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An Econometric Analysis of Retail Gasoline Prices in El Paso

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Abstract

Previous studies show that a variety of different variables influence retail gasoline price fluctuations. In the case of El Paso, Texas, those variables would include wholesale gasoline prices, local economic conditions, weather, and, more uniquely, cross-border economic variables associated with Ciudad Juárez, Chihuahua in Mexico. To analyze the contributions of these variables to monthly price movements for gasoline in El Paso, a theoretical model is specified. From the latter construct, a reduced form equation is extracted. That specification is then expressed within an error correction framework to allow accounting for both long-run and short-run behaviors in this metropolitan economy. Results indicate that the border poses a fairly substantial barrier to economic integration in this specific region.

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Chapter 1: Introduction

The purpose of this study is to examine the determinants of local gasoline prices in the El Paso metropolitan economy and how they vary over time. Many studies of the border region have analyzed gasoline demand, but not price (Haro and Ibarrola, 1999; Ayala and Gutiérrez, 2004; Ibarra and Sortres, 2008). This issue is of interest as many cities encourage ownership of personal vehicles due to urban sprawl and lack of options for pedestrians (Sinha, 2003; Bento et al., 2005). Consequently, families allocate significant fractions of household income for gasoline purchases. Because of its location on the U.S.-Mexico border, consumers in El Paso can treat gasoline from either country as substitute goods (Fullerton et al., 2012). Gasoline prices, thus, provide an indicator of how closely the metropolitan components of the Borderplex economy are integrated with each other.

Gasoline prices in Mexico are set by Mexico's Secretaria de Haciena y Crédito Público and changed only on a monthly basis (Plante and Jordan, 2013). The price set must be the same at all stations throughout the country except in northern Mexico. Although a single price is used for the entire region, northern gasoline prices are lower than in the rest of the country in order to reduce fuel tourism to the United States. This implies that gasoline prices in El Paso can respond to price changes in Ciudad Juárez, but the converse does not hold. Thus, there is no danger of simultaneity arising from any mutual influence between the cities.

The economic importance of crude oil and gasoline has created a broad range of literature. Research topics include price asymmetries (Karrenbrock, 1991; Borenstein et al., 1997; Galeotti et al., 2003), Edgeworth cycles in gasoline markets (Eckert, 2002; Wang, 2009), and the impacts

of regulation and tax incidence on gasoline prices (Rietveld and Woudenberg, 2005; Bello and Contín-Pilart, 2012). Several studies also analyze the role of consumer behavior and the willingness of consumers to travel in response to cheaper substitutes (Banfi et al., 2005; Manuszak and Moul, 2009). Much of this research uses national or state data, but research at the metropolitan level is scarce. Efforts that examine cross-border interactions tend to compare neighboring countries rather than city pairs.

This article uses monthly data from 2001 to 2013 to analyze average gasoline prices. The development of a structural model for gasoline prices at the city level is complicated by the lack of consumption data (Eckert, 2011). The approach utilized should overcome this problem. A theoretical model and reduced form equation are developed to analyze price by means of national and local determinants without the need of consumption data. Parameter estimation is utilized to examine the various roles played by the variables incorporated in the analysis in long-run and short-run settings.

This paper proceeds as follows. Chapter 2 discusses the existing literature on retail gasoline prices. Chapter 3 discusses the data collected and hypothesized relationships between the explanatory variables and gasoline prices. Chapter 4 specifies a theoretical model and develops a reduced form equation. An error correction framework for the reduced form equation is also specified. Chapter 5 reviews empirical estimation results. Chapter 6 presents out-of-sample simulation results of the econometric model against random walk benchmarks. Chapter 7 provides a brief summary of the empirical findings and implications.

Chapter 2: Literature Review

A wide array of literature examines factors that influence gasoline prices. A substantial part of the research focuses on asymmetric price behavior. Pricing asymmetries occur when the lag time required for prices to react to changes in upstream prices is different for a price decrease than for a price increase. In the context of the gasoline industry, several studies document that gasoline prices generally respond more quickly to an increase in the price of crude oil than to a decrease, presumably because retailers attempt to capture larger profit margins as input prices go down (Borenstein et al., 1997; Chen et al., 2005; Davis, 2007; Grasso and Manera, 2007; Deltas, 2008. Other studies (Galeotti et al., 2003; Bachmeier and Griffin, 2003; Douglas, 2010; Angelopoulou and Gibson, 2010) argue there is little evidence of asymmetrical response to price shocks. Karrenbrock (1991) claims that although there is evidence of price asymmetry in response to wholesale price changes, consumers eventually do benefit from price decreases as fully as they do for increases.

A recently growing related area of research proposes that gasoline prices follow Edgeworth cycles (Eckert, 2002; Noel, 2007; Doyle et al., 2010; Zimmerman et al., 2013). Edgeworth price cycles, as described by Maskin and Tirole (1988), are characterized by a pattern of gradually falling prices followed by rapid hikes. Edgeworth cycles occur when prices oscillate due to the strategic behavior of firms rather than only due to changes in input prices or consumer demand. Competing firms begin by selling a product at a relatively high price, and each firm has an incentive to undercut its competitors by lowering the price. Firms continue to undercut each other during the 'price war phase' until prices fall to unsustainably low levels. In the subsequent 'relenting phase,' one firm will finally relent and increase its prices, leading other firms to follow

suit and begin the cycle anew. Wang (2009) finds evidence that the behavior of retail gasoline prices is consistent with Edgeworth cycles, and that the larger firms tend to be the ones that first relent and increase their prices.

A variety of other factors also affect retail gasoline prices. Some studies look for upstream determinants by analyzing the response of retail prices to changes in wholesale prices (Karrenbrock, 1991; Tsuruta, 2008) or crude oil prices (Radchenko, 2005). Eckert and West (2004) present evidence that retail gasoline prices can vary between cities due to differences in market structures and the level of competition from 'maverick firms' that complicate tacit collusion among stations. Bello and Contín-Pilart (2012) specify a model for Spanish gasoline prices that posits regional gasoline prices as a function of taxes and numerous cost and demand variables that potentially contribute to gasoline price formation. The latter include weather, income, and demographics. Results indicate that regional price differences are mainly due to tax differences, while the other cost shifting and demand shifting determinants explain only a small portion of price differentiation.

There is evidence that taxes can play a major role in determining gasoline prices and, thus, in explaining price variation across countries and states. The existence of varying tax regimes across contiguous geographical regions creates an incentive for fuel tourism to emerge. Rietveld and Woudenberg (2005) find that small countries in Europe try to capture this fuel tourism by setting gasoline taxes significantly lower than those of nearby countries. The city-states of Singapore and Hong Kong charge higher taxes than neighboring regions, but set regulatory restrictions that work as deterrents to fuel tourism. Banfi et al. (2005) investigate the impact of

price differentials between Switzerland and its neighbors, concluding that about nine percent of Swiss gasoline sales stem from fuel tourism. Manuszak and Moul (2009) analyze data on Indiana and Illinois to measure the effect of different tax regimes on gasoline consumption. The spikes in prices along the borders of different tax regions point to the effects of consumers traveling to avoid higher tax areas.

Academic research on US-Mexico fuel tourism has tended to focus on the south side of the border. Haro López and Ibarrola Pérez (1999) calculate the price elasticity of gasoline in the northern region to be less than unitary and confirm that U.S. gasoline acts as a substitute good for most of the border. Ibarra Salazar and Sortres Cervantes (2008) explore the same issue and also conclude that the presence of a substitute good makes gasoline demand on Mexico's northern border much more sensitive to price changes than that of interior regions. Ayala and Gutiérrez (2004) analyze a sharp decrease in gasoline sales in northern Mexico from 1997 to 2000. Survey responses indicate that over a third of all polled families cross the border to purchase U.S. gasoline. U.S. gasoline is seen to act as a 'product hook' that greatly increases the probability Mexican consumers will make other purchases across the border that would otherwise occur in Mexico.

Fullerton et al. (2012) estimate the demand for gasoline in Ciudad Juárez as a function of employment, local gasoline prices, and the price of gasoline in El Paso. The study concludes that cross-border prices have a net positive effect on sales in Ciudad Juárez, indicating that El Paso gasoline serves as a substitute good. A natural extension of that study is to examine the retail gasoline market of El Paso. To date, very little research exists on retail automotive fuel markets on the north side of the U.S.-Mexico border. This study attempts to at least partially fill that void.

Chapter 3: Data

Monthly frequency time series data from January 2001 to October 2013 are used to model gasoline prices in El Paso. Table 1 presents the name, definition, source, and units of measure for each variable employed in the analysis. Average regular gasoline prices at mid-month are available from GasBuddy.com. Although prices posted on this and similar sites are provided by voluntary spotters, Atkinson (2008) documents that data reported by these volunteers are generally accurate and finds no evidence of a systematic bias towards gasoline stations with unusually high or low prices. Although taxes can affect data consistency, the Texas gasoline tax has not varied during the sample period utilized.

Table 1: Variables

Variable Name	Definition	Units	Source
P	El Paso real gasoline price	Dollars/gallon	GasBuddy.com
Y	El Paso real personal income per capita	1982-1984 Dollars	IHS Global Insight
CJ	Real price of Ciudad Juárez Magna gasoline	Dollars/gallon	INEGI
BC	Total number of northbound personal vehicles crossing the border	Personal vehicles	BTS
TEMP	Average monthly temperature in El Paso region	Fahrenheit	NOAA
W	USA real wholesale gasoline price	Dollars/gallon	EIA

A major determinant of any local retail gasoline price is the wholesale gasoline price. The wholesale price is the bulk acquisition price retailers pay for inventories. Wholesale price fluctuations will likely explain a large share of the total variation in El Paso gasoline prices. The

portion of local gasoline prices left unexplained by national wholesale prices is presumably determined by variables reflecting local market conditions. Wholesale price data are obtained from the U.S. Energy Information Administration (EIA, 2014).

A number of studies document positive relationships between regional income levels and gasoline prices (Chouinard and Perloff, 2007; Hosken et al., 2008; Bello and Contin-Pilart, 2012). A similar pattern is expected to prevail in El Paso. Quarterly income estimates for El Paso are available from Global Insight (IHS, 2014). Monthly income per capita is interpolated using monthly employment data and then dividing over population. Monthly employment data are available from the Bureau of Labor Statistics (BLS, 2014). Population data are available from the Bureau of Economic Analysis (BEA, 2014). Income and all of the gasoline prices are adjusted for inflation to reflect 1982-1984 price levels using the Consumer Price Index (BLS, 2014). Quarterly income data are regressed on quarterly employment data as shown in Table 2. Moving average terms are included to account for serial correlation. The resulting coefficients are then used to estimate monthly income by means of monthly employment:

Table 2: Personal Income Regression Analysis

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-27905.37	4121.899	-6.770028	0.0000
EMP	172.4001	15.32835	11.24714	0.0000
MA(1)	0.737385	0.082233	8.967012	0.0000
MA(2)	0.728665	0.085425	8.529881	0.0000
R-squared	0.951201	Mean dependent variable		18294.01
Adjusted R-squared	0.948386	S.D. dependent variable		2463.095
S.E. of regression	559.5848	Akaike information criterion		15.56102

Sum of squared residuals	16283029	Schwarz criterion	15.70568
Log likelihood	-431.7085	Hannan-Quinn criterion	15.61710
F-statistic	337.8659	Durbin-Watson statistic	1.930722
Probability (F-statistic)	0.000000		
Inverted MA Roots	-.37-.77i	-.37+.77i	

Notes:
Dependent Variable: Income
Method: Least Squares
Sample: 2000Q1 – 2013Q4
Included observations: 56
Convergence achieved after 10 iterations
MA Backcast: 1999Q3 – 1999Q4

As mentioned above, cross-border price differentials tend to encourage fuel tourism. Ayala and Gutierrez (2004) report that a third of survey respondents in Ciudad Juárez cross the border for gasoline purchases. To determine whether fuel tourism affects El Paso gasoline prices, border crossings are included as an explanatory variable. If an increase in border crossings reflects an increase in fuel tourism from Mexico, then the variable is predicted to have a positive effect on price. However, if the increase in border crossings represents return trips by U.S. fuel tourists, the expected marginal effect is negative. Since it is not clear which of these scenarios is more likely to occur, no hypothesis is advanced regarding the effect of border crossings on the price of gasoline. Personal vehicle border crossing data are obtained from the Bureau of Transportation Statistics (BTS, 2014).

To further test whether fuel tourism affects El Paso gasoline prices, the price of gasoline in Mexico is also included as a regressor. A positive relationship is expected to exist between the price of Mexican gasoline and demand for the most readily available substitute good, U.S. gasoline. Increased demand for gasoline on the north side of the border is anticipated to result in

higher prices. Thus, gasoline prices in Ciudad Juárez are hypothesized to have a positive impact on prices in El Paso. The Mexican equivalent to United States regular gasoline is Magna. Magna prices are from the national statistics agency (INEGI, 2014). These data are originally expressed in pesos per liter, and are changed into dollars per gallon using the peso/dollar exchange rate (INEGI, 2014).

Gasoline prices are generally lower during winter months, so it is often helpful to include seasonal variables in gasoline price equations. Temperature variations have an effect on gasoline prices in a number of ways, such as increased use of air conditioning during summer months and increased production of diesel fuel during winter months (Borenstein et al., 1997; Chouinard and Perloff, 2007; Angelopoulou and Gibson, 2010). Local temperature data are from the National Climatic Data Center (NOAA, 2014). A positive correlation between temperature and gasoline prices is hypothesized.

Table 3 provides descriptive statistics for each of the variables. Northbound automobile border crossings varied considerably during the sample period, reaching a maximum of nearly 1.7 million per month immediately prior to the terrorist attacks of 11 September 2001 and oscillating over a wide range in subsequent years. The U.S. wholesale price of gasoline, W, and the local retail price, P, exhibit the highest degree of variability of any of the time series, as measured by ratio of the standard deviation to the mean. A lower degree of variability is observed for the Ciudad Juárez gasoline price series. Although gasoline prices are set at lower levels in northern regions of Mexico than in other regions of the country, Ciudad Juárez gasoline prices are not always lower

than El Paso gasoline prices. As shown in Figure 1, Ciudad Juárez gasoline prices exceeded those charged in El Paso during much of 2013.

Table 3: Summary Statistics

Variable	Mean	Standard Deviation	Minimum	Maximum
P	1.15	0.31	0.60	1.80
Y	24,205	1,134	21,522	27,011
CJ	1.17	0.14	0.82	1.49
BC	1,069,567	222,883	688,921	1,695,692
TEMP	65.2	13.2	42.0	85.7
W	1.09	0.31	0.45	1.70

Notes:
For each variable there are 154 monthly observations, January 2001 – October 2013.

Figure 1: El Paso and Ciudad Juárez Gasoline Prices

Wholesale prices account for supply and demand factors that affect gasoline prices at the national level, while local determinants primarily exercise demand effects. To incorporate all of these variables, a theoretical model is developed and an equilibrium specification is specified. Next, to account for both long-run and short-run influences, the static, reduced form equation is re-cast in an error-correction framework.

Chapter 4: Methodology

The factors that influence supply and demand in gasoline markets are generally well understood (Dahl and Sterner, 1991; Bello and Contín-Pilart, 2012). Given equations for supply (Q_S) and demand (Q_D), it is possible to extract a reduced form equation for price (Pindyck and Rubinfeld, 1998). One advantage of this approach is that it does not require data on gasoline consumption, which are unavailable for El Paso during the sample period. Reduced form equations are common in the literature on gasoline prices (Vita, 2000; Chouinard and Perloff, 2007).

The implicit demand equation is $Q_D = D(P, Y, CJ, BC, TEMP)$ and the implicit supply equation is $Q_S = S(P, W)$. The supply and demand equations can be written as follows, along with the expected signs for each parameter shown parenthetically:

$$Q_D = \alpha_0 + \alpha_1 P_t + \alpha_2 Y_t + \alpha_3 CJ_t + \alpha_4 BC_t + \alpha_5 TEMP_t + e_t \qquad (1)$$

(-) (+) (+) (?) (+)

$$Q_S = \beta_0 + \beta_1 P_t + \beta_2 W_t + u_t \qquad (2)$$

(+) (-)

The equilibrium price can be solved by equating supply and demand ($Q_D = Q_S$). Doing so with equations (1) and (2) yields the expression for price shown in equation (5):

$$\beta_1 p_t - \alpha_1 P_t = \alpha_0 + \alpha_2 Y_t + \alpha_3 CJ_t + \alpha_4 BC_t + \alpha_5 TEMP_t + e_t - \beta_0 - \beta_2 W_t - u_t \qquad (3)$$

$$(\beta_1 - \alpha_1) P_t = \alpha_0 - \beta_0 + \alpha_2 Y_t + \alpha_3 CJ_t + \alpha_4 BC_t + \alpha_5 TEMP_t - \beta_2 W_t + e_t - u_t \qquad (4)$$

$$P_t = \frac{\alpha_0 - \beta_0}{\beta_1 - \alpha_1} + \frac{\alpha_2}{\beta_1 - \alpha_1} Y_t + \frac{\alpha_3}{\beta_1 - \alpha_1} CJ_t + \frac{\alpha_4}{\beta_1 - \alpha_1} BC_t + \frac{\alpha_5}{\beta_1 - \alpha_1} TEMP_t - \frac{\beta_2}{\beta_1 - \alpha_1} W_t + \frac{e_t - u_t}{\beta_1 - \alpha_1} \qquad (5)$$

Equation (5) can be rewritten more compactly as:

$$P_t = \gamma_0 + \gamma_1 Y_t + \gamma_2 CJ_t + \gamma_3 BC_t + \gamma_4 TEMP_t + \gamma_5 W_t + v_t \qquad (6)$$

The expected signs of the parameters in Equation 6 can be ascertained by including the hypothesized sign of each parameter from Equations (1) and (2) in Equation (5). This yields the following hypotheses.

$$\gamma_1 > 0, \gamma_2 > 0, \gamma_4 > 0, \gamma_5 > 0 \qquad (7)$$

Based on the assumptions made for Equations (1) and (2), the hypothesized signs for γ_1, γ_2, γ_4, and γ_5 will be positive. The sign of γ_3 remains ambiguous as a rise in border crossings may result in either an increase or a decrease in local demand, depending on the direction of cross-border fuel tourism.

Error correction models are commonly employed to estimate gasoline price equations because they can handle long-run price dynamics as well as short-run deviations from equilibrium (Borenstein et al., 1997; Bachmeier and Griffin, 2003; Radchenko, 2005; Grasso and Manera, 2007). The basic framework consists of two equations, a long-run cointegrating equation and a short-run error correction equation. The long-run equation is estimated using non-differenced variables. Within such an approach, Equation (6) represents the long-run cointegrating equation. If the residuals from Equation (6) are stationary, a cointegrating relationship has been found and the equation can be estimated in a statistically reliable fashion (Maddala and Kim, 1998).

The short-run error correction equation is estimated using first differences of the same variables included in the long-run equation plus a one-period lag of the long-run equation residual:

$$\Delta P_t = \pi_1 + \pi_2 \Delta Y_t + \pi_3 \Delta \mathrm{CJ}_t + \pi_4 \Delta \mathrm{BC}_t + \pi_5 \Delta \mathrm{TEMP}_t + \pi_6 \Delta W_t + \pi_7 \hat{v}_{t-1} + z_t \qquad (8)$$

In Equation (8), Δ is a difference operator, $\hat{v}_{t-1}$ are the lagged residuals from Equation 6, and w is a random error term. The coefficient π_7 represents the speed of adjustment to any deviation

away from the long-run equilibrium price and, because it offsets prior period disequilibria, should be negative. The amount of time (in months) required for any disequilibria to fully dissipate is equal to $\frac{1}{|\pi_7|}$.

Chapter 5: Empirical Results

Table 4 lists the parameter estimates for Equation (6). All variables are logarithmically transformed prior to estimation. Consequently, the coefficients can be interpreted as elasticities. An augmented Dickey-Fuller test on the regression residuals indicates that gasoline prices are cointegrated with the explanatory variables. Residual autocorrelation is corrected by including a first order autoregressive term in the equation specification.

Table 4: Long-Run Cointegration Equation for El Paso Gasoline Prices

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-4.215136	1.914131	-2.202114	0.0292
LOG(Y)	0.525452	0.173305	3.031944	0.0029
LOG(CJ)	0.081680	0.069846	1.169438	0.2441
LOG(TEMP)	0.031938	0.033881	0.942642	0.3474
LOG(BC)	-0.084060	0.039336	-2.136976	0.0342
LOG(W)	0.766624	0.034703	22.09079	0.0000
AR(1)	0.536760	0.072256	7.428587	0.0000

R-squared	0.969965	Mean dependent var	0.101913
Adjusted R-squared	0.968748	S.D. dependent var	0.286179
S.E. of regression	0.050592	Akaike info criterion	-3.085948
Sum squared resid	0.378809	Schwarz criterion	-2.948503
Log likelihood	246.1609	Hannan-Quinn criter.	-3.030121
F-statistic	796.6060	Durbin-Watson stat	1.830826
Prob(F-statistic)	0.000000		

Inverted AR Roots	.54

Notes:
Dependent Variable: LOG(PRICE)
Method: Least Squares
Sample (adjusted): 2001M02 2013M12
Included observations: 153 after adjustments
Convergence achieved after 15 iterations

Real per capita income exerts a strong positive impact on retail gasoline prices in El Paso. As shown in Table 4, a ten percent increase in per capita income results in a 5.3 percent increase in gasoline prices. This aligns well with previously documented evidence that business cycle movements explain a large portion of long-run variation in gasoline prices (Kilian, 2009).

The coefficient on Ciudad Juárez gasoline price is positive as hypothesized. However, the coefficient is statistically insignificant, implying that gasoline prices in El Paso and Ciudad Juárez are, at most, weakly related in the long-run. This is similar to evidence reported in Leal et al. (2009) that indicates that the impacts of cross-border purchases on regional automotive fuel markets in Spain are muted in the long-run, but statistically significant in the short-run. One reason for this outcome may be that gasoline prices in northern Mexico generally move in tandem with U.S. wholesale gasoline prices, albeit with deviations that last for relatively short periods of time. Over the long-run, multicollinearity between the two gasoline price regressors may explain the insignificance of Ciudad Juárez gasoline as an explanatory variable. When wholesale prices are omitted from the regression, the parameter estimated for Ciudad Juárez gasoline prices becomes statistically significant.

When border automobile crossings increase by ten percent, El Paso gasoline prices decline by 0.8 percent. The negative sign indicates that border commuters purchase more gasoline in Ciudad Juárez than in El Paso. That result is in contrast with outcomes obtained by Fullerton et al. (2012) that document negligible impacts of bridge crossings on Ciudad Juárez gasoline demand.

The coefficient for temperature in Table 4 is also positive but fails to satisfy the significance criterion. The statistical insignificance of this coefficient in a long-run regression equation may be explained in part by the seasonal nature of ambient monthly temperatures. Chouinard and Perloff (2007) show that weather conditions play an important role in explaining short-term fluctuations in retail gasoline prices but explain little of the long-term trends in prices.

Wholesale prices exert significant and strong effects on long-run retail gasoline price variations in El Paso. A ten percent increase in wholesale prices leads El Paso retail gasoline prices to increase by 7.7 percent. This coefficient is similar in magnitude to previously published estimates of the relationship between wholesale and retail gasoline prices (Deltas, 2008). The fact that the estimated parameter for the wholesale price is only 0.77 in Table 4 highlights the importance of taking into account local economic conditions and weather patterns when modeling metropolitan retail gasoline prices.

Table 5 summarizes the estimation results for the short-run error-correction equation. Real per capita personal income affects El Paso gasoline prices in a direct manner. Other things equal, a ten percent increase in per capita income is associated with a 3.14 percent rise in prices at the pump.

The price of Ciudad Juárez gasoline is a statistically significant predictor of El Paso prices in the short-term. A ten percent increase in gasoline price in Juárez would lead to an increase of 1.5 percent in El Paso gasoline prices. On the surface, the inelasticity of retail prices relative to what is charged south-of-the-border indicates that the Magna grade of gasoline is a highly

imperfect substitute for regular gasoline in El Paso. A more plausible explanation is that ongoing difficulties in traversing the international boundary over the course of the sample period weaken the relationship that would otherwise exist between these two price series in neighboring metropolitan economies (Fullerton, 2007; Walke and Fullerton, 2014).

As shown in Table 5, the impact of northbound bridge crossings on short-run motor fuel price movements is not measurably different from zero. Average monthly temperature has a positive and significant effect on short-run gasoline price fluctuations. As noted by Lin et al. (1985), warmer temperatures may increase the likelihood of engaging in outdoor activities, including driving, and increased use of motor vehicles in warmer periods is likely to exert upward pressure on prices. A one percent increase in temperature leads to a 0.08 percent increase in prices. In other words, a seasonal increase from the approximate sample mean of 65 degrees to 80 degrees will lead to an 2 cent rise in the real price of gasoline (1982-84 = 100) from the sample mean of US$1.15 per gallon to US$1.17.

Table 5: Short-Run Error-Correction Equation for El Paso Gasoline Prices

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.001540	0.003912	0.393597	0.6944
DLOG(Y)	0.313495	0.169804	1.846214	0.0669
DLOG(CJ)	0.145995	0.083009	1.758784	0.0807
DLOG(TEMP)	0.080389	0.036326	2.212954	0.0284
DLOG(BC)	-0.034590	0.055389	-0.624489	0.5333
DLOG(W)	0.433103	0.055649	7.782822	0.0000
RES(-1)	-0.553612	0.085573	-6.469492	0.0000
R-squared	0.616598	Mean dependent var		0.003645

Adjusted R-squared	0.600949	S.D. dependent var	0.076577
S.E. of regression	0.048374	Akaike info criterion	-3.175329
Sum squared resid	0.343983	Schwarz criterion	-3.037286
Log likelihood	251.5004	Hannan-Quinn criter.	-3.119256
F-statistic	39.40162	Durbin-Watson stat	1.677678
Prob(F-statistic)	0.000000		

Notes:
Dependent Variable: LOG(PRICE)
Method: Least Squares
Sample (adjusted): 2001M03 2013M12
Included observations: 152 after adjustments

Not surprisingly, wholesale price changes also play prominent roles in determining short-run retail gasoline price variations. A ten percent increase in real wholesale prices increases El Paso retail gasoline prices by 4.3 percent. This outcome closely matches results reported in Polemis (2012).

The coefficient for the error correction term is negative as hypothesized. Its coefficient is 0.56 which means that any short-run deviation from the long-term equilibrium fully dissipates in less than two months. Most of the previous literature on this topic indicates that, after a shock, gasoline prices in other markets also return to long-run equilibria in a matter of months (Asplund et al., 2000; Kaufman and Laskowski, 2005).

Chapter 6: Out-of-Sample Simulation Results

Forecasts of gasoline prices can help consumers and corporate planners anticipate likely future trends in shipping and transportation costs. Using the error correction framework, it is possible to incorporate both long-run and short-run price dynamics into out-of-sample simulations. To accomplish this, the long-run equation for El Paso gasoline prices:

$$P_t = \gamma_0 + \gamma_1 Y_t + \gamma_2 CJ_t + \gamma_3 BC_t + \gamma_4 TEMP_t + \gamma_5 W_t + v_t \quad (9)$$

is combined with the short-run equation:

$$\Delta P_t = \pi_1 + \pi_2 \Delta Y_t + \pi_3 \Delta \mathrm{CJ}_t + \pi_4 \Delta \mathrm{BC}_t + \pi_5 \Delta \mathrm{TEMP}_t + \pi_6 \Delta W_t + \pi_7 \hat{v}_{t-1} + z_t \quad (10)$$

Rearranging Equation (9) to solve for v_t and then substituting the right-hand-side of the equation into Equation (10), yields the following:

$$\Delta P_t = \pi_1 + \pi_2 \Delta Y_t + \pi_3 \Delta \mathrm{CJ}_t + \pi_4 \Delta \mathrm{BC}_t + \pi_5 \Delta \mathrm{TEMP}_t + \pi_6 \Delta W_t + \pi_7 (P_{t-1} - \gamma_0 - \gamma_1 Y_{t-1} - \gamma_2 CJ_{t-1} - \gamma_3 BC_{t-1} - \gamma_4 TEMP_{t-1} - \gamma_5 W_{t-1}) + z_t \quad (11)$$

$$\Delta P_t = \pi_1 - \pi_7 \gamma_0 + \pi_2 \Delta Y_t + \pi_3 \Delta \mathrm{CJ}_t + \pi_4 \Delta \mathrm{BC}_t + \pi_5 \Delta \mathrm{TEMP}_t + \pi_6 \Delta W_t + \pi_7 P_{t-1} - \pi_7 \gamma_1 Y_{t-1} - \pi_7 \gamma_2 CJ_{t-1} - \pi_7 \gamma_3 BC_{t-1} - \pi_7 \gamma_4 TEMP_{t-1} - \pi_7 \gamma_5 W_{t-1} + z_t \quad (12)$$

Knowing that:

$$P_t = P_{t-1} + \Delta P_t \quad (13)$$

Equation (12) can be incorporated into the level-form forecast:

$$P_t = P_{t-1} + \pi_1 - \pi_7 \gamma_0 + \pi_2 \Delta Y_t + \pi_3 \Delta \mathrm{CJ}_t + \pi_4 \Delta \mathrm{BC}_t + \pi_5 \Delta \mathrm{TEMP}_t + \pi_6 \Delta W_t + \pi_7 P_{t-1} - \pi_7 \gamma_1 Y_{t-1} - \pi_7 \gamma_2 CJ_{t-1} - \pi_7 \gamma_3 BC_{t-1} - \pi_7 \gamma_4 TEMP_{t-1} - \pi_7 \gamma_5 W_{t-1} + z_t \quad (14)$$

$$P_t = P_{t-1}(1 + \pi_7) + \pi_1 - \pi_7 \gamma_0 + \pi_2 \Delta Y_t + \pi_3 \Delta \mathrm{CJ}_t + \pi_4 \Delta \mathrm{BC}_t + \pi_5 \Delta \mathrm{TEMP}_t + \pi_6 \Delta W_t - \pi_7 \gamma_1 Y_{t-1} - \pi_7 \gamma_2 CJ_{t-1} - \pi_7 \gamma_3 BC_{t-1} - \pi_7 \gamma_4 TEMP_{t-1} - \pi_7 \gamma_5 W_{t-1} + z_t \quad (15)$$

Equation (15) can be rewritten as:

$$P_t = \mu_0 + \mu_7 P_{t-1} + \mu_2 \Delta Y_t + \mu_3 \Delta \mathrm{CJ}_t + \mu_4 \Delta \mathrm{BC}_t + \mu_5 \Delta \mathrm{TEMP}_t + \mu_6 \Delta W_t + \mu_8 Y_{t-1} + \mu_9 CJ_{t-1} + \mu_{10} BC_{t-1} + \mu_{11} TEMP_{t-1} + \mu_{12} W_{t-1} + z_t \quad (16)$$

Using Equation (13), a rolling re-estimation and simulation procedure is employed to produce multiple sets of gasoline price forecasts for the years 2011 to 2013. There are thirty six one-month ahead forecasts, thirty five two-month ahead forecasts, and so on until reaching twenty five twelve-month ahead forecasts. Random walk and random walk with drift forecasts are also generated and used as benchmarks. The Root Mean Squared Error (RMSE) and Theil's inequality coefficient, also known as the U-statistic, are calculated for each set of forecasts (Pindyck and Rubinfeld, 1998). Both statistics measure how well the forecasted values of a series track the actual values and, in both cases, a value of zero represents perfect forecast precision. While the RMSE can range between 0 and ∞, the *U*-statistic is constrained to fall between 0 and 1.

Furthermore, the second moment of the U-statistic can be broken down into three components (Pindyck and Rubinfeld, 1998). The first component, U^M, indicates the amount of error due to bias. The second component, U^S, indicates the degree to which forecasts replicate the actual observed variance of the series. The third component, U^C, indicates the amount of unsystematic error. The sum of these components is one and, if $U \neq 0$, then a high value for U^C and low values for U^M and U^S indicate good forecasting performance. These statistics are calculated as follows:

$$U = \frac{\sqrt{\frac{1}{n}\sum(F_t - A_t)^2}}{\sqrt{\frac{1}{n}\sum F_t^{\,2}} + \sqrt{\frac{1}{n}\sum A_t^{\,2}}} \quad (17)$$

$$U^M = \frac{\bar{F} - \bar{A}}{\frac{1}{n}\sum(F_t - A_t)^2} \quad (18)$$

$$U^S = \frac{\sigma_F - \sigma_A}{\frac{1}{n}\sum(F_t - A_t)^2} \quad (19)$$

$$U^C = \frac{2(1-r)\sigma_F \sigma_A}{\frac{1}{n}\sum(F_t - A_t)^2} \quad (20)$$

Where F_t and A_t are the forecasted and actual values at time *t*, $\bar{F}, \bar{A}$ and σ_F, σ_A are the means and standard deviations of *F* and *A*, and *r* is their correlation coefficient.

Table 6 shows that forecasts generated using the structural econometric model are more precise than either benchmark for forecasts up to three months in advance. For four-month ahead forecasts and beyond, the structural model is less accurate than the random walk benchmark.

Table 6: Theil Coefficient and Proportional Component Results

Forecast	RMSE	U-Stat	U-bias	U-var	U-cov
One Month Ahead					
Structural	0.05357	**0.018165**	0.000179	0.297975	0.701846
Random-Walk	0.0778	0.026603	6.98E-08	0.000265	0.999735
Random-Walk w/ Drift	0.08284	0.028269	2.41E-06	0.015969	0.984029
Two Months Ahead					
Structural	0.07184	**0.024195**	0.000241	0.340438	0.659321
Random-Walk	0.07812	0.026632	1.63E-07	0.000443	0.999557
Random-Walk w/ Drift	0.08338	0.028363	4.98E-06	0.009333	0.990662
Three Months Ahead					
Structural	0.07769	**0.026065**	0.000291	0.353071	0.646637
Random-Walk	0.07899	0.026864	7.1E-07	0.001488	0.998511
Random-Walk w/ Drift	0.08448	0.028674	6.72E-06	0.007473	0.99252
Four Months Ahead					
Structural	0.07978	0.026755	0.000377	0.337843	0.66178
Random-Walk	0.07342	**0.024964**	1.07E-05	0.002625	0.997364
Random-Walk w/ Drift	0.08015	0.027197	2.41E-05	0.007689	0.992287
Five Months Ahead					
Structural	0.08168	0.027456	0.000457	0.299029	0.700513
Random-Walk	0.07244	**0.024699**	2.38E-05	3.24E-05	0.999944
Random-Walk w/ Drift	0.08033	0.027342	3.73E-05	0.018585	0.981378
Six Months Ahead					
Structural	0.08310	0.028027	0.000566	0.235543	0.76389
Random-Walk	0.07328	**0.025103**	3.23E-05	0.002728	0.99724
Random-Walk w/ Drift	0.081613	0.02792	4.17E-05	0.026489	0.97347

Seven Months Ahead					
Structural	0.08598	0.029053	0.000627	0.211668	0.787705
Random-Walk	0.07196	**0.024756**	2.07E-05	0.000607	0.999372
Random-Walk w/ Drift	0.07817	0.02687	2.54E-05	0.004202	0.995773
Eight Months Ahead					
Structural	0.08825	0.029875	0.00068	0.201445	0.797876
Random-Walk	0.07306	**0.025206**	1.95E-05	0.001137	0.998843
Random-Walk w/ Drift	0.07879	0.027172	2.01E-05	0.001533	0.998447
Nine Months Ahead					
Structural	0.09054	0.030687	0.000753	0.179962	0.819285
Random-Walk	0.07420	**0.02566**	1.79E-05	0.001832	0.998151
Random-Walk w/ Drift	0.07956	0.027513	1.53E-05	0.000312	0.999673
Ten Months Ahead					
Structural	0.09292	0.031514	0.000878	0.154328	0.844794
Random-Walk	0.07556	**0.026189**	1.95E-05	0.001637	0.998343
Random-Walk w/ Drift	0.08080	0.028014	1.3E-05	4.5E-05	0.999942
Eleven Months Ahead					
Structural	0.09561	0.032408	0.000958	0.152752	0.846289
Random-Walk	0.07538	**0.026163**	1.03E-05	0.003746	0.996243
Random-Walk w/ Drift	0.07958	0.02764	3.81E-06	0.000684	0.999312
Twelve Months Ahead					
Structural	0.09859	0.033356	0.001026	0.171744	0.82723
Random-Walk	0.07600	**0.026361**	4.95E-06	0.003255	0.99674
Random-Walk w/ Drift	0.07962	0.027648	2.85E-07	0.000596	0.999404

The RMSE, Theil Coefficient, and its second moment error proportions are useful for comparing competing forecasts, but are only descriptive. To test whether the difference in accuracy between two alternative sets of forecasts is statistically significant, formal statistical tests are needed. Ashley, Granger, and Schmalensee (1980) develop a procedure that tests the null hypothesis:

$$H_0: MSE(e_1) = MSE(e_2) \quad (21)$$

where MSE is the mean squared error and e_1 and e_2 are the forecast errors for two competing sets of forecasts. In this article, $MSE(e_1)$ represents the mean squared error for the random walk or the random walk with drift forecasts, and $MSE(e_2)$ represents the mean squared error for the structural econometric forecasts. If we define:

$$\Delta_t = e_{1t} - e_{2t} \text{ and } \Sigma_t = e_{1t} + e_{2t} \quad (22)$$

Equation (21) can be rewritten:

$$MSE(e_1) - MSE(e_2) = [\widehat{cov}(\Delta, \Sigma)] + [m(e_1)^2 - m(e_2)^2] \quad (23)$$

Forecast errors are judged to be statistically different if it is possible to reject the joint null hypothesis that $\mu(\Delta) = 0$ and $cov(\Delta, \Sigma) = 0$. Ashley, Granger, and Schmalensee (1980) develop a regression-based procedure to test this null hypothesis. The regression equation to be estimated depends on the signs of the error means of each forecast. When the means of the errors are of the same sign, Equation (24) is used:

$$\Delta_t = \beta_1 + \beta_2[\Sigma_t - m(\Sigma_t)] + u_t \quad (24)$$

where m denotes the sample mean, and the intercept β_1 denotes the difference in errors to test $\mu(\Delta) = 0$.

A special case occurs in the one month ahead forecasts, where the error means differ in sign. In such a case a different regression must be used where the dependent variable is now the sum of the forecast errors:

$$\Sigma_t = \beta_1 + \beta_2[\Delta_t - m(\Delta_t)] + u_t \quad (25)$$

The results of the error regression differentials are presented in Table 7 and Table 8.

Table 7. Error Regression Results: Random Walk v. Structural Econometric Model Forecast Errors

Variable	**B1 (t-statistic)**	**B2 (t-statistic)**	**Joint F-test (probability)**	**Most Accurate**
One Month Ahead	0.025	1.038***	15.410	SEM
(RW neg.; SEM pos.)	(1.555)	(3.926)	(0.000)	
Two Months Ahead	-0.038***	0.181	2.725	RW
(Both error means pos.)	(-2.962)	(1.651)	(0.108)	
Three Months Ahead	-0.043***	0.166	1.777	RW
(Both error means pos.)	(-2.964)	(1.333)	(0.192)	
Four Months Ahead	-0.043***	0.145	1.000	RW
(Both error means pos.)	(-2.860)	(1.000)	(0.325)	

Five Months Ahead	-0.045***	0.159	1.044	RW
(Both error means pos.)	(-2.884)	(1.022)	(0.315)	
Six Months Ahead	-0.048***	0.220	1.897	RW
(Both error means pos.)	(-3.134)	(1.377)	(0.179)	
Seven Months Ahead	-0.055***	0.190	1.532	RW
(Both error means pos.)	(-3.603)	(1.238)	(0.226)	
Eight Months Ahead	-0.057***	0.191	1.453	RW
(Both error means pos.)	(-3.617)	(1.206)	(0.238)	
Nine Months Ahead	-0.061***	0.202	1.578	RW
(Both error means pos.)	(-3.730)	(1.256)	(0.220)	
Ten Months Ahead	-0.065***	0.246	2.349	RW
(Both error means pos.)	(-4.019)	(1.533)	(0.138)	
Eleven Months Ahead	-0.071***	0.224	2.050	RW
(Both error means pos.)	(-4.345)	(1.432)	(0.165)	
Twelve Months Ahead	-0.075***	0.195	1.600	RW
(Both error means pos.)	(-4.495)	(1.265)	(0.219)	

* Significant at 10%, ** significant at 5%, *** significant at 1%

Table 8. Error Regression Results: Random Walk with Drift v. Structural Econometric Model Forecast Errors

Variable	B1 (t-statistic)	B2 (t-statistic)	Joint F-test (probability)	Most Accurate
One Month Ahead	-0.021**	0.350***	17.075	Inconclusive
(Both error means pos.)	(-2.168)	(4.132)	(0.000)	
Two Months Ahead	-0.033**	0.240*	3.903	Inconclusive
(Both error means pos.)	(-2.296)	(1.975)	(0.057)	
Three Months Ahead	-0.038**	0.231	2.799	RW with Drift
(Both error means pos.)	(-2.362)	(1.673)	(0.104)	
Four Months Ahead	-0.038**	0.232	2.079	RW with Drift
(Both error means pos.)	(-2.281)	(1.442)	(0.159)	
Five Months Ahead	-0.040**	0.265	2.413	RW with Drift
(Both error means pos.)	(-2.352)	(1.553)	(0.131)	
Six Months Ahead	-0.045**	0.332*	3.797	Inconclusive
(Both error means pos.)	(-2.667)	(1.949)	(0.061)	
Seven Months Ahead	-0.053***	0.273	2.780	RW with Drift
(Both error means pos.)	(-3.210)	(1.667)	(0.107)	
Eight Months Ahead	-0.056***	0.269	2.560	RW with Drift

(Both error means pos.)	(-3.314)	(1.600)	(0.121)	
Nine Months Ahead	-0.061***	0.275	2.629	RW with Drift
(Both error means pos.)	(-3.498)	(1.621)	(0.117)	
Ten Months Ahead	-0.066***	0.312*	3.575	Inconclusive
(Both error means pos.)	(-3.879)	(1.891)	(0.070)	
Eleven Months Ahead	-0.073***	0.275*	2.937	Inconclusive
(Both error means pos.)	(-4.280)	(1.714)	(0.099)	
Twelve Months Ahead	-0.078***	0.237	2.247	RW with Drift
(Both error means pos.)	(-4.491)	(1.499)	(0.147)	

* Significant at 10%, ** significant at 5%, *** significant at 1%

Results from the error differential regressions lead to different conclusions about the relative accuracy of econometric and random walk forecasts than the RMSE and U-statistics. The structural econometric forecasts are only significantly more accurate for a forecast horizon of one month, while the random walk benchmark is more accurate for longer forecast horizons. This implies that the structural econometric model is useful for predicting local price variations one month ahead, but for longer-run predictions it is important to examine historical trends in gasoline prices.

Chapter 7: Conclusion

The border metropolitan economies of El Paso and Ciudad Juárez are physically adjacent to each other and consumers from both cities make cross-border gasoline purchases. Because regular gasoline is a fairly homogeneous product, the behavior of border region retail gasoline prices provides at least some insight to the degree of economic integration that exists between neighboring metropolitan economies along the border between the United States and Mexico. To shed some light on this possibility, a model is specified and estimated for monthly El Paso retail gasoline price movements.

Estimation results corroborate much of what has been recorded for other regional gasoline markets. In particular, wholesale gasoline prices play prominent roles in determining both long-run and short-run retail fuel price fluctuations in El Paso. Beyond that, real per capita income and the volume of northbound automobile border crossings are found to reliably influence long-term gasoline price movements. In the short-run, real income, cross-border gasoline price changes in Ciudad Juárez, and outdoor temperatures are all found to affect El Paso gasoline prices in statistically significant manners. Deviations from the long-term equilibrium price are also found to be corrected in less than 60 days.

The long-term cointegration and short-term error correction results both indicate that El Paso gasoline prices react in very inelastic manners to variations in their south-of-the-border retail counterparts. That Magna gasoline prices are found to exercise only limited influence on monthly regular grade gasoline price in El Paso should not be interpreted as evidence that consumers treat these products as highly imperfect substitutes. More than likely, it is an indication of how

effectively the international boundary limits regional economic integration between these Borderplex neighbors.

From that perspective, it is difficult to argue that these two metropolitan economies are very integrated. Whether this is also the case for other border metropolitan economies has not been widely investigated. More research on this topic for areas such as Brownsville - Matamoros, McAllen - Reynosa, Laredo – Nuevo Laredo, Calexico – Mexicali, and San Diego – Tijuana appears warranted. Results obtained herein indicate that the international boundary still represents a formidable barrier to cross-border economic integration.

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Appendix 1: Historical Data

Date	P	Y	TY	CJ	BC	TEMP	W	ER	CPI	EMP	POP
Jan-2001	0.74	23,401	16,039	1.12	1,420,232	43.6	0.67	9.8	175.1	254.9	685,420
Feb-2001	0.73	23,556	16,160	1.12	1,476,329	52.9	0.68	9.8	175.8	255.6	686,037
Mar-2001	0.73	24,037	16,505	1.15	1,533,673	55.7	0.67	9.6	176.2	257.6	686,655
Apr-2001	0.73	23,388	16,074	1.18	1,466,347	67.7	0.78	9.35	176.9	255.1	687,273
May-2001	0.73	23,668	16,281	1.18	1,536,305	75.4	0.84	9.3	177.7	256.3	687,892
Jun-2001	0.81	23,446	16,143	1.21	1,463,662	82.7	0.73	9.15	178.0	255.5	688,512
Jul-2001	0.73	22,398	15,436	1.21	1,498,694	83.9	0.63	9.25	177.5	251.4	689,163
Aug-2001	0.69	23,203	16,005	1.21	1,695,692	81.3	0.68	9.27	177.5	254.7	689,784
Sep-2001	0.73	23,756	16,401	1.17	1,073,827	75.7	0.71	9.58	178.3	257.0	690,405
Oct-2001	0.73	22,962	15,867	1.21	981,917	67	0.57	9.35	177.7	253.9	691,026
Nov-2001	0.69	23,165	16,022	1.22	942,106	56.8	0.49	9.33	177.4	254.8	691,648
Dec-2001	0.61	23,119	16,005	1.24	1,047,051	46.4	0.46	9.26	176.7	254.7	692,271
Jan-2002	0.61	22,327	15,470	1.24	1,077,356	48.1	0.48	9.3	177.1	251.6	692,895
Feb-2002	0.61	22,382	15,522	1.25	986,307	46.7	0.49	9.23	177.8	251.9	693,518
Mar-2002	0.60	23,057	16,005	1.26	1,083,372	56	0.60	9.09	178.8	254.7	694,143
Apr-2002	0.60	23,185	16,108	1.21	1,074,452	70.5	0.67	9.46	179.8	255.3	694,768
May-2002	0.75	23,264	16,177	1.17	1,142,678	76.1	0.66	9.79	179.8	255.7	695,393
Jun-2002	0.73	22,995	16,005	1.14	1,066,031	82.9	0.65	10.13	179.9	254.7	696,020
Jul-2002	0.75	22,238	15,488	1.17	1,071,091	80.2	0.67	9.9	180.1	251.7	696,446
Aug-2002	0.72	23,304	16,246	1.15	1,101,819	82.5	0.66	10.09	180.7	256.1	697,143
Sep-2002	0.73	24,491	17,091	1.12	1,045,390	75.2	0.67	10.35	181.0	261.0	697,840
Oct-2002	0.73	23,875	16,677	1.13	1,112,502	65.1	0.70	10.29	181.3	258.6	698,538
Nov-2002	0.85	24,245	16,953	1.14	1,137,130	52.2	0.64	10.27	181.3	260.2	699,237
Dec-2002	0.71	24,443	17,108	0.88	1,197,025	46	0.65	10.54	180.9	261.1	699,937
Jan-2003	0.72	22,745	15,936	0.87	1,087,767	48.8	0.70	11.05	181.7	254.3	700,637
Feb-2003	0.84	22,919	16,074	0.97	1,005,282	50.9	0.80	11.18	183.1	255.1	701,338
Mar-2003	0.84	22,970	16,126	1.06	1,101,772	57.7	0.80	10.92	184.2	255.4	702,040
Apr-2003	0.82	23,020	16,177	1.12	1,089,218	66.8	0.73	10.43	183.8	255.7	702,742
May-2003	0.76	22,777	16,022	1.02	1,144,601	76	0.68	10.47	183.5	254.8	703,445
Jun-2003	0.75	21,873	15,402	1.02	1,160,069	80.2	0.69	10.6	183.7	251.2	704,149
Jul-2003	0.76	21,522	15,177	0.94	1,157,488	81.2	0.71	10.72	183.9	249.9	705,200
Aug-2003	0.79	22,344	15,781	1.05	1,215,898	81.5	0.80	11.18	184.6	253.4	706,259
Sep-2003	0.84	23,286	16,470	1.05	1,168,516	74.5	0.74	11.15	185.2	257.4	707,319
Oct-2003	0.79	23,153	16,401	0.95	1,242,349	66.1	0.70	11.2	185.0	257.0	708,381
Nov-2003	0.76	23,362	16,574	0.92	1,114,110	56.4	0.68	11.5	184.5	258.0	709,444
Dec-2003	0.72	23,400	16,626	0.93	1,212,136	47.1	0.67	11.33	184.3	258.3	710,509
Jan-2004	0.79	22,395	15,936	0.92	1,189,769	48	0.74	11.15	185.2	254.3	711,575
Feb-2004	0.81	22,725	16,195	1.04	1,165,730	48	0.79	11.19	186.2	255.8	712,644

Mar-2004	0.84	22,739	16,229	1.04	1,268,440	60.8	0.84	11.28	187.4	256.0	713,713
Apr-2004	0.87	22,729	16,246	1.02	1,201,825	64.1	0.87	11.55	188.0	256.1	714,785
May-2004	0.99	22,984	16,453	1.01	1,247,463	74.8	0.98	11.54	189.1	257.3	715,858
Jun-2004	0.95	22,517	16,143	1.00	1,166,787	80.1	0.91	11.65	189.7	255.5	716,932
Jul-2004	0.93	22,446	16,108	1.02	1,207,978	80.5	0.91	11.51	189.4	255.3	717,652
Aug-2004	0.90	22,511	16,177	1.02	1,266,821	78	0.89	11.52	189.5	255.7	718,657
Sep-2004	0.95	23,246	16,729	1.02	1,221,841	72.7	0.90	11.53	189.9	258.9	719,664
Oct-2004	0.97	23,428	16,884	1.01	1,282,394	66.1	0.97	11.65	190.9	259.8	720,672
Nov-2004	0.96	23,611	17,039	1.05	1,316,460	51.1	0.91	11.24	191.0	260.7	721,682
Dec-2004	0.93	23,530	17,005	1.05	1,281,698	45.4	0.79	11.32	190.3	260.5	722,693
Jan-2005	0.88	22,234	16,091	1.05	1,274,870	50.5	0.85	11.32	190.7	255.2	723,706
Feb-2005	0.93	22,536	16,332	1.05	1,171,016	49.4	0.89	11.23	191.8	256.6	724,720
Mar-2005	1.01	22,909	16,626	1.04	1,348,723	55.4	1.00	11.3	193.3	258.3	725,735
Apr-2005	1.11	23,304	16,936	1.04	1,310,532	63.2	1.06	11.2	194.6	260.1	726,752
May-2005	1.06	23,460	17,074	1.06	1,358,234	72.1	1.00	11.03	194.4	260.9	727,770
Jun-2005	1.08	23,333	17,005	1.09	1,333,307	81.1	1.04	10.8	194.5	260.5	728,789
Jul-2005	1.15	22,536	16,453	1.09	1,391,523	82.5	1.10	10.72	195.4	257.3	730,094
Aug-2005	1.24	23,021	16,832	1.07	1,404,166	78.3	1.24	10.9	196.4	259.5	731,190
Sep-2005	1.43	24,093	17,643	1.06	1,315,125	77.9	1.36	10.9	198.8	264.2	732,288
Oct-2005	1.32	24,057	17,643	1.07	1,360,750	64.9	1.19	10.92	199.2	264.2	733,387
Nov-2005	1.11	24,302	17,850	1.10	1,329,297	55.7	0.98	10.7	197.6	265.4	734,488
Dec-2005	1.09	24,406	17,953	1.11	1,374,196	47.7	0.99	10.77	196.8	266.0	735,590
Jan-2006	1.10	23,246	17,126	1.30	1,346,057	50.1	1.06	10.57	198.3	261.2	736,695
Feb-2006	1.09	23,609	17,419	1.29	1,264,703	52.2	1.03	10.58	198.7	262.9	737,800
Mar-2006	1.19	24,157	17,850	1.33	1,421,264	61	1.15	11.01	199.8	265.4	738,908
Apr-2006	1.33	23,771	17,591	1.39	1,354,207	71	1.34	11.2	201.5	263.9	740,017
May-2006	1.39	23,945	17,746	1.22	1,361,859	77.1	1.36	11.4	202.5	264.8	741,128
Jun-2006	1.37	23,607	17,522	1.20	1,295,406	81.6	1.37	11.55	202.9	263.5	742,240
Jul-2006	1.42	22,726	16,884	1.24	1,274,777	81.9	1.44	11.08	203.5	259.8	742,936
Aug-2006	1.43	23,343	17,367	1.24	1,250,131	78.6	1.35	11.05	203.9	262.6	743,977
Sep-2006	1.24	24,491	18,246	1.24	1,205,300	72.2	1.09	11.12	202.9	267.7	745,019
Oct-2006	1.07	24,457	18,246	1.18	1,295,490	65.7	1.01	10.89	201.8	267.7	746,063
Nov-2006	1.05	24,815	18,539	1.26	1,228,507	56.4	1.01	11.08	201.5	269.4	747,108
Dec-2006	1.06	25,218	18,867	1.27	1,304,901	45	1.04	10.93	201.8	271.3	748,155
Jan-2007	1.04	23,848	17,867	1.22	1,228,688	42	0.96	11.13	202.4	265.5	749,203
Feb-2007	1.05	24,159	18,125	1.23	1,175,333	50.8	1.03	11.25	203.5	267.0	750,253
Mar-2007	1.20	24,584	18,470	1.23	1,264,020	60	1.18	11.15	205.4	269.0	751,304
Apr-2007	1.37	24,802	18,660	1.23	1,212,309	62.8	1.32	11.05	206.7	270.1	752,356
May-2007	1.52	25,088	18,901	1.24	1,244,505	70.5	1.44	10.85	207.9	271.5	753,410
Jun-2007	1.50	24,641	18,591	1.23	1,070,325	78.4	1.36	10.92	208.4	269.7	754,466
Jul-2007	1.45	23,966	18,108	1.22	1,090,273	78.8	1.32	11.05	208.3	266.9	755,578
Aug-2007	1.31	24,406	18,470	1.21	1,079,901	80.1	1.25	11.15	207.9	269.0	756,788
Sep-2007	1.36	25,618	19,418	1.22	1,086,239	76.5	1.27	11.02	208.5	274.5	758,000

Oct-2007	1.31	26,258	19,936	1.24	1,171,689	67.9	1.27	10.8	208.9	277.5	759,213
Nov-2007	1.43	26,556	20,194	1.21	1,147,098	55.5	1.37	11.02	210.2	279.0	760,429
Dec-2007	1.35	27,012	20,574	1.21	1,291,673	47.9	1.32	11.03	210.0	281.2	761,647
Jan-2008	1.34	26,110	19,918	1.22	1,233,296	46	1.32	10.95	211.1	277.4	762,866
Feb-2008	1.37	26,474	20,229	1.23	1,165,293	53	1.33	10.85	211.7	279.2	764,088
Mar-2008	1.46	26,567	20,332	1.23	1,255,277	57.7	1.41	10.75	213.5	279.8	765,312
Apr-2008	1.52	26,187	20,074	1.24	1,080,519	65.2	1.50	10.65	214.8	278.3	766,537
May-2008	1.68	26,482	20,332	1.26	1,097,362	74.1	1.61	10.45	216.6	279.8	767,764
Jun-2008	1.79	25,767	19,815	1.25	1,117,507	83.9	1.70	10.43	218.8	276.8	768,994
Jul-2008	1.80	24,773	19,074	1.29	1,131,448	79.1	1.63	10.13	220.0	272.5	769,930
Aug-2008	1.69	25,265	19,487	1.27	1,121,945	77.8	1.55	10.38	219.1	274.9	771,317
Sep-2008	1.68	25,800	19,936	1.21	1,217,417	69.8	1.52	11.05	218.8	277.5	772,707
Oct-2008	1.47	26,422	20,453	1.05	1,170,161	64.2	1.15	12.96	216.6	280.5	774,099
Nov-2008	1.07	26,374	20,453	1.03	1,071,449	54	0.79	13.55	212.4	280.5	775,494
Dec-2008	0.77	26,282	20,418	0.82	1,054,760	47.8	0.62	13.95	210.2	280.3	776,891
Jan-2009	0.82	25,039	19,487	0.95	885,420	47.5	0.73	14.4	211.1	274.9	778,290
Feb-2009	0.94	24,817	19,349	0.91	843,510	53.2	0.79	15.2	212.2	274.1	779,692
Mar-2009	0.92	24,706	19,298	0.96	892,848	59	0.83	14.3	212.7	273.8	781,097
Apr-2009	0.92	24,838	19,436	0.98	861,952	64.9	0.88	14	213.2	274.6	782,504
May-2009	1.02	24,639	19,315	1.03	888,444	74.5	1.03	13.3	213.9	273.9	783,914
Jun-2009	1.20	24,419	19,177	1.02	916,424	80.8	1.16	13.3	215.7	273.1	785,327
Jul-2009	1.15	23,257	18,298	1.02	860,488	83.1	1.08	13.3	215.4	268.0	786,759
Aug-2009	1.21	23,478	18,505	1.01	1,002,373	81.3	1.16	13.4	215.8	269.2	788,176
Sep-2009	1.14	24,178	19,091	0.99	880,035	72.7	1.10	13.6	216.0	272.6	789,596
Oct-2009	1.11	24,614	19,470	1.02	881,927	64.5	1.13	13.3	216.2	274.8	791,019
Nov-2009	1.21	24,809	19,660	1.04	805,842	55.1	1.15	13	216.3	275.9	792,444
Dec-2009	1.19	24,960	19,815	1.05	810,222	43.8	1.12	13	215.9	276.8	793,872
Jan-2010	1.21	24,048	19,125	1.05	805,561	43.3	1.15	13.1	216.7	272.8	795,302
Feb-2010	1.18	24,329	19,384	1.08	759,456	46.2	1.12	12.9	216.7	274.3	796,735
Mar-2010	1.25	24,890	19,867	1.13	875,272	54	1.20	12.4	217.6	277.1	798,170
Apr-2010	1.27	25,126	20,091	1.15	845,043	64.6	1.23	12.3	218.0	278.4	799,608
May-2010	1.29	25,360	20,315	1.09	877,169	73.6	1.16	13	218.2	279.7	801,049
Jun-2010	1.21	25,121	20,160	1.11	835,520	83.3	1.15	12.95	218.0	278.8	802,492
Jul-2010	1.23	23,531	18,918	1.14	842,936	78.9	1.15	12.7	218.0	271.6	803,995
Aug-2010	1.26	23,919	19,263	1.10	846,058	82	1.13	13.3	218.3	273.6	805,363
Sep-2010	1.22	24,776	19,987	1.16	810,440	76.2	1.13	12.7	218.4	277.8	806,733
Oct-2010	1.23	24,862	20,091	1.19	844,708	67.3	1.18	12.5	218.7	278.4	808,106
Nov-2010	1.22	25,160	20,367	1.20	801,832	54.6	1.19	12.5	218.8	280.0	809,481
Dec-2010	1.26	25,351	20,556	1.21	823,964	49.1	1.26	12.48	219.2	281.1	810,858
Jan-2011	1.32	24,459	19,867	1.25	768,179	45.5	1.28	12.2	220.2	277.1	812,238
Feb-2011	1.36	24,524	19,953	1.25	688,921	47.8	1.32	12.2	221.3	277.6	813,620
Mar-2011	1.55	24,736	20,160	1.27	789,780	63.7	1.47	11.98	223.5	278.8	815,004
Apr-2011	1.65	25,053	20,453	1.32	758,532	70.7	1.58	11.6	224.9	280.5	816,391

May-2011	1.69	24,989	20,436	1.32	763,071	74.3	1.56	11.65	226.0	280.4	817,780
Jun-2011	1.58	24,778	20,298	1.31	741,542	85.6	1.46	11.8	225.7	279.6	819,171
Jul-2011	1.56	24,057	19,746	1.32	767,779	84.5	1.49	11.85	225.9	276.4	820,790
Aug-2011	1.53	24,336	20,005	1.26	813,216	85.7	1.45	12.5	226.5	277.9	822,022
Sep-2011	1.53	24,990	20,574	1.13	783,232	76.7	1.42	13.95	226.9	281.2	823,256
Oct-2011	1.45	24,430	20,143	1.19	796,634	67.3	1.39	13.4	226.4	278.7	824,492
Nov-2011	1.39	24,832	20,505	1.17	725,603	55	1.34	13.8	226.2	280.8	825,730
Dec-2011	1.31	25,066	20,729	1.16	751,888	43.2	1.31	14.1	225.7	282.1	826,969
Jan-2012	1.34	24,300	20,125	1.25	784,497	48.4	1.37	13.1	226.7	278.6	828,210
Feb-2012	1.47	24,658	20,453	1.28	742,377	50.3	1.46	12.9	227.7	280.5	829,454
Mar-2012	1.61	24,850	20,642	1.27	793,541	60.7	1.57	12.95	229.4	281.6	830,699
Apr-2012	1.66	25,206	20,970	1.27	752,976	70.2	1.57	13.1	230.1	283.5	831,946
May-2012	1.60	25,396	21,160	1.16	764,487	73.5	1.49	14.4	229.8	284.6	833,195
Jun-2012	1.52	24,841	20,729	1.25	747,929	83.2	1.38	13.55	229.5	282.1	834,445
Jul-2012	1.40	24,278	20,298	1.27	769,910	80.2	1.40	13.5	229.1	279.6	836,043
Aug-2012	1.42	24,757	20,729	1.29	806,673	82.1	1.52	13.35	230.4	282.1	837,298
Sep-2012	1.53	25,151	21,091	1.33	778,396	74.4	1.55	13	231.4	284.2	838,555
Oct-2012	1.53	25,339	21,280	1.32	817,928	66.6	1.45	13.2	231.3	285.3	839,814
Nov-2012	1.44	25,568	21,504	1.35	825,008	58.7	1.34	13.05	230.2	286.6	841,074
Dec-2012	1.35	25,755	21,694	1.37	877,999	50.4	1.29	13	229.6	287.7	842,337
Jan-2013	1.29	24,899	21,005	1.40	825,186	45.4	1.32	12.85	230.3	283.7	843,601
Feb-2013	1.44	25,065	21,177	1.40	796,749	50.1	1.48	12.85	232.2	284.7	844,868
Mar-2013	1.49	25,313	21,418	1.45	899,228	57.9	1.46	12.5	232.8	286.1	846,136
Apr-2013	1.44	25,458	21,573	1.49	874,424	64.6	1.40	12.3	232.5	287.0	847,406
May-2013	1.45	25,522	21,660	1.43	832,057	72.6	1.45	12.95	232.9	287.5	848,678
Jun-2013	1.43	24,733	21,022	1.41	813,673	82.8	1.41	13.15	233.5	283.8	849,952
Jul-2013	1.45	24,499	20,867	1.45	923,019	79.3	1.44	12.95	233.6	282.9	851,728
Aug-2013	1.43	24,623	21,005	1.40	954,560	81.9	1.42	13.55	233.9	283.7	853,048
Sep-2013	1.40	24,787	21,177	1.43	891,095	75.5	1.37	13.3	234.1	284.7	854,371
Oct-2013	1.32	24,950	21,349	1.46	948,199	65.6	1.30	13.2	233.5	285.7	855,695
Nov-2013	1.28	25,193	21,591	1.47	917,933	51.8	1.27	13.25	233.1	287.1	857,021
Dec-2013	1.29	25,274	21,694	1.46	968,596	45.2	1.28	13.5	233.0	287.7	858,350

P: Gasoline price in El Paso deflated by CPI.
Units: Dollars per Gallon. Source: Gasbuddy

Y: Real monthly income per capita in El Paso obtained by dividing estimated total monthly income over population.
Units: Dollars. Source: Global Insight

TY: Estimated total real monthly income in El Paso. Real quarterly income data are regressed by quarterly employment and real monthly income is interpolated using monthly employment data.
Units: Millions of Dollars. Source: Global Insight

CJ: Gasoline price (Magna) in Ciudad Juárez, adjusted to US dollar terms using the nominal exchange rate and deflated by CPI.
Units: Dollars per Gallon. Source: Instituto Nacional de Estadística y Geografía

BC: Total number of northbound personal vehicles crossing the border.

Units: Personal vehicles. Source: Bureau of Transportation Statistics

TEMP: Average monthly temperature in El Paso region.
Units: Degrees Fahrenheit. Source: National Oceanic and Atmospheric Administration

W: USA wholesale gasoline price deflated by CPI.
Units: Dollars per Gallon. Source: Energy Information Administration

ER: Mexico/US nominal exchange rate
Units: Pesos per Dollar. Source: Instituto Nacional de Estadística y Geografía

CPI: U.S. Consumer Price Index
Base Period: 1982-1984 = 100 Source: Bureau of Labor Statistics

EMP: Total El Paso employment
Units: One thousand jobs Source: Bureau of Labor Statistics

POP: Total El Paso monthly population linearly interpolated from available yearly population data.
Units: Persons Source: Bureau of Economic Analysis

Appendix 2: Econometric Forecasts

Date	Actual	One Month Ahead	Two Months Ahead	Three Months Ahead	Four Months Ahead	Five Months Ahead	Six Months Ahead	Seven Months Ahead	Eight Months Ahead	Nine Months Ahead	Ten Months Ahead	Eleven Months Ahead	Twelve Months Ahead
Jan-11	1.32	1.35											
Feb-11	1.36	1.39	1.41										
Mar-11	1.55	1.47	1.49	1.50									
Apr-11	1.65	1.62	1.59	1.60	1.60								
May-11	1.69	1.63	1.62	1.60	1.61	1.61							
Jun-11	1.58	1.61	1.58	1.58	1.57	1.57	1.57						
Jul-11	1.56	1.60	1.61	1.59	1.59	1.58	1.58	1.59					
Aug-11	1.53	1.54	1.55	1.56	1.55	1.55	1.54	1.54	1.54				
Sep-11	1.53	1.49	1.50	1.51	1.51	1.50	1.50	1.49	1.50	1.50			
Oct-11	1.45	1.50	1.49	1.49	1.49	1.49	1.49	1.49	1.48	1.49	1.49		
Nov-11	1.39	1.44	1.46	1.45	1.45	1.46	1.46	1.45	1.45	1.45	1.45	1.45	
Dec-11	1.31	1.38	1.40	1.41	1.41	1.41	1.41	1.41	1.41	1.41	1.40	1.41	1.41
Jan-12	1.34	1.40	1.43	1.44	1.45	1.45	1.45	1.45	1.46	1.45	1.45	1.44	1.44
Feb-12	1.47	1.45	1.48	1.50	1.51	1.52	1.51	1.51	1.52	1.52	1.51	1.51	1.50
Mar-12	1.61	1.55	1.55	1.56	1.57	1.58	1.58	1.58	1.58	1.58	1.59	1.58	1.58
Apr-12	1.66	1.62	1.59	1.59	1.60	1.60	1.61	1.61	1.61	1.61	1.61	1.61	1.61
May-12	1.60	1.57	1.55	1.54	1.54	1.55	1.55	1.55	1.56	1.55	1.55	1.56	1.56
Jun-12	1.52	1.54	1.52	1.52	1.51	1.51	1.52	1.52	1.52	1.52	1.52	1.52	1.52
Jul-12	1.40	1.51	1.52	1.52	1.51	1.51	1.51	1.51	1.52	1.52	1.52	1.52	1.52
Aug-12	1.42	1.53	1.58	1.58	1.58	1.58	1.57	1.57	1.57	1.58	1.58	1.58	1.58
Sep-12	1.53	1.54	1.59	1.61	1.61	1.61	1.61	1.60	1.60	1.61	1.61	1.61	1.62
Oct-12	1.53	1.51	1.52	1.54	1.55	1.55	1.55	1.55	1.54	1.54	1.54	1.55	1.55
Nov-12	1.44	1.48	1.47	1.47	1.48	1.49	1.49	1.49	1.49	1.48	1.48	1.49	1.49
Dec-12	1.35	1.41	1.43	1.42	1.42	1.43	1.43	1.44	1.43	1.43	1.43	1.43	1.43
Jan-13	1.29	1.40	1.43	1.44	1.44	1.44	1.44	1.45	1.45	1.45	1.44	1.44	1.44
Feb-13	1.44	1.45	1.51	1.52	1.53	1.53	1.53	1.53	1.54	1.54	1.54	1.53	1.53

Date	Actual	One Month Ahead	Two Months Ahead	Three Months Ahead	Four Months Ahead	Five Months Ahead	Six Months Ahead	Seven Months Ahead	Eight Months Ahead	Nine Months Ahead	Ten Months Ahead	Eleven Months Ahead	Twelve Months Ahead
Mar-13	1.49	1.50	1.50	1.53	1.54	1.54	1.54	1.54	1.55	1.55	1.55	1.55	1.55
Apr-13	1.44	1.51	1.51	1.51	1.53	1.54	1.54	1.54	1.54	1.54	1.55	1.55	1.55
May-13	1.45	1.51	1.54	1.55	1.55	1.56	1.56	1.56	1.56	1.56	1.57	1.57	1.57
Jun-13	1.43	1.49	1.52	1.53	1.53	1.53	1.54	1.55	1.55	1.55	1.55	1.55	1.56
Jul-13	1.45	1.48	1.51	1.52	1.53	1.53	1.53	1.53	1.54	1.54	1.54	1.54	1.55
Aug-13	1.43	1.47	1.49	1.50	1.51	1.51	1.51	1.51	1.52	1.52	1.52	1.52	1.52
Sep-13	1.40	1.46	1.47	1.48	1.49	1.49	1.50	1.50	1.50	1.50	1.51	1.51	1.51
Oct-13	1.32	1.39	1.42	1.42	1.43	1.43	1.44	1.44	1.44	1.44	1.45	1.45	1.46
Nov-13	1.28	1.34	1.37	1.39	1.39	1.39	1.40	1.40	1.40	1.40	1.40	1.41	1.42
Dec-13	1.29	1.31	1.35	1.37	1.37	1.38	1.38	1.38	1.38	1.39	1.39	1.39	1.40

Vita

Alan Jiménez was born in El Paso, Texas. The first born of Jesus Antonio Jiménez and Maria Guadalupe Rodríguez, he graduated from Immanuel Christian School, El Paso, Texas, in the spring of 2007 and entered the University of Texas at El Paso in the fall. In the spring of 2011, he graduated with a double major in Philosophy and Political Science, and entered the Masters of Science in Economics program in the summer of 2012. During his time in the Economics graduate program, he worked as a research assistant at the Border Region Modeling Project and was offered an assistantship at Texas A&M to pursue his Economics PhD beginning on the fall of 2014.

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