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Borderplex Bridge and Air Econometric Forecast Accuracy

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ABSTRACT

El Paso, Texas and Ciudad Juárez, Mexico jointly comprise a large cross-border metropolitan economy. El Paso is an important port-of-entry for international cargo, as well as a key transit point for regional trade flows in the southwestern United States. Reflective of those traits, the borderplex econometric forecasting system includes two blocks of transportation equations. One sub-system models northbound surface traffic across the international bridges from Ciudad Juárez. The other deals with passenger, cargo, and mail flows at El Paso International Airport. To gauge model reliability, an analysis of borderplex transportation variable forecast accuracy relative to a random walk benchmark is completed. Empirical evidence is mixed with respect to model precision for the 1998-2003 sample period for which data are currently available.

Keywords: Econometric Forecasts, Air Transportation, Border Economics

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1. INTRODUCTION

Given the historical importance of regional and international trade flows through El Paso, Texas, transportation variables have formed part of the borderplex econometric model from its inception in 1997. Currently comprised by 218 individual equations, two sets of transportation equations are included in the borderplex model (Fullerton 2001). One block of transportation equations is for northbound traffic categories on the international bridges connecting El Paso with Ciudad Juárez, Mexico. Another sub-system models passenger, cargo, and mail flows at El Paso International Airport.

Short-term cyclical forecasts of borderplex business and economic conditions have been generated using the model from 1998 forward (for a recent example, see Fullerton and Tinajero 2003). The out-of-sample forecast period for transportation variables included in these publications is three years in length. For some other variables, the effective simulation period is longer due to lags in data collection and dissemination. When missing values for the last historical period of any series occur, the model is simulated to provide estimates of the missing observations for those variables. Data release delays occasionally contribute to that circumstance. To date, formal prediction accuracy assessments have not been conducted for the transportation variables included in the border region system of simultaneous equations.

Material below examines the accuracy of the borderplex transportation variable forecasts published for the years between 1998 and 2003. Predictive accuracy is assessed relative to a random walk benchmark. Subsequent sections of the paper include short discussions of regional econometric forecasting research, borderplex model attributes, and an empirical analysis of transportation forecast accuracy between 1998 and 2003. A summary and suggestions for future research are provided in the conclusion.

2. REGIONAL AND BORDER ECONOMETRIC FORECASTING RESEARCH

Structural model forecasting analysis for regional and national economies can be traced back to 1936 (Dhane and Barten 1989). Overall design flexibility has made it a widely employed tool for corporate planning efforts and public policy analysis. Structural models have been applied to a wide variety of regional and metropolitan economies in the United States, Europe, and Asia (Klein 1969; Bolton 1985; Kim 1995; Hunt and Snell 1997). Since 1997, one such model has been utilized to simulate economic and business conditions in the cross-border regional economy comprised by El Paso, Texas; Las Cruces, New Mexico; Ciudad Juárez, Mexico; and Ciudad Chihuahua, Mexico (Fullerton 2001).

Out-of-sample forecasting accuracy and simulation analyses have been proposed by several authors as important tools for assessing econometric model reliability (Leamer 1983; West 1995; Granger 1996; McCloskey and Ziliak 1996). Out-of-sample forecasts

are model simulations that go beyond the end of the sample period for which historical data are available. A growing number of studies have carried out efforts of this nature for the regional class of structural equation models (West and Fullerton 1996; Fullerton and West 1998; Fullerton, Luevano, and West 2000; Lenze 2000; Fullerton, Laaksonen, and West 2001; West 2003). Those studies indicate that regional forecasts for many variables such as employment, income, and population are relatively accurate. Regional housing activity forecast track records to date, however, are less successful.

Infrastructure planning efforts have long required systematic forecasting efforts for transportation systems. Numerous methodologies have been examined over the years (Schneider 1975; Beenstock and Vergottis 1989; Matthews 1995; Caves 1997; Dennis 2002). To date, relatively few regional transportation forecasting programs have been examined for historical accuracy. This gap in the literature is partially addressed in this paper by examining the accuracy of borderplex air and bridge traffic forecasts published between 1998 and 2003.

Figure 1 depicts the basic strategy deployed in the borderplex system of simultaneous equations. In addition to being affected by national economic trends in the United States, El Paso is also affected by national business cycle fluctuations in Mexico, as well as regional business cycles in Ciudad Juárez. The reverse circumstance also holds true for Ciudad Juárez. Consequently, individual equation specifications in the model may contain national macroeconomic, domestic regional, international macroeconomic, and/or cross-border metropolitan variables (Fullerton 2001).

Recent economic history along the Mexican border in Texas succinctly reflects the attributes shown in Figure 1. The "Tequila Effect" peso devaluation of December 1994 precipitated a severe loss in Mexican consumer purchasing power that led to a decline in international bridge crossings and a reduction in retail sales in El Paso (Fullerton 1998; Fullerton 2000). Macroeconomic shocks on the north side of the border also impact the local economy. The United States recession of 2001 hurt manufacturing plants throughout the borderplex. In response to that, plus a changed inspection environment subsequent to 11 September 2001, cargo vehicle traffic from Mexico sagged (Fullerton and Tinajero 2002).

The borderplex model is used for a variety of purposes. The most important is regional business trend monitoring and econometric forecasting analysis. While there are a small number of commercially available forecasts for El Paso County (Leppold 2002; Shankar 2003), those efforts generally ignore cross-border business conditions and omit transportation flows. The model is also used in a variety of public policy analysis exercises such as the provision of simulation data utilized in testimony provided to Texas State Senate committees regarding local income trends and NAFTA adjustment efforts. Local governmental units and public utilities have engaged a series of annual contracts with the University of Texas at El Paso Border Region Modeling Project for special simulation exercises designed to assist infrastructure planning efforts. Access to

comprehensive forecasts involving both sides of the border developed using a common set of exogenous variable assumptions are critical to those endeavors.

To accomplish the aforementioned goals, sectoral coverage in the model is necessarily broad. Twelve separate equation blocks are utilized. They include demographics, employment, personal income, labor earnings, disaggregated retail sales, residential real estate, nonresidential construction, maquiladora activity, northbound international border crossings, air transportation, water consumption, and regional bankruptcy trends. The structure of the model is contains numerous direct and indirect feedback loops connecting the various equation blocks (Fullerton 2001). Because annual data are employed, lag structures are fairly short in all of the different blocks. They are confirmed every year via goodness-of-fit tests.

The current version of the border forecasting system contains 218 equations offering at least partial detail for each of the twelve different blocks of endogenous equations. Statistical output for the econometric equations currently comprising the borderplex model are available from the author. Included in the 218 equations are 40 identities and 178 stochastic equations. Over the years, some equation specifications have remained unchanged, while multiple variations have been tested for others. Specification updates may arise due to new data acquisitions, alternative possibilities identified in the literature, and/or as a consequence of previous relationships not performing well following the annual data bank updates and parameter re-estimation exercises. Heightened security inspection efforts and post-9/11 travel disruptions also caused equation modifications in both 2002 and 2003. Of the 178 fitted results ultimately selected every year, most exhibit good statistical traits, but nearly all contain at least partial design and/or empirical flaws.

Serial correlation correction techniques are required in 51 of the 178 regression equations. Three categories of data generating processes are observed in the affected residual series: 18 autoregressive, 28 moving average, and 5 mixed autoregressive-moving average sets of parameters are employed. Given the variety of autocorrelation processes involved, parameter estimation is accomplished using a nonlinear ARMAX procedure (Pagan 1974). That more than one-fourth of all the border model stochastic specifications require serial correlation correction in part reflects widespread data constraints that have long affected regional econometric modeling efforts. Unavailable data series occasionally prevent some systematic variation in dependent variables from being handled as satisfactorily as well as they can be in macroeconometric models (Fullerton and West 1998). As with national econometric models, persistence effects probably also contribute to the prevalence autocorrelation in borderplex equation residuals (Fair 1984; Campbell and Mankiw 1987).

Table 1 lists and describes the variables included in the transportation blocks of the border model. Empirical summaries for all of the air and bridge equation parameter estimates are reported in Table 2. Border Region Modeling Project historical data used to estimate those blocks of equations can be accessed via the University of Texas at El Paso

College of Business Administration web site (www.utep.edu). The statistical diagnostics for these two groups of equations worsened notably once 2001 observations were included in the historical sample set in 2002. That circumstance continued in 2003 even after 2002 data became available. Most notably, the 18 stochastic equations include 22 separate slope coefficients that fail to satisfy the 5-percent significance criterion. It is anticipated that this development is temporary and will eventually fade as the aftermath of the 11 September 2001 air travel and border disruptions dissipates.

Air transportation activities are usually omitted from multi-equation regional econometric forecasting systems. The borderplex model partially overcomes this customary gap with a 12-equation sub-system encompassing air passenger, freight, and mail flows through the El Paso International Airport. Domestic passenger arrivals and departures are modeled as functions of metropolitan real wage and salary disbursements and a real price variable for air travel (Howry 1969). International passenger traffic flows are dependent upon the inflation-adjusted value of the peso and the relative price index for air transportation (González and Moral 1995). As shown in Equations 1 through 12 of Table 2, a combination of national and border region variables are used to model both freight and airmail shipments and deliveries.

International bridge traffic from Mexico is modeled with a block of eleven equations, eight of which are stochastic. Coverage in this portion of the model is confined to northbound border commuting across the three bridges that are within the El Paso city limits and excludes other regional crossings data as a consequence of time series information constraints. Merchandise trade statistics for El Paso extend back only to 1993, precluding the estimation of trade flow equations that might otherwise be of interest to policy analysts and corporate planners. Three categories of traffic flows are included in the current version of the border model: pedestrians, personal automobiles, and cargo vehicles. Greater than 9 million pedestrians, 11 million light vehicles, and 700 thousand cargo vehicles crossed the border using these arteries in 2001 (Fullerton and Tinajero 2003). Not surprisingly, a mixture of national and international exogenous variables, plus border region endogenous data, is used in the specifications shown in Equations 13 through 23 in Table 2 (Sawyer and Sprinkle 1986; Cobb, Molina, and Sokulsky 1989; Fullerton 2001).

In addition to the transportation endogenous variables that are analyzed for historical predictive accuracy, air travel and air mail price indices are also included in the borderplex model. Similar to other equations in the transportation blocks of the model, their respective empirical traits continued to be acceptable in both 2002 and 2003. Curiously, however, the estimated parameter for the autoregressive lag of the mail price index is not statistically significant. Given the nature of postal service price increases, the partial adjustment specification is probably correct. Prior to 2003, it obtained better estimation results for the lagged dependent variable regression coefficient.

3. HISTORICAL ACCURACY ASSESSMENT: 1998 – 2003

The preceding section provides descriptive insights with respect to the overall structure of the borderplex model. It does not shed any light with respect to its general forecast reliability for the transportation equations. To examine this question, a straightforward accuracy assessment is devised along the regional modeling guidelines proposed by West (1995). Historically, extrapolations from univariate ARIMA equations are regarded as the most reliable benchmarks against which structural model performance should be measured (Granger 1996). Because annual data are employed in the border model, small sample sizes preclude estimating ARIMA equations.

To circumvent that obstacle, random walk projections are used to provide the backdrop against which the previously published structural model forecasts are compared. As illustrated by Figures 2 and 3, variable growth rates are observed for many borderplex transportation series during the sample period under consideration. Given that, the random walks employed utilize only the last historical observation available for each variable. While apparently simple, this type of benchmark has proven surprisingly effective in other regional forecasting contexts where sawtooth growth patterns occur (Fullerton, Laaksonen, and West 2001). The 1998 – 2003 outlook publications allow assembling the original data for each dependent variable, thus avoiding the common problem of inadvertently handicapping the structural simulations when revised data must be utilized to generate the random walk forecasts (West and Fullerton 1996).

Three-year forecasts are simulated and published for all of the transportation variables using the borderplex model every year. Those data are reported in Table 3. The forecasts are *ex ante*, dynamic simulations and do not employ historical data for the right-hand-side variables. National consultant service subscriptions provide forecast data for United States and Mexico macroeconomic variables used as exogenous regressors (Alemán 2003; Behravesh, Hodge, and Latta. 2003; Zandi 2003). For the 1998 – 2003 sample period, this allows 15 observations to be assembled for each of the air and bridge dependent variables of interest.

The previously published forecasts for each transportation variable are compared to random walk benchmarks. As shown for four representative variables in Table 3, both sets of 3-year forecasts are printed in order of publication. Accordingly, prediction data for 1998, 1999, and 2000 are followed by similar numbers for 1999, 2000, and 2001, next, and so forth. For the last two sets of previously published forecasts, only two and one historical data points are currently available for accuracy comparisons. Accuracy measures applied to the data include root mean square error statistics (RMSEs) and Theil inequality coefficients, also known as U-statistics (Pindyck and Rubinfeld 1998). U-statistics can take values between 0 and 1. A value of 0 indicates a perfect fit. For the covariance proportions of the prediction error second moments, the optimal values are 0,

0, and 1. Specific information on the calculation of those measures is provided in the Appendix.

Predictive accuracy results for air passenger traffic, air freight, and airmail flows in and out of El Paso International Airport are summarized in Table 4. Passenger traffic variables analyzed for out-of-sample forecast precision include in-bound passengers from domestic flights originating in United States, in-bound passengers from international flights originating outside of the United States, out-bound passengers to domestic destinations in the United States, out-bound passengers to international destinations outside of the United States. The other stochastic equation series examined include in-bound freight, out-bound freight, in-bound mail, and out-bound mail.

In Table 4, the first row for each variable contains the structural model predictive summary statistics and the second row reports the same estimates for the random walk extrapolations. With the exception of the airmail series, U-statistics close to 0 are obtained for both sets of airport activity forecasts. Examination of the second moment prediction error proportions reveals that the passenger variable structural model forecasts tend to be biased, but the same problem afflicts the random walk counterparts for those series. Similar to the regional housing starts results obtained for Florida (Fullerton and West 1998; Fullerton, Luevano, and West 2000), the borderplex model passenger forecasts obtain higher U-statistic values than do their respective random walk alternatives.

In contrast, the structural model air cargo and airmail variables also analyzed in Table 4 obtain U-coefficients that are lower than those of their respective random walk counterparts. Those outcomes are more in line with regional results previously obtained for variables such as employment, population, or personal income (West and Fullerton 1996; Lenze 2000). Interestingly, the distributions of the inequality coefficient second moment proportions (U-bias, U-variance, U-covariance) are much closer to the optimum 0, 0, 1 distribution for the non-passenger variables. Those improvements, however, are observed for the structural model and random walk data alike.

Table 5 reports the accuracy estimates for the international bridge data included as part of the borderplex modeling system. For the eight series modeled, results point to superior accuracy by the random walk benchmarks in only two cases. Both of those cases, however, involve cargo vehicle traffic, an increasingly important traffic category as trade liberalization occurs under the auspices of NAFTA (Orrenius, Phillips, and Blackburn 2001; Fullerton and Tinajero 2002). For both sets of cargo vehicle structural forecasts, bias is indicated to be a problem in Table 5. Additional testing is obviously warranted for the specifications associated with both of the bridge cargo econometric specifications.

Results in Table 5 for the pedestrian and personal vehicle traffic flows from Ciudad Juárez to El Paso all point to relatively better simulation precision by the econometric model. Those outcomes are encouraging because both categories influence

retail sales performance in El Paso in noticeable manners and represent key indicators for the regional economy (Fullerton 2001). Personal vehicles are also important in terms of emissions impacts on the environment (Roderick 1993; Funk et al. 2001). As with earlier documented regional employment and income results (West and Fullerton 1996; Fullerton, Tinajero, and Waldman 2004), outcomes shown in Table 5 indicate that borderplex model forecasts of automobile and pedestrian categories of northbound bridge traffic are accurate relative to random walk benchmarks. These results are encouraging because simulations from the model are being used in transportation planning exercises conducted by the El Paso Metropolitan Planning Organization. The presence of bias in two of the pedestrian and two of the automobile sets of forecasts indicates, however, that even these equations experience simulation flaws.

Due to the small numbers of similar studies for regional transportation forecasting efforts and for other border economies, it is hard to assess whether the outcomes shown in Tables 4 and 5 are unique to the borderplex economy. Given their relatively high U-coefficients, caution should be exercised with respect to using the out-of-sample air passenger and bridge cargo forecasts published using the borderplex model. At a minimum, subscribers and other users should use the latest available historical observations as "sanity checks" for those extrapolations (Fullerton and West 1998). Although the random walk approach using the latest historical observations has been presented herein as a competitive benchmark, practice has shown that the information content of random walk forecasts frequently complements that contained in structural model counterparts (Granger 1996). Over time, it will become possible to assess whether structural model simulation reliability improves for these variable categories.

4. CONCLUSION

Transportation variables have formed integral components of the borderplex econometric forecasting effort from its inception in 1997. Included among the 218 equations in the border model are two blocks of transportation equations. The latter cover international bridge crossings from Ciudad Juárez as well as air traffic activity at El Paso International Airport. To examine out-of-sample forecast reliability, extrapolation accuracy is examined for those variables during the 1998 – 2003 period.

Results indicate that the air freight, airmail, bridge auto, and bridge pedestrian series forecasts are somewhat more accurate than random walk benchmarks over the course of the sample period in question. Outcomes for the air passenger and bridge cargo simulations are less encouraging. In each of those cases, the random walk benchmarks obtain lower root mean square error statistics and Theil inequality coefficients. Care should be exercised when assessing the usefulness of forecasts for those variables. Future forecasts for those variables should probably be compared to the last available historical observations for each of them, respectively. That step can potentially help insure that the model simulations do not stray too far what might be reasonably expected during multi-step prediction periods.

Border region econometric forecasting analysis is still a relatively new endeavor. As additional outlooks are published, greater numbers of observations will eventually permit more formal testing to be engaged. The sample utilized herein is also geographically limited in scope. Replication for other border areas such as San Diego – Tijuana and Laredo – Nuevo Laredo would be helpful. Should similar efforts be carried out for other international metropolitan economies, evidence obtained for the borderplex indicates that transportation forecasting accuracy can be achieved in some cases. Because accuracy relative to random walk benchmarks is not achieved for all of the variables examined, evidence from other regions will help document whether that is a problem specific to the borderplex, or one that is general in nature.

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6. APPENDIX

Equation (A1) shows how the RMSEs are computed. In (1), Y^s is the forecast value for variable Y, Y^a is

$$\text{RMSE} = \sqrt{\frac{1}{T}\sum_{t=1}^{T}(Y_t^s - Y_t^a)^2} \tag{A1}$$

the actual historical value for Y, and T is the total number of forecasts for Y.

Equation (A2) provides the details for calculating the U-statistics. The

$$U = \frac{\sqrt{\frac{1}{T}\sum_{t=1}^{T}(Y_t^s - Y_t^a)^2}}{\sqrt{\sum_{t=1}^{T}(Y_t^s)^2} + \sqrt{\sum_{t=1}^{T}(Y_t^a)^2}} \tag{A2}$$

denominator in (A2) causes inequality coefficients to vary between 0 and 1. When U=0, $Y_t^s = Y_t^a$ for all *t* and a perfect fit is obtained. At the other extreme, if U=1, the predictive performance of the model cannot be any worse (Pindyck and Rubinfeld, 1998).

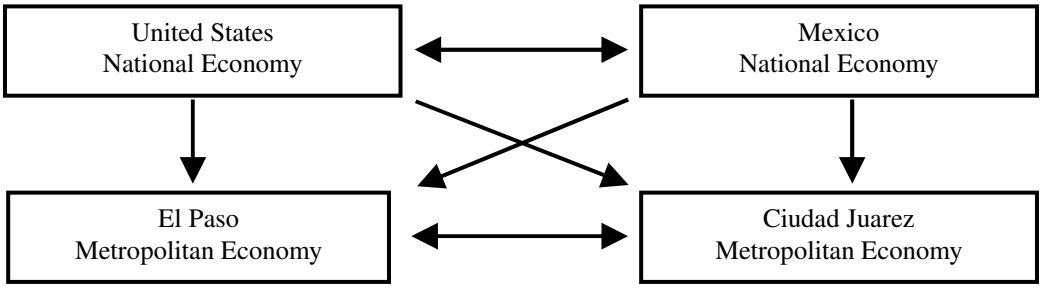
Equation (A3) illustrates and the formulae for the second moment inequality proportions. U^M, U^S, and U^C represent bias, variance, and covariance proportions,

$$U^M = \frac{(\overline{Y}_t^s - \overline{Y}_t^a)^2}{(1/T)\sum_{t=1}^{T}(Y_t^s - Y_t^a)^2}, \qquad U^S = \frac{(\sigma_s - \sigma_a)^2}{(1/T)\sum_{t=1}^{T}(Y_t^s - Y_t^a)^2}, \qquad \text{and}$$

$$U^C = \frac{2(1-\rho)\sigma_s\sigma_a}{(1/T)\sum_{t=1}^{T}(Y_t^s - Y_t^a)^2} \qquad \text{(A3)}$$

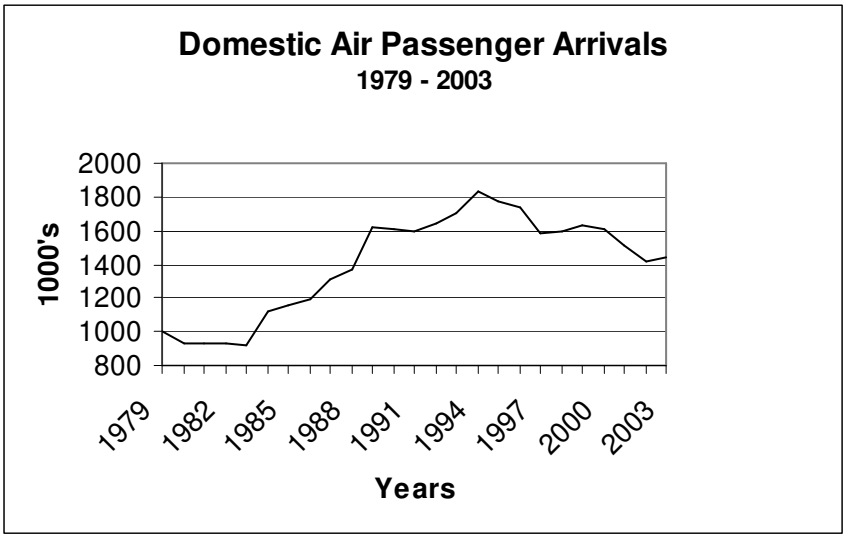
respectively, of the second moment of the prediction errors (Theil 1961). The bias proportion measures the extent to which the average values of the simulated and actual series deviate from each other. It thus provides an indication of systematic error. Optimally, the bias proportion will approach zero. The variance proportion indicates the ability of the model to replicate the degree of variability in the variable of interest. Again, as simulation performance improves, the variance proportion approaches zero. The covariance proportion measures unsystematic error. As simulation accuracy improves, the covariance proportion approaches one. As noted by Theil (1961), the optimal distribution of the second moment inequality proportions is $U^M = 0$, $U^S = 0$, and $U^C = 1$.

FIGURE 1 Borderplex Model Design



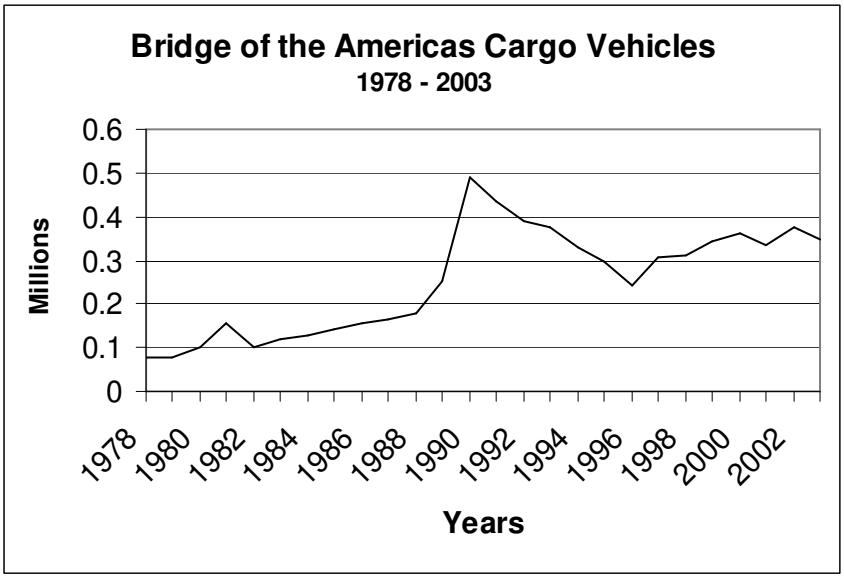
Borderplex Bridge and Air Econometric Forecast Accuracy
Figure 1

FIGURE 2 Borderplex Air Activity



Borderplex Bridge and Air Econometric Forecast Accuracy
Figure 2

FIGURE 3 Borderplex Bridge Activity



Borderplex Bridge and Air Econometric Forecast Accuracy
Figure 3

TABLE 1 Borderplex Model Variables and Equation Statistics

Series	Description
Endogenous Variables	
AIRP	United States Air Travel Price Index, 1982-1984 = 100
ELAFDT	El Paso International Airport In-Bound Freight Shipments, 1000 tons
ELAFET	El Paso International Airport Out-Bound Freight Shipments, 1000 tons
ELAMD	El Paso International Airport In-Bound U.S. Mail, 1000 tons
ELAME	El Paso International Airport Out-Bound U.S. Mail, 1000 tons
ELBAC	Bridge of the Americas Northbound Light Vehicle Traffic, Millions
ELBAT	Bridge of the Americas Northbound Cargo Vehicle Traffic, Millions
ELBAW	Bridge of the Americas Northbound Pedestrian Traffic, Millions
ELBPC	Paso del Norte Northbound Light Vehicle Bridge Traffic, Millions
ELBPW	Paso del Norte Northbound Pedestrian Bridge Traffic, Millions
ELBTC	Total Northbound Light Vehicles, Millions
ELBTT	Total Northbound Cargo Vehicles, Millions
ELBTW	Total Northbound Pedestrians, Millions
ELBYC	Ysleta-Zaragoza Northbound Light Vehicle Bridge Traffic, Millions
ELBYT	Ysleta-Zaragoza Northbound Cargo Vehicle Bridge Traffic, Millions
ELBYW	Ysleta-Zaragoza Northbound Pedestrian Bridge Traffic, Millions
ELAPDD	El Paso International Airport Domestic Passenger Arrivals, 1000s
ELAPDI	El Paso International Airport International Passenger Arrivals, 1000s
ELAPDT	El Paso International Airport Total Passenger Arrivals, 1000s
ELAPED	El Paso International Airport Domestic Passenger Departures, 1000s
ELAPEI	El Paso International Airport International Passenger Departures, 1000s
ELAPET	El Paso International Airport Total Passenger Departures, 1000s
MAILP	United States Air Mail Price Index, 1996 = 100
Exogenous Variables	
CESTRNPI	U.S. Consumption Expenditures, Intercity Travel, Billion $
CJMQM	Ciudad Juárez Maquiladora Employment, 1000s
CJPOP	Ciudad Juárez Jluy 1 Population, 1000s
DV911	Airport & Bridge Inspection Dummy Var. = 1 for 2001, 2002, …
ELBDC	Dedicated Commuter Lane Northbound Light Vehicles, Millions
ELGMP96	El Paso Gross Metropolitan Product, Billion 1996 $
ELPPOP	El Paso July 1 Population, 1000s
ELYLP	El Paso Labor & Proprietor Earnings, Million $
ELYWSD	El Paso Wage & Salary Disbursements, Million $
GDP96	United States Gross Domestic Product, Billion 1996 $

MXREX	Mexico, Real Exchange Rate Index, Peso/$, 1997 = 100
PDCCESTRNPI	United States Intercity Chained Travel Deflator, 1996 = 100
PDCGDP	United States GDP Chained Price Deflator, 1996 = 100

Equation Statistics

SUM SQ	Error Sum of Squares
STD ERR	Standard Error of Regression
LHS MEAN	Left Hand Side Dependent Variable Sample Mean
R SQ	R-Squared Coefficient of Determination
R BAR SQ	Adjusted R-Squared Coefficient of Determination
F	F Statistic for Joint Slope Coefficient Equality to Zero Hypothesis
DW	Durbin Watson Serial Correlation Statistic
H	Durbin H Lagged Dependent Variable Serial Correlation Statistic

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Borderplex Bridge and Air Econometric Forecast Accuracy
Table 1

TABLE 2 Borderplex Bridge and Air Equation Estimation Results

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Equations 1 – 2 are Air Transportation Identities
Equations 3 – 12 are Air Transportation Stochastic Equations

Equation 1 Air Passengers, Total Departures, 1000s

ELAPET = ELAPED + ELAPEI

Equation 2 Air Passengers, Total Arrivals, 1000s

ELAPDT = ELAPDD + ELAPDI

Equation 3 Air Travel Price Index, 1982-1984 = 100

AIRP = f(AIRP.1,PDCGDP)

Ordinary Least Squares, Annual data for 39 periods from 1964 to 2002

airp = 0.84754 * airp[-1] + 44.5066 * pdcgdp - 8.24792
(17.0174) (3.72458) (2.51809)

Sum Sq	946.932	Std Err	5.1287	LHS Mean	105.877
R Sq	0.9955	R Bar Sq	0.9952	F 2, 36	3947.49
DW(1)	1.8062	DW(2)	2.5556	H	0.5858

Equation 4 Air Passengers, Domestic Departures, 1000s

ELAPED = f(ELAPED.1, ELYWSD/AIRP, DV911)

Nonlinear Least Squares, Annual data for 22 periods from 1981 to 2002

Elaped = 0.82612 * elaped[-1] + 21.0483 * elywsd/airp
(7.04844) (1.03279)
- 150.688 * dv911 - 324.617
(1.98167) (0.60654)

Sum Sq	128582	Std Err	86.9694	LHS Mean	1482.80
R Sq	0.9322	R Bar Sq	0.9163	F 4, 17	58.4537
DW(1)	2.2001	DW(2)	2.0029	H	-0.6211

AR_0 = 0.27511 * AR_1
(1.06312)

Equation 5 Air Passengers, International Departures, 1000s

ELAPEI = f(ELAPEI.1, MXREX, PDCCESTRNPI/PDCGDP, DV911)

Ordinary Least Squares, Annual data for 23 periods from 1980 to 2002

elapei = 0.49491 * elapei[-1] - 0.19892 * mxrex - 6.81160 * dv911
(3.23979) (2.54669) (1.48202)
- 13.6134 * pdccestrnpi/pdcgdp + 41.6922
(1.15825) (2.61212)

Sum Sq	445.716	Std Err	4.9761	LHS Mean	11.9377
R Sq	0.6691	R Bar Sq	0.5956	F 4, 18	9.1001
DW(1)	1.2223	DW(2)	1.8125	H	0.5157

Equation 6 Air Passengers, Domestic Arrivals, 1000s

ELAPDD = f(ELAPDD.1, CESTRNPI/PDCCESTRNPI, DV911)

Ordinary Least Squares, Annual data for 23 periods from 1980 to 2002

elapdd = 0.91955 * elapdd[-1] + 0.88772 * cestrnpi/pdccestrnpi
(9.43567) (0.16531)
- 121.591 * dv911 + 115.683
(1.57280) (1.13256)

Sum Sq	158515	Std Err	91.3394	LHS Mean	1422.51
R Sq	0.9206	R Bar Sq	0.9080	F 3, 19	73.3817
DW(1)	1.7249	DW(2)	1.6678	H	0.4568

Equation 7 Air Passengers, International Arrivals, 1000s

ELAPDI = f(ELAPDI.1, MXREX, PDCCESTRNPI/PDCGDP)

Ordinary Least Squares, Annual data for 23 periods from 1980 to 2002

elapdi = 0.77877 * elapdi[-1] - 0.11833 * mxrex
(6.00170) (1.89065)
+ 0.21759 * pdccestrnpi/pdcgdp + 14.4671
(0.01736) (1.09570)

Sum Sq	493.062	Std Err	5.0942	LHS Mean	15.3853
R Sq	0.8035	R Bar Sq	0.7725	F 3, 19	25.8982
DW(1)	1.6222	DW(2)	1.7017	H	-0.4845

Equation 8 Air Freight, Outbound, 1000 Tons

ELAFET = f(ELAFET.1, GDP96, DV911)

Ordinary Least Squares, Annual data for 23 periods from 1980 to 2002

elafet = 0.34113 * elafet[-1] + 0.00576 * gdp96 - 6.9705 * dv911
(2.02867) (4.38056) (3.70933)
- 25.2374
(4.19841)

Sum Sq	89.6066	Std Err	2.1717	LHS Mean	20.8295
R Sq	0.9687	R Bar Sq	0.9637	F 3, 19	195.943
DW(1)	1.4562	DW(2)	1.8892	H	2.0793

Equation 9 Air Freight, Inbound, 1000 Tons

ELAFDT = f(ELAFDT.1, ELYLP/PDCCESTRNPI, ELGMP96, DV911)

Ordinary Least Squares, Annual data for 23 periods from 1980 to 2002

elafdt = 0.41934 * elafdt[-1] + 0.00034 * elylp/pdccestrnpi
(4.22055) (0.30584)
+ 5.25436 * elgmp96 - 5.90542 * dv911 - 43.0747
(3.24465) (3.66921) (4.5494)

Sum Sq	62.8499	Std Err	1.9073	LHS Mean	26.7198
R Sq	0.9900	R Bar Sq	0.9871	F 5, 17	337.956
DW(1)	1.8939	DW(2)	2.3568	H	0.1479

MA_0 = - 0.93588 * MA_1
(3.38261)

Equation 10 Air Mail Price Index, 1996 = 100

MAILP = f(MAILP.1, PDCGDP)

Ordinary Least Squares, Annual data for 39 periods from 1964 to 2002

mailp = 0.06430 * mailp[-1] + 32.1832 * pdcgdp - 3.01038
(0.43204) (6.34350) (4.71268)

Sum Sq	21.9588	Std Err	0.7810	LHS Mean	19.2099
R Sq	0.9946	R Bar Sq	0.9943	F 2, 36	3299.64
DW(1)	1.9237	DW(2)	2.1208	H	0.4443

Equation 11 Air Mail, Outbound, 1000 Tons

ELAME = f(ELAME.1, ELGMP96, MAILP/PDCGDP, DV911)

Ordinary Least Squares, Annual data for 28 periods from 1975 to 2002

elame = 0.65473 * elame[-1] + 0.04247 * elgmp96
(3.94033) (1.44456)
- 0.01800 * mailp/pdcgdp - 1.14069 * dv911 + 0.75765
(0.54124) (6.30882) (0.92028)

Sum Sq	1.0553	Std Err	0.2142	LHS Mean	1.7473
R Sq	0.7345	R Bar Sq	0.6883	F 4, 23	15.9039
DW(1)	1.9430	DW(2)	2.1283	H	0.1106

Equation 12 Airmail, Inbound, 1000 Tons

ELAMD = f(ELAMD.1, ELGMP96, MAILP/PDCGDP, DV911)

Ordinary Least Squares, Annual data for 28 periods from 1975 to 2002

elamd = 0.83160 * elamd[-1] + 0.06354 * elgmp96
(6.21740) (0.95369)
+ 0.01042 * mailp/pdcgdp - 1.44147 * dv911 - 0.40496
(0.14702) (3.70439) (0.22777)

Sum Sq	4.8725	Std Err	0.4603	LHS Mean	2.8202
R Sq	0.7252	R Bar Sq	0.6774	F 4, 23	15.1713
DW(1)	1.6837	DW(2)	1.8787	H	1.0486

Equations 13 – 15 are International Bridge Identities
Equations 16 – 23 are International Bridge Stochastic Equations

Equation 13 International Bridges, Total Cargo Vehicles, Millions

ELBTT = ELBAT + ELBYT

Equation 14 International Bridges, Total Light Vehicles, Millions

ELBTC = ELBAC + ELBDC + ELBYC + ELBPC

Equation 15 International Bridges, Total Pedestrians, Millions

ELBTW = ELBAW + ELBYW + ELBPW

Equation 16 Bridge of the Americas, Cargo Vehicles, Millions

ELBAT = f(ELBAT.1, CJMQM, DV911)

Ordinary Least Squares, Annual data for 26 periods from 1977 to 2002

elbat = 0.72275 * elbat[-1] + 0.00042 * cjmqm - 0.01454 * dv911
(5.27650) (1.53320) (0.31027)
+ 0.02716
(1.06493)

Sum Sq	0.0733	Std Err	0.0577	LHS Mean	0.2438
R Sq	0.8138	R Bar Sq	0.7885	F 3, 22	32.0614
DW(1)	1.7214	DW(2)	2.0725	H	0.9385

Equation 17 Bridge of the Americas, Light Vehicles, Millions

ELBAC = f(MXREX, ELPPOP.1+CJPOP.1, DV911)

Ordinary Least Squares, Annual data for 26 periods from 1977 to 2002

elbac = -0.01704 * mxrex + 0.00165 * elppop[-1]+cjpop[-1]
(2.12403) (3.23975)
- 2.44885 * dv911 + 6.78609
(4.05759) (6.36514)

Sum Sq	10.9309	Std Err	0.7049	LHS Mean	7.1934
R Sq	0.4886	R Bar Sq	0.4189	F 3, 22	7.0068
DW(1)	1.6757	DW(2)	1.9535		

Equation 18 Bridge of the Americas, Pedestrians, Millions

ELBAW = f(ELBAW.1, CJMQM, DV911)

Ordinary Least Squares, Annual data for 26 periods from 1975 to 2002

elbaw = 0.36724 * elbaw[-1] + 0.00047 * cjmqm
(2.33034) (1.32460)
+ 0.33277 * dv911 + 0.30128
(3.45088) (2.99741)

Sum Sq	0.3336	Std Err	0.1179	LHS Mean	0.5942
R Sq	0.5671	R Bar Sq	0.5130	F 3, 24	10.4817
DW(1)	1.5787	DW(2)	1.6586	H	0.9508

Equation 19 Paso del Norte Bridge, Light Vehicles, Millions

ELBPC = f(ELBPC.1, ELPPOP.1+CJPOP.1, MXREX, DV911)

Ordinary Least Squares, Annual data for 33 periods from 1970 to 2002

elbpc = 0.50442 * elbpc[-1] + 0.00001 * elppop[-1]+cjpop[-1]
(3.00439) (0.03346)
+ 0.00141 * mxrex - 0.48639 * dv911 + 2.14509
(0.30880) (1.33118) (2.55494)

Sum Sq	5.2607	Std Err	0.4335	LHS Mean	4.5782
R Sq	0.2961	R Bar Sq	0.1955	F 4, 28	2.9441
DW(1)	1.7126	DW(2)	2.4887	H	2.6796

Equation 20 Paso del Norte Bridge, Pedestrians, Millions

ELBPW = f(ELBPW.1, CJMQM, DV911)

Ordinary Least Squares, Annual data for 28 periods from 1975 to 2002

elbpw = 0.59209 * elbpw[-1] + 0.00113 * cjmqm
(4.29580) (0.47648)
+ 1.35238 * dv911 + 1.79973
(2.15409) (2.25472)

Sum Sq	13.9889	Std Err	0.7635	LHS Mean	4.9874
R Sq	0.5408	R Bar Sq	0.4834	F 3, 24	9.4228
DW(1)	1.5463	DW(2)	1.9588	H	1.4861

Equation 21 Ysleta-Zaragoza Bridge, Cargo Vehicles, Millions

ELBYT = f(ELBYT.1, CJMQM, MXREX, DV911)

Ordinary Least Squares, Annual data for 33 periods from 1970 to 2002

elbyt = 0.89245 * elbyt[-1] + 0.00033 * cjmqm - 0.00046 * mxrex
(10.9453) (2.39713) (1.60623)
- 0.04697 * dv911 + 0.03436
(2.17479) (1.33619)

Sum Sq	0.0180	Std Err	0.0253	LHS Mean	0.1041
R Sq	0.9691	R Bar Sq	0.9646	F 4, 28	219.208
DW(1)	1.6956	DW(2)	2.4523	H	0.9429

Equation 22 Ysleta-Zaragoza Bridge, Light Vehicles, Millions

ELBYC = f(ELBYC.1, CJPOP.1, DV911)

Nonlinear Least Squares, Annual data for 28 periods from 1975 to 2002

elbyc = 0.73020 * elbyc[-1] + 0.00109 * cjppop[-1]
(4.67118) (2.31758)
- 0.27012 * dv911 + 0.17834
(1.59233) (1.39335)

Sum Sq	0.7507	Std Err	0.1769	LHS Mean	2.2453
R Sq	0.9585	R Bar Sq	0.9533	F 3, 24	184.796
DW(1)	1.5615	DW(2)	2.0065	H	1.9514

Equation 23 Ysleta-Zaragoza Bridge, Pedestrians, Millions

ELBYW = f(ELBYW.1, MXREX, CJMQM, DV911)

Ordinary Least Squares, Annual data for 33 periods from 1970 to 2002

elbyw = 0.82936 * elbyw[-1] + 0.00143 * mxrex
(7.42629) (2.26824)
+ 0.00020 * cjmqm + 0.25096 * dv911 - 0.11255
(0.83996) (5.25357) (1.92377)

Sum Sq	0.0931	Std Err	0.0577	LHS Mean	0.2314
R Sq	0.9226	R Bar Sq	0.9116	F 4, 28	83.4640
DW(1)	2.0700	DW(2)	1.9894	H	-1.0059

Borderplex Bridge and Air Econometric Forecast Accuracy
Table 2

TABLE 3 Borderplex Transportation Historical and Forecast Data

Year	Actual Data	Structural Model Forecast	Random Walk
Domestic Passenger Air Arrivals, 1000s			
1998	1590.138	1627.300	1600.500
1999	1631.010	1677.700	1600.500
2000	1611.738	1729.600	1600.500
1999	1631.010	1630.900	1607.100
2000	1611.738	1654.900	1607.100
2001	1516.602	1679.800	1607.100
2000	1611.738	1664.200	1631.000
2001	1516.602	1701.500	1631.000
2002	1414.823	1743.500	1631.000
2001	1516.602	1573.200	1611.700
2002	1414.823	1560.400	1611.700
2003	1443.058	1581.000	1611.700
2002	1414.823	1451.100	1451.100
2003	1443.058	1476.000	1451.100
2003	1443.058	1413.200	1414.800
In-Bound Air Freight, 1000 tons			
1998	47.396	41.475	39.273
1999	55.600	44.802	39.273
2000	55.204	48.565	39.273
1999	55.600	44.237	40.317
2000	55.204	48.800	40.317
2001	46.013	53.467	40.317
2000	55.204	58.673	56.131
2001	46.013	63.098	56.131
2002	51.637	67.427	56.131
2001	46.013	48.556	54.958
2002	51.637	47.683	54.958
2003	45.366	50.941	54.958
2002	51.637	52.066	46.013
2003	45.366	54.573	46.013
2003	45.366	46.854	51.637

Bridge of the Americas Northbound Light Vehicle Traffic, Millions			
1998	7.553	7.870	7.421
1999	8.196	8.048	7.421
2000	8.168	8.229	7.421
1999	8.196	8.090	7.942
2000	8.168	8.209	7.942
2001	7.295	8.327	7.942
2000	8.168	8.276	8.196
2001	7.295	8.394	8.196
2002	4.708	8.534	8.196
2001	7.295	7.723	8.168
2002	4.708	7.800	8.168
2003	4.680	7.889	8.168
2002	4.708	4.655	7.295
2003	4.680	4.771	7.295
2003	4.680	4.820	3.658

Ysleta-Zaragoza Bridge Northbound Cargo Vehicles, Millions			
1998	0.294	0.327	0.289
1999	0.329	0.368	0.289
2000	0.365	0.411	0.289
1999	0.329	0.345	0.314
2000	0.365	0.374	0.314
2001	0.331	0.403	0.314
2000	0.365	0.356	0.329
2001	0.331	0.379	0.329
2002	0.329	0.400	0.329
2001	0.331	0.367	0.365
2002	0.329	0.369	0.365
2003	0.311	0.372	0.365
2002	0.329	0.319	0.331
2003	0.311	0.326	0.331
2003	0.311	0.319	0.329

Borderplex Bridge and Air Econometric Forecast Accuracy
Table 3

TABLE 4 Air Series Predictive Accuracy

Series	RMSE	U-Statistic	U-Bias	U-Variance	U-Covariance
El Paso International Airport Domestic Passenger Arrivals					
ELAPDD[1]	125.9	0.004	0.514	0.012	0.474
ELAPDD[2]	99.70	0.003	0.330	0.020	0.650
El Paso International Airport International Passenger Arrivals					
ELAPDI[1]	6.947	0.276	0.741	0.020	0.239
ELAPDI[2]	4.867	0.203	0.749	0.032	0.219
El Paso International Airport Domestic Passenger Departures					
ELAPED[1]	140.9	0.004	0.375	0.008	0.617
ELAPED[2]	118.1	0.004	0.258	0.110	0.631
El Paso International Airport International Passenger Departures					
ELAPEI[1]	5.796	0.255	0.693	0.001	0.306
ELAPEI[2]	4.657	0.202	0.683	0.033	0.285
El Paso International Airport In-Bound Freight					
ELAFDT[1]	8.622	0.055	0.019	0.101	0.880
ELAFDT[2]	9.838	0.063	0.065	0.094	0.841
El Paso International Airport Out-Bound Freight					
ELAFET[1]	4.889	0.046	0.051	0.011	0.937
ELAFET[2]	5.399	0.052	0.026	0.022	0.952
El Paso International Airport In-Bound U.S. Mail					
ELAMD[1]	1.231	0.507	0.226	0.037	0.737
ELAMD[2]	1.361	0.552	0.276	0.152	0.572
El Paso International Airport Out-Bound U.S. Mail					
ELAME[1]	0.934	0.957	0.254	0.060	0.740
ELAME[2]	1.035	0.978	0.233	0.084	0.683

Sample Period: 1998 – 2003
1. Previously published borderplex structural model forecast.
2. Random walk forecast calculated as last available historical observation.

Borderplex Bridge and Air Econometric Forecast Accuracy
Table 4

TABLE 5 Bridge Series Predictive Accuracy

Series	RMSE	U-Statistic	U-Bias	U-Variance	U-Covariance
Bridge of the Americas Northbound Light Vehicle Traffic					
ELBAC[1]	1.573	0.181	0.310	0.017	0.673
ELBAC[2]	1.900	0.241	0.274	0.063	0.663
Bridge of the Americas Northbound Cargo Vehicle Traffic					
ELBAT[1]	0.089	0.831	0.449	0.310	0.241
ELBAT[2]	0.026	0.269	0.079	0.014	0.907
Bridge of the Americas Northbound Pedestrian Traffic					
ELBAW[1]	0.273	0.760	0.009	0.037	0.954
ELBAW[2]	0.327	0.883	0.122	0.048	0.830
Paso del Norte Bridge Northbound Light Vehicle Traffic					
ELBPC[1]	0.430	0.091	0.258	0.006	0.736
ELBPC[2]	0.506	0.110	0.153	0.032	0.815
Paso del Norte Bridge Northbound Pedestrian Traffic					
ELBPW[1]	1.237	0.228	0.624	0.003	0.373
ELBPW[2]	1.469	0.272	0.736	0.003	0.261
Ysleta-Zaragoza Bridge Northbound Light Vehicle Traffic					
ELBYC[1]	0.339	0.110	0.003	0.020	0.977
ELBYC[2]	0.432	0.141	0.079	0.053	0.868
Ysleta-Zaragoza Bridge Northbound Cargo Vehicle Traffic					
ELBYT[1]	0.041	0.451	0.609	0.053	0.338
ELBYT[2]	0.035	0.406	0.023	0.019	0.958
Ysleta-Zaragoza Bridge Northbound Pedestrian Traffic					
ELBYW[1]	0.209	0.929	0.265	0.018	0.717
ELBYW[2]	0.248	0.995	0.462	0.116	0.422

Sample Period: 1998 – 2003
1. Previously published borderplex structural model forecast.
2. Random walk forecast calculated as last available historical observation.

Borderplex Bridge and Air Econometric Forecast Accuracy
Table 5