Nominal Funding Rate

Source: Author's estimates using data from Banco de México, INEGI, and the US Federal Reserve Bank.
Notes: The estimated model is as follows: $Y_{t,t+k} = \alpha_0 + \alpha_1 Spread_t \mathbb{1}(\hat{\theta}_t < \phi) + \alpha_2 Spread_t \mathbb{1}(\hat{\theta}_t \geq \phi) + \sum_{i=3}^{5} \alpha_i x_{it} + \varepsilon_t$, where $Y_{t,t+k}$ is the annualized cumulative IGAE growth over the next k months, or $Y_{t+k-12,t+k} = \alpha_0 + \alpha_1 Spread_t \mathbb{1}(\hat{\theta}_t < \phi) + \alpha_2 Spread_t \mathbb{1}(\hat{\theta}_t \geq \phi) + \sum_{i=3}^{5} \alpha_i x_{it} + \varepsilon_t$, where $Y_{t+k-12,t+k}$ is the annualized marginal percentage change in output from month $t+k-12$ to future month $t+k$. $Spread_t$ represents the slope of the yield curve, $\hat{\theta}_t$ is the term premium, ϕ is the estimated term premium threshold, and $\mathbb{1}(\cdot)$ is an indicator function that takes the value of 1 if the expression is true and 0 otherwise. The model also includes as control variables x_{it} the lagged growth of IGAE, cumulative or marginal depending on what dependent variable is used, the nominal funding interest rate, and the slope of the US yield curve. The coefficients associated to these variables are α_3, α_4, and α_5, respectively. ε_t is an error term. In parentheses are Newey and West (1987) heteroskedasticity and autocorrelation consistent standard errors. The lag used in order to obtain them turned out to be four. ***, **, and * denote statistically significant at the 1 percent, 5 percent, and 10 percent levels in two-tailed test respectively. Row k is based on estimation for t=2004:M1 through 2019:M12-k.

Horizon	Number of	Cumulative Change								
k	observations	α_0	α_1	α_2	α_3	α_4	α_5	α_6	ϕ	$\overline{R}^2$
3	189	2.34	0.53	1.54**	-0.06	-0.57	-1.50	-3.84*	2.40	0.23
		(2.24)	(0.59)	(0.66)	(0.09)	(0.54)	(1.00)	(2.08)		
6	186	2.83	0.99*	1.78***	-0.34	-0.50	-1.61	-2.82**	2.55	0.23
		(2.60)	(0.52)	(0.65)	(0.14)	(0.58)	(1.07)	(1.40)		
9	183	2.60	-0.03	1.23***	-0.29**	-0.21	-1.17	-1.31	1.54	0.25
		(1.83)	(0.75)	(0.40)	(0.12)	(0.36)	(0.78)	(1.15)		
12	180	2.21	0.27	1.16***	-0.22**	-0.11	-0.88	-0.34	1.54	0.25
		(1.35)	(0.64)	(0.43)	(0.11)	(0.28)	(0.61)	(0.91)		
18	174	0.95	-0.45	0.73**	-0.08	0.01	0.01	0.05	1.06	0.31
		(0.83)	(1.15)	(0.33)	(0.12)	(0.19)	(0.39)	(0.59)		
24	168	0.88*	-0.56	0.41*	-0.17**	0.03	0.45	0.01	1.07	0.46
		(0.51)	(0.87)	(0.24)	(0.07)	(0.14)	(0.33)	(0.41)		
36	156	1.08*	0.63	0.03	-0.21*	-0.02	0.77***	0.39	0.94	0.65
		(0.58)	(0.42)	(0.22)	(0.12)	(0.11)	(0.24)	(0.28)		

Horizon	Number of	Marginal Change								
k	observations	α_0	α_1	α_2	α_3	α_4	α_5	α_6	ϕ	$\overline{R}^2$
3	189	0.34	0.24	0.69***	0.59***	-0.20	-0.50**	-2.19***	2.59	0.78
		(0.83)	(0.22)	(0.22)	(0.06)	(0.17)	(0.24)	(0.54)		
6	186	1.10	0.63*	1.22***	0.21*	-0.29	-0.93*	-2.53***	2.60	0.53
		(1.48)	(0.33)	(0.39)	(0.11)	(0.30)	(0.49)	(0.83)		
9	183	1.34	0.39	1.27***	-0.14	-0.12	-1.05*	-2.03**	1.54	0.34
		(1.60)	(0.67)	(0.40)	(0.13)	(0.28)	(0.61)	(0.89)		
12	180	2.21	0.27	1.16***	-0.22**	-0.11	-0.88	-0.34	1.54	0.25
		(1.35)	(0.64)	(0.43)	(0.11)	(0.28)	(0.61)	(0.91)		
18	174	-1.68	2.91**	1.14**	0.14	0.42**	0.64	2.07**	0.76	0.32
		(1.32)	(1.15)	(0.45)	(0.09)	(0.20)	(0.44)	(0.85)		
24	168	-3.48***	0.71*	0.06	0.11	0.41**	2.17***	0.49	1.99	0.48
		(1.51)	(0.41)	(0.36)	(0.10)	(0.17)	(0.54)	(0.80)		
36	156	0.75	1.75	-0.74	-0.24**	-0.14	1.50**	-0.19	1.07	0.40
		(1.14)	(1.26)	(0.55)	(0.12)	(0.24)	(0.63)	(0.68)		

Table A.4: Threshold Model Estimates by including the FCI

Source: Author's estimates using data from Banco de México, INEGI, and the US Federal Reserve Bank.
Notes: The estimated model is as follows: $Y_{t,t+k} = \alpha_0 + \alpha_1 Spread_t \mathbb{1}(\hat{\theta}_t < \phi) + \alpha_2 Spread_t \mathbb{1}(\hat{\theta}_t \geq \phi) + \sum_{i=3}^{6} \alpha_i x_{it} + \varepsilon_t$, where $Y_{t,t+k}$ is the annualized cumulative IGAE growth over the next k months, or $Y_{t+k-12,t+k} = \alpha_0 + \alpha_1 Spread_t \mathbb{1}(\hat{\theta}_t < \phi) + \alpha_2 Spread_t \mathbb{1}(\hat{\theta}_t \geq \phi) + \sum_{i=3}^{6} \alpha_i x_{it} + \varepsilon_t$, where $Y_{t+k-12,t+k}$ is the annualized marginal percentage change in output from month $t+k-12$ to future month $t+k$. $Spread_t$ represents the slope of the yield curve, $\hat{\theta}_t$ is the term premium, ϕ is the estimated term premium threshold, and $\mathbb{1}(\cdot)$ is an indicator function that takes the value of 1 if the expression is true and 0 otherwise. The model also includes as control variables x_{it} the lagged growth of IGAE, cumulative or marginal depending on what dependent variable is used, the real interest rate, the slope of the US yield curve, and the Financial Condition Index (FCI) for Mexico. The coefficients associated to these variables are α_3, α_4, α_5, and α_6, respectively. ε_t is an error term. In parentheses are Newey and West (1987) heteroskedasticity and autocorrelation consistent standard errors. The lag used in order to obtain them turned out to be four. ***, **, and * denote statistically significant at the 1 percent, 5 percent, and 10 percent levels in two-tailed test respectively. Row k is based on estimation for t=2004:M1 through 2019:M12-k.

Horizon	Number of	Cumulative Change								
k	observations	α_0	α_1	α_2	α_3	α_4	α_5	α_6	ϕ	$\overline{R^2}$
3	189	4.27^{**}	-0.21	0.86^{**}	0.10	-0.63	-1.30	0.31^{**}	2.08	0.25
		(2.24)	(0.66)	(0.46)	(0.10)	(0.45)	(0.88)	(0.12)		
6	186	3.65^{*}	0.39	1.11^{**}	-0.11	-0.48	-1.26	0.26^{**}	2.08	0.27
		(2.60)	(0.56)	(0.44)	(0.09)	(0.45)	(0.82)	(0.11)		
9	183	2.92^{**}	-0.07	1.07^{**}	-0.17^{**}	-0.25	-1.02	0.16^{**}	1.54	0.29
		(1.83)	(0.70)	(0.41)	(0.08)	(0.33)	(0.68)	(0.07)		
12	180	2.11^{**}	-0.04	1.01^{**}	-0.17^{*}	-0.15	-0.70	0.14^{***}	1.15	0.30
		(1.35)	(0.65)	(0.44)	(0.10)	(0.26)	(0.56)	(0.05)		
18	174	0.68	-0.55	0.63^{**}	-0.05	-0.01	0.18	0.11^{***}	1.06	0.36
		(0.83)	(1.07)	(0.30)	(0.11)	(0.19)	(0.37)	(0.04)		
24	168	0.72	-0.66	0.33	-0.14^{*}	0.01	0.56^{*}	0.07^{**}	1.07	0.49
		(0.51)	(0.81)	(0.23)	(0.07)	(0.14)	(0.32)	(0.03)		
36	156	0.88	0.36	-0.07	-0.20	-0.03	0.87^{***}	0.04^{**}	0.94	0.66
		(0.58)	(0.37)	(0.21)	(0.12)	(0.10)	(0.23)	(0.02)		

Horizon	Number of	Marginal Change								
k	observations	α_0	α_1	α_2	α_3	α_4	α_5	α_6	ϕ	$\overline{R^2}$
3	189	1.46^{**}	0.00	0.56^{***}	0.80^{***}	-0.31^{*}	-0.49^{*}	0.07^{**}	2.43	0.73
		(0.83)	(0.22)	(0.21)	(0.07)	(0.19)	(0.27)	(0.03)		
6	186	2.46^{*}	0.36	1.09^{***}	0.45^{***}	-0.44	-0.95^{**}	0.12^{**}	2.55	0.49
		(1.48)	(0.33)	(0.36)	(0.10)	(0.32)	(0.48)	(0.05)		
9	183	1.75	0.80^{*}	1.23^{***}	0.09	-0.19	-0.94^{*}	0.17^{***}	2.08	0.37
		(1.60)	(0.47)	(0.42)	(0.10)	(0.30)	(0.54)	(0.05)		
12	180	2.11^{**}	-0.04	1.01^{**}	-0.17^{*}	-0.15	-0.70	0.14^{***}	1.15	0.30
		(1.35)	(0.65)	(0.44)	(0.10)	(0.26)	(0.56)	(0.05)		
18	174	-2.86^{**}	1.35^{***}	0.89^{**}	-0.05	0.48^{**}	0.95^{*}	0.03	2.33	0.29
		(1.32)	(0.49)	(0.43)	(0.08)	(0.22)	(0.51)	(0.05)		
24	168	-3.80^{**}	0.75	0.06	0.06	0.42^{**}	2.22^{***}	0.02	1.99	0.48
		(1.51)	(0.46)	(0.37)	(0.06)	(0.17)	(0.57)	(0.03)		
36	156	0.72	1.90	-0.68	-0.22^{***}	-0.13	1.48^{**}	-0.02	1.07	0.40
		(1.14)	(1.31)	(0.56)	(0.07)	(0.24)	(0.65)	(0.03)		

Table A.5: Threshold Model Estimates by including the Mexican Stock Market Index

Source: Author's estimates using data from Banco de México, INEGI, and the US Federal Reserve Bank.
Notes: The estimated model is as follows: $Y_{t,t+k} = \alpha_0 + \alpha_1 Spread_t \mathbb{1}(\hat{\theta}_t < \phi) + \alpha_2 Spread_t \mathbb{1}(\hat{\theta}_t \geq \phi) + \sum_{i=3}^{6} \alpha_i x_{it} + \varepsilon_t$, where $Y_{t,t+k}$ is the annualized cumulative IGAE growth over the next k months, or $Y_{t+k-12,t+k} = \alpha_0 + \alpha_1 Spread_t \mathbb{1}(\hat{\theta}_t < \phi) + \alpha_2 Spread_t \mathbb{1}(\hat{\theta}_t \geq \phi) + \sum_{i=3}^{6} \alpha_i x_{it} + \varepsilon_t$, where $Y_{t+k-12,t+k}$ is the annualized marginal percentage change in output from month $t+k-12$ to future month $t+k$. $Spread_t$ represents the slope of the yield curve, $\hat{\theta}_t$ is the term premium, ϕ is the estimated term premium threshold, and $\mathbb{1}(\cdot)$ is an indicator function that takes the value of 1 if the expression is true and 0 otherwise. The model also includes as control variables x_{it} the lagged growth of IGAE, cumulative or marginal depending on what dependent variable is used, the real interest rate, the slope of the US yield curve, and the Mexican Stock Market Index. The coefficients associated to these variables are α_3, α_4, α_5, and α_6, respectively. ε_t is an error term. In parentheses are Newey and West (1987) heteroskedasticity and autocorrelation consistent standard errors. The lag used in order to obtain them turned out to be four. ***, **, and * denote statistically significant at the 1 percent, 5 percent, and 10 percent levels in two-tailed test respectively. Row k is based on estimation for t=2004:M1 through 2019:M12-k.

Horizon	Number of	Cumulative Change				
k	observations	α_0	α_1	α_2	ϕ	$\overline{R^2}$
3	189	0.80	0.25	0.89***	2.08	0.07
		(0.97)	(0.45)	(0.32)		
6	186	0.95	-0.15	0.69**	1.54	0.09
		(1.10)	(0.82)	(0.34)		
9	183	0.99	-0.30	0.71**	1.54	0.16
		(0.96)	(0.71)	(0.31)		
12	180	0.75	0.06	0.77**	1.54	0.20
		(0.97)	(0.65)	(0.31)		
18	174	0.76	-0.48	0.75***	1.06	0.32
		(0.69)	(1.06)	(0.22)		
24	168	0.84	-0.45	0.69***	1.06	0.38
		(0.62)	(0.99)	(0.21)		
36	156	0.91*	0.45***	0.68***	2.59	0.31
		(0.47)	(0.16)	(0.13)		

Horizon	Number of	Marginal Change				
k	observations	α_0	α_1	α_2	ϕ	$\overline{R^2}$
3	189	0.69	1.14***	0.59**	1.91	0.09
		(0.75)	(0.44)	(0.25)		
6	186	0.37	1.10**	0.80***	1.87	0.13
		(0.93)	(0.51)	(0.26)		
9	183	0.66	0.27	0.82***	1.54	0.20
		(0.94)	(0.65)	(0.30)		
12	180	0.75	0.06	0.77**	1.54	0.20
		(0.97)	(0.65)	(0.31)		
18	174	0.73	-0.87	0.77***	1.06	0.24
		(0.78)	(1.50)	(0.25)		
24	168	0.82	-0.66	0.67**	1.07	0.17
		(0.89)	(1.42)	(0.31)		
36	156	0.31	3.24**	0.47	1.07	0.11
		(1.30)	(1.40)	(0.37)		

Table A.6: Threshold Model Estimates by excluding Lagged Growth, Monetary Policy and the U.S Yield Curve

Source: Author's estimates using data from Banco de México, INEGI, and the US Federal Reserve Bank.
Notes: The estimated model is as follows: $Y_{t,t+k} = \alpha_0 + \alpha_1 Spread_t \mathbb{1}(\hat{\theta}_t < \phi) + \alpha_2 Spread_t \mathbb{1}(\hat{\theta}_t \geq \phi) + \varepsilon_t$, where $Y_{t,t+k}$ is the annualized cumulative IGAE growth over the next k months, or $Y_{t+k-12,t+k} = \alpha_0 + \alpha_1 Spread_t \mathbb{1}(\hat{\theta}_t < \phi) + \alpha_2 Spread_t \mathbb{1}(\hat{\theta}_t \geq \phi) + \varepsilon_t$, where $Y_{t+k-12,t+k}$ is the annualized marginal percentage change in output from month $t+k-12$ to future month $t+k$. $Spread_t$ represents the slope of the yield curve, $\hat{\theta}_t$ is the term premium, ϕ is the estimated term premium threshold, and $\mathbb{1}(\cdot)$ is an indicator function that takes the value of 1 if the expression is true and 0 otherwise. ε_t is an error term. In parentheses are Newey and West (1987) heteroskedasticity and autocorrelation consistent standard errors. The lag used in order to obtain them turned out to be four. ***, **, and * denote statistically significant at the 1 percent, 5 percent, and 10 percent levels in two-tailed test respectively. Row k is based on estimation for t=2004:M1 through 2019:M12-k.

Forecasting Horizon		Without Threshold					With Threshold						
k Months Ahead	Nobs.	β_0	β_1	β_2	R^2_{McF}	R^2_{Est}	γ_0	γ_1	γ_2	γ_3	ϕ	R^2_{McF}	R^2_{Est}
6	186	-0.51**	-0.94***	0.34*	0.25	0.18	-1.00***	0.44	-0.93***	0.50**	0.75	0.29	0.22
		(0.26)	(0.22)	(0.19)			(0.34)	(0.60)	(0.23)	(0.21)			
12	180	0.01	-1.24***	0.15	0.35	0.27	-0.76*	0.59	-1.24***	0.37	0.80	0.43	0.34
		(0.32)	(0.30)	(0.21)			(0.43)	(0.65)	(0.35)	(0.24)			
18	174	1.39***	-2.22***	-0.60**	0.52	0.42	1.48**	-1.04	-9.85**	-0.68*	0.76	0.70	0.59
		(0.48)	(0.59)	(0.27)			(0.63)	(0.86)	(4.95)	(0.35)			
24	168	0.65**	-0.84***	-0.55***	0.39	0.31	0.16	0.43	-0.71**	-0.47**	0.85	0.43	0.34
		(0.33)	(0.26)	(0.19)			(0.40)	(0.63)	(0.28)	(0.20)			

Table A.7: Probit Model Estimates (Trimming Percentage=20)

Source: Author's estimates using data from Banco de México, INEGI, and the US Federal Reserve Bank.
Notes: The estimated model without threshold is $Pr[Con_{t+k} = 1] = F(\beta_0 + \beta_1 Spread_t + \beta_2 Spread_t^*)$, while the estimated model with threshold is $Pr[Con_{t+k} = 1] = F(\gamma_0 + \gamma_1 Spread_t \mathbb{1}(\hat{\theta}_t < \phi) + \gamma_2 Spread_t \mathbb{1}(\hat{\theta}_t \geq \phi) + \gamma_3 Spread_t^*)$, where Pr denotes probability, F is the cumulative normal distribution, and the binary variable Con equals unity during those months considered as contractions. $Spread_t$ represents the slope of the yield curve, $Spread_t^*$ is the yield spread in the US, $\hat{\theta}_t$ is the term premium, ϕ is the estimated term premium threshold, and $\mathbb{1}(\cdot)$ is an indicator function that takes the value of 1 if the expression is true and 0 otherwise. In parentheses are asymptotic standard errors. ***, **, and * denote statistically significant at the 1 percent, 5 percent, and 10 percent levels in two-tailed test respectively. Row k is based on estimation for t=2004:M1 through 2019:M12-k.

Forecasting Horizon		Without Threshold					With Threshold						
k Months Ahead	Nobs.	β_0	β_1	β_2	R^2_{McF}	R^2_{Est}	γ_0	γ_1	γ_2	γ_3	ϕ	R^2_{McF}	R^2_{Est}
2	62	-0.44	-1.10**	0.40	0.27	0.20	-1.31**	0.86	-1.06*	0.58	0.94	0.39	0.29
		(0.47)	(0.46)	(0.34)			(0.65)	(1.04)	(0.58)	(0.39)			
4	60	0.17	-1.57**	0.24	0.39	0.30	-0.10	-0.36	-1.42**	0.20	0.71	0.41	0.31
		(0.61)	(0.66)	(0.39)			(0.68)	(1.42)	(0.70)	(0.40)			
6	58	1.75*	-2.74**	-0.58	0.57	0.46	1.13	0.29	-2.65*	-0.52	0.67	0.67	0.55
		(0.95)	(1.18)	(0.54)			(1.15)	(2.04)	(1.37)	(0.69)			
8	56	0.79	-0.98*	-0.54	0.41	0.33	0.25	5.79	-0.66	-0.57	0.61	0.55	0.45
		(0.61)	(0.53)	(0.34)			(0.65)	(5.65)	(0.51)	(0.37)			

Table A.8: Probit Model Estimates on a Quarterly Basis

Source: Author's estimates using data from Banco de México, INEGI, and the US Federal Reserve Bank.
Notes: The estimated model without threshold is $Pr[Con_{t+k} = 1] = F(\beta_0 + \beta_1 Spread_t + \beta_2 Spread_t^*)$, while the estimated model with threshold is $Pr[Con_{t+k} = 1] = F(\gamma_0 + \gamma_1 Spread_t \mathbb{1}(\hat{\theta}_t < \phi) + \gamma_2 Spread_t \mathbb{1}(\hat{\theta}_t \geq \phi) + \gamma_3 Spread_t^*)$, where Pr denotes probability, F is the cumulative normal distribution, and the binary variable Con equals unity during those months considered as contractions. $Spread_t$ represents the slope of the yield curve, $Spread_t^*$ is the yield spread in the US, $\hat{\theta}_t$ is the term premium, ϕ is the estimated term premium threshold, and $\mathbb{1}(\cdot)$ is an indicator function that takes the value of 1 if the expression is true and 0 otherwise. In parentheses are asymptotic standard errors. ***, **, and * denote statistically significant at the 1 percent, 5 percent, and 10 percent levels in two-tailed test respectively. Row k is based on estimation for t=2004:Q1 through 2019:Q4-k.

Forecasting Horizon		Without Threshold				With Threshold					
k Months Ahead	Nobs.	β_0	β_1	R^2_{McF}	R^2_{Est}	γ_0	γ_1	γ_2	ϕ	R^2_{McF}	R^2_{Est}
6	186	-0.26	-0.73***	0.22	0.16	-0.51**	0.43	-0.63***	0.67	0.25	0.18
		(0.22)	(0.18)			(0.26)	(0.67)	(0.19)			
12	180	0.15	-1.20***	0.34	0.26	-0.32	0.41	-1.14***	0.80	0.41	0.32
		(0.26)	(0.30)			(0.32)	(0.63)	(0.36)			
18	174	0.69**	-1.96***	0.48	0.38	0.57	-0.48	-9.32**	0.76	0.67	0.56
		(0.32)	(0.48)			(0.42)	(0.79)	(5.09)			
24	168	0.21	-0.99***	0.32	0.25	-0.13	1.81*	-0.83***	0.57	0.38	0.30
		(0.27)	(0.23)			(0.29)	(1.09)	(0.23)			

Table A.9: Probit Model Estimates by excluding the US Yield Curve

Source: Author's estimates using data from Banco de México, INEGI, and the US Federal Reserve Bank.
Notes: The estimated model without threshold is $Pr[Con_{t+k} = 1] = F(\beta_0 + \beta_1 Spread_t)$, while the estimated model with threshold is $Pr[Con_{t+k} = 1] = F(\gamma_0 + \gamma_1 Spread_t \mathbb{1}(\hat{\theta}_t < \phi) + \gamma_2 Spread_t \mathbb{1}(\hat{\theta}_t \geq \phi))$, where Pr denotes probability, F is the cumulative normal distribution, and the binary variable Con equals unity during those months considered as contractions. $Spread_t$ represents the slope of the yield curve, $\hat{\theta}_t$ is the term premium, ϕ is the estimated term premium threshold, and $\mathbb{1}(\cdot)$ is an indicator function that takes the value of 1 if the expression is true and 0 otherwise. In parentheses are asymptotic standard errors. ***, **, and * denote statistically significant at the 1 percent, 5 percent, and 10 percent levels in two-tailed test respectively. Row k is based on estimation for t=2004:M1 through 2019:M12-k.