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ADDITIONAL EVIDENCE REGARDING LAS CRUCES HOUSING PRICE DYNAMICS

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ABSTRACT

To examine housing price dynamics for Las Cruces, New Mexico, a theoretical model is developed that takes into account the supply and demand sides. The employed ARDL estimation methodology allows for more realistic modeling of market dynamics than prior studies of this residential real estate market, the second largest in New Mexico. A slightly larger sample size is also utilized. The results obtained corroborate evidence reported in several previous housing studies. Some unexpected outcomes also indicate that consistently reliable interlinkages between housing prices and explanatory variables may be elusive. Among the latter, an inverse relationship between apartment rents and single-family housing prices is most surprising but may be a consequence of the large university and college student population in Las Cruces. As post-secondary enrollments increase, so too do faculty numbers, allowing both housing prices and apartment rents to increase simultaneously. That implies that apartments and single-unit houses may be complements rather than substitutes in college towns like Las Cruces. Additional research using data for other small- and medium-sized urban economies would be helpful.

Contribution/Originality: This study is one of very few to have investigated housing price dynamics in a small- or medium-sized metropolitan economy. The results obtained indicate that owner-occupied housing and rental apartments may function as complements rather than substitutes over the long-run in college towns. Further analyses of smaller market housing price fluctuations appear warranted.

1. INTRODUCTION

Residential real estate is among the most important segments of any metropolitan economy. In many urban economies, the greatest number of housing units are existing, or previously built, single-family residential homes. Although Las Cruces is the second-largest metropolitan economy in New Mexico, to date, relatively few studies have analyzed the Las Cruces housing sector.

One recent effort examined the factors that influence Las Cruces housing price fluctuations (Fullerton, Holcomb, & Fullerton, 2021). The results of that study indicate that local housing price changes are correlated with local income variations and national housing price movements. However, the empirical framework employed did not allow for elaborate dynamic patterns. Given that limitation, plus the exploratory nature of the research, confirmation of the empirical outcomes reported would be useful.

This study, therefore, extends the earlier inquiry in two ways. First, it updates the data sample by including additional information. Second, it employs a different estimation methodology that allows for more intricate temporal linkages than those contemplated in the original study.

The remainder of the paper is organized as follows. Section 2 provides a brief review of the theoretical model. Section 3 summarizes the data employed and the empirical results obtained. Section 4 encapsulates the principal outcomes and offers concluding remarks.

2. THEORETICAL MODEL

The supply function is based upon that employed by DiPasquale and Wheaton (1994). The variables in Equation 1 include the Las Cruces housing supply, or stock, per capita, denoted by S, and the median real price per single-family housing unit in Las Cruces, indicated by P. The annual rate of depreciation is δ. The t subscript is a time index. The model parameters in Equation 1 are α_0, α_1, and α_2.

$$\Delta S_t = \alpha_0 + \alpha_1 P_t - \delta S_{t-1}$$

$$S_t - S_{t-1} = \alpha_0 + \alpha_1 P_t - \delta S_{t-1}$$

$$S_t = \alpha_0 + \alpha_1 P_t - \delta S_{t-1} + S_{t-1}$$

$$S_t = \alpha_0 + \alpha_1 P_t + (1-\delta) S_{t-1}$$

$$S_t = \alpha_0 + \alpha_1 P_t + \alpha_2 S_{t-1} \quad (1)$$

As shown in Equation 1, the housing stock (S) is expected to increase as the real price per unit (P) increases. Specifically, the variable S is hypothesized to be positively correlated with the contemporaneous lag of P and with a one-year lag of S. As P increases, home builders are able to construct more expensive single-family housing units because higher costs of material and labor can be covered (DiPasquale & Wheaton, 1994). A depreciation/ demolition rate coefficient, δ, is also included. The rate of demolition is generally less than 2 percent of the existing stock.

Housing demand, D, is specified in Equation 2, in a manner similar to DiPasquale and Wheaton (1994) and Fullerton and Kelley (2008). As was the case in Equation 1, P is the real median price for a stand-alone dwelling in Las Cruces. INC is the real per capita income for Las Cruces. RM denotes the real mortgage rate, calculated as the difference between the nominal mortgage rate and the personal consumption expenditures deflator inflation rate. The real monthly rent variable, RENT, controls for competition from the non-owner portion of the residential real estate market. The national real median price for single-family houses, NHP, is included in Equation 2 to account for the investment motive that underlies housing demand.

$$D_t = \beta_0 + \beta_1 INC_t - \beta_2 RM_t + \beta_3 RENT_t + \beta_4 NHP_t - \beta_5 P_t \quad (2)$$

Equation 3 develops an expression for P by equating Equations 1 and 2 and solving for P. The result expresses P as a function of contemporaneous lags of INC, RM, RENT, and NHP. It also includes a one-period lag of S as a right-hand regressor.

$$S_t = D_t$$

$$\alpha_0 + \alpha_1 P_t + \alpha_2 S_{t-1} = \beta_0 + \beta_1 INC_t - \beta_2 RM_t + \beta_3 RENT_t + \beta_4 NHP_t - \beta_5 P_t$$

$$\alpha_1 P_t = \beta_0 - \alpha_0 + \beta_1 INC_t - \alpha_2 S_{t-1} - \beta_2 RM_t + \beta_3 RENT_t + \beta_4 NHP_t - \beta_5 P_t$$

$$\alpha_1 P_t + \beta_5 P_t = \beta_0 - \alpha_0 + \beta_1 INC_t - \alpha_2 S_{t-1} - \beta_2 RM_t + \beta_3 RENT_t + \beta_4 NHP_t$$

$$(\alpha_1 + \beta_5) P_t = \beta_0 - \alpha_0 + \beta_1 INC_t - \alpha_2 S_{t-1} - \beta_2 RM_t + \beta_3 RENT_t + \beta_4 NHP_t$$

$$P_t = (\beta_0 - \alpha_0 + \beta_1 INC_t - \alpha_2 S_{t-1} - \beta_2 RM_t + \beta_3 RENT_t + \beta_4 NHP_t) / (\alpha_1 + \beta_5)$$

$$P_t = \gamma_0 + \gamma_1 INC_t + \gamma_2 S_{t-1} + \gamma_3 RM_t + \gamma_4 RENT_t + \gamma_5 NHP_t \quad (3)$$

The algebra for Equation 3 yields a specific hypothesis for each of the explanatory variable reduced form coefficients. Two of the five slope parameters above are hypothesized to be negative: $\gamma_2 < 0$; $\gamma_3 < 0$. The three remaining slope parameters are postulated to be positive: $\gamma_1 > 0$; $\gamma_4 > 0$; $\gamma_5 > 0$. Because it has fairly reasonable data requirements, Equation 3 offers a good starting point for analyzing prices in smaller urban housing markets. Greater detail on the various components associated with this model can be found in Fullerton et al. (2021). The results of that study indicate that local income, INC, and national housing prices, NHP, provide useful information regarding Las Cruces housing prices. The specification in Equation 3 does not allow for very elaborate dynamic linkages between the regressors and P. To provide better insights into that aspect of the Las Cruces housing market, an autoregressive distributed lag (ARDL) modeling framework is employed. An ARDL approach is useful because it can capture both the short-run and long-run dynamics associated with local housing prices (Ozturk & Acaravci, 2011; Pesaran, Shin, & Smith, 2001).

3. SAMPLE DATA

Table 1 lists the names, descriptions, units, and sources of the all the variables that have been collected for the data sample. Of the six variables included in the data set, four had missing observations: median Las Cruces single-family housing price (P), median 2-bedroom apartment rent (RENT), single-family housing stock (S), and real mortgage rate (RM). For P, RENT, and RM, linear regression equations were applied to impute the missing values (Friedman, 1962). As for single-family housing stock (S), percentage changes of households and population were used to extrapolate the per capita housing stock data (Sweet & Grace-Martin, 2012). Each variable, aside from single-family housing stock, was converted from nominal to real figures.

Table 1. Variable names, definitions, and units of measure.

Variable	Description	Units of Measure	Sources
P	Las Cruces Real Median Single-Family Housing Price	2012 Real $, 1000s	IHS and BRMP
INC	Las Cruces Real Income Per Capita	2012 Real $, 1000s	BEA and Census
S	Las Cruces Single-Family Housing Stock Per Capita	SF Houses Per Person	IHS, Economy.com, and BRMP
RM	Real Mortgage Rate	Percent	BRMP
RENT	Las Cruces Real Median 2-BR Apartment Rent	2012 Real $, 1000s	HUD and BRMP
NHP	USA Real Median SF Housing Price	2012 Real $, 1000s	FRED and BRMP

Notes:
BEA, U.S. Bureau of Economic Analysis.
Census, U.S. Census Bureau.
Economy.com, Moody's Analytics Economy.com.
FRED, Federal Reserve Bank of St. Louis Economic Data.
HUD, U.S. Department of Housing and Urban Development.
IHS, IHS Markit, formerly Wharton Econometrics.
BRMP, University of Texas at El Paso Border Region Modeling Project.

Summary statistics for each of the variables are reported in Table 2. Over the course of the 49-year sample period, P, the real price of a single-family housing unit in Las Cruces ranges from a minimum of $71.73 thousand in 1971 to a maximum of $163.04 thousand in 2007. As in many other regions, the price peak occurred during the global housing bubble (Kim & Renaud, 2009). Real per capita income (INC) ranges from a low of $16.27 thousand in 1971 to a maximum of $34.23 thousand in 2019. Although the peak years differ for P and INC, the correlation coefficient between the two variables is 0.925. S, per capita single-family housing stock, reached a low of 0.193 in 1993 and 1994 before ascending to 0.255 in 2019. Although a greater supply of single-family housing stock is generally associated with lower prices, the variables P and S are positively correlated with each other over time.

The real mortgage rate, RM, reaches negative territory during the first global oil shock in 1974, at -1.2 percent. Due to several factors, including a fairly tight monetary policy, RM rose to 10.49 percent in 1982 (Brazelton, 1994). RM and P have a negative correlation coefficient of -0.081. Adjusted for inflation, the median 2-bedroom apartment rent in Las Cruces, RENT, registers a minimum value of $584 per month in 1996 and a maximum of $763 per month in 2014. The median real national single-family housing price, NHP, posts a minimum of $115.496 in 1971 and a maximum of $304.221 thousand in 2017. The correlation coefficient for P and NHP is 0.901.

Table 2. Summary statistics.

Statistic	P	INC	S	RM	RENT	NHP
Mean	$117.891	$23.483	0.218	4.526	$638	$202.695
Median	$115.921	$21.249	0.215	3.888	$634	$193.016
Maximum	$163.039	$34.231	0.255	10.485	$763	$304.221
Minimum	$68.743	$15.401	0.193	-1.221	$584	$115.496
Std. Dev.	$25.019	$5.864	0.016	2.415	$40	$53.169
Skewness	-0.113	0.426	0.687	0.458	0.911	0.293
Kurtosis	2.256	1.734	2.793	3.251	4.137	2.070
Coef Var	0.212	0.250	0.074	0.534	0.062	0.262

Notes:
Sample period: 1971-2019.
P, INC & NHP are monetary units expressed in 2012 constant thousands of dollars.
RENT is monetary units expressed in 2012 constant dollars per month.
Std Dev is an acronym used for standard deviation due to space constraints.
Coef Var is an acronym used for coefficient of variation due to space constraints.

Table 3. Augmented Dickey-Fuller unit root test results.

Series	Computed Statistic	Probability
D(LP)	-3.95	0.0035
D(LINC)	-7.25	0.0000
D(LS)	-2.92	0.0499
D(LRM)	-6.27	0.0000
D(LRENT)	-2.98	0.0442
D(LNHP)	-4.68	0.0004

Notes:
Sample period: 1971-2019.
All data transformed using natural logarithms prior to differencing.
Intercept, without trend outcomes presented.
MacKinnon (1996) one-sided P values.

Table 4. ARDL model.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LP(-1)	0.874	0.162	5.403	0.0000
LP(-2)	-0.281	0.141	-1.990	0.0561
LINC	0.0779	0.085	0.916	0.3670
LS	-0.551	0.483	-1.139	0.2638
LS(-1)	0.344	0.764	0.450	0.6560
LS(-2)	-1.111	0.782	-1.420	0.1663
LS(-3)	0.835	0.743	1.124	0.2701
LS(-4)	0.900	0.504	1.784	0.0850
LRM	0.007	0.003	2.355	0.0255
LRM(-1)	0.001	0.004	0.237	0.8147
LRM(-2)	-0.006	0.003	-2.178	0.0377
LRENT	-0.158	0.103	-1.539	0.1346
LRENT(-1)	-0.183	0.108	-1.690	0.1017
LRENT(-2)	-0.107	0.112	-0.955	0.3472
LRENT(-3)	-0.254	0.106	-2.402	0.0229
LNHP	0.222	0.068	3.255	0.0029
C	5.695	1.427	3.990	0.0004
R-squared	0.991		Mean dep. var.	4.786
Adj. R-squared	0.987		S.D. dependent var.	0.186
S.E. Regression	0.021		Akaike info. criterion	-4.576
Sum sq. resid.	0.013		Schwarz criterion	-3.900
Log likelihood	122.252		Hannan-Quinn crit.	-4.323
F-statistic	211.212		Prob(F-statistic)	0.0000
Durbin-Watson	2.340			

Notes:
Sample period: 1971-2019.
All data transformed using natural logarithms.

4. ECONOMETRIC METHODOLOGY AND EMPIRICAL RESULTS

Variations in the median price of single-family housing are analyzed using an autoregressive distributed lag (ARDL) approach. The model includes five independent variables, as shown in Equation 3 and described in Tables 1 and 2. With the exception of RM, all of the data are transformed using natural logarithms prior to parameter estimation. Performing that step on the non-zero "amount" variables in the sample helps ensure that the normality assumption is satisfied (Gelman & Jennifer, 2006).

Table 5. Breusch-Godfrey LM serial correlation test results.

Test	Computed Statistic	Probability
F(2.27)	2.878	0.0736
Chi-squared	8.083	0.0176

Table 6. Breusch-Pagan-Godfrey heteroscedasticity test results.

Test	Computed Statistic	Probability
F(16.29)	1.285	0.2702
Chi-squared	19.085	0.2643

Lag length selection for the unit root ADF tests is determined using the Akaike information criterion (Pindyck & Daniel, 1998). First differencing is required to induce stationarity in all of the variables. After first differencing, all the variables are stationary at the standard 5-percent significance threshold, as shown in Table 3.

The estimation results for the ARDL model are reported in Table 4. Of particular relevance is a lag structure that goes substantially beyond that of the theoretical starting point provided by Equation 3. Two autoregressive lags of P, plus multi-year lags of S, RM, and RENT, are included in the empirical counterpart to Equation 3.

The residuals from the estimated ARDL equation are well behaved. The results of a Breusch-Godfrey Lagrange Multiplier (LM) test in Table 5 indicate that serial correlation is not present in the residuals (Asteriou & Stephen, 2016). The results of a Breusch-Pagan-Godfrey LM heteroscedasticity test in Table 6 further indicate that the residuals are homoscedastic.

Table 7. ARDL bounds test.

Test	Computed Stat.	k
F-statistic	5.781	5
Critical Value Bounds		
Significance	I(0) Bound	I(1) Bound
10%	2.26	3.35
5%	2.62	3.79
2.5%	2.96	4.18
1%	3.41	4.68

Table 7 reports the results of the ARDL bounds test. The computed F-statistic of 5.871 exceeds the upper bound critical values calculated by Narayan (2005). That implies that a cointegrating relationship does exist and corroborates evidence obtained by Abraham and Patric (1996); Malpezzi (1999) and Capozza, Hendershott, and Mack (2004). It differs, however, from what was uncovered for other regional real estate markets by Gallin (2006). The CUSUM and CUSUMSQ test results in Figures 1 and 2 confirm the stability of the model parameters (Greene, 2000). Computed statistics for both tests remain within the 5-percent critical bounds.

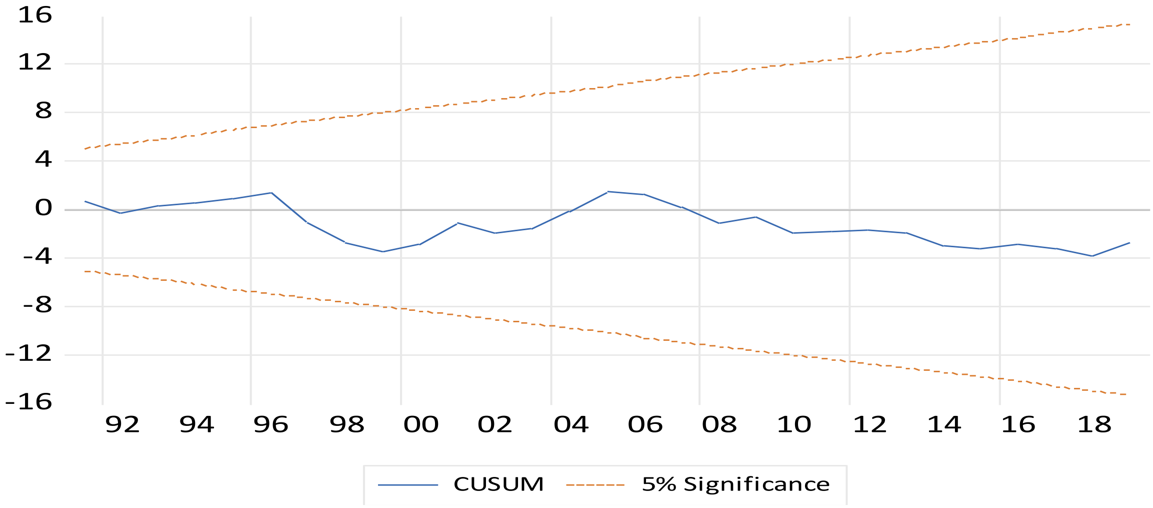

Figure 1. Cumulative sum structural break test results.

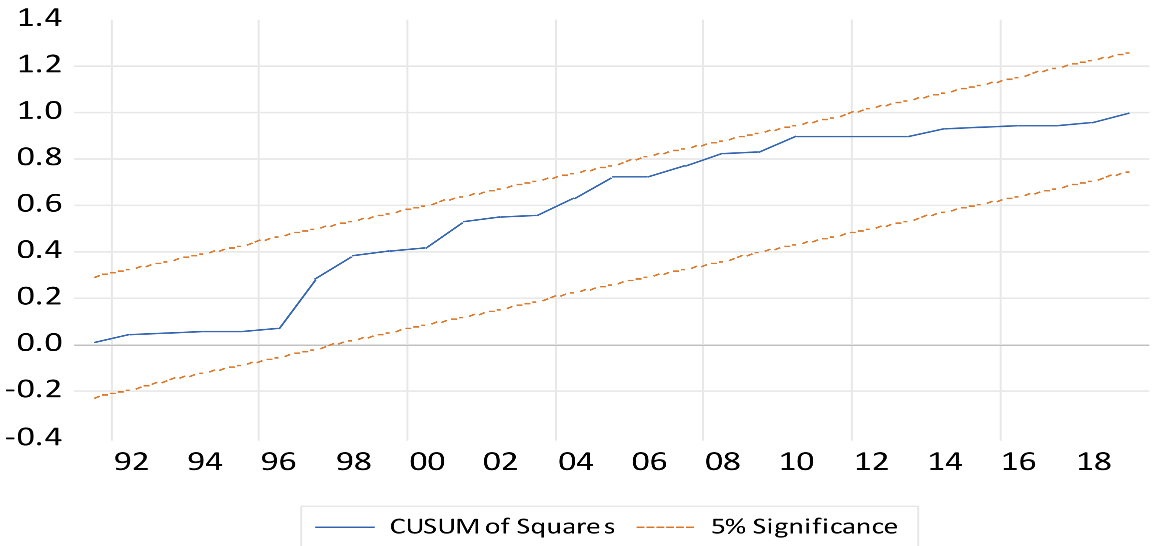

Figure 2. Cumulative sum of squares structural break test results.

Tables 8 and 9 summarize the estimation output for the long-run cointegrating and long-run level models. Table 8 contains several unexpected results. The slope coefficient for INC, the local real income variable, is positive, as hypothesized. However, the standard deviation for that coefficient is also fairly large, indicating that the relationship is somewhat unreliable. Nonetheless, the coefficient magnitude is economically plausible (Ziliak, 2008). In contrast to expectations, the parameter estimate for S, the per capita housing stock, is greater than zero and statistically significant.

The slope coefficient for RM, the real mortgage rate, is also positive but is very close to zero and economically insignificant. The fourth slope parameter in Table 9 has a sign that runs counter to what is hypothesized is that of RENT, the real apartment rent regressor. The negative sign for the RENT coefficient indicates that stand-alone housing units and apartment units in Las Cruces are not substitutes but complement one another. That intriguing possibility may be related to the important role that higher education plays in the Mesilla Valley. When enrollments at New Mexico State University and Doña Ana County Community College increase, apartment rents also increase. The consequent increases in business and economic activity are also likely to increase the demand for owner-occupied housing and raise single-family home prices. The inclusion of INC in the model specification is designed to control for that channel of causality, so further inquiry is merited.

Table 8. Long-run cointegrating model.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	5.695	1.427	3.990	0.0004
LP(-1)	-0.407	0.073	-5.538	0.0000
LINC	0.078	0.085	0.916	0.3670
LS(-1)	0.417	0.139	2.995	0.0056
LRM(-1)	0.002	0.002	0.761	0.4531
LRENT(-1)	-0.702	0.187	-3.744	0.0008
LNHP	0.222	0.068	3.255	0.0029
D(LP(-1))	0.281	0.141	1.990	0.0561
D(LS)	-0.551	0.483	-1.139	0.2638
D(LS(-1))	-0.623	0.528	-1.180	0.2477
D(LS(-2))	-1.734	0.536	-3.236	0.0030
D(LS(-3))	-0.900	0.504	-1.784	0.0850
D(LRM)	0.007	0.003	2.355	0.0255
D(LRM(-1))	0.006	0.003	2.178	0.0377
D(LRENT)	-0.158	0.103	-1.539	0.1346
D(LRENT(-1))	0.361	0.129	2.805	0.0089
D(LRENT(-2))	0.256	0.106	2.402	0.0229
R-squared	0.723		Mean dep. var.	0.015
Ad. R-squared	0.634		S.D. dep. var.	0.033
S.E. Regression	0.020		Akaike info. crit.	-4.796
Sum sq. resid.	0.013		Schwarz criterion	-4.317
Log likelihood	122.252		Hannan-Quinn crit.	-4.615
F-statistic	8.083		Prob(F-statistic)	0.0000
Durbin-Watson stat.	0.0000			

Notes:
Sample period: 1971-2019.
All data transformed using natural logarithms.

Table 9. Long-run coefficients.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LINC	0.191	0.197	0.972	0.3391
LS	1.024	0.305	3.361	0.0022
LRM	0.005	0.006	0.786	0.4382
LRENT	-1.725	0.392	-4.401	0.0001
LNHP	0.545	0.164	3.326	0.0024

Similar to the reported results of Fullerton et al. (2021), the real national housing price, NHP, slope coefficient is greater than zero in both Table 8 and Table 9. Potentially reflective of the popularity of Las Cruces as a retirement location for residents from larger urban economies with higher residential real estate prices, the magnitude of the elasticity in Table 9 is fairly large (LCB, 2019). It indicates that when NHP increases by 10 percent, P increases by 5.45 percent. Higher values of NHP tend to be associated with greater mobility. Migrants who sell houses in one region tend to bid up housing values in retirement destinations such as Las Cruces. As posited above, investment motives also contribute to this result (Miles, 2019).

A one-year lag of the residuals from the long-run cointegrating model in Table 8 is employed as a regressor in the error correction model specification. The estimation outcomes for the short-run error correction regression are reported in Table 10. As expected, most of the short-run elasticities are smaller in magnitude than the corresponding long-run elasticities. The short-run results in Table 10 align with most of the model hypotheses.

The constant term, C, indicates that real housing prices contain a deterministic component and increase by approximately $5.70 per year (2012 constant dollars). A one-year lag of the dependent variable, D(P), is used as a regressor. That implies a relatively pronounced inertial component in short-run housing price movements in Las Cruces. Both results partially corroborate the residential real estate investment rate of return hypothesis (D'Lima & Schultz, 2021).

Table 10. Error-correction model.

Variable	Coefficient	Std. Error	t-statistic	Probability
C	5.695	0.896	6.355	0.0000
D(LP(-1))	0.281	0.101	2.775	0.0095
D(LS)	-0.551	0.396	-1.392	0.1747
D(LS(-1))	-0.623	0.450	-1.385	0.1767
D(LS(-2))	-1.734	0.453	-3.832	0.0006
D(LS(-3))	-0.900	0.429	-2.099	0.0446
D(LRM)	0.007	0.002	3.123	0.0040
D(LRM(-1))	0.006	0.002	2.720	0.0109
D(LRENT)	-0.158	0.076	-2.076	0.0469
D(LRENT(-1))	0.361	0.098	3.690	0.0009
D(LRENT(-2))	0.254	0.088	2.877	0.0075
COINTEQ(-1)	-0.407	0.064	-6.348	0.0000

Notes: Sample period, 1971-2019.
All data transformed using natural logarithms.

In contrast to the long-run results, the lags of the per capita stock variable, S, exercise the hypothesized downward impact on price in Table 10. That is not the case for the real mortgage rate, RM. Both estimated parameters for RM are positive and surpass the 5-percent significance criterion. That differs from what has been documented in other studies (Chong, 2020) and may reflect the prevalence of alternate channels of influence in the Las Cruces housing market (Hattapoglu & Indrit, 2021). The sum of the real rent, RENT, parameter estimates in Table 10 is positive as anticipated. This is in partial alignment with prior research that emphasizes the importance of taking into account the rental side of residential real estate markets when analyzing housing prices (Campbell, Davis, Gallin, & Martin, 2009; Gallin, 2008). Surprisingly, no lags of NHP, the real median national housing price, are included in the error correction model. The last regression coefficient in Table 10 is the one estimated for the one-year lag of the long-run cointegrating model residuals. The error correction term is negative as hypothesized. Its magnitude implies that nearly 41 percent of any housing price disequilibrium will dissipate within one year in Las Cruces. Slightly less than 2.5 years are required for any deviation from the long-run equilibrium price to fully disappear. That is fairly similar to what is calculated for national housing price disequilibrium adjustment by Riddel (2004).

5. CONCLUSION

Residential real estate represents an important sector of all metropolitan economies. Although housing prices receive a lot of research attention, relatively few analyses are conducted for small- and medium-sized economies. Historically, that has been due to data constraints. This study employs a theoretical model that takes into account both supply and demand aspects of housing markets but does not have very extensive data requirements.

Data are collected for Las Cruces, the second-largest metropolitan economy in New Mexico. The sample period covers 1971 through 2019. As might be anticipated, the data exhibit interesting patterns of variability for this period of wide-ranging economic conditions. An autoregressive distributed lag (ARDL) modeling procedure is used to allow for realistic housing market dynamics. The empirical results support a number of individual outcomes documented in previous studies. Several unexpected results are also obtained that depart from what is implied by the underlying theoretical framework. In particular, the results indicate that rental apartments and single-family housing units may be complements rather than substitutes in college towns like Las Cruces. Additional research using data for other small- and medium-sized real estate markets seems warranted.

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