Asian Journal of Economic Modelling
ISSN(e): 2312-3656
ISSN(p): 2313-2884
DOI: 10.18488/journal.8.2018.61.56.64
Vol. 6, No. 1, 56-64

URL: www.aessweb.com

YIELD SPREADS, THE EXCHANGE RATE, AND RECESSION PREDICTABILITY FOR NORTHERN MEXICO BORDER ECONOMIES

Thomas M. Fullerton, Jr[1+]
Laura M. Saenz Rojo[2]

[1]*Department of Economics & Finance University of Texas at El Paso, USA*
Email: tomf@utep.edu
[2]*Corporate Planning Department SMart Corporation Ciudad Juárez, Chihuahua, México*
Email: laura.saenz.26@hotmail.com

(+ Corresponding author)

Article History
Received: 8 August 2017
Revised: 28 December 2017
Accepted: 2 January 2018
Published: 5 January 2018

Keywords
Recession prediction
Yield curve
Real exchange rate
Border economics.

JEL Classification:
E32, Business cycles, E43, Interest rates, R15, Regional econometric models.

ABSTRACT

Prior research suggests that the yield spread between long-term and short-term interest rates contains information regarding the likelihood of future recessions. Linkages between the yield spread and regional business cycles in emerging economies have, to date, received little attention. This study employs yield spreads for Mexico and for the United States, as well as a real exchange rate index, as potential predictors of recessions in eight metropolitan economies located in northern Mexico. The results suggest that, in most cases, the United States yield spread provides early warning signals of potential economic downturns, as does the real exchange rate index.

Contribution/Originality: This study contributes to the existing literature on yield curves and recession predictability by amplifying the framework to include a currency market measure as well as international interest rate variables. It is one of very few studies that have applied this methodology to border region metropolitan economies.

1. INTRODUCTION

Policymakers and managers are justifiably concerned over recessionary prospects for their respective economies. Being able to predict incoming recessions allows implementing measures to ameliorate the effects of negative economic growth. Research by Estrella and Mishkin (1996); Estrella and Mishkin (1998) and Dueker (1997) identifies the yield spread as a useful indicator for anticipating business cycle downturns. Among various financial variables included in those studies, the spread between long-term bond and short-term bond interest rates proves to be a relatively reliable indicator of the likelihood of future recessionary contractions.

The yield curve representing interest rates at different maturities is normally upward-sloping due to the higher risk associated with longer-term investments. However, in advance of economic slowdowns, short-term interest rates tend to rise while long-term interest rates tend to fall. In some cases, this can result in an inverted yield

curve. Inverted, or even relatively flat, yield curves often serve as warning signals for short-run economic prospects (Dueker, 1997). The yield spread has been extensively used to analyze business cycles in high income economies. Analyses of downturn probabilities for low- and middle-income economies are less common. This is especially the case for regional and metropolitan economies in the latter groups of countries.

This research examines business cycle prediction for eight of the most important northern border metropolitan economies in Mexico. Mexican 1-month, 3-month and 1-year interest rates, the currency value of the peso, and United States 10-year Treasury bond and 3-month Treasury bill rate data are included in the sample. The interest rate data from the United States and the real exchange rate index are included due to the geographic proximity of the eight cities to the northern border. Prior research has documented various economic synchronicities between Mexico and the United States (Miles and Vijverberg, 2011). Northern metropolitan economies in Mexico are often influenced by cross-border business cycle fluctuations due to trade linkages (Fullerton, 2003). The next section reviews the existing literature on the yield spread as a predictor of economic contractions. The subsequent section describes the model and data utilized for this analysis. The results of the analysis are then presented, followed by a summary of principal findings.

2. LITERATURE REVIEW

Previous research examines the relation between the yield curve, also called the term structure of interest rates, and future consumption, inflation, and economic activity. Harvey (1988) documents links between expected returns and future consumption growth. Mishkin (1990) presents evidence that the term structure reflects information about expected inflation when analyzing maturities greater than 6 months. Fama (1990) finds that the interest rate spread contains information about future inflation and predictive power improves for longer horizons.

International evidence also corroborates the usefulness of yields for business cycle downturn analysis. Harvey (1991) and Hu (1993) analyze the relation between term structures and real economic activity in seven high income countries. Both studies find that the slope of the yield curve is positively related to expected growth. Harvey (1991) further confirms this using out of sample simulations.

Several studies evaluate the explanatory power of the interest rate spread in comparison with other potential predictors of the probability of recession. Estrella and Mishkin (1996) focus on the ability of four financial variables to predict recessions. The yield spread is found to out-perform leading economic indicators, a stock price index, and an economic composite index. It is argued that even predicted probabilities as low as 25 percent are strong signals of upcoming recessions. Dueker (1997) compares the predictive power of the yield curve slope relative to a variety of other potential financial market recession predictors. The results of these analyses confirm that the yield curve best predicts recessions at horizons beyond three months. Estrella and Mishkin (1998) also examine the out of sample capacities of various financial variables to predict business cycle downturns. In the very short run, an economic composite index performs best. For step lengths of two quarters and beyond, the yield spread is found to produce better results.

The predictability of regional recessions using yield curves has also been the subject of some research. Gauger and Schunk (2002) estimate a series of probit models to analyze regional business cycle fluctuations. Using real earnings for each region, a binary variable is created to identify recessions, defined as two or more consecutive quarters of negative growth. The performance of the yield spread in predicting recessions is strongest for regions that exhibit relatively high responsiveness to changes in monetary policy. In another probit analysis, Shoesmith (2003) finds that the yield spread is a significant predictor of recessions for 34 of the 50 states. Unemployment insurance claims, by contrast, only exhibit statistically significant predictive capacity for 9 states.

Although numerous studies have been completed for the United States, relatively little research of this type has been conducted for developing economies. Because of that, Kanagasabapathy and Goyal (2002) examine the relation between the yield spread and economic activity in India. As expected, a flattening of the yield curve presages a

slowdown in industrial activity. Mehl (2009) finds that the United States and euro area yield curves often outperform domestic yield curves as predictors of industrial production in emerging economies. This effect is attributed to cross-border spillovers of monetary policy changes in industrial countries.

In a study of the Mexican economy, Gonzalez *et al.* (2000) explore the predictive power of the yield spread for four macroeconomic variables. The yield spread is defined as the difference between interest rates for 6-month and 1-month bonds (CETES) due to the unavailability of complete data for longer-maturity bonds. Empirical results confirm the ability of the yield spread to predict macroeconomic changes during a period of economic crisis and recovery (1995-1997), but the results are less conclusive for the preceding period of relative stability (1991-1994).

In this study, an assessment of yield spread predictive ability is completed for the Mexican border economies of Tijuana, Mexicali, Nogales, Ciudad Juárez, Acuña, Nuevo Laredo, Reynosa, and Matamoros. A probit approach is utilized to investigate if the yield spread between 1-year treasury bonds and 3-month treasury bills in Mexico, along with a real exchange rate index and a United States yield spread, can help forecast economic fluctuations in these cities. Trade links have been found to influence international business cycle linkages, thus the potential importance of the currency market for the regional economic fluctuations analyzed in this effort (Asteriou and Moudatsou, 2015). Evidence of such links has also been documented for geographically adjacent metropolitan economies on the United States side of the order (Fullerton *et al.*, 2017). Prior research has not, however, examined recession predictability for urban economies in upper middle income countries such as Mexico. This study attempts to at least partially fill this gap in the regional economics literature.

3. DATA AND METHODOLOGY

Probit model analysis is used to estimate recession probabilities for each of the border economies in the sample. The traditional static probit model can be stated as in Equation (1),

$$\mathrm{P}(y = 1|x) = \Phi(\alpha_0 + \beta_0 x_t) = \Phi(\pi_t) \quad (1)$$

where $\mathrm{P}(y = 1|x)$ is the probability that an event will occur given the effects of x, Φ(.) is the standard normal cumulative distribution function, and x is an explanatory variable. Probit models are applied when dealing with limited dependent variables, where the latter are assigned a value of one, if an event occurs, or zero, otherwise. For this binary response model, the dummy variable (y) takes on a value of one if the economy is in a recession at period t and takes a value of zero otherwise. Dueker (1997) enhances the traditional probit model approach with the inclusion of a lag of the dependent variable as a regressor, adding information on the previous state of the economy.

Several subsequent studies (Kauppi and Saikkonen, 2008; Nyberg, 2010; Ng, 2012) indicate that dynamic probit models outperform the traditional static models. Accordingly, equation (2) includes a lagged value of y_t on the right hand of the model.

$$\pi_t = \alpha + \beta_1 MXSP_{t-h} + \beta_2 REX_{t-j} + \beta_3 USSP_{t-k} + \delta_1 y_{t-1} \quad (2)$$

In equation (2), π represents a linear function of the explanatory variables with h, j, and k representing lags of unknown order. The interest rate yield spread variable (*MXSP*) is defined as the difference between the long term interest rate (longer than 1 year) and short term Treasury bill rate (usually 3 months).

Because of the close relationship that exists among border economies, variables from the United States are also included in the sample. Reyna *et al.* (2009) find that the United States yield spread has significant predictive power for the Mexican economy. It may be helpful to add a real exchange rate index (REX) and a United States interest rate spread $(USSP)$ as explanatory variables when analyzing border region economic downturns in Mexico. A

similar specification using regressors from Mexico has been found to help predict recessions in the eight cities located across the border in the United States (Fullerton *et al.*, 2017).

Various recession forecasting studies point out that predictive power typically varies depending on the specific lag order employed (Estrella and Mishkin, 1998; Kauppi and Saikkonen, 2008; Nyberg, 2010). Consequently, the equations are estimated using multiple potential lag orders. Only the best-fitting equations are reported in the estimation results. To evaluate the accuracy of the models, the pseudo R^2 developed by Estrella (1998) is employed. It is expressed as shown in Equation (3).

$$Pseudo\ R^2 = 1 - \left(\frac{L_U}{L_C}\right)^{-(2/n)*L_C} \tag{3}$$

In equation (5), L_U is the unconstrained maximum value of the likelihood function, n is the number of observations and L_C is the maximum value when all coefficients except for the constant are constrained to equal zero. The values of the pseudo R^2 are constrained to fall between zero and one, where a value of one reflects perfect fit. For most probit models, low pseudo R^2 values are common. That is due to the typically small correlation between the binary variable and predicted probabilities.

Quarterly data are used for parameter estimation. The dependent variables are developed using employment data for the export manufacturing sector. The data are available for northern border economies in Mexico from Q4:1990 to Q1:2015 from the national statistics agency (INEGI, 2015). In the case of Nogales, seasonally adjusted employment data are used to develop the dependent variable due to a relatively high degree of seasonality in that series. Data availability in 2007 was temporarily interrupted by the cancellation of the maquiladora tax provisions. Because of that, export manufacturing employment estimates for the first two quarters of 2007 for all eight cities are interpolated using the United States industrial production index (Friedman, 1962). For Reynosa, the Mexico industrial production index is also used to interpolate the two missing data points for that urban area.

A commonly accepted definition for recessionary periods is two consecutive quarters of negative growth. In this case, two or more periods of negative change in employment is utilized as the criterion for defining periods of recession in each northern border economy in the sample. The reason for not using a continuous series like manufacturing employment as the dependent variable is that such variables blend information on the timing of recessions with information on the size of expansions and contractions (Dueker, 1997). The binary recession indicators, by contrast, contain only the recession-timing information that is important for this type of study.

For this study, monthly interest rate data are available for Mexico from 1978 to 2015 for two categories of Treasury Certificates (CETES) with short-term maturities. One is 1-month (28-day) CETES and the other is 3-month (91-day) CETES. Data for 1-year (364-day) CETES are available only from 1990 forward (BM, 2015). Ten-year maturity bond rates are available from July 2001 forward, but there are several periods of missing observations for those bonds. Although most of current literature uses the 10-year – 3-month spread, due to data availability and the relatively recent introduction of the long-term bonds in Mexico, the 1-year – 3-month spread (denoted *MXSP3*) is employed for this study. Reyna *et al.* (2009) also use the 1-year – 3-month spread to predict recessions in Mexico. Additionally, because a wider spread can contribute more information, the 1-year – 1-month spread (denoted *MXSP1*) is also be tested. Names and definitions for the explanatory variables are listed in Table 1.

Table-1. Explanatory Variable Names and Definitions

Mnemonic	Definition
MXSP1	Mexico 1-year – 1-month yield spread
MXSP3	Mexico 1-year – 3-month yield spread
USSP	United States 10-year – 3-month yield spread
REX	Real exchange rate index, Mexican peso relative to 111 foreign currencies

Data Sources: Author calculations using data from Federal Reserve Bank of St. Louis and Banco de México.

U.S. interest rates data are from the Federal Reserve Bank of St. Louis (FRED, 2015). Data for Mexican interest rates and the real exchange rate index are from the central bank of Mexico (BM, 2015). The real exchange rate index is defined as the weighted average of the peso exchange rate with respect to 111 currencies, after adjusting for inflation differences. This means that a decline in the real exchange rate index results from an appreciation of the peso against other currencies. When this happens, Mexican products tend to be more expensive and exports tend to decrease, causing reductions in aggregate demand (Niels and Francois, 2006). Under those conditions, the probability of a recession should increase. Thus, a negative coefficient for the real exchange rate variable is hypothesized. The contributing role of the inflation adjusted currency value of the peso in national business cycle fluctuations has been documented in prior studies (Aiolfi *et al*., 2011; Boschi and Girardi, 2011).

Negative signs are also hypothesized for the United States and Mexico yield spread regression parameters. The rationale for the predicted inverse relationship is as follows. The expectation hypothesis implies that the expected return from investing continuously in multiple short-term bonds is exactly the same as investing for one long-term bond in the same period (Dueker, 1997). When an economic slowdown is anticipated, short-term interest rates are expected to decrease in the subsequent periods. In order to maintain the expectation hypothesis identity, the long-term interest rate should decrease more rapidly than the short-term interest rate to allow for an equal expected return. Accordingly, when the difference between the long-term and short-term interest rate is negative, the probability of an upcoming recession is greater.

4. ESTIMATION RESULTS

Quarterly data from 1990:Q4 to 2015:Q1 are employed for parameter estimation. The Pseudo-R^2 from Equation (5) is used as the criterion for identifying the best model for each city (Estrella, 1998). Estimation results for all eight border economies are reported in Tables 2 and 3. In all cases, dynamic models outperform static models, so lags of the recession indicator are included among the regressors following Equation (2). The difference between 1-year and 1-month interest rates is the optimal yield spread variable for Mexico in four of eight cases. The 1-year minus 3-month interest rate differential is optimal for the other four cities. Explanatory power associated with the yield spread and other regressors varies due to differing characteristics of each regional economy.

Table-2. Estimation Results for Western Border Metropolitan Economies

	Tijuana	**Mexicali**	**Nogales**	**Ciudad Juárez**
Model	Dynamic	Dynamic	Dynamic	Dynamic
Lag order (k)	4	3	5	2
$MXSP1_{t-k}$	-0.0762	-0.0587		
$MXSP3_{t-k}$			0.0485	0.0440
$USSP_{t-k}$	-0.3091**	-0.0219	-0.4531***	-0.2037
REX_{t-k}	-0.0595**	-0.0363*	-0.0143	-0.0669**
y_{t-1}	1.0449**	1.1414***	1.6946***	2.1985***
Constant	3.9414*	1.7534	0.6099	3.9643*
Pseudo-R^2	0.3273	0.1857	0.4809	0.6040
Log-likelihood	-29.2130	-38.7183	-28.9505	-21.8535
Akaike Info. Criterion	0.7279	0.9204	0.7301	0.5594
Likelihood Ratio Stat.	30.4382	17.6400	46.1404	59.6403

Note: The sample period analyzed is 1990:Q4 to 2015:Q1
* Statistically significant at 10%
** Statistically significant at 5%
*** Statistically significant at 1%

Table-3. Estimation Results for Eastern Border Metropolitan Economies

	Acuña	Nuevo Laredo	Reynosa	Matamoros
Model	Dynamic	Dynamic	Dynamic	Dynamic
Lag order (k)	5	3	5	2
$MXSP1_{t-k}$		-0.0455		-0.3356***
$MXSP3_{t-k}$	-0.0747		0.1204	
$USSP_{t-k}$	-0.0680	-0.0074	-0.4169**	-0.1081
REX_{t-k}	-0.0454**	-0.0304*	-0.0153	-0.0446**
y_{t-1}	1.6166***	1.6132***	0.8568*	1.8323***
Constant	2.4527	1.2786	0.5231	2.7392*
Pseudo-R^2	0.3917	0.3467	0.2047	0.4755
Log-likelihood	-34.3652	-40.5506	-28.3496	-37.4172
Akaike Info. Criterion	0.8466	0.9590	0.7172	0.8837
Likelihood Ratio Stat.	37.4800	34.1032	18.5514	48.7161

Note: The sample period analyzed is 1990:Q4 to 2015:Q1.
* Statistically significant at 10%
** Statistically significant at 5%
*** Statistically significant at 1%

Optimal lag orders for in-sample estimation are reported for each of the eight border cities. The yield spread and exchange rate variables are lagged between two and five quarters. Similarly, some of the studies conducted for the United States find that the yield curve is an especially accurate predictor of real economic activity more than three months into the future (Dueker, 1997; Estrella and Mishkin, 1998). Those studies also document that the yield curve clearly outperforms alternative recession predictors for lead times greater than one quarter ahead. In contrast, the results presented here for northern Mexico indicate that the real exchange rate index provides comparatively strong early warning signals of oncoming recessions in several cases. The lag structures in Tables 2 and 3 are similar to those reported for the United States sister economies on the other side of the border (Fullerton *et al.*, 2017). The coefficient signs indicate the direction of the impact of each regressor on the probability of future recessions. The 1-year – 3-month Mexican yield spread coefficients are unexpectedly positive in three of four cases, but never significantly different from zero. The 1-year – 1-month yield spread is negative as hypothesized, but only statistically significant in the case of Matamoros. The spotty performance of the Mexican yield spread for border economies echoes results obtained at the national level in Gonzalez *et al.* (2000) which also uses bond maturity differentials of less than one year to define the yield spread variables. Furthermore, Reyna *et al.* (2009) document counterintuitive signs for 1-year minus 3-month Mexican yield spread coefficients in some cases. Ironically it differs from results obtained for the majority of the sister cities across the border from the metropolitan economies included in this sample (Fullerton *et al.*, 2017). Because of the relatively small maturity differential, the Mexican yield spread variable may not fully capture expectations regarding growth prospects beyond one year into the future. The coefficients for the United States yield spread variable have the expected negative sign for all eight urban economies and surpass the 5-percent significance level for Tijuana, Nogales, and Reynosa. Similarly, Reyna *et al.* (2009) report that the United States yield spread contributes more to the prediction of future economic activity in Mexico than does the domestic interest rate differential. Confirmation of that hypothesis is plausible for at least three reasons. Interest rate policy changes in industrial countries often trigger similar changes in emerging economies and, thus, provide early warning signals regarding future business cycle prospects in those economies (Mehl, 2009). More generally, the predictive capacity of cross-border financial variables may be a corollary of the increasing economic synchronization that several studies document for the United States and Mexico (Torres and Vela, 2003; Herrera, 2004; Chiquiar and Ramos-Francia, 2005). Of course, downturns in export-processing employment, which are used to define the dependent variables for each urban economy in the sample, are also influenced by business conditions in the primary target market of the United States (Fullerton and Novela, 2010). Across the border, all of the corresponding parameter estimates for the adjacent cities in the United States pass the standard significance threshold and exhibit the hypothesized negative sign. The real exchange rate coefficients

exhibit the hypothesized arithmetic sign in all eight equations and are statistically significant at the 5-percent level for Tijuana, Ciudad Juárez, Acuña, and Matamoros. The negative sign indicates that appreciation of the peso increases the probability that a metropolitan downturn will occur. Similarly, Blecker (2009) finds that peso appreciation reduces economic growth in Mexico at the national level. Other studies have also documented similar exchange rate effects in the export processing sectors of several urban economies in northern Mexico (Coronado *et al*., 2004; Fullerton and Torres-Ruiz, 2004; Cañas *et al*., 2007). The relatively strong explanatory power of exchange rates for lead times of two to five quarters suggest that currency market variables serve as useful complements to yield spreads for predicting regional recessions along the northern border of Mexico. That also holds true for the majority of the counterpart economies on the north side of the international boundary (Fullerton *et al*., 2017).

5. CONCLUSION

Business cycle downturn prediction is a widely studied topic. Previous research finds that, in comparison to a variety of other financial variables, the yield spread is a fairly informative indicator of the likelihood of future recessions in the United States. Probit modeling, the most widely utilized method employed for this type of analysis, enables quantifying the probability that a recession will occur. This study evaluates the merits of the Mexico yield spread, the United States yield spread, and the real exchange index as potential predictors of business cycle recessions for the border economies of Tijuana, Mexicali, Nogales, Ciudad Juárez, Acuña, Nuevo Laredo, Reynosa, and Matamoros. The results reveal that both the Mexico and United States yield spreads contain information about recessions for at least some of the eight urban economies included in the sample. In most cases, however, the United States yield spread provides more reliable information regarding the probability of recession than does the domestic yield spread from Mexico. Several factors likely contribute to this result, including the role of the United States as the principal consumer of Mexican exports and increasing cross border economic integration over the course of the sample period. Another noteworthy finding is that the real exchange rate index is a more statistically reliable predictor of recessions than either yield spread for Mexicali, Ciudad Juárez, and Nuevo Laredo. This contrasts with previous research for some other regions in which the yield spread clearly outperforms alternative potential recession predictors for lead times of one quarter ahead or more. In general, the results obtained mirror those reported for United States urban economies located just across the border from the cities included in this study. An unavoidable drawback for this research is limited data availability. Information on regional economic activity for the Mexican cities is only available from 1990:Q1 and data on Mexican long term bonds begin in 1990:Q3. Additionally, the United States yield spread includes the 10-year maturity bond, while the longest term bond with sufficient historical observations for the Mexican yield spread has a maturity of only 1 year. This may partially explain why the United States interest rate differential provides more information about changes in economic activity for these border economies in northern Mexico. Sales and yield data for 10-year bonds are currently available from the Bank of Mexico back through 2001. Replication of this study is recommended for other emerging markets where long-term bond rate degree of freedom constraints are less binding. It should be noted, however, that results in this study indicate that business cycle assessment is still possible for regional economies that face both data constraints and degree of freedom limitations.

Funding: Financial support for this research was provided by El Paso Water Utilities, Hunt Communities, City of El Paso Office of Management & Budget, National Science Foundation Grant DRL-1740695.
Competing Interests: The authors declare that they have no competing interests.
Contributors/Acknowledgement: The UTEP Center for the Study of Western Hemispheric Trade, and the Hunt Institute for Global Competitiveness at UTEP. Helpful comments and suggestions were provided by Adam Walke and Dennis Bixler-Márquez. Econometric research assistance was provided by Ernesto Duarte and Omar Solis.

REFERENCES

Aiolfi, M., L.A.V. Catão and A. Timmerman, 2011. Common factors in Latina America's business cycles. Journal of Development Economics, 95(2): 212-228. *View at Google Scholar | View at Publisher*

Asteriou, D. and A. Moudatsou, 2015. Business cycle synchronization in the EU. Review of Development Economics, 19(1): 196-207. *View at Google Scholar | View at Publisher*

Blecker, R.A., 2009. External shocks, structural change, and economic growth in Mexico, 1979-2007. World Development, 37(7): 1274-1284. *View at Google Scholar | View at Publisher*

BM, 2015. Securities market. México, DF: Banco de México.

Boschi, M. and A. Girardi, 2011. The contribution of domestic, regional and international factors to Latin America's business cycle. Economic Modelling, 28(3): 1235-1246. *View at Google Scholar | View at Publisher*

Cañas, J., T.M.J. Fullerton and W.D. Smith, 2007. Maquiladora employment dynamics in Nuevo Laredo. Growth and Change, 38(1): 23-28. *View at Google Scholar | View at Publisher*

Chiquiar, D. and M. Ramos-Francia, 2005. Trade and business-cycle synchronization: Evidence from Mexican and U.S. manufacturing industries. North American Journal of Economics & Finance, 16(2): 187-216. *View at Google Scholar | View at Publisher*

Coronado, R., T.M.J. Fullerton and D.P. Clark, 2004. Short-run maquiladora employment dynamics in Tijuana. Annals of Regional Science, 38: 751–763. *View at Google Scholar | View at Publisher*

Dueker, M.J., 1997. Strengthening the case for the yield curve as a predictor of U.S. recession. Federal Reserve Bank of St. Louis Review, 79(2): 41-51. *View at Google Scholar | View at Publisher*

Estrella, A., 1998. A new measure of fit for equations with dichotomous dependent variables. Journal of Business and Economic Statistics 16(2): 198-205. *View at Google Scholar | View at Publisher*

Estrella, A. and F.S. Mishkin, 1996. The yield curve as a predictor of U.S. recessions. Current Issues in Economics and Finance, 2(7): 1-6. *View at Google Scholar | View at Publisher*

Estrella, A. and F.S. Mishkin, 1998. Predicting U.S. recessions: Financial variables as leading indicators. Review of Economics and Statistics, 80(1): 45-61. *View at Google Scholar | View at Publisher*

Fama, E.F., 1990. Term-structure forecasts of interest rates, inflation, and real returns. Journal of Monetary Economics, 25(1): 59-76. *View at Google Scholar | View at Publisher*

FRED, 2015. Economic data. St. Louis, MO: Federal Reserve Bank of St. Louis.

Friedman, M., 1962. The interpolation of time series by related series. Journal of the American Statistical Association, 57(300): 729–757. *View at Google Scholar | View at Publisher*

Fullerton, T.M., Jr. 2003. Recent trends in border economics. Social Science Journal, 40(4): 583-592. *View at Google Scholar | View at Publisher*

Fullerton, T.M., Jr. and G. Novela, 2010. Metropolitan maquiladora econometric forecast accuracy. Romanian Journal of Economic Forecasting, 13(3): 124-140. *View at Google Scholar*

Fullerton, T.M., Jr., E.D. Saenz-Rojo and A.G. Walke, 2017. Yield spreads, currency movements, and recession predictability for Southern border economies in the United States. Applied Economics, 49(30): 2910-2921. *View at Google Scholar | View at Publisher*

Fullerton, T.M., Jr. and L.B. Torres-Ruiz, 2004. Maquiladora employment dynamics in Chihuahua City, Mexico. Journal of Developing Areas, 38(1): 1-17. *View at Google Scholar | View at Publisher*

Gauger, J. and D. Schunk, 2002. Predicting regional recessions via the yield spread. Review of Regional Studies, 32(2): 151-170. *View at Google Scholar*

Gonzalez, J.G., R.W. Spencer and D.T. Waltz, 2000. The term structure of interest rates and the Mexican economy. Contemporary Economic Policy, 18(3): 284-294. *View at Google Scholar | View at Publisher*

Harvey, C.R., 1988. The real term structure and consumption growth. Journal of Financial Economics, 22(2): 305-333. *View at Google Scholar | View at Publisher*

Harvey, C.R., 1991. The term structure and world economic growth. Journal of Fixed Income, 1(1): 7-19. View at Google Scholar

Herrera, H.J., 2004. Business cycles in Mexico and the United States. Journal of Applied Economics, 7(2): 303-323. View at Google Scholar

Hu, Z., 1993. The yield curve and real activity. International Monetary Fund Staff Papers, 40(4): 781-806. View at Google Scholar | View at Publisher

INEGI, 2015. Banco de información económica. Aguascalientes, MX: Instituto Nacional de Estadística y Geografía.

Kanagasabapathy, K. and R. Goyal, 2002. Yield spread as a lead indicator of real economic activity - an empirical exercise on the Indian economy. Economic and Political Weekly, 37(35): 3670-3676. View at Google Scholar

Kauppi, H. and P. Saikkonen, 2008. Predicting US recessions with dynamic binary response models. Review of Economics and Statistics, 90(4): 777-791. View at Google Scholar | View at Publisher

Mehl, A., 2009. The yield curve as a predictor and emerging economies. Open Economies Review, 20(5): 683-716. View at Google Scholar | View at Publisher

Miles, W. and C.C. Vijverberg, 2011. Mexico's business cycles and synchronization with the USA in the post-NAFTA years. Review of Development Economics, 15(4): 638-750. View at Google Scholar | View at Publisher

Mishkin, F.S., 1990. The information in the longer maturity term structure about future inflation. Quarterly Journal of Economics, 105(3): 815-828. View at Publisher

Ng, E.C., 2012. Forecasting US recessions with various risk factors and dynamic probit models. Journal of Macroeconomics, 34(1): 112-125. View at Google Scholar | View at Publisher

Niels, G. and J. Francois, 2006. Business cycles, the exchange rate, and demand for antidumping protection in Mexico. Review of Development Economics, 10(3): 388-399. View at Google Scholar | View at Publisher

Nyberg, H., 2010. Dynamic probit models and financial variables in recession forecasting. Journal of Forecasting 29(1-2): 215-230. View at Google Scholar | View at Publisher

Reyna, M., D. Salazar and H. Salgado-Banda, 2009. La curva de rendimiento y su relación con la actividad económica: Una aplicación para México. Monetaria 32(3): 297-357.

Shoesmith, G.L., 2003. Predicting national and regional recessions using probit modeling and interest-rate spreads. Journal of Regional Science, 43(2): 373-392. View at Google Scholar | View at Publisher

Torres, A. and O. Vela, 2003. Trade integration and synchronization between the business cycles of Mexico and the United States. North American Journal of Economics & Finance, 14(3): 319-342. View at Google Scholar | View at Publisher