Cross Border Business Cycle Impacts on Commercial Electricity Demand

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Abstract

Border region electric utilities face unique circumstances in attempting to assess overall business and load demand conditions. A basic question arises with respect to such situations as to whether international economic fluctuations can be systematically incorporated into electricity demand models. Transfer function ARIMA analysis is utilized to examine whether commercial electricity sales in El Paso, Texas respond to the national and metropolitan business cycles affecting economic performance in Ciudad JuÆrez, Chihuahua in Mexico.

Resumen

Empresas de alumbrado elØctrico en regiones fronterizas se enfrentan[1] con circunstancias especiales al analizar y pronosticar el consumo de energ a elØctrica. El presente trabajo tiene como meta investigar la sis- temÆtica incorporaci n de fluctuaciones econ micas internacionales[1] en modelos estratificados de demanda de energ a elØctrica. El art culo[1] emplea funciones de transferencia ARIMA para medir la reacci n del consumo elØctrico de empresas privadas en El Paso, Texas, impulsado por cambios en los ciclos econ micos que caracterizan al mercado metropolitano de Ciudad JuÆrez, Chihuahua, y a la econom a nacional de MØxico.

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INTRODUCTION1

As long noted by area business managers, public administrators, and academic researchers, the international border regions between Texas and Mexico follow very different business cycles than do either of the national macroeconomics with which El Paso and Ciudad JuÆrez are associated. Additionally, border economic conditions on both sides of the Rio Grande are impacted by what happens in the respective regional economies on the opposite side of the river. The effects are pervasive and can cause especially noticeable impacts on commercial retail activities. Although business and policy analysts have long been aware of the complicated factors that cause the two sides of the international metroplex to follow unique expansion paths, it is difficult to model such an economy. It is to the latter that this study is directed within the context of commercial electricity demand in El Paso.

Over time, two basic modeling approaches have proven useful in the analysis of international, national, regional, and metropolitan business cycles. They include large-scale systems of equations econometric models and small-scale time series statistical models. For commercial electricity demand, these approaches represent relatively uncharted domains because very few modeling efforts have ever been conducted for cross-border regions involving an advanced economy and a developing economy. Consequently, this paper represents an exploratory effort to develop monthly commercial electric energy demand models that incorporate variables that reflect overall business conditions in Ciudad JuÆrez. The latter is of interest due to the unique problems faced by border region public utilities that are not faced by electric companies that do not operate in service areas located near international boundaries.

Subsequent sections of the study are as follows. A short review of relevant literature is provided in the next section. A brief discussion of the general methodologies to be employed is next. Empirical analysis is summarized

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in the next section. Conclusions and suggestions for future research comprise the final segment of the paper.

RELATED LITERATURE

El Paso Electric Company is a public utility corporation engaged in the generation, transmission, and distribution of electricity for a 10,000 square mile service area covering southern New Mexico and west Texas. Wholesale customers are served in California, Mexico, New Mexico, and Texas. More than half of its 270 000 residential, commercial, and industrial retail customers are located in El Paso, Texas, a metropolitan area of nearly 700 000 residents located directly on the international border between Mexico and the United States (for additional detail, see El Paso Electric, 1997).

Because so much of its retail electricity is distributed in an international metropolitan market. El Paso Electric faces a unique set of factors that set it apart from other public utilities in the United States, Namely, border area electric power demand is affected by regional business cycle fluctuations on both sides of the Rio Grande. This problem is especially apparent with respect to commercial electricity sales in El Paso due to the fact that approximately 20 percent of all retail sales activity in this important Texas city accrues from Mexican shoppers that cross the border (Totty and Barta, 1997). Further, when the tequila effect devaluation occurred in late 1994, the resulting 1995 recession in Mexico coincided with the closure of 70 retail outlets in El Paso *(The Economist,* 1998). Two basic questions, therefore, arise. Do business and economic fluctuations in Northern Mexico affect commercial electricity sales in El Paso? If so, are these impacts systematic enough to be captured within the standard modeling frameworks already utilized by El Paso Electric to forecast budget year electricity sales.

The systems of equations approach to modeling, forecasting, and policy analysis for regional and national economies can be traced back to 1936 (Dhane and Barten, 1989). Its overall design flexibility has made it an invaluable tool for corporate planning and public policy analysis. In the United States, these methods have been extensively applied to both regional and metropolitan economies during the past quarter century using quarterly and annual data (Bolton, 1985). This is especially true in Texas where the Comptroller of Public Accounts maintains an extensive modeling system for the state, its 27 metropolitan areas, and its 254 individual counties (Plaut, Preuss, and Ferguson, 1996). El Paso Electric also utilizes this approach as part of its service area modeling research efforts (Jordan, 1996). The methodology has further built an impressive track record with respect to the study of economies in Latin America (Fullerton and Araki, 1996). Some sector specific models have even been developed for cross-border linkages in recent years (Sawyer and Sprinkle, 1986), but very little has been done with respect to short-term modeling issues involving monthly data sets.

Modern times series analysis for univariate and small modeling systems dates from 1969 (Pankratz, 1983). These models are especially useful in short-term dynamic forecasting applications. They are also helpful in examining the quantitative impacts associated with new legislative and executive branch regulations and treaties such as the 1994 North American Free Trade Agreement and the various peso devaluations that have occurred since 1976. Their flexibility has allowed them to be applied to a wide range of regional taxation issues in the United States (Fullerton, 1987) and international monetary topics in Latin America (Fullerton, 1993). El Paso Electric has long relied upon univariate modeling strategies in determining short-term load demand (Fullerton, 1983). To examine the impacts of cross-border business cycle fluctuations on commercial electricity sales, however, requires a more elaborate modeling strategy that allows for the incorporation of input variables to the basic equation. Transfer function modeling offers one means for attaining this goal.

DATA AND METHODOLOGY

Detailed county and metropolitan data in the United States and Mexico are published at annual and monthly frequencies. Given this fact, it is possible to apply short-term modeling techniques utilizing the monthly data sets that are currently available in both hard copy and electronic formats. Information assembled for the El Paso - Ciudad JuÆrez international borderplex is designed to reflect business cycle fluctuations in both urban jurisdictions.

For El Paso, a comprehensive monthly frequency regional economic indicator is provided by total nonagricultural employment. Data for this series is available from the Texas Workforce commission. Also utilized as regressors for the time series models and equation systems estimated are inflation adjusted average electricity rates for three commercial sales categories. The latter are calculated by dividing total revenue collected for each rate class by total kilowatt hours (KWH) sold, as reported by El Paso Electric Company. Those results are then divided by the United States consumer price index, compiled by the Internado-nal Monetary Fund. The commercial rate categories utilized by El Paso Electric Company segregate the firms by peak demand levels. Rate 302 is for small commercial firms with peak demand levels of 15 kilowatts or less. Rate 324 is for general service commercial firms with peak loads between 15 and 600 kilowatts. Rate 325 is for large commercial firms with peak demand levels between 600 and 1000 kilowatts.

In the case of the Ciudad JuÆrez metropolitan economy, two independent variables are required to characterize local business conditions. Overall purchasing power variations are accounted for by the real exchange rate, calculated by multiplying the nominal exchange rate by the U.S. consumer price index and dividing it by the corresponding measure for Mexico. The aforementioned series are all collected by the International Monetary Fund. Reflecting the fact that the local economy often diverges from its national counterpart, total maquiladora in-bond assembly manufacturing employment is also incorporated into the modeling framework. Monthly maquiladora employment data are reported by the national statistical institute in Mexico City. Real currency devaluations such as those observed in 1986 and December 1994 lower labor costs in dollar terms, thus leading to output and employment expansion for this important industrial sector during periods in which Mexican consumer incomes actually decline.

As mentioned above, transfer function analysis offers one means for examining whether a systematic link exists between economic conditions in Ciudad JuÆrez and commercial energy demand in El Paso. This statistical methodology is an mathematically advanced modeling procedure that is closely related to the univariate time series techniques that have been employed by El Paso Electric Company since the mid-1970s. In fact, univariate autoregressive-moving average (ARIMA) analysis is one of the key components in transfer ARIMA modeling (Box and Jenkins, 1976).

Univariate ARIMA analysis utilizes the statistical information contained within a single variable to model it. The basic steps involved in developing a univariate equation are identification, estimation, and diagnostic checking of a model built to explain variation in the stationary component of a given data series (a stationary series is one whose mean and variance are both constant). Univariate ARIMA equation residuals, or unexplained movements in the dependent variable, are used to suggest input variable lag structures in multi-input transfer models. Subsequent steps involve estimation and diagnostic checking, also.

The first stage in transfer ARIMA modeling involves estimating univariate ARIMA equations for an output or dependent variable, as well as for each of the input or independent regressors. Cross correlation functions (CCFs) are then calculated between the output variable residuals and the independent variable residuals. The latter results may also be augmented by CCFs estimated for the stationary data series themselves. The transfer equation to be estimated will then involve a combination of the autoregressive and moving average parameters from the output variable univariate model plus lags of the regressor input variables. Standard diagnostic checking may require several rounds of re-estimation before a final model specification is selected. These results will indicate whether a systematic relationship exists between economic performance in Ciudad JuÆrez and retail sector electricity consumption in El Paso.

The general functional format for the three classes of commercial electricity sales modeled can be summarized as follows:

1. KWH t = f(AR,.,, MA,.¡, Real Price t.k, El Paso Emp t-l,, Maquiladora Emp t-m, Real Peso t.n),

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

where the algebraic signs under each of the independent variables indicates the nature of the hypothesized relationship between said regressor and kilowatt hour demand. In the case of the inflation adjusted value of the peso, as it becomes overvalued, its arithmetic value declines. When this occurs, it becomes increasingly less expensive for pesos to be exchanged for dollars, thus making shopping trips to the north side of the border more affordable. The time lags are allowed to vary for each of the explanatory variables as well as for the autoregressive and moving average parameters resulting from the univariate stage of the time series analysis.

EMPIRICAL RESULTS

The first stage of any transfer function modeling effort is to develop univariate ARIMA equations for all of the series to be included in the system. Stationary series, whose means (first moments) and variances (second moments) do not change over time, may have to be filtered from the raw series. For the data utilized herein, it was necessary to difference all of the series to obtain stationary working series. Table 1 summarizes the model specifications selected as part of the unvariate time series modeling procedure. The sample period is from January 1987 to December 1996. Regressor lag lengths appear in parentheses.

A total of nine univariate ARIMA models are listed in Table 1, one each for the three customer sales categories and their corresponding average rate charges, and one each for the three input regressor variables. Three of the nine equations contain moving average terms at lag one, not surprising given the fact that all of the data were differenced prior to estimation (for details on the univariate output, see Fullerton, 1998). Even more interesting is the fact that only one equation, that for maquiladora in-bond assembly employment, contains a statistically significant constant term. For regular differenced data of order one, this result implies that in-bond assembly manufacturing employment in Ciudad JuÆrez follows a virtually deterministic upward trend, adding nearly 620 new employees per month. The latter is both economically and statistically plausible given the consistently strong growth pattern observed in this sector over the past three decades.

TABLE 1. *Univariate ARIMA Model Specifications.*

Variable	*Descriptiom*	*Equation Specification*	
S302M	Small Commercial KWH Sales		MA(8, 12)
S324M	Medium Commercial Service KWH Sales	AR(12)	MA(1)
S325M	Large Commercial Service KWH Sales		MA(6, 12)
RP302	Real Commercial Price	AR(12)	MA(1)
RP324	Real General Service Price		MA(12)
RP325	Real Large Service Price		MA(7)
ELMCES	El Paso Employment	AR(12)	
CJMMAQ	Juárez Maquiladora Employment	Constant	MA(1)
REX	Real Peso per Dollar Exchange Rate	AR(3)	MA(4)

TABLE 2. *Transfer ARIMA Model Specifications.*

Variable		*Model Specification*		
S302M	Small Service Sales		MA(8,12)	ELMCES(7)
		RP302(11)	CJMMAQ(4)	REX(2)
S324M	Medium Service Sales	AR(12)	MA(1)elmces(9)	
		rp324(3)	cjmmaq(6)	rex(11)
SR25M	Large Service Sales		MA(6, 12)	ELMCES(1)
		RP325	CJMMAQ(6)	REX(4)

That the various electricity sales and price equations do not include intercept terms that are statistically distinguishable from zero is also plausible. Demand sensitivity to relatively high energy prices has been a reality that has confronted public utilities dating all the way back to the mid-1970s. Furthermore, the regulatory environments in both Texas and New Mexico have not been conducive to rate hikes for many years. Not surprisingly, then, none of the sales and price models would be expected to exhibit systematic upward trends over long periods of time.

That the real exchange rate model also does not contain a statistically significant constant term is similarly plausible. If currency markets are allowed to equalize international prices for goods and services, there is no reason to expect an inflation adjusted exchange rate to move systematically in favor of one currency or the other where pesos or dollars are concerned. It is worth pointing out, however, that this result differs from that reported for the 1979-1988 sample period in which the peso is found to systematically lose ground against the dollar (Fullerton, 1997). Somewhat more surprising is that the univariate equation for nonagricultural employment in El Paso contains a positive (as expected), but statistically insignificant intercept. That result is counterintuitive due to the fact that economic expansion in El Paso has caused its metropolitan jobs base to expand fairly rapidly. Additional investigation is certainly warranted.

Residuals from the three commercial rate classes for electricity sales univariate models are cross correlated against lags of the other univariate equation residuals. The CCF output suggested the initial lag structures to be built into the three transfer ARIMA models. The final output specifications are reported in

Table 2. Regressor lag lengths appear in parentheses. It should be recalled that all of the sales variable univariate parameters are also included in the transfer model specifications. Statistical results for the equations are detailed below.

All of the regressor series are found to impact commercial electricity consumption within a fairly short time frame. The latter observation is reflected by the fact that none of the input variables have lag lengths of more than eleven months associated with them. While all of the independent regressors have coefficients with the expected algebraic signs associated with them, most of the coefficient estimates are not significant at the 5-percent level. Equation 2 summaries the statistical output for small commercial service monthly electricity sales (S302M in KWH):

2. Small Commercial Electricity Service: Peak Demand < 15KW

D(S302M) = 30.683*D(ELMCES(-7))	- 41.090*D(RP302(-11)) +		
(0.497)	(1.803)		
0.027*D(CJMMAQ(-4))	- 14.352*D(REX(-2))-		
(1.843)	(1.050)		
0.165*MA(8) + 0.727*MA(12)			
(15.374)	(13.802)		
S.E.R.	1088.666	Log Likelihood	-922.196
Akaike	14.038	Schwarz	14.186
F-statistic	20.561	Q(12)	26.501

Increases in nonagricultural employment in El Paso lead to increased electricity consumption within seven months for small retailers, presumably due to greater overall wage and salary disbursements leading to greater purchasing activity on the part of consumers. An increase in maquiladora employment has an even shorter lead time, only four months, with respect to increased electricity consumption by small commercial firms in El Paso. Much of the downtown retailing sector on the north side of the border consists of small retail operations that cater to Mexican shoppers. A real depreciation in the peso, and consequent loss in south-of-the-border customer purchasing power, precedes a reduction small commercial electricity consumption by a mere two months, implying a very short reaction period. Reductions in electricity consumption occur eleven months after real prices for this customer rate class increase.

Among the various diagnostic measures reported for Equation 2, the parameter t-statistics appear in parentheses below their respective coefficient estimates. As mentioned above, the regression parameters are not significant at the 5-percent level, indicating that some caution must be used in interpreting these results. Overall goodness-of-fit measures for the equation are, however, fairly strong. In particular, the F-statistic is significant at the 1 -percent level. Also, the Q-statistic for white noise with twelve lags reaches the same level of significance in rejecting the hypothesis that movements in the residuals are non-random. Taken together, these measures imply that the model does a good job of explaining movements in small customer commercial electricity sales in El Paso.

Equation 3 summarizes the statistical traits associated with the transfer function model estimated for monthly electricity sales to medium service category commercial clients (S324M measured in KWH). Again, the sample covers the decade long period between January 1987 and December 1996:

3. Medium Commercial Electricity Service: 15KW < Peak Demand < 600KW

$$
\begin{aligned}
D(S324M) = {} & \underset{(1.436)}{138.081*D(ELMCES(-9))} - \underset{(0.459)}{55.333*D(RP324(-3))} + \\
& \underset{(0.615)}{0.042*D(CJMMAQ(-11))} - \underset{(0.660)}{53.655*D(REX(-11))} + \\
& \underset{(25.374)}{0.868*AR(11)} + \underset{(33.802)}{0.885*MA(12)}
\end{aligned}
$$

S.E.R.	4065.322	Log Likelihood	-976.174
Akaike	16.682	Schwarz	16.843
F-statistic	40.873	Q(12)	26.825

Reaction times to changes in the different explanatory vary with respect to those shown above, but still occur relatively quickly within eleven months or less. While individual t-statistics for the input series coefficients are not statistically significant at the prescribed 5-percent level, overall diagnostics for the model are good. Specifically, both the F-statistic and the Q-statistic exceed the 1-percent levels of significance, implying that the model is fairly successful in accounting for variations in month-to-month electricity sales for this rate class.

Modeling results for sales to the largest commercial class of electricity customers are presented in Equation 4:

4. Large Commercial Electricity Service: 600KW < Peak Demand < 1000KW

$$\begin{aligned} D(S325M) = {} & \underset{(1.601)}{66.560}{*}D(ELMCES(-1)) - \underset{(2.475)}{69.551}{*}D(RP325(-9)) + \\ & \underset{(0.767)}{0.011}{*}D(CJMMAQ(-6)) - \underset{(1.763)}{24.599}{*}D(REX(-4)) - \\ & \underset{(3.140)}{0.345}{*}MA(6) + \underset{(3.686)}{0.449}{*}MA(12) \end{aligned}$$

S.E.R.	1031.812	Log Likelihood	-849.425
Akaike	13.935	Schwarz	14.090
F-statistic	10.504	Q(12)	13.896

As with smaller rate classes, reaction times with respect to changes in the regressors are fairly rapid, occurring within nine months or less for large commercial electricity customers in El Paso. Changes in the real price for electricity charged to this rate class elicit the expected downward response in KWH purchases with a 9-month lag in a statistically significant manner. The t-statistics for the other independent variable estimated coefficients are not significant at the 5-percent level, but do carry the algebraic signs posited in Equation 1. Because the F-statistic and Q-statistic goodness-of-fit measures are both significant at the 1 -percent level, the equation models this category of commercial electricity fairly well.

As shown above, it is possible to capture the impacts of Mexican purchasing power variations and regional business cycle fluctuations in an econometrically plausible manner utilizing a transfer ARIMA modeling strategy. Although many of the individual t-statistics for the explanatory variables are not significant at the 5-percent level, F-statistics for all three commercial electricity sales categories are significant at the 1 -percent level, implying that multicollinearity may be a problem, but the overall model fits are robust. This contention is further underscored by statistically significant Q-statistics estimated for twelve lags. The latter indicates that residuals for all three equations follow white noise patterns and do not fail to explain any systematic movements in the dependent variables in question.

It is possible, of course, that inclusion of the real exchange rate index and the maquiladora employment series does not help explain movements in commercial electricity sales. If this is true, then exclusion of these variables from the stratified demand system will not cause the computed Q-statistics associated with each rate class equation to increase. To examine this eventuality, all of the above models were re-estimated using only domestic regressors on the right-hand side of the respective specifications. Associated Q-statistic results are reported in Table 3. Most notably, all three white noise portmanteau measures increased, underscoring the usefulness of the real peso index and the metropolitan in-bond assembly payroll data in modeling commercial electricity consumption on the north side of the border.

CONCLUSION

Regional econometric modeling research for border area metropolitan economies is complicated due to the interplay of cross-border national and regional business cycle fluctuations. This paper employs time series econometric techniques are to attempt to uncover a linkage between business cycle developments in Mexico and commercial electricity consumption in El Paso, Texas. Results for three separate commercial rate classes provide fairly good evidence that monthly energy sales to business entities in El Paso are systematically affected by economic conditions on the south side of the border.

Given these initial results, additional research utilizing alternative estimation methodologies and lower frequency (quarterly and annual) data should be undertaken in order to confirm the relationships uncovered above. It would also be useful to attempt to extend these results to other segments of the economy such as the various retail sales categories that are subject to state and local sales taxation. Similarly, investigating whether these relationships can be replicated for other border metropolitan areas in Texas, Arizona, and California would provide evidence as to whether these results are unique to El Paso. If the results uncovered herein are replicated in other geographic markets it would provide fairly strong evidence on cross-border regional economic linkages between the United States and Mexico.

Future research should take into account that these initial results re not immune from several econometric shortcomings. Potential problems that may resurface include multicollinearity and statistical insignificance associated with individual regression coefficients. As an alternative to the stratified demand system approach employed above, useful information may be uncovered by estimating models for aggregate KWH consumption series. Experimentation with both longer and shorter sample periods may help uncover potential parameter heterogeneity due to structural breakpoints in the underlying economies. Numerous avenues for subsequent investigative efforts remain open. Pursuit of them should help clarify as well as quantify the empirical regularities associated with cross-border business and economic linkages between Mexico and the United States.

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