

# PREDICTING RECESSIONS USING THE YIELD SPREAD: THE MEXICAN NORTHERN BORDER CASE

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# Outline

1. Introduction
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4. Data and Methodology
5. In-sample, Out-of-sample and Bivariate Probit Results
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# 1. Introduction

- Being able to predict an incoming recession allows implementing measures to ameliorate the effects of downturns.
- Research by Estrella and Mishkin (1996), Estrella and Mishkin (1998) and Dueker (1997) analyzes the yield spread and other financial variables in the context of foretelling economic deceleration.
- In general, an inverted yield curve presages downturns. Short-term interest rates tend to rise while long-term interest rates tend to fall in advance of economic slowdowns. Consequently, flat or inverted yield curves serve as warning signals for short-run economic prospects.

## 2. Main Objective

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 research examines business cycle prediction for eight of the most important northern border metropolitan economies in Mexico.

# 3. Literature Review

- Previous research examines the relation between the yield spread, also referred as term structure of interest rates, with future consumption, inflation, and economic activity.
- Harvey (1991) and Hu (1993) analyze the relation between term structures and real economic activity in high income countries. Both studies find that the slope of the yield curve is positively related to expected economic growth.
- Estrella and Mishkin (1996), Dueker (1997), and Estrella and Mishkin (1998) examine the ability of various financial variables to predict the probability of a recession. The yield curve spread is found to out-perform leading economic indicators, a stock price index, and an econometric composite index.

# 3. Literature Review

- 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. Regions that exhibit relatively high responsiveness to changes in monetary policy are easiest to analyze using the yield spread.
- Shoemith (2003) analyzes data for all 50 states using the yield spread and unemployment insurance claims. Probit model results indicate that the spread works reliable for 34 of the 50 states

# 3. Literature Review

- Gonzalez et al. (2000) explores the predictive power of the Mexican yield spread for economic variables for a 1991-1997 sample period. Four variables are employed as dependent variables: consumer prices, industrial production, the peso/dollar exchange rate, and merchandise imports.
- 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.

# 4. 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 follows:

$$P(y = 1|x) = \Phi(\alpha_0 + \beta_0 X_t) = \Phi(\pi_t) \quad (1)$$

Where  $P(y = 1|x)$  is the probability that an event will occur given the effects of  $X$ ,  $\Phi$  is the standard normal cumulative distribution, and  $X$  is an explanatory variable.

# 4. Data and Methodology

Dueker (1997) enhances the traditional probit model approach with the inclusion of a lag of the dependent variable as a regressor, adding information of the previous state of the economy. Several subsequent studies (Kauppi & Saikkonen, 2008; Ng, 2012; Nyberg, 2010) indicate that dynamic-autoregressive probit models outperform the traditional static models.

## 4. Data and Methodology

Combining both dynamic and autoregressive models, the model takes the form:

$$P(y = 1|x) = \pi_t = \alpha + \delta_1 Y_{t-1} + \beta_1 MEXSPREAD_{t-k} + \beta_2 REX_{t-k} + \beta_3 USSPREAD_{t-k} + \gamma \pi_{t-1} \quad (5)$$

## 4. Data and Methodology

- To evaluate the accuracy of the model, the pseudo  $R^2$  developed by Estrella (1998) is used. It is expressed as:

$$\textit{Pseudo } R^2 = 1 - \left( \frac{\log Lu}{\log Lc} \right)^{-(2/n) * \log Lc}$$

# 4. Data and Methodology

- To evaluate the performance of the economic activity, employment data from the export manufacturing sector are available for border cities, from Q4:1990 to Q1:2015 from INEGI.
- The yield spread is measured with short- and long-term interest rates. For this study, monthly Mexican interest rates data are available for Mexico from 1978 to 2015 for both the 1- (28 days CETES) and 3-month (91 days CETES) treasury securities; 1-year (CETES 364 days) maturity bonds are obtainable since 1990.
- Data for Mexican interest rates and real exchange rate index are available from the central bank. Exchange rate quarterly data are obtainable since 1954. U.S. interest rates are from the Federal Reserve Bank of St. Louis database.

# 5. In-Sample Results

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 the difference between the long-term and short-term interest rate is negative, the probability of an upcoming recession is greater.

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 a reduction in aggregate demand.

# 5.-In-Sample Results

	Tijuana	Mexicali	Nogales	Ciudad Juárez	Acuña	Nuevo Laredo	Reynosa	Matamoros
<b>Model</b>	Dynamic-AR	Dynamic-AR	Autoregressive	Dynamic-AR	Dynamic-AR	Dynamic-AR	Dynamic-AR	Dynamic-AR
<b>Forecast Horizon</b>	6 Q	3Q	8Q	6Q	3Q	8Q	6Q	4Q
<b>MX Yield Spread (1yr-1m)</b>		(-0.079)*				(-0.0767)		(-0.0462)
<b>MX Yield Spread (1yr-3m)</b>	.5957***		0.427***	0.1208	(-0.133)*		0.7287***	
<b>US Yield Spread</b>	(-0.3392)	0.0758	(-0.505)***	(-0.434)*	(-0.0488)	(-0.242)*	(-0.56)**	(-0.475)***
<b>Real Exchange Rate</b>	(-0.0282)	(-0.031)*	0.0187	(-0.0225)	(-0.035)**	(-0.0127)	0.0139	(-0.0642)***
<b>Autoregressive term</b>	1.1314***	1.1266***	1.601***	1.9987***	1.7486***	1.743***	0.4944	1.32963***
<b>Dynamic Term</b>	1.25E-05	2.3E-05		(-3E-06)	2.0E-05	2.1E-05	6E-05***	(-6.6E-05)**
<b>Pseudo R2</b>	0.443263	0.203545	0.515695	0.527389	0.311415	0.270798	0.475221	0.305974
<b>Log-likelihood</b>	-25.2105	-37.8497	-27.0304	-22.3167	-34.5642	-35.8506	-22.4386	-36.4881
<b>Akaike Info Criterion</b>	0.67849	0.92315	0.711787	0.61558	0.85398	0.93001	0.61823	0.90400
<b>LR statistic</b>	37.6357	19.37711	48.24332	56.58049	38.26098	36.50646	30.07046	48.867100

Sample period analyzed is 1990:Q4 to 2015:Q1

\* Statistically significant at 10%

\*\* Statistically significant at 5%

\*\*\* Statistically significant at 1%

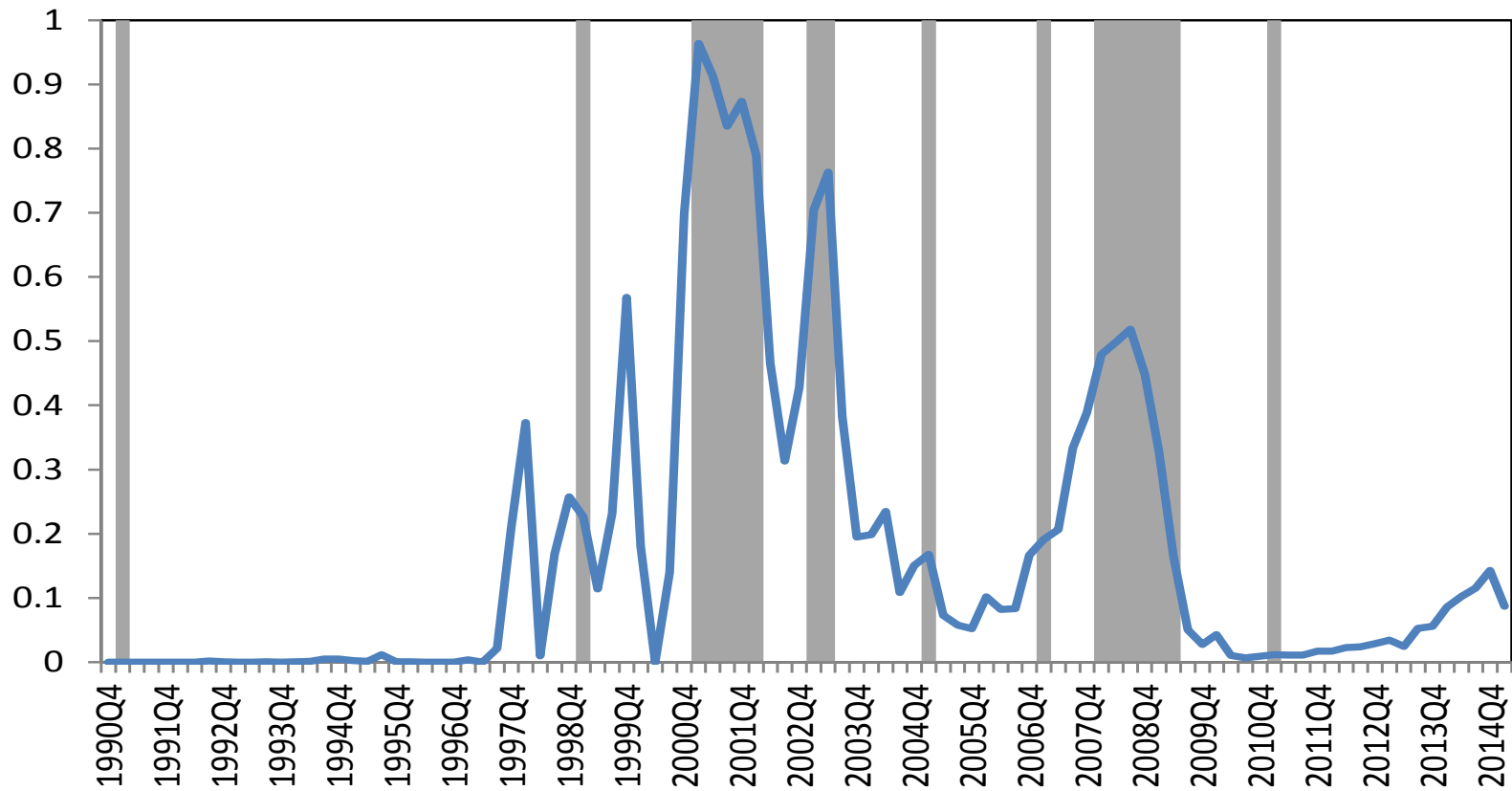


# 5.-In-Sample Results

- For Tijuana, a dynamic-autoregressive specification provides the best in-sample results.
- Optimal forecast horizon of six quarters.
- United States yield spread and the real exchange rate parameters show hypothesized signs.
- While the Mexico interest rate spread coefficient is significant at the 1% level, the sign of that coefficient is contrary to what was expected.
- The Mexican yield spread is computed using bond interest rates for 1 year and 3 months.

# 5.-In-Sample Results

## In-Sample Predictions for Tijuana

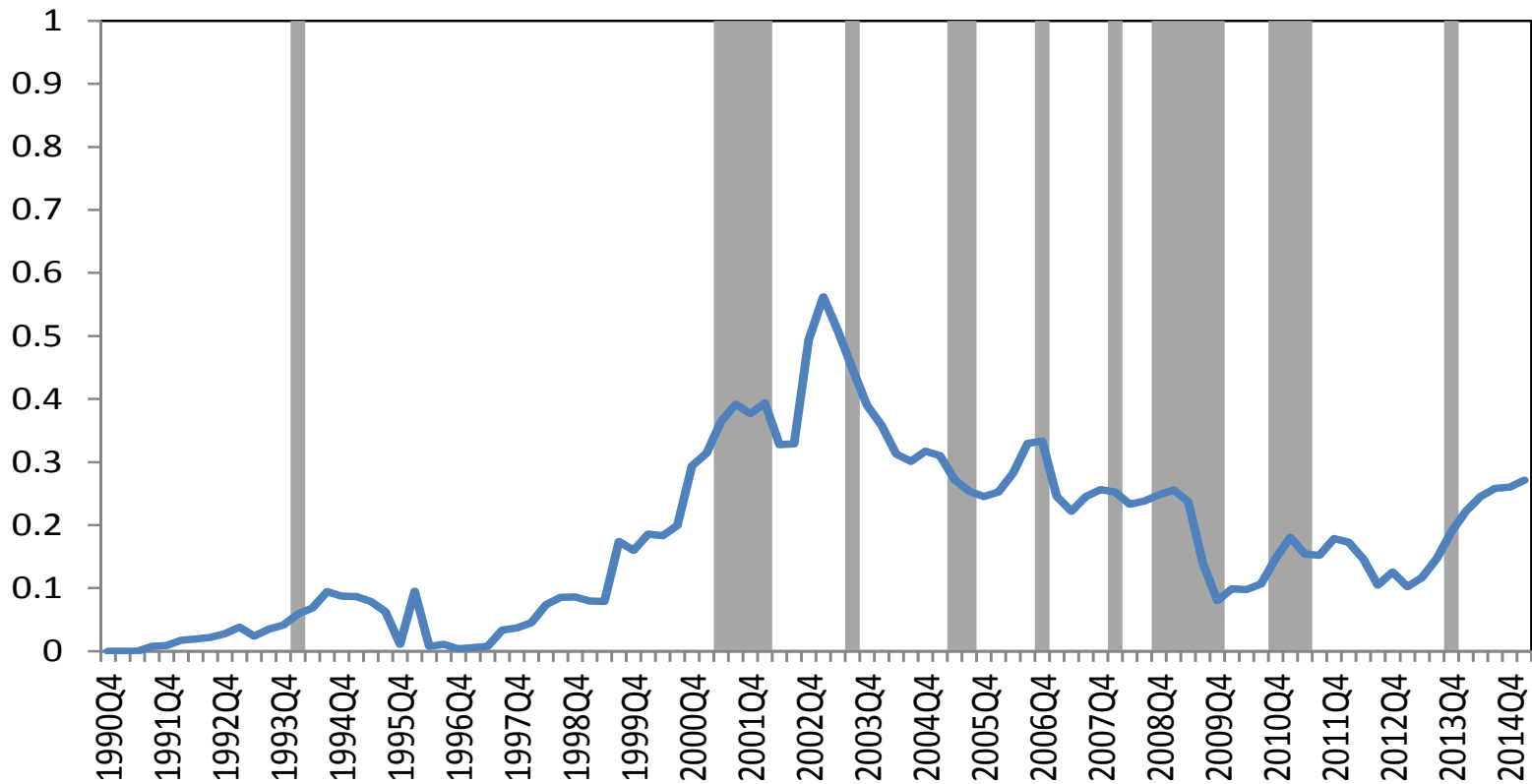


# 5.-In-Sample Results

- For Mexicali, a dynamic-autoregressive specification yields the best in-sample results.
- Optimal forecast horizon of eight quarters.
- The U.S. yield spread is not found to help predict recessions for this economy.
- The Mexican yield spread and the real exchange rate do provide some statistical insights about recessions in Mexicali. When the Mexican yield spread increases the probability of recession declines.
- The model specification explains about 20.4% of the variability of recessions in Mexicali.

# 5.-In-Sample Results

## In-Sample Predictions for Mexicali

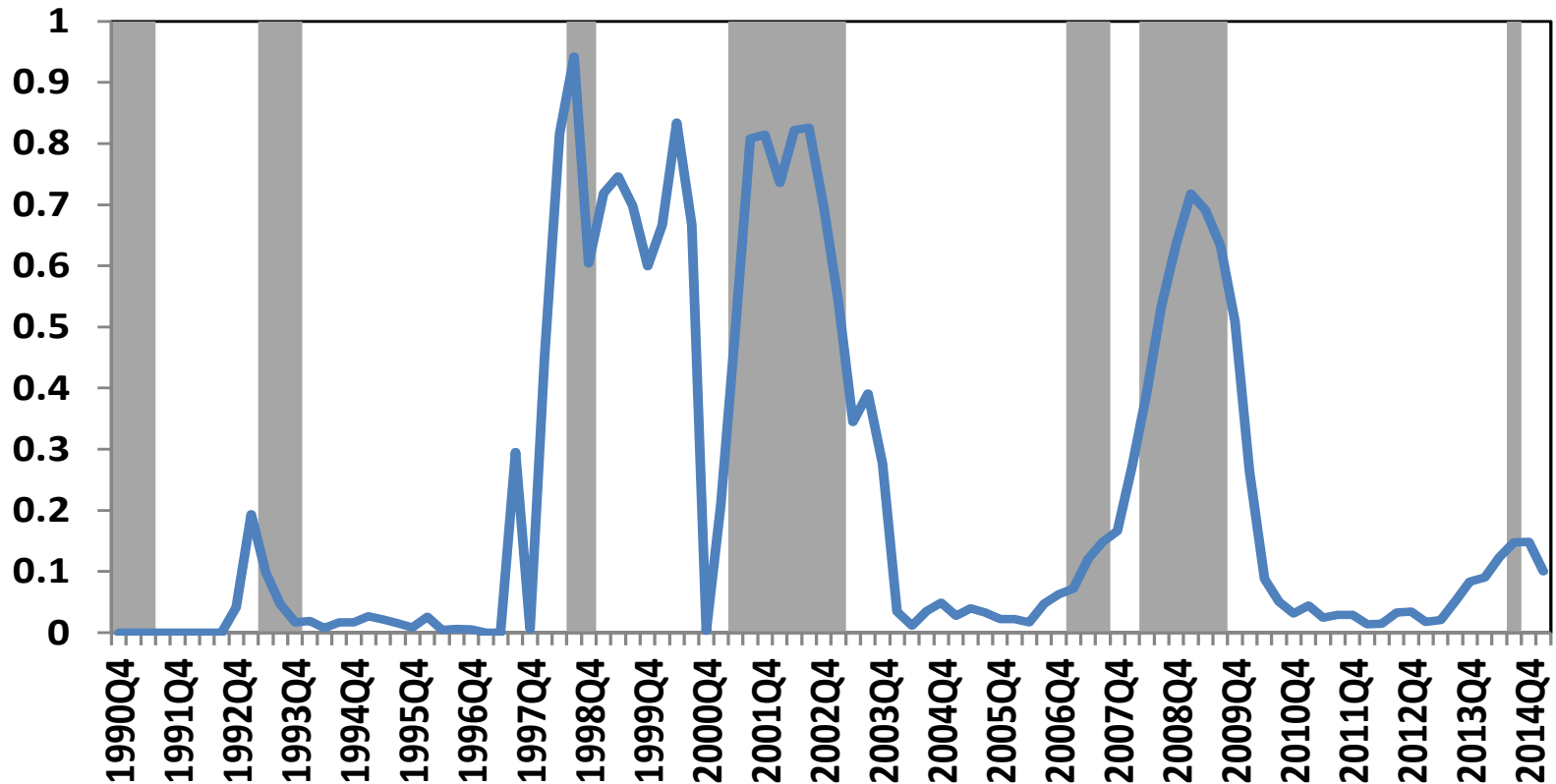


# 5.-In-Sample Results

- In the case of Nogales, an autoregressive specification achieves the best in-sample results.
- Best forecast horizon is eight quarters ahead.
- Mexican and United States interest rates provide information about upcoming recessions.
- Impact of the Mexican yield spread is significant, the coefficient is contrary to what is hypothesized.
- An increase of one percentage point in the United States yield spread reduces the probability of recession by about 8%.
- The model accounts for 51% of the variations in the dependent variable.

# 5.-In-Sample Results

## In-Sample Predictions for Nogales

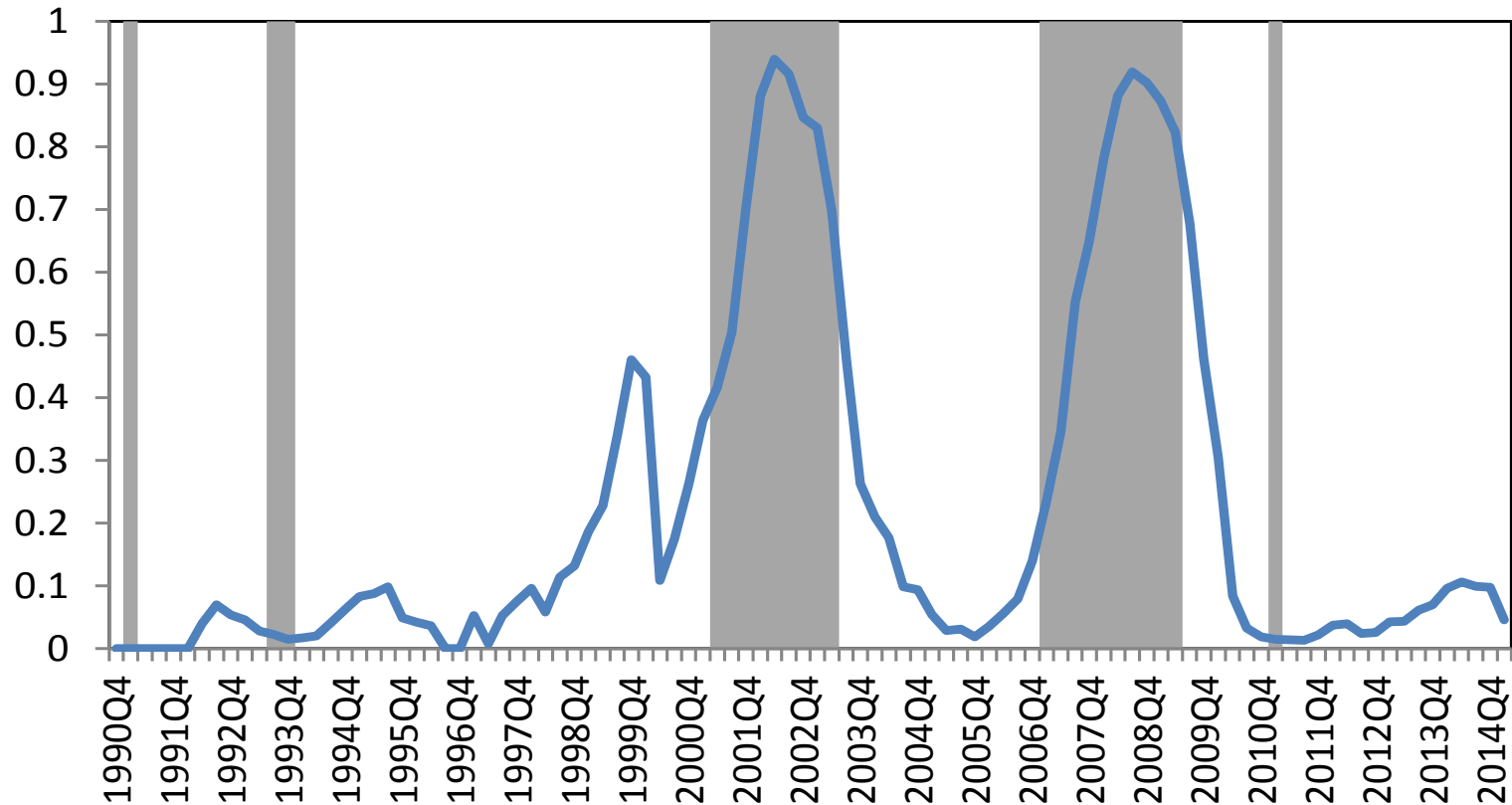


# 5.-In-Sample Results

- The dynamic-autoregressive model specification for Ciudad Juárez stands out among all those considered in this analysis as having the best in-sample performance, with a pseudo- $R^2$  of 52.7%.
- Optimal forecast horizon for this city is six quarters into the future.
- The Mexican yield spread does not provide statistical information regarding business cycle fluctuations in Ciudad Juárez.
- The United States yield spread coefficient is significant at the 10% level and exhibits the expected sign, indicating that an increase of one percentage point in the U.S. interest rate differential would result in a decrease in the probability of recession of 5.8%.

# 5.-In-Sample Results

## In-Sample Predictions for Ciudad Juárez

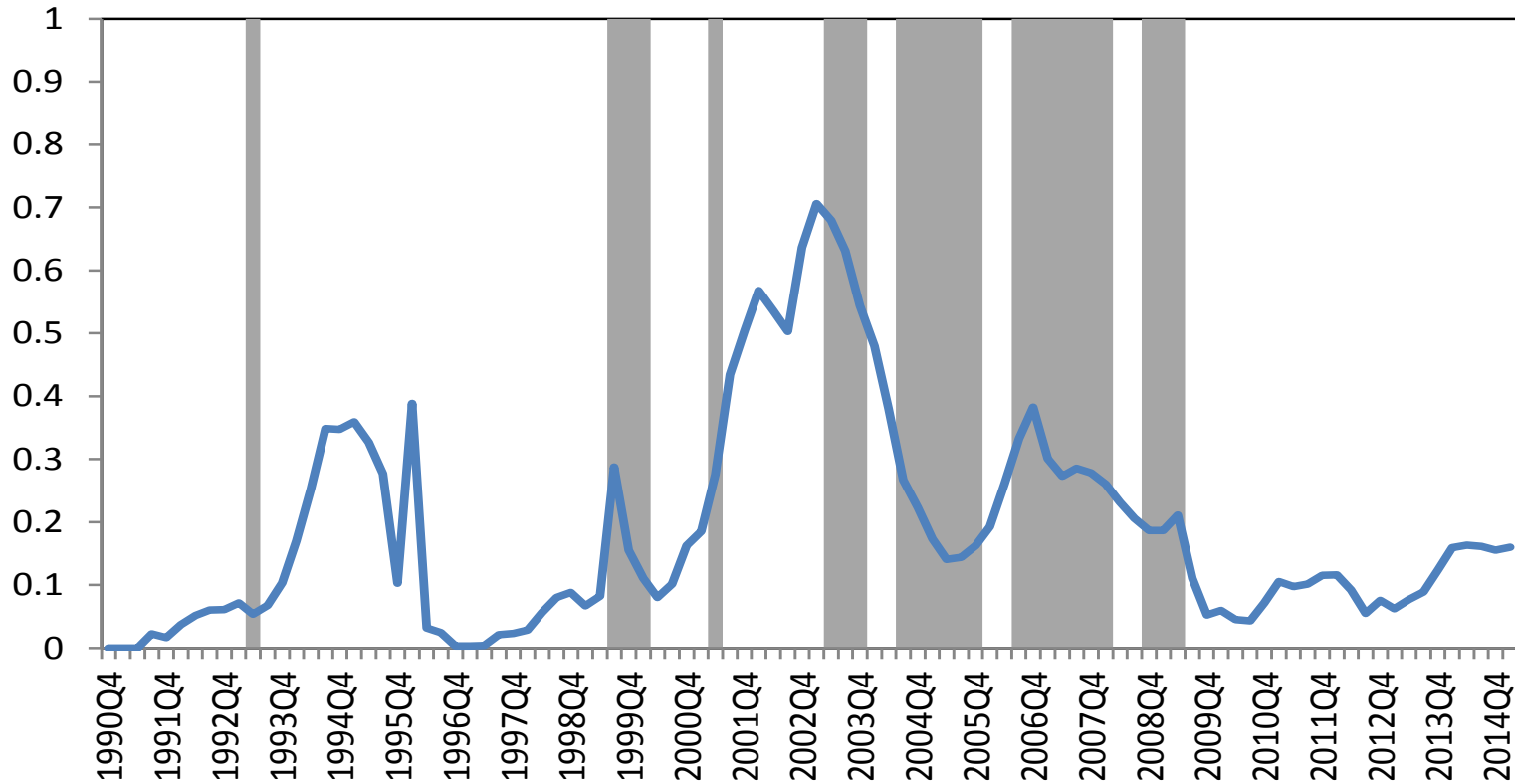


# 5.-In-Sample Results

- A dynamic-autoregressive specification provides the best results for the city of Acuña.
- Optimal forecast horizon of 3 quarters ahead.
- For this city, the Mexican yield spread shows better results when calculated for 1 year minus 3 months rather than for 1-year minus 1-month.
- An increase of one percentage point in the Mexican interest rate spread would affect the probability of recession by -2.7%.
- The United States interest rate spread coefficient also has the expected sign but it is not statistically significant.
- The real exchange rate parameter estimate is significant and displays the expected negative sign, implying that an increment of one unit in the real exchange rate index decreases the probability of recession by 0.71%.

# 5.-In-Sample Results

## In-Sample Predictions for Acuña

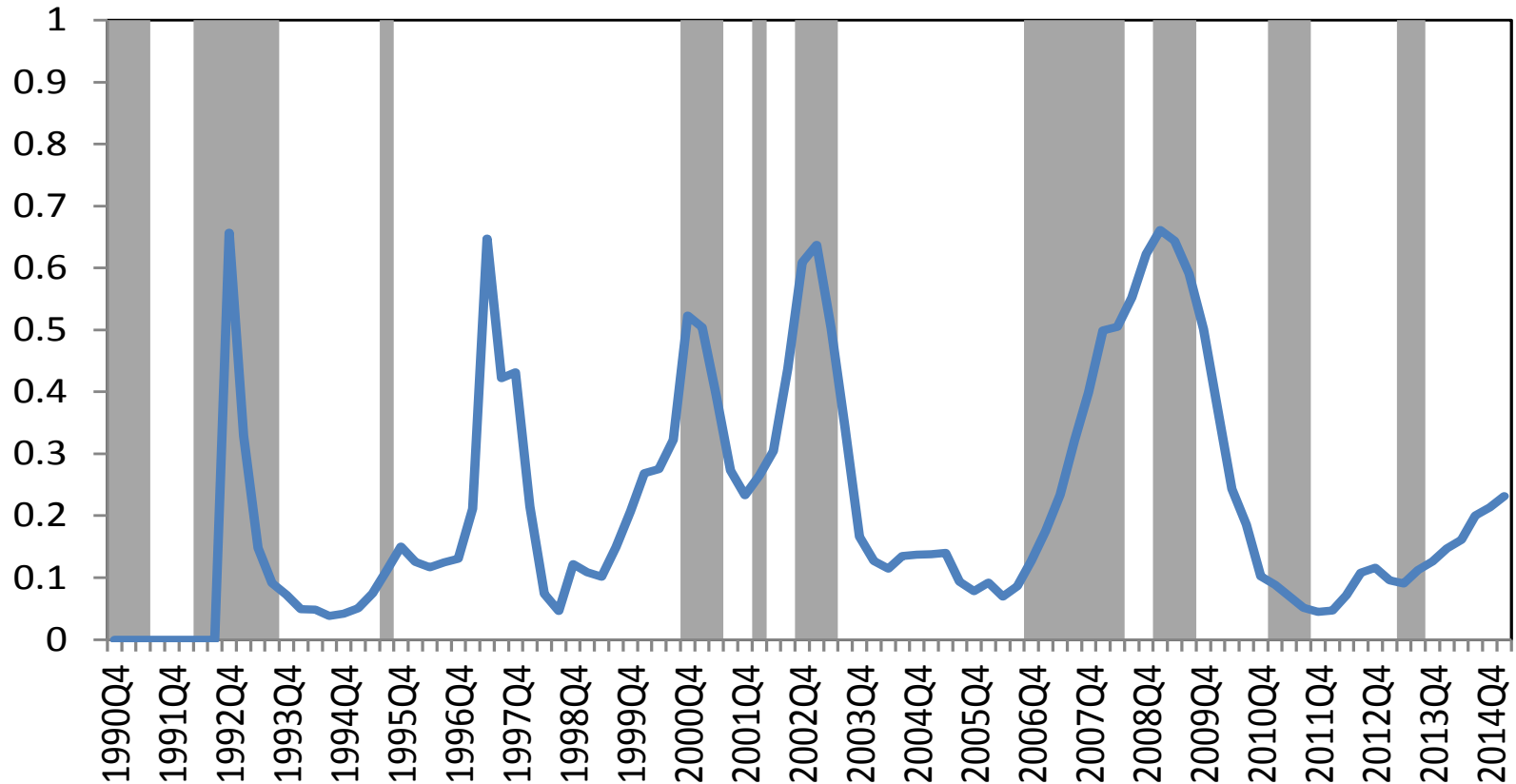


# 5.-In-Sample Results

- Nuevo Laredo model uses a dynamic-autoregressive specification.
- The highest pseudo- $R^2$  is obtained for a forecast horizon of 8 quarters.
- The Mexico yield spread coefficient, defined as 1-year minus 1-month interest rate, is not statistically significant but has the expected sign.
- The United States interest rate spread has the hypothesized sign and is statistically significant at the 10% level. If the United States yield spread increases, the probability that a recession hits the local economy decreases.
- For Nuevo Laredo, the selected model specification accounts for 27.1% of the recession variations.

# 5.-In-Sample Results

## In-Sample Predictions for Nuevo Laredo

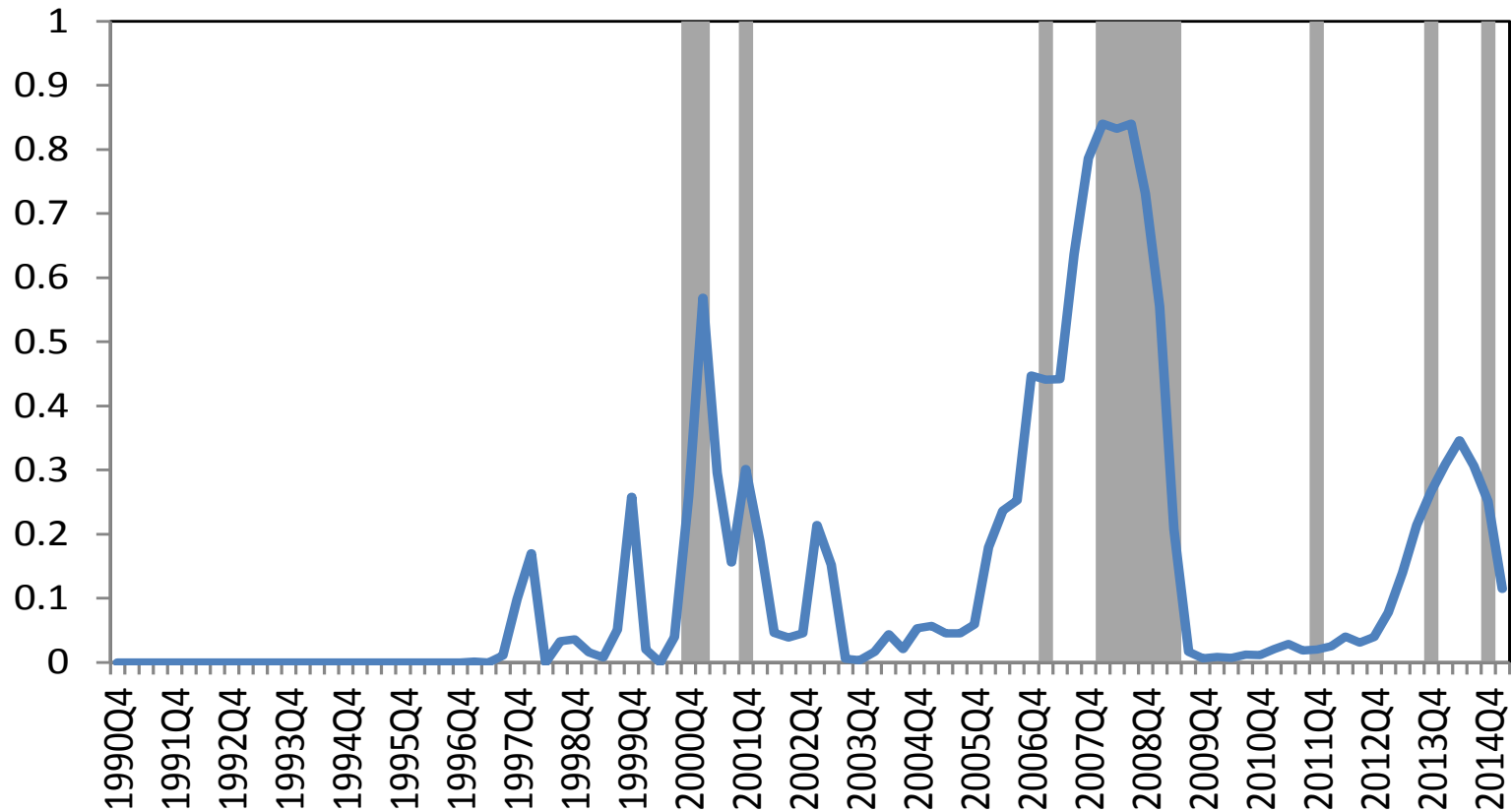


# 5.-In-Sample Results

- For Reynosa, the highest pseudo- $R^2$  of 47.5% is found using dynamic autoregressive model specification with a lead forecast horizon of 6 quarters.
- Results indicate that the Mexican yield spread provides information about recessions in Reynosa, but the expected sign of the coefficient is contrary to what is expected.
- The United States interest spread coefficient exhibits the expected sign and is significant at the 1% level.
- Reynosa is the only economy with a significant dynamic term at a 1% significance level, indicating that economic activity in a previous quarter provides information regarding an upcoming recession in the current quarter.

# 5.-In-Sample Results

## In-Sample Predictions for Reynosa

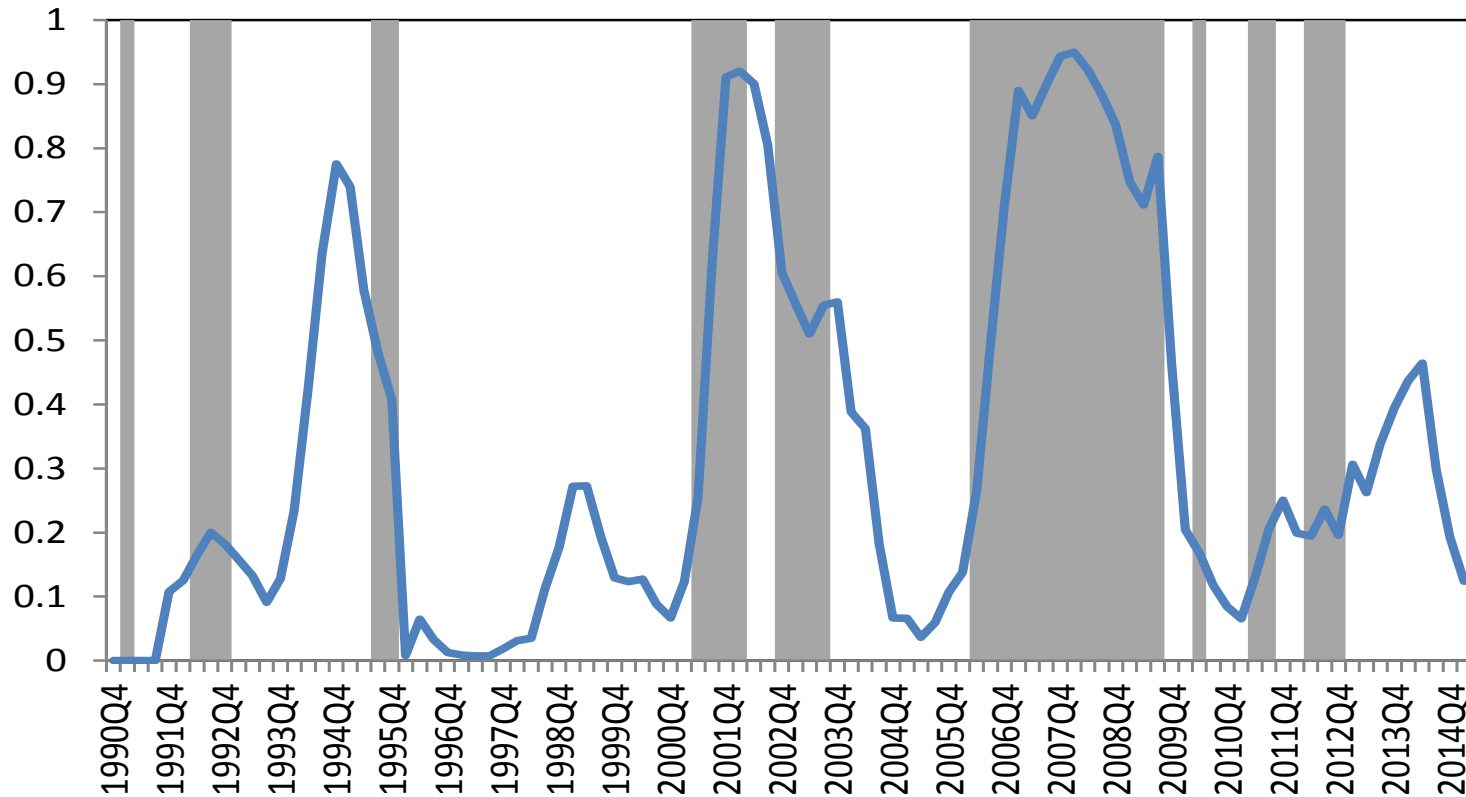


# 5.-In-Sample Results

- For the city of Matamoros, the model that performs best also has a dynamic-autoregressive specification.
- The optimal forecast horizon is four quarters ahead and almost all of the parameter estimates are significant.
- The 1-year bond minus the 1-month bill Mexican yield spread is utilized. The latter variable has a negative coefficient as expected.
- Estimation results show a pseudo- $R^2$  of 30.6%.

# 5.-In-Sample Results

## In-Sample Predictions for Matamoros

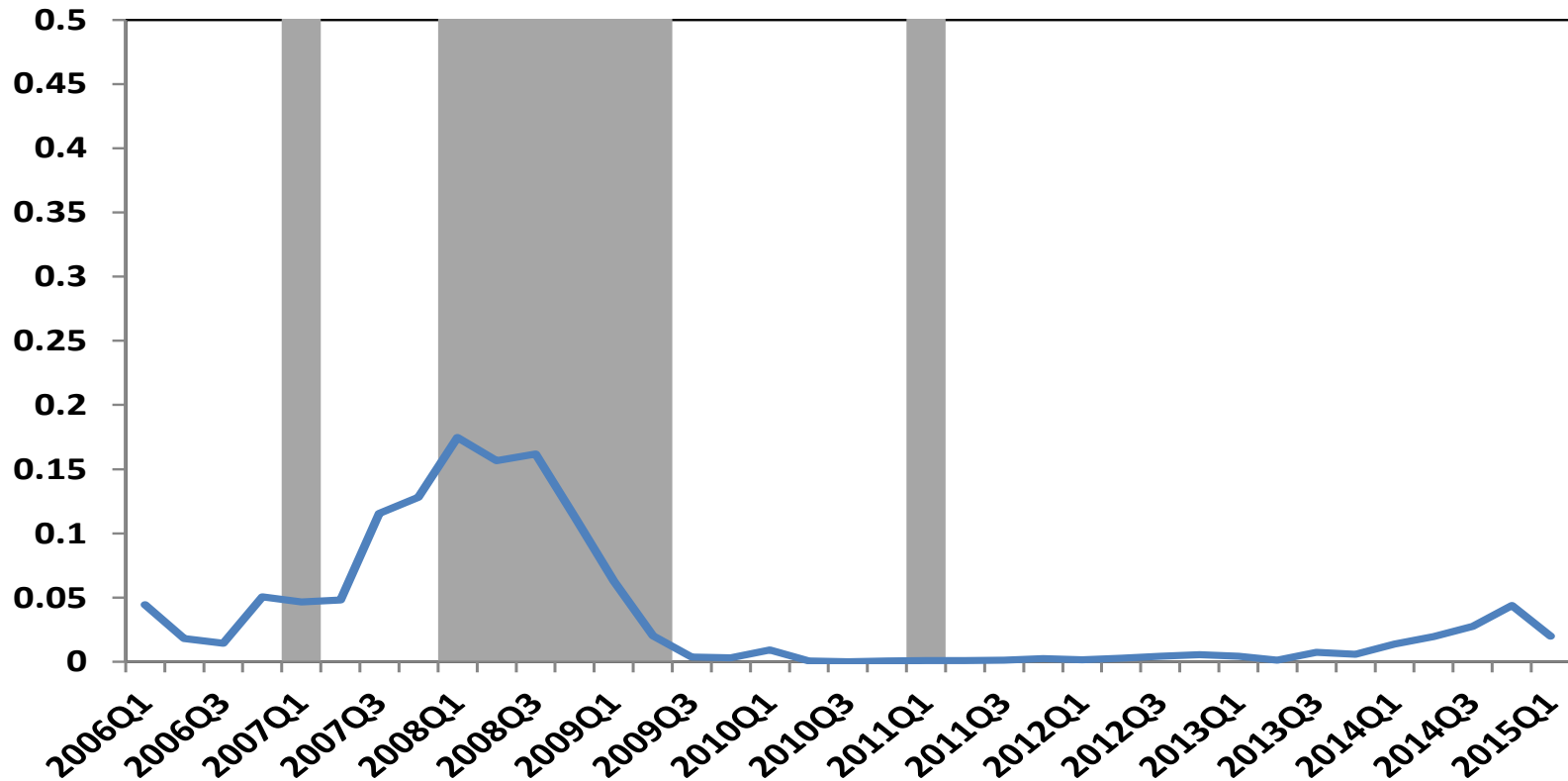


## 5.2 Out-of-Sample Results

- The sample period utilized for out-of-sample analysis is from 1990:Q4-2005:Q4.
- Starting from the last sample observation, which is 2005:Q4, forecasts are made one year ahead.
- Estrella & Mishkin (1998) and Gauger & Schunk (2002) find that the out-of-sample predictive capabilities associated with a model sometimes exceed the in-sample explanatory power of the same model. With the exception of Reynosa, the same results are found for the cities analyzed in this study.

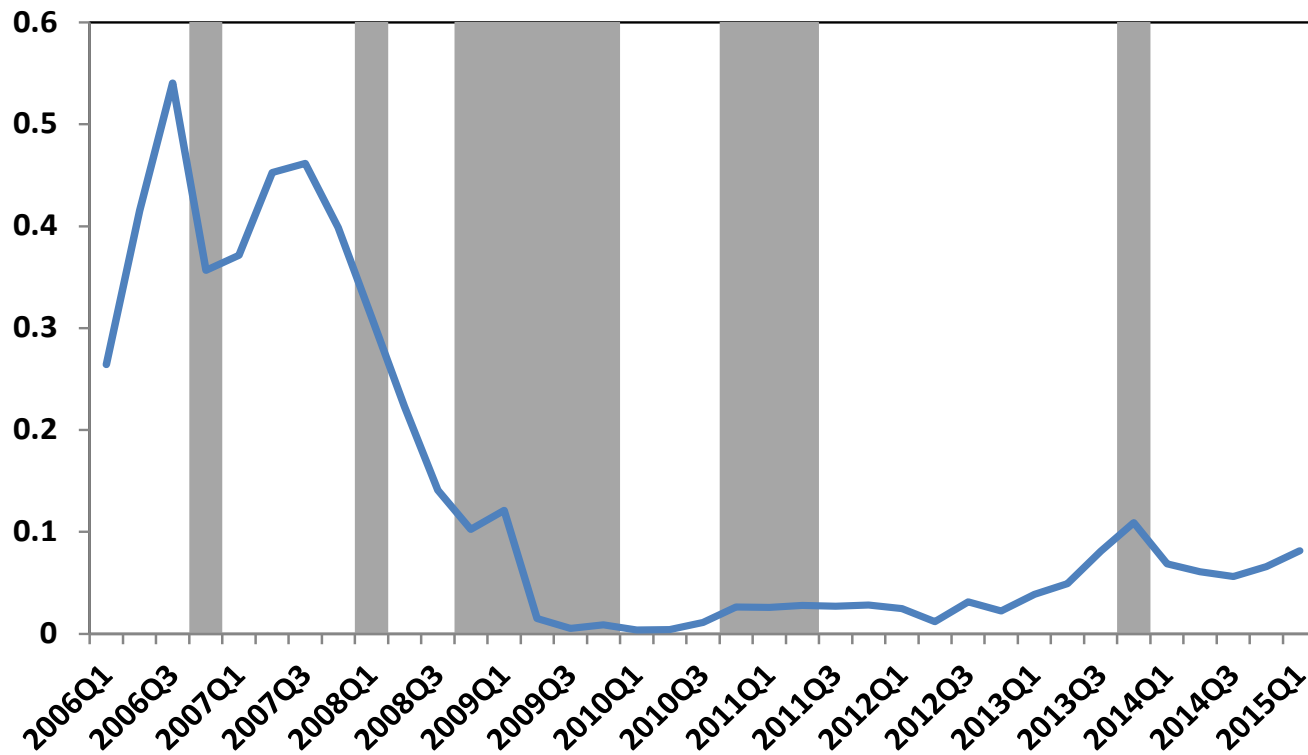
# 5.2 Out-of-Sample Results

*Out-of-Sample Probabilities for Tijuana*



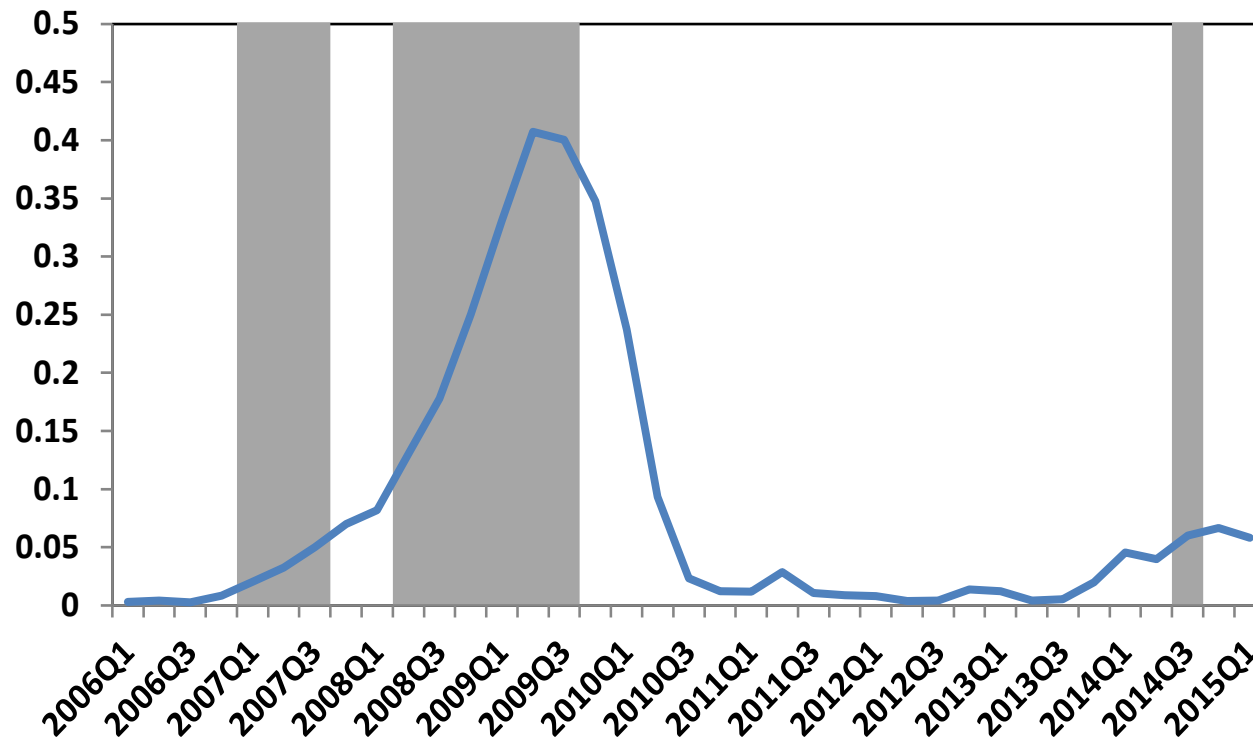
# 5.2 Out-of-Sample Results

*Out-of-Sample Probabilities for Mexicali*



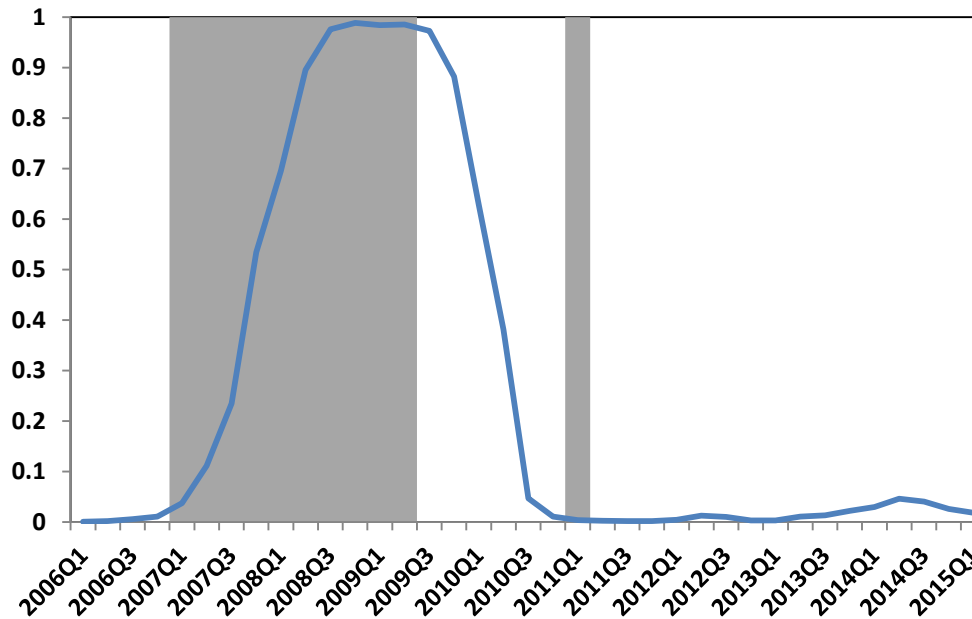
# 5.2 Out-of-Sample Results

*Out-of-Sample Probabilities for Nogales*



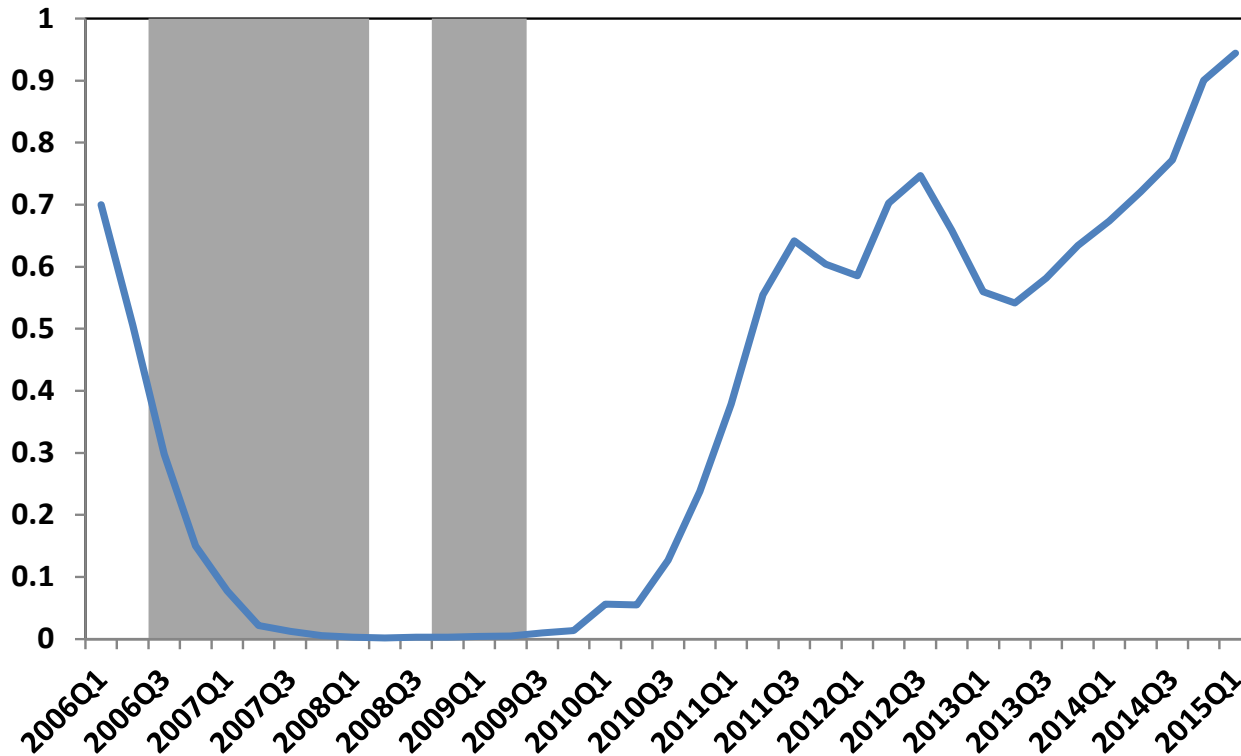
# 5.2 Out-of-Sample Results

*Out-of-Sample Probabilities for Ciudad Juárez*



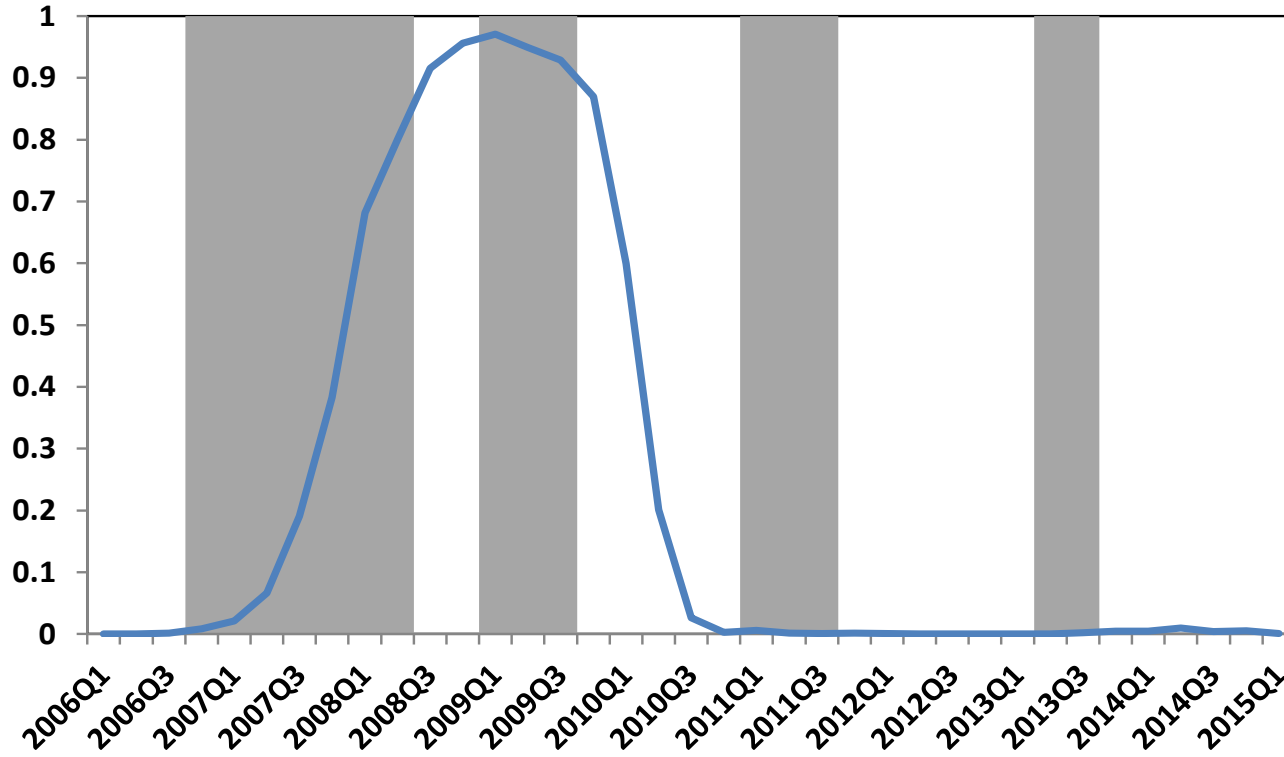
# 5.2 Out-of-Sample Results

## *Out-of-Sample Probabilities for Acuña*



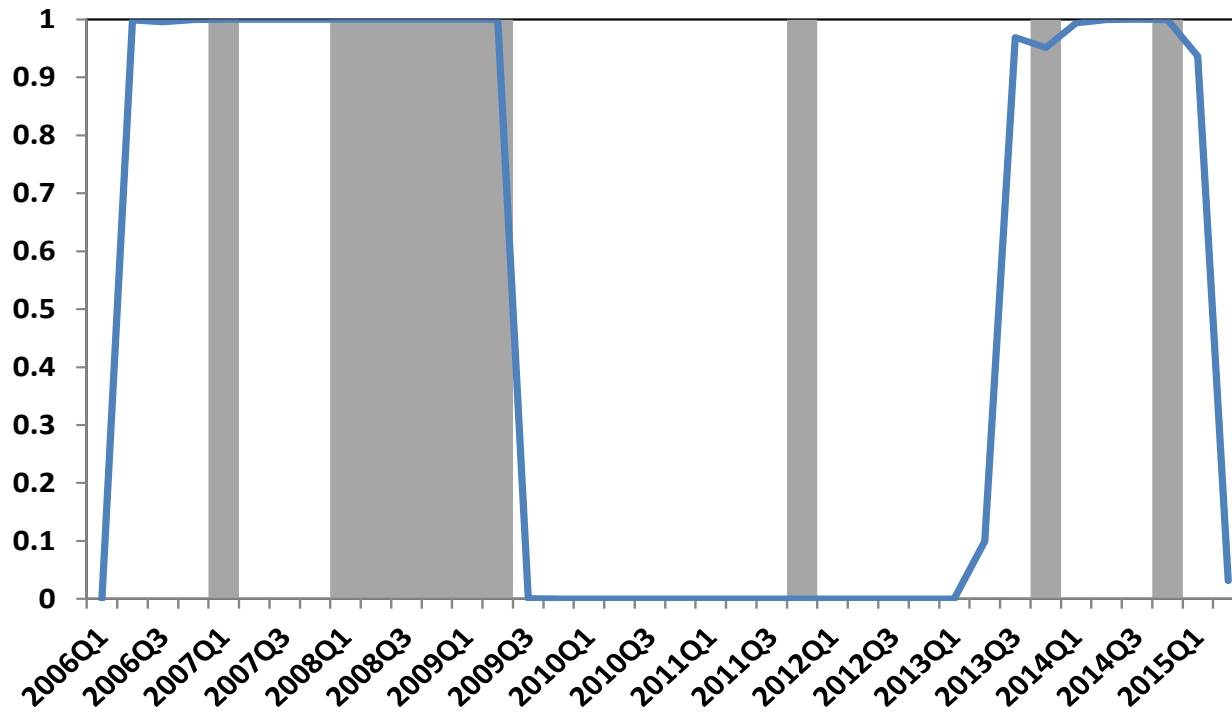
# 5.2 Out-of-Sample Results

## *Out-of-Sample Probabilities for Nuevo Laredo*



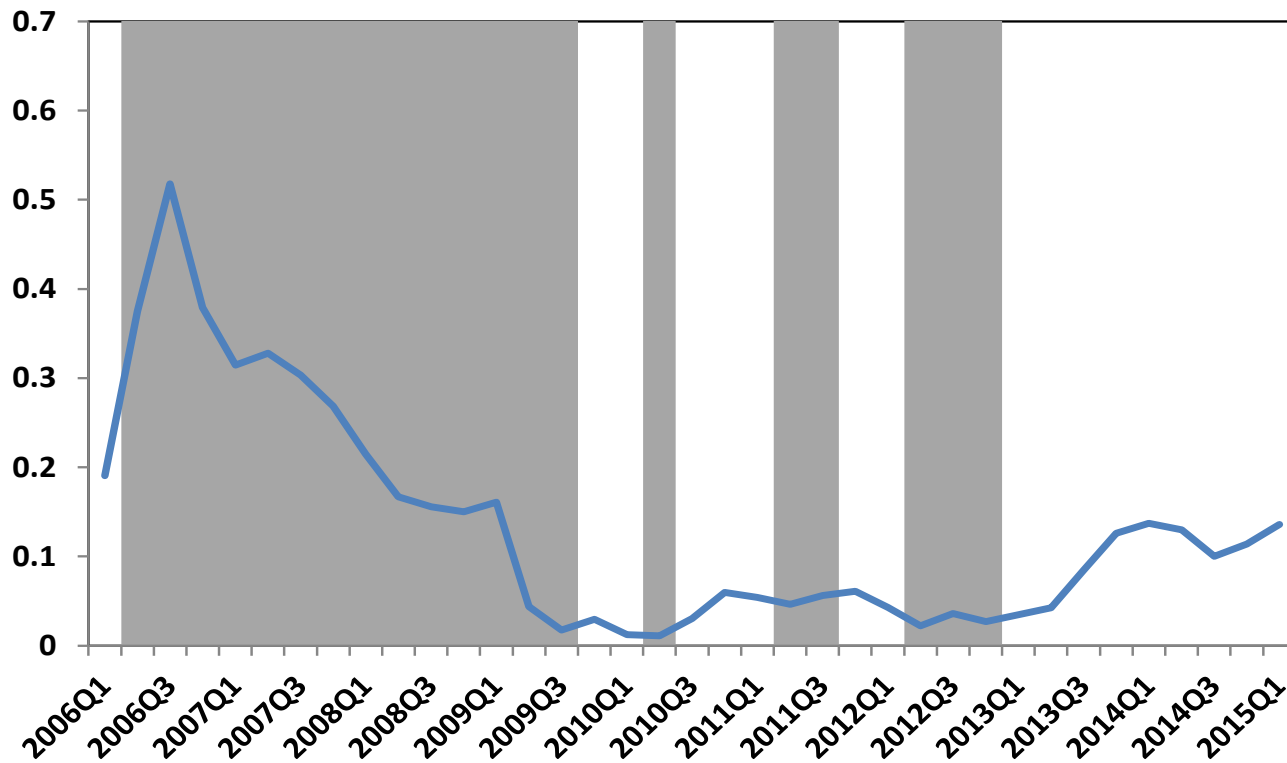
# 5.2 Out-of-Sample Results

## *Out-of-Sample Probabilities for Reynosa*



# 5.2 Out-of-Sample Results

## *Out-of-Sample Probabilities for Matamoros*



## 5.3 Bivariate Probit Results

- Seemingly unrelated bivariate probit models were computed to determine if a joint model of two binary outcomes outperforms individual probit estimations.
- When analyzing border cities, the cross-border economic relationship has to be taken into account.





# 5.3 Bivariate Probit Results

## Matamoros-Brownsville

```
Seemingly unrelated bivariate probit           Number of obs   =           89
                                                Wald chi2(10)    =           48.36
Log likelihood = -45.745229                   Prob > chi2      =           0.0000
```

	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
<hr/>						
matamorosrec						
ecoactmat1	.0000143	.0000299	0.48	0.632	-.0000443	.000073
matamorosr~1	1.804342	.3509288	5.14	0.000	1.116534	2.49215
yield1four	.0456135	.082863	0.55	0.582	-.1167951	.208022
usys4	-.1044355	.1928551	-0.54	0.588	-.4824247	.2735536
xr4	.001768	.0016322	1.08	0.279	-.0014309	.004967
_cons	-2.349299	1.881674	-1.25	0.212	-6.037312	1.338713
<hr/>						
brownsville						
brur1	-1.342144	.486836	-2.76	0.006	-2.296325	-.3879633
brownsville1	4.114018	.8696516	4.73	0.000	2.409532	5.818504
xr8	-.041537	.016215	-2.56	0.010	-.0733179	-.0097561
mxys8	-.6712067	.446365	-1.50	0.133	-1.546066	.2036527
usys8	-1.68856	.8936936	-1.89	0.059	-3.440168	.063047
_cons	24.31094	9.340653	2.60	0.009	6.003595	42.61828
<hr/>						
/athrho	-19.74767	847.1653	-0.02	0.981	-1680.161	1640.666
<hr/>						
rho	-1	0			-1	1

```
Likelihood-ratio test of rho=0:           chi2(1) = 5.17246           Prob > chi2 = 0.0229
```

## 5.3 Bivariate Probit Results

- The model employs the recessionary variables for the two border cities as functions of the Mexico and United States yield spreads, the real exchange rate, and dynamic and autoregressive terms.
- Insufficient data are available for the city of Del Rio. As a result, an Acuña-Del Rio bivariate probit model could not be estimated.
- About 70 % of the parameters of the three models show the hypothesized sign and 16 out of 30 coefficients are statistically significant.

## 6. Conclusions

In-sample results reveal that both the Mexico and United States yield spreads contain information about recessions for the border Mexican cities, although most of the results indicate that only the United States yield spread has the hypothesized impact on the probability of future recessions.

When the autoregressive term is added, the performance of the models, for most of the cities, increases by about 20 percent.

## 6. Conclusions

SUR bivariate probit estimates indicate that Nogales, Reynosa, and Matamoros recession predictions can be better explained jointly with their respective border counterparts (Nogales-Nogales, Reynosa-McAllen, and Matamoros-Brownsville) than by running each probit model separately.

# 6. Conclusions

Drawbacks for this research include 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 long term bond utilized for the Mexican yield spread has a maturity of only 1 year.

The 10 year maturity bonds have been released by BANXICO since 2001.

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Thank You!

# 5.3 Bivariate Probit Results (Backup)

## Tijuana-San Diego

Seemingly unrelated bivariate probit

Number of obs = 91

Log likelihood = -34.226012

Wald chi2(10) = 31.68

Prob > chi2 = 0.0005

	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
tijuana						
xr6	.0086689	.0054901	1.58	0.114	-.0020916	.0194293
yield2six	.9573373	.3369446	2.84	0.004	.2969381	1.617737
ecoacttij1	3.08e-06	.0000149	0.21	0.836	-.0000261	.0000323
tijuanaec1	1.301543	.4582001	2.84	0.005	.4034871	2.199599
usyield6	-.531589	.265123	-2.01	0.045	-1.051221	-.0119574
_cons	-4.804638	2.535978	-1.89	0.058	-9.775063	.1657871
sandiego						
xr5	-.005477	.0035875	-1.53	0.127	-.0125085	.0015544
mxys5	-.3935545	.3979754	-0.99	0.323	-1.173572	.3864629
usys5	-1.068744	.551598	-1.94	0.053	-2.149857	.012368
sandiego1	2.047185	.6224231	3.29	0.001	.8272581	3.267112
sdurl	.4954286	.2965195	1.67	0.095	-.085739	1.076596
_cons	-1.619852	.8348824	-1.94	0.052	-3.256191	.0164873
/athrho	11.50482	1160.124	0.01	0.992	-2262.297	2285.307
rho	1	4.72e-07			-1	1

Likelihood-ratio test of rho=0:      chi2(1) = 3.48427      Prob > chi2 = 0.0620





