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Business Cycle Downturn Estimation for Ciudad Juarez: 1991-2022

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BORDER REGION MODELING PROJECT TECHNICAL REPORT

UTEP BRMP Technical Report TX23-2

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Abstract

A monthly frequency metropolitan business cycle downturn likelihood equation is estimated for Ciudad Juarez. The binary index of economic conditions is based upon monthly IMMEX export oriented manufacturing employment. A dynamic probit methodology is used for parameter estimation. Continuous explanatory variables include a 1-year minus 1-month Mexico interest rate spread, a 2015 = 100 weighted real exchange rate index, and a 10-year minus 3-month USA interest rate spread. Parameter estimation results confirm the various hypotheses examined. However, model simulation outcomes are less favorable with the results indicating that accurate forecasting of the post-2010 business cycles may require additional refinement to the index.

Keywords

Yield Spreads; Metropolitan Business Cycle Predictability; Real Exchange Rates; Border Economics

JEL Codes:

C53, Econometric Forecasting; E32, Business Cycles; R15, Regional Econometrics

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Introduction

There continues to be substantial interest in business cycle downturn prospects for national, regional, and metropolitan economies. The ability to anticipate economic recessions allows implementing measures to, at least partially, mitigate the impacts of negative economic growth. Spreads between long-term bond and short-term bond yields have often been identified as consistently reliable harbingers of recessionary contractions (Estrella and Mishkin, 1996; Estrella and Mishkin, 1998).

Yield curves depict interest rates at different maturities for given economies. These curves tend to be upward sloping because of greater uncertainty associated with longer-term investments. On the eve of recessions, short-term interest rates often rise and long-term interest rates decline. Sometimes, this will result in an inverted yield curve that is downward sloping. Inverted, or even fairly flat, yield curves frequently provide early warning signals for worsening economic prospects (Dueker, 1997). Yield spreads have been extensively employed for the analysis of business cycles in high-income economies. Downturn probability studies for low- and middle-income economies are far less numerous. That is particularly true for regional and metropolitan economies in less prosperous countries (Fullerton and Sáenz-Rojo, 2018).

This study examines economic downturn prediction for Ciudad Juarez, Chihuahua, Mexico. Ciudad Juarez is one of the most important northern border metropolitan economies in Mexico and has the largest number of maquiladora jobs in the entire country (Fullerton and Novela, 2010). Sample data include a monthly business cycle index for Ciudad Juarez, yield spread measures for Mexico and the United States, and a real peso weighted exchange rate index. A variety of trade linkages and economic synchronicities have been documented between Mexico and the United States (Fullerton, 2003; Miles and Vijverberg, 2011), but monthly frequency recession predictability has not previously been analyzed. The next section provides an overview of the literature on yield spreads and economic contractions. The following section describes the model and data employed for this effort. Empirical results are discussed next, followed by a summary of key findings.

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 in the United States (Harvey, 1988; Mishkin, 1990; Fama, 1990). International evidence also corroborates the usefulness of yields for business cycle downturn analysis in other high-income economies (Hu, 1993). The relationship between the yield curve slope and expected global growth has also been confirmed using out-of-sample simulations (Harvey, 1991).

Regional business cycle downturn predictability using yield curves has also been examined in several studies. Probit models are employed by Gauger and Schunk (2002) to analyze potential links between yield spreads and regional fluctuations in real earnings. Shoesmith (2003) also uses probit models and finds that the yield spread is a significant predictor of recessions for 34 of the 50 states. In both of these efforts, recession dates are defined using a combination of data and judgement.

Much of the work to date on this topic has been conducted for the United States. Comparatively less downturn predictability research has been completed for developing economies. Kanagasabapathy and Goyal (2002) analyze the relation between the yield spread and economic activity in India and yield curve flattening is found to precede industry slowdowns. Interestingly, Mehl (2009) reports evidence that euro area and United States and yield curves tend to outperform domestic yield curves as predictors of emerging economy industrial conditions. That outcome may be due to cross-border monetary policy change spillovers from higher-income countries.

For Mexico, both domestic and United States yield spreads help anticipate the onset of business cycle contractions. Long-term yield data paucities force Gonzalez, Spencer and Walz (2000) to employ the difference between interest rates for 6-month and 1-month treasury bonds (CETES) as the domestic yield spread. Empirical results partially confirm the ability of the yield spread to forecast macroeconomic fluctuations during a period of contraction and recovery (1995-1997). However, outcomes are less compelling for the 1991-1994 period of relative stability.

More recently, Fullerto and Sáenz-Rojo (2018) use quarterly data to assess the downturn forecasting precision of yield spreads and a real exchange rate measure for several northern border economies. A probit approach is deployed for parameter estimation using quarterly data. For the Mexico yield spread, the difference between 1-year treasury bond and 3-month treasury bond rates is used. For the United States yield spread, the difference between 10-year treasury note and 90-day treasury bill rates is employed. Inclusion of the United States yield spread and the weighted real peso exchange rate index is motivated by external shock impacts on international business cycle fluctuations (Blecker, 2009; Asteriou and Moudatsou, 2015; Fullerton, Sáenz-Rojo, and Walke, 2017). Similar to Gauger and Schunk (2002) and Shoesmith (2003), the binary recession indicator for each metropolitan economy is defined on the basis of both regional insights and data.

Data and Methodology

Probit model analysis is used to estimate recession probabilities for Ciudad Juarez. A basic static probit model representation is shown in Equation (1),

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

where $P(y = 1|x)$ is the likelihood that an event will occur given the effects of x, $\Phi(.)$ is the standard normal cumulative distribution function, and x is an explanatory variable. Probit models are useful when analyzing binary dependent variables, where a value of one is assigned if an event occurs. If that outcome does not occur, the binary variable takes on a value of zero, instead. For this study, the dummy variable (y) takes on a value of one if Ciudad Juarez experiences a recession in period t and takes a value of zero otherwise.

Dueker (1997) augments the static probit equation shown above by including of a lag of the dependent variable as a regressor. Doing so adds information on the previous state of the economy. Several studies report evidence that dynamic probit models outperform static models in terms of out-of-sample forecast accuracy (Kauppi and Saikkonen, 2008; Ng, 2012; Nyberg, 2010). Equation (2) includes a lagged value of y_t on the right hand of the model.

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

In Equation (2), π represents a linear function of the explanatory variables with h, j, and k used to represent potentially differing lag lengths. Two interest rate yield spread variables (*MXSP*, *USSP*) are defined as the differences between a long-term interest rate and short-term interest rate in each country (Mexico and the United States). Both Mehl (2009) and Reyna Cerecero, Salgado Cavazos, and Salazar Bando (2008) find that the United States yield spread has significant predictive power for the Mexican economy. It has also been found to help predict recessions using quarterly data for the eight city pairs located along the border from the United States (Fullerton, Sáenz-Rojo, and Walke, 2017; Fullerton and Sáenz-Rojo, 2018). A real exchange rate index (REX) is also included as an explanatory variable because of the importance it plays in border region business cycles in Mexico (Fullerton, 2003).

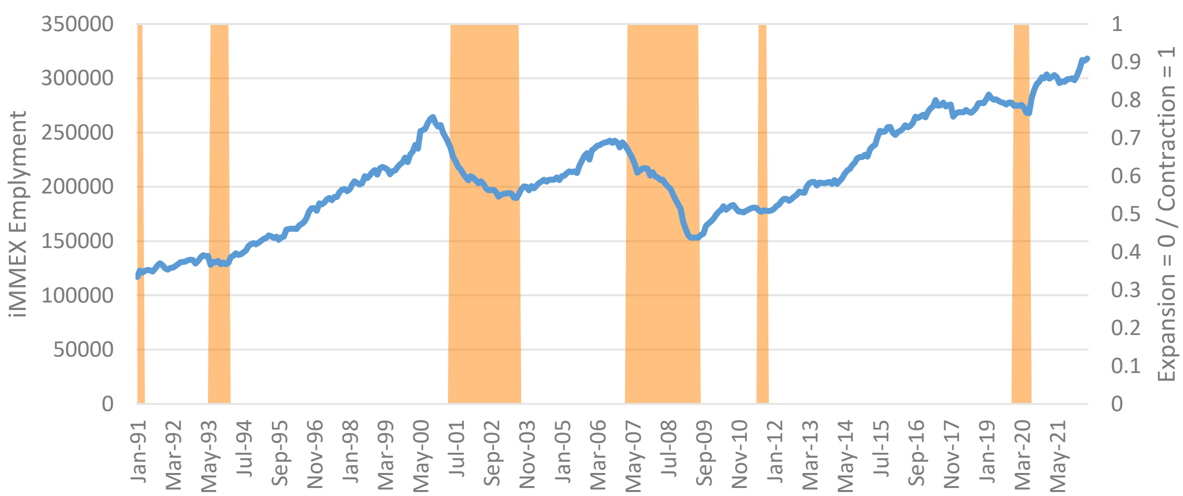
Prior research indicates that predictive power is often affected by the specific lag order employed (Estrella and Mishkin, 1998; Kauppi and Saikkonen, 2008; Nyberg, 2010). For that reason, Equation (2) allows individual lag lengths to vary for each regressor. That raises the possibility that more than one empirical version of Equation (2) may seem viable. To help select between competing empirical specifications, the pseudo coefficient of determination, proposed by McFadden (1974) is employed. That measure is calculated as shown in Equation (3).

$$Pseudo\ R^2 = 1 - (L_U / L_C) \qquad (3)$$

In Equation (3), 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 other than the constant are constrained to equal zero. The values of the pseudo R^2 will fall between zero and one, where values closer to one indicate better fits. For most probit equations, low pseudo R^2 values are typical. That is due to the generally modest correlation between the binary variable and predicted probabilities. All else equal, the pseudo R^2 from Equation (3) is used as the principal, tie-breaking criterion for identifying the best model fit.

Monthly data are used for parameter estimation. The dependent variable is developed using employment data for the export manufacturing sector in Ciudad Juarez (see Figure 1). The sample data are from January 1991 through May 2022. That sample period is long enough to contain large-scale currency market fluctuations, interest rate regime changes, and cross-border business cycle oscillations. While business cycles affect more than a single sector of any metropolitan economy, export manufacturing accounts for more than 55 percent of total formal sector jobs in Ciudad Juarez and is a leading indicator for the regional economy (Su, 1996; Cañas and Gutierrez, 2015; Fullerton and Fullerton, 2023). As shown in Figure 1 and Table 1, six different recessions are postulated for Ciudad Juarez during the period under consideration.

FIGURE 1
IMMEX EMPLOYMENT & METROPOLITAN RECESSIONS



Notes:
IMMEX stands for Ciudad Juarez international manufacturing employment.
Orange shading identifies months when the Ciudad Juarez economy is in recession.
Source: UTEP Border Region Modeling Project using INEGI data.

TABLE 1
CIUDAD JUAREZ METROPOLITAN BUSINESS CYCLE RECESSION DATES

Beginning Date	Ending Date
August 1990	March 1991
June 1993	December 1993
May 2001	August 2003
March 2007	July 2009
July 2011	October 2011
December 2019	May 2020

Source:
UTEP Border Region Modeling Project.

While there is no official definition of what constitutes a metropolitan economic recession, all metropolitan business cycle indices are dependent in one way or another on labor market information (Arias, Gascon, and Rapach, 2016; Fullerton and Subia, 2017). This is especially true for Latin American urban economies where time series data are not available for many indicator variables such as housing prices (Christiansen, Eriksen, and Moller, 2019; Gianetti, 2021), digital activity (Mossberger et al., 2023), consumer confidence (Biolsi and Du, 2020), gross metropolitan product (Koop et al., 2020), or retail sales fluctuations (Downs and Fullerton, 2017). Historically, two or more quarters of declining employment has been utilized as the criterion for identifying metropolitan downturns (Fullerton and Sáenz-Rojo, 2018). That pattern did not occur during the Covid-19 recession and substantial regional heterogeneity has been documented for that contraction (Connaughton, Cebula, and Amato, 2023). Monthly data may better allow for those types of downturn heterogeneities.

For the short-term rate of return, the yield on 1-month (28-day) Mexico Treasury Certificates (CETES) is employed. For the longer maturity yield, data for 1-year (364-day) CETES are utilized. Ten-year maturity bond rates are available from July 2001 forward, but there are several periods of missing observations for those bonds (BM, 2023). Many studies use 10-year – 3-month spreads, but data availability associated with the relatively recent introduction of long-term bonds in Mexico force the 1-year – 1-month spread (denoted *MXSP1*) to be deployed for this study. Reyna Cerecero, Salgado Cavazos, and Salazar Bando (2008) uses the 1-year – 3-month spread to predict national recessions in Mexico. Given that, additional estimation was also conducted using the 1-year – 3-month spread (denoted *MXSP3*), but the results favor inclusion of *MXSP1* as the Mexico yield spread variable. Names and definitions for the explanatory variables are shown in Table 2.

TABLE 2
EXPLANATORY VARIABLE NAMES AND DEFINITIONS

Variable	Definition	Hypothesized Coefficient Sign
MXSP1	Mexico 1-year – 1-month yield spread	(-)
USSP	USA 10-year – 3-month yield spread	(-)
REX	Real exchange rate index, peso versus 111 foreign currencies	(-) or (+)

A standard 10-year – 3-month yield spread is calculated with United States Treasury interest rate data from the Federal Reserve Bank of St. Louis database (FRED, 2023). The economic and geographic adjacencies of Ciudad Juarez to the United States make it highly sensitive to financial and economic developments (Fullerton, 2003; Fullerton and Sáenz-Rojo, 2018). An inverted yield curve is frequently associated with both national and regional economic recessions (Dueker, 1997; Gauger and Schunk, 2002; Shoesmith, 2003). Similar to regional economies in the United States, an inverse relationship is hypothesized to exist between *USSP* and the metropolitan business cycle in Ciudad Juarez.

Data for the real exchange rate index calculated as a weighted average of an inflation adjusted peso exchange rate with respect to 111 trading partner currencies are available from the central bank of Mexico (BM, 2023). A decline in the real exchange rate index results from an appreciation of the peso against other currencies. When this happens, Mexican exports tend to become more expensive and sales tend to decrease, leading to reductions in aggregate demand (Niels and Francois, 2006). Under those circumstances, the likelihood of a recession should increase (Aiolfi, Catão, and Timmerman, 2011; Boschi and Girardi, 2011). However, an appreciation in the peso also causes purchasing power shifts that encourage retail activity to jump the border while commercial activity in Ciudad Juarez suffers (Fullerton and Walke, 2014). Consequently, the parameter sign for *REX* is ambiguous.

Empirical Results

Estimation results for the dynamic probit equation are reported in Table 3. As in many economies, domestic monetary policy is found to operate on this metropolitan economy only after a lag. The lag on *MXSP* is 14 months. The negative sign indicates that an inverted yield curve in Mexico is followed, 14 months later, by a recession in Ciudad Juarez. That runs counter to what is documented using quarterly data over a shorter time span in Fullerton and Sáenz-Rojo (2018). Fluctuations in the real exchange rate index also impact the business cycle in this northern Mexico urban economy. The lag on *REX* is 7 months. The positive sign implies that peso depreciation results in business cycle upswings, probably due to reduced costs of production for international manufacturing operations.

TABLE 3
ESTIMATION RESULTS

Variable	Coefficient	Std. Error	z-Statistic	Prob.
Constant	-4.396	0.655	-6.713	0.000
$MXSP_{t-14}$	-0.059	0.041	-1.422	0.155
REX_{t-7}	3.306	0.618	5.348	0.000
$USSP_{t-1}$	-0.144	0.077	-1.876	0.061
Y_{t-7}	0.989	0.189	5.239	0.000

McFadden Pseudo R^2	0.193	Std. Err. Regression	0.367
Sum Squared Residuals	48.101	Hannan-Quinn Inf. Criterion	0.928
Log Likelihood, Unconstrained	-159.513	Log Likelihood, Constrained	-197.564
Likelihood Ratio Statistic	76.103	Prob. (LR Statistic)	0.000
Deviance	319.025	Restricted Deviance	395.128
Observations with Dep Var = 0	299	Observations with Dep Var = 1	78
Total Observations	377		

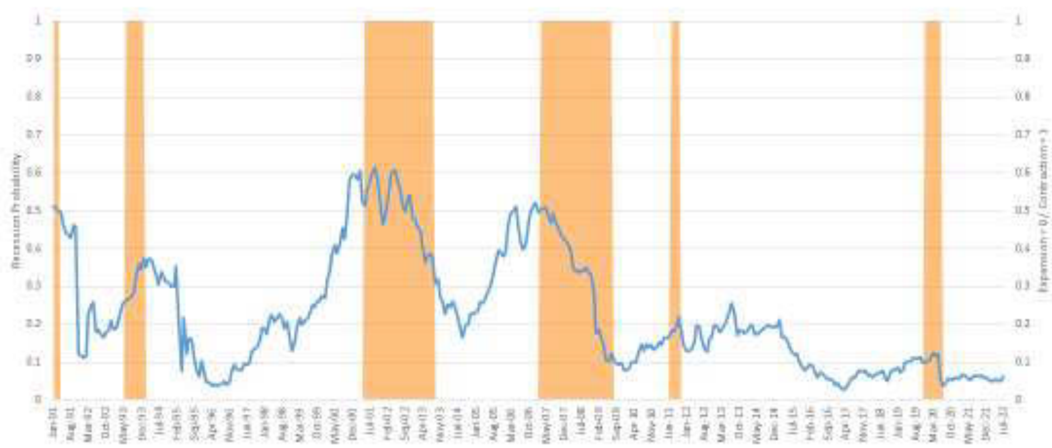
Notes:
The sample period analyzed is January 1991 – May 2022.
Deviance is a goodness of fit measure estimated for the final parameter estimates.
Restricted Deviance is the deviance measured for a constant-only version of the model.

Several studies provide empirical evidence that variations in north-of-the-border business conditions lead to very rapid south-of-the-border economic consequences. Such evidence has been primarily documented using national business cycle data (Chiquiar and Ramos-Francia, 2005; Miles and Vijverberg, 2011; Torres and Vela, 2003). In Table 3, that is regionally corroborated by a *USSP* parameter estimate with a very short 2-month lag. Similar to what Reyna Cerecero, Salgado Cavazos, and Salazar Bando (2008) documents for the national economy, the negative sign suggests that an inverted yield curve in the United States also precedes a metropolitan downturn in Ciudad Juarez. The final coefficient reported is that for a 7-month lag of the metropolitan recession indicator. It confirms a notable degree of business cycle inertia for this urban economy.

The in-sample estimation results align well with what is hypothesized about the Ciudad Juarez business cycle. The complementary roles of *USSP* and *REX*, in conjunction with *MXSP*, for modeling recession likelihoods for this border economy are also confirmed. Contrary to what is documented using quarterly data (Fullerton and Sáenz-Rojo, 2018), the monthly frequency data results in this study imply that peso currency depreciations lead to local economic expansion. The latter may be a consequence of the predominant role of export manufacturing in Ciudad Juarez.

Although the in-sample estimation outcomes are encouraging, in-sample simulations are also deployed as an additional means for examining model reliability. When a model simulation value exceeds 0.5, it indicates that there is better than a 50 percent chance of a recession occurring. As shown in Figure 2, the simulations provide early warning signals for three of the four recessions that occur before 2010, but not for the two downturns that occur after 2010. For the latter downturns, the simulated probabilities do not even reach 0.3. Four circumstances likely contribute to the poor post-2010 simulation performances.

FIGURE 2
RECESSION PROBABILITY SIMULATION OUTCOMES



Notes:
Ciudad Juarez recession probabilities result from simulations using the output shown in Table 3.
Ciudad Juarez recession probabilities are graphed using the blue colored line.
Orange shading identifies months when the Ciudad Juarez economy is in recession.
Source: Author calculations using UTEP Border Region Modeling Project data.

One is that the 2010 to 2012 commercial economic performance in northern Mexico was adversely affected by narcotics-related violence during the administration of President Felipe Calderon (Trevino and Genna, 2017). A second is the U-shaped yield curve that existed for much of 2019 in the United States due to unconventional monetary policy actions and non-macroeconomic developments (Kucera, 2020). A third is the 2020 to 2021 lockdown impacts of anti-pandemic measures on commercial activities across northern Mexico (Robles-Robles, Romero-Espinoza, and Romero-Vivar, 2021). All of these events caused temporary departures from the normal linkages between Ciudad Juarez economic conditions and *MXSP*, *USSP*, and *REX* subsequent to 2010.

A fourth potential factor is the growing importance of tertiary sector activities in this urban economy. That development may necessitate eventual modification of the index to reflect an urban economy that is less industrial in nature. At present, the commercial time series data for northern Mexico that would allow taking that step within a formal quantitative framework are not available. Accordingly, judgement will continue to play a central role in any attempt to define metropolitan economic business cycle dates throughout Mexico.

A final factor may also affect the post-2010 simulations. Both of the downturns exhibit shorter durations than what has, historically, been documented for Ciudad Juarez. Shorter duration recessions are empirically more difficult to distinguish from noise in the data as well as to simulate accurately.

Conclusion

Metropolitan business cycle downturn prediction is not very widely studied. That is particularly the case in Latin America due various types of time series data constraints. As has been done for various regions facing similar data shortages within the United States, this study examines predictability of urban economic recession predictability for Ciudad Juarez, Chihuahua, Mexico. Ciudad Juarez is an important manufacturing center located directly on the border with the United States. A dynamic probit modeling methodology is employed for the analysis.

In contrast to earlier research for northern Mexico, monthly data are utilized instead of quarterly data. Estimation results confirm prior research indicating that several financial variables enable quantifying the likelihood that a downturn will occur. Those variables include a Mexico interest rate yield spread, a United States yield spread, and a real exchange index. The estimation results support the various hypotheses associated with the model.

Although the estimation results are encouraging, the simulation outcomes are not as successful. The model does fairly well predicting the four recessions that occur prior to 2010. The relatively short durations of the 2011 (four months) and 2019-2020 (seven months) downturns may contribute to the lesser success documented for the latter part of the sample period. A more prominent services sector may also play a role in the latter period simulation outcomes. To examine if these outcomes are unique to Ciudad Juarez, additional testing for other northern border economies in Mexico may be a useful step to execute.

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Borderplex Historical Data to 2018

UTEP is pleased to announce the 2020 edition of its primary source of Borderplex long-term historical economic information. Topics covered include demography, employment, personal income, retail sales, residential real estate, transportation, international commerce, and municipal water consumption. These data comprise the backbone of the UTEP Border Region Econometric Model developed under the auspices of a corporate research gift from El Paso Electric Company and maintained using externally funded research support from El Paso Water and Hunt Communities.

The authors of this publication are UTEP Professor & Trade in the Americas Chair Tom Fullerton and UTEP Border Region Modeling Project Associate Director & Economist Steven Fullerton. Dr. Fullerton holds degrees from UTEP, Iowa State University, Wharton School of Finance at the University of Pennsylvania, and University of Florida. Prior experience includes positions as Economist in the Executive Office of the Governor of Idaho, International Economist at Wharton Econometrics, and Senior Economist at the Bureau of Economic and Business Research at the University of Florida. Steven Fullerton has published research on Major League Baseball, the National Football League, and housing price fluctuations in Las Cruces.

The border long-range historical data reference can be purchased for $20 per copy. Please indicate to what address the report(s) should be mailed (also include telephone, fax, and email address):

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Borderplex Long-Term Economic Trends to 2049

UTEP is pleased to announce the 2020 edition of its primary source of long-term structural trend border economic information. Topics covered include demography, employment, personal income, retail sales, residential real estate, transportation, international commerce, and municipal water consumption. Forecasts are generated utilizing the 250-equation UTEP Border Region Econometric Model developed under the auspices of a corporate research gift from El Paso Electric Company and maintained using externally funded research support from El Paso Water and Hunt Communities.

The authors of this publication are UTEP Professor & Trade in the Americas Chair Tom Fullerton and UTEP Border Region Modeling Project Associate Director & Economist Steven Fullerton. Dr. Fullerton holds degrees from UTEP, Iowa State University, Wharton School of Finance at the University of Pennsylvania, and University of Florida. Prior experience includes positions as Economist in the Executive Office of the Governor of Idaho, International Economist at Wharton Econometrics, and Senior Economist at the Bureau of Economic and Business Research at the University of Florida. Steven Fullerton has published research on Major League Baseball, the National Football League, and housing price fluctuations in Las Cruces.

The border long-range outlook through 2049 can be purchased for $25 per copy. Please indicate to what address the report(s) should be mailed (also include telephone, fax, and email address):

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The UTEP Border Region Modeling Project & Editorial UACJ

Announce the Availability of

Basic Border Econometrics

The University of Texas at El Paso Border Region Modeling Project is pleased to announce **Basic Border Econometrics**, a publication from Universidad Autónoma de Ciudad Juárez. Editors of this new collection are Martha Patricia Barraza de Anda of the Department of Economics at Universidad Autónoma de Ciudad Juárez and Tom Fullerton of the Department of Economics & Finance at the University of Texas at El Paso.

Professor Barraza is an award winning economist who has taught at several universities in Mexico and has published in academic research journals in Mexico, Europe, and the United States. Dr. Barraza currently serves as Research Provost at UACJ. Professor Fullerton has authored econometric studies published in academic research journals of North America, Europe, South America, Asia, Africa, and Australia. Dr. Fullerton has delivered economics lectures in Canada, Colombia, Ecuador, Finland, Germany, Japan, Korea, Mexico, the United Kingdom, the United States, and Venezuela.

Border economics is a field in which many contradictory claims are often voiced, but careful empirical documentation is rarely attempted. **Basic Border Econometrics** is a unique collection of ten separate studies that empirically assess carefully assembled data and econometric evidence for a variety of different topics. Among the latter are peso fluctuations and cross-border retail impacts, border crime and boundary enforcement, educational attainment and border income performance, pre- and post-NAFTA retail patterns, self-employed Mexican-American earnings, maquiladora employment patterns, merchandise trade flows, and Texas border business cycles.

Contributors to the book include economic researchers from the University of Texas at El Paso, New Mexico State University, University of Texas Pan American, Texas A&M International University, El Colegio de la Frontera Norte, and the Federal Reserve Bank of Dallas. Their research interests cover a wide range of fields and provide multi-faceted angles from which to examine border economic trends and issues.

A limited number of **Basic Border Econometrics** can be purchased for $10 per copy. Please contact Lic. Luz de Lourdes Ortiz Quintana of Universidad Autónoma de Ciudad Juárez at luz.ortiz@uacj.mx to order copies of the book.

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Most ***UTEP BRMP Technical Reports*** and ***Borderplex Economic Outlook*** reports, can be downloaded for free from the University of Texas at El Paso Library: https://scholarworks.utep.edu/border_region/

BORDER REGION MODELING PROJECT TECHNICAL REPORT

The UTEP Border Region Modeling Project (BRMP) is a research unit within the Department of Economics & Finance at the Woody L. Hunt College of Business of The University of Texas at El Paso. The *Border Region Modeling Project Technical Report* series publishes research of topical interest to the Borderplex regional economy. BRMP first published the *Technical Report* in January 1997. In addition to the *Technical Report* series, BRMP also publishes *Borderplex Economic Outlook* reports, the monthly *Borderplex Business Barometer*, and the quarterly *Mexico Consensus Economic Forecast*. Additional information regarding BRMP research and business cycle monitoring efforts are available at: https://www.utep.edu/business/border-region-modeling-project/index.html. The BRMP mailing address is: Border Region Modeling Project - CBA 236, UTEP Department of Economics & Finance, 500 West University Avenue, El Paso, TX 79968-0543, USA, (915) 747-7775.