Housing Price Dynamics in the Greater Los Angeles Metropolitan Region

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Abstract: This study finds evidence for a ripple effect in the housing prices in five southern California counties in the Los Angeles metropolitan region. Specifically, housing prices in Los Angeles County and Orange County, the traditional business centers in the region, Granger-cause those in Ventura County, Riverside County, and San Bernardino County. However, there is no Granger-causal relation in housing prices between Los Angeles County and Orange County. Empirical evidence also shows that housing prices in several metropolitan statistical areas in the Los Angeles metropolitan region are co-integrated, which makes it possible to exploit the long-run equilibrium relation in forecasting housing prices within the region.

Keywords: Housing prices, ripple effect, diffusion, cointegration, Southern California

Introduction

The aim of the study is to gain a better understanding of how housing prices transmit through neighboring cities. We examine the housing price dynamics in the neighboring counties within the Los Angeles metropolitan region. Economic theory stipulates that housing prices depend on factors such as economic growth, demographic changes, and information asymmetry. It is hypothesized that business cycle shocks affect the business center first and gradually expand to peripheral cities in an unplanned sprawl. A boom in a business center draws in professionals, which initiates an increase in demand for housing. High demand outpaces relatively less elastic supply, which results in a run in housing prices. This causes a

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flight to suburbs not unlike the migration of Los Angeles residents' outflows to cities such as Palmdale, Lancaster and Moreno Valley in the 1980s. On the other hand, Clapp, Dolde, and Tiriroglu (1995) suggest that business centers enjoy an informational advantage with more professionals and intensive competition over the peripheral areas. As a result, business centers have a positive scale of economies in processing information and investors in business centers are more informed than those in remote areas. Therefore, housing prices react to information faster in the business centers than in the more remote areas.[1]

The greater Los Angeles metropolitan region is the second largest metropolitan area in the United States. According to the U.S. Census estimate in 2006, there are more than 17 million people living in the region. The real estate market in California leads every real estate boom and bust in the United States and the Los Angeles metropolitan region is in the center of the real estate boom and bust in California. Yet, there is no detailed study on the housing price transmission and dynamics in this important region.

In this study, we examine quarterly housing price indexes by the Office of Federal Housing Enterprise Oversight (OFHEO) for five southern California counties surrounding the Los Angeles metropolitan region. As discussed above, both business-cycle theory and the asymmetric information model suggest price diffusion from business centers to peripheral areas. We extend the literature by applying a vector autoregressive (VAR) approach to test whether there is a lead-lag relation in housing prices between the five counties in the southern California region. In addition, we conduct a co-integration test. An error correction model can be used to improve forecasting with two non-stationary housing price time series as long as they are integrated of order 1. From a practical viewpoint, it is very valuable if forecasting can be improved with error correction models. As a result, this study sheds light on economic theory and appeals to regulators and practitioners.

Literature Review

A ripple effect in price transmission has been documented in several international metropolitan regions. For example, Meen (1999) finds a ripple effect for regions in Great Britain based on structural differences and housing market heterogeneity. He characterized Great Britain's housing market as a series of interlinked local markets rather than as a national market. Berg (2002) finds evidence that housing prices in Stockholm Granger cause those in other six cities in Sweden. Cook (2003) and Wood (2003) find price changes exhibit a ripple effect pattern in that more desirable housing markets in the South East UK lead prices in other parts of the country. Similarly, using data from 1987 to 2004, Oikarinen (2006) finds that housing prices in the Helsinki metropolitan area leads those in regional centers. However, housing prices in the suburbs of the Helsinki metropolitan area Granger cause prices in the city center.

For regional housing markets in the United States, Clapp and Tirtiroglu (1994) analyze housing price changes in Hartford, Connecticut, and find a diffusion pattern in neighboring

[1] Notice that a migration of residents under this theory is not needed for a lead-lag relation in housing prices from business centers to remote areas.

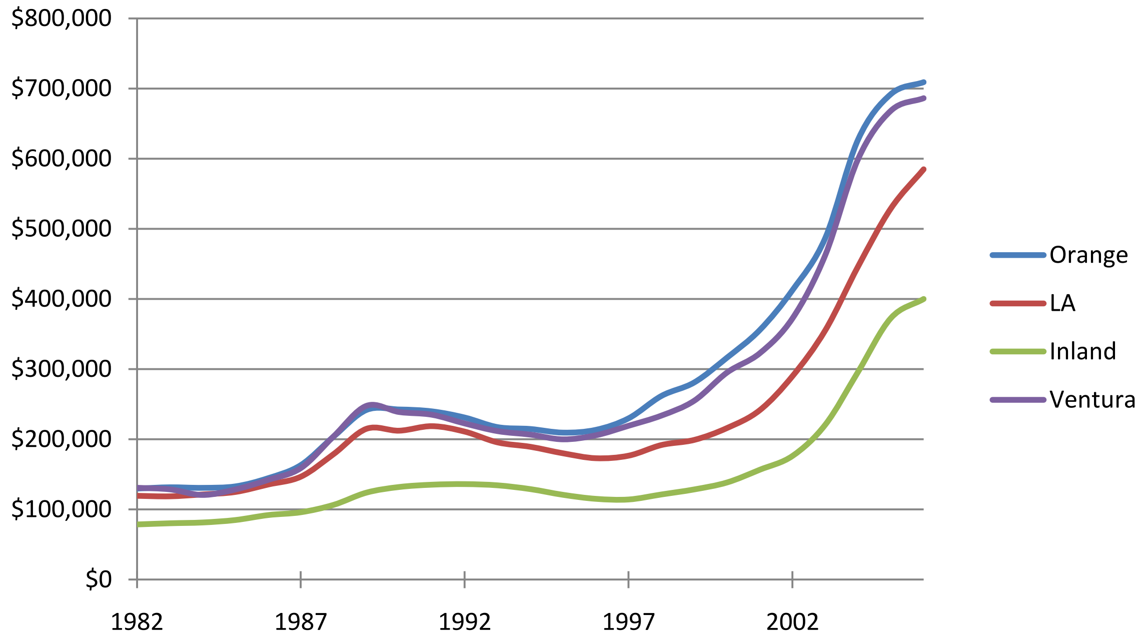
Figure 1
Map of Los Angeles Metropolitan Region

towns. Examining data from Hartford and San Francisco areas, Clapp, Dolde, and Tiriroglu (1995) and Dolde and Tirtiroglu (1997) confirm a lead-lag relation from business centers to surrounding areas. Using quarterly data, He and Winder (1999) find evidence that housing prices in three adjacent cities in the Hampton Road metropolitan area in Virginia are co-integrated, i.e., there is a stable long-run relation among prices. Using quarterly data for 5 southern California counties between 1992 and 2001, Gallet (2004) finds that housing prices in the coastal counties are not converging with those in the more inland areas within the region. He concluded that the five counties constitute unique housing sub-markets.

The Region of Five Southern California Counties

As shown in Figure 1, in the center is Los Angeles County, surrounded by Ventura County to the northwest, Kern County to the north, Orange County to the south, Riverside County to the southeast, and San Bernardino County to the northeast. The first three counties are coastal areas. In contrast, Riverside and San Bernardino counties constitute the so-called Inland Empire because the two are inland.

Figure 2
Average Annual Housing Prices in Four Regions from 1982 to 2006



Historically, the city of Los Angeles in Los Angeles County and the city of Anaheim in Orange County have served as the main business hubs for the metropolitan region. As shown in Table 1, there are more people and jobs in Los Angeles County and Orange County than in the other three counties. Orange County is the richest county in the region. It has the highest per capita income and the highest level of education among its residents as well as the lowest unemployment rate. Major businesses in Orange County include tourism, high tech, and agribusiness with the whole world as their markets. Not surprisingly, Orange County has the highest median housing value. As shown in Figure 2, Orange County has the highest average housing prices throughout the period of 1982-2006. The statistics fit the widely-held view that Orange County is a wealthy county that is very demographically apart from its bigger neighbor - Los Angeles County.

Table 1
Demographics and Housing markets in Five Counties

Panel A. Demographics

	Orange County	Ventura County	Riverside County	San Bernardino County	Los Angeles County
<u>Demographics</u>					
Population, 2006	3,002,048	799,720	2,026,803	1,999,332	9,948,081
Population growth rate[1]	5.47%	6.18%	31.15%	16.96%	4.50%
Bachelor's degree or higher[2]	30.80%	26.90%	16.60%	15.90%	24.90%
<u>Housing Markets</u>					
Housing units, 2005	1,017,219	266,554	699,474	652,802	3,339,763
Median housing value, 2006	$676,000	$648,000	$414,000	$378,100	$574,100
<u>Economics</u>					
Per capita income, 2006	$31,869	$30,517	$22,737	$20,728	$24,544
Employed Workers, 2006	1,465,894	390,136	952,021	853,493	4,566,995
Unemployment rate in 2006[3]	3.4%	4.3%	5.0%	4.7%	4.7%

Panel B. Distance in Miles between Adjacent City Centers

	Thousand Oaks	Santa Ana	Riverside	San Bernardino
Los Angeles	45	33	55	61
Santa Ana			38	52

Source: Employment Development Department, State of California.

Note: Among the five Southern California counties in the Los Angeles metropolitan region, Los Angeles County and Orange County are the traditional business centers. In Panel B, the distance between the city of Los Angeles and the city of Santa Ana, both of which are county seats, and other major satellite population centers are listed. Sources: U.S. Census Bureau unless indicated otherwise.

1. Growth rate is based on population estimate in 2006 over that in 2000.
2. Bachelor's degree or higher is the percent of persons age 25+ in Year 2000.

Data source: California Association of Realtors

Demographic data in Table 1 also confirm that Ventura, Riverside, and San Bernardino are fast growing counties as people leave Los Angeles and Orange Counties for less crowded conditions and more affordable housing. Among all five counties in the region, Riverside has had the highest annual population growth rate at 31%. The median value of houses is the lowest in Riverside and San Bernardino counties. Consequently, more housing units are built in the Inland Empire to accommodate the spillover of people from the traditional business centers of Los Angeles and Orange Counties.

Although the greater Los Angeles metropolitan region spans a vast territory, most of the residents are concentrated in a few population centers. Most of the territory consists of deserts and mountainous areas that are sparsely populated. Orange County is the smallest and most densely populated county. For Los Angeles County, most residents live in the southern part, south of the San Gabriel Mountains. For Ventura County, most people live in the southeastern part along the highway corridor between Los Angeles County and Ventura County. For San Bernardino County, a majority of the residents live in the southeastern part along the county line with Los Angeles County. For Riverside County, the population center is in the western part along the county line with Orange County and there is a sparsely populated mountain range and very little development between Southern Riverside and Northeast San Diego County. Notice that there is no major population center in the south part of Orange County, even though there are a few well known beach resort towns such as Laguna Beach and San Clemente. In addition, the northern part of San Diego County is sparsely populated due to the mountainous terrain and the presence of the San Onofre nuclear power plant and Camp Pendleton, one of the largest U.S. military bases, comprising a 123,000 acre buffer between Northern San Diego County and Southern Orange County. As a result, the U.S. Census Bureau lists San Diego County as a separate Metropolitan Statistical Area and San Diego County does not share a border with Los Angeles County. Hence, we did not include San Diego County in our study; however, for further expansion of the research, we may wish to include Santa Barbara and San Diego, but that is currently beyond our scope.

Most of the approximately 17 million people in our study live within a 60-mile radius of downtown Los Angeles. Distances between city centers are as follows: 35 miles from Santa Ana to Los Angeles; 45 miles from Thousand Oaks to Los Angeles; 55 miles from Riverside to Los Angeles; and 61 miles from San Bernardino to Los Angeles.[2] Many residents in Riverside and San Bernardino counties work in either Los Angeles County or Orange County. Some areas in the southwestern part of Riverside County are nicknamed the “New Orange County” due to the influx of residents from pricy Orange County.[3]

[2] The distance between Riverside and San Bernardino is only 10 miles and both of them are considered bedroom communities to Los Angeles and Orange Counties.

[3] See for example “Mortgage-relief plan divides neighbors,” by Jonathan Karp, *The Wall Street Journal*, December 17, 2007, Page 1.

Data

The U.S. Census Bureau identifies four Metropolitan statistical areas (MSAs) in the Los Angeles metropolitan region. They are 1) Los Angeles-Long Beach-Glendale in Los Angeles County (hereafter LA); 2) Santa Ana-Anaheim-Irvine in Orange County (hereafter Orange); 3) Oxnard-Thousand Oaks-Ventura in Ventura County (hereafter Ventura); and 4) Riverside-San Bernardino in Riverside County and San Bernardino County (hereafter the Inland Empire).
The Office of Federal Housing Enterprise Oversight publishes its quarterly housing price indexes for many MSAs including all the five southern California counties surrounding LA. The data are from the 2nd quarter of 1976 to the 4th quarter of 2006. Seasonal variations are inherited in quarterly housing prices. As a result, following Clapp, Dolde, and Tirtiroglu (1995), year-to-year price appreciation rates are calculated as in Equation 1.

$$\Delta P_t = \ln(P_t) - \ln(P_{t-4}) \quad (1)$$

where *P* is the price index level in quarter t.

Panel A of Table 2 shows LA and Ventura have a higher average price appreciation rate than that of Orange County and the Inland Empire. The Panel also illustrates that the Inland Empire and Los Angeles County had the highest standard deviation of price appreciation rate. However, as shown in Panel B of Table 2, the difference in price appreciation rates is significant only in two pairs: namely, LA-Inland Empire and Ventura-Inland Empire. Panel C of Table 2 shows that price appreciation rates are highly correlated among these four MSAs. The LA-Orange pair has the highest correlation coefficient, whereas the Ventura-Inland Empire pair has the lowest correlation coefficient.

Figure 3 shows that prices experience more swings in Ventura and the Inland Empire than in both LA and Orange. For example, prices drop more during bust periods in the Inland Empire and Ventura than in LA and Orange. Such a result is consistent with the finding in Case and Shiller (1994), who report that lower-tier properties in the Boston area appreciate the most during booms and their prices decrease more than higher-tier properties during busts. However, most previous studies generally find the opposite. For example, Smith and Taserake (1991) show that high-quality, i.e., most sought-after, houses in the Houston metropolitan area enjoy a higher price appreciation than low-quality houses during boom periods. However, these high-quality houses experience more severe price drops than low-quality houses during bust cycles. Case and Mayer (1996) show that houses in more desirable suburbs closer to Boston appreciate much more than those in more distant industrial cities. Figure 3 also provides anecdotal evidence that housing prices climb first in LA and Orange. For example, during the boom in the late 1980s, prices in both Ventura and the Inland Empire continued to rise even though those in both Los Angeles and Orange had already peaked.

Table 2
Summary Information for County/City in Los Angeles Metropolitan Region

Panel A. Housing Price Appreciation Rate in Four Southern California MSAs

Major City Cluster	County	Mean Appreciation Rate	Standard Deviation
LA	Los Angeles	8.44%	9.75%
Ventura	Ventura	8.45%	9.64%
Orange	Orange	8.14%	9.27%
Inland Empire	Riverside and San Bernardino	7.64%	9.78%

Panel B. Difference in Price Appreciation Rates between City Clusters

	LA	Ventura	Orange
Ventura	0.01% (0.04)		
Orange	-0.3% (-1.38)	0.31% (1.41)	
Inland Empire	0.79% (2.75**)	0.81% (1.95*)	0.50% (1.46)

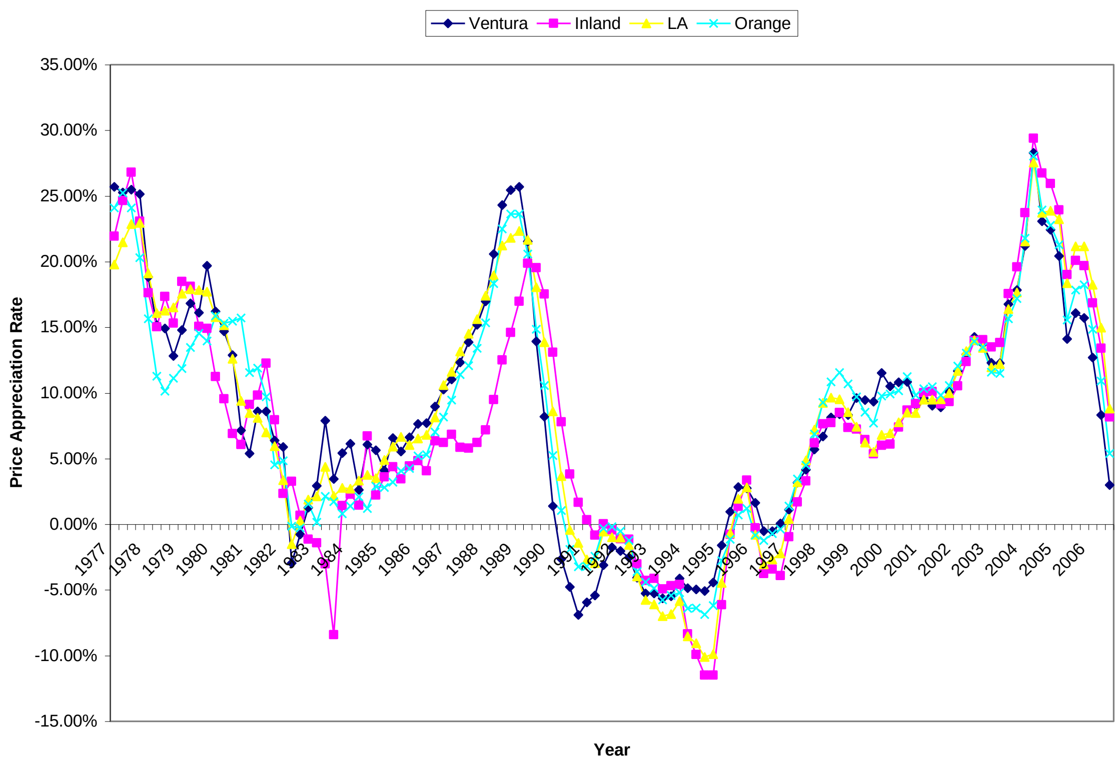
Panel C. Pearson Correlation Coefficient in Price Appreciation Rate between MSAs

	LA	Ventura	Orange
Ventura	0.96**		
Orange	0.97**	0.96**	
Inland Empire	0.94**	0.87**	0.91**

Source: Quarterly housing price index data from 2nd quarter of 1976 to 4th quarter of 2006 are obtained from (Office of Federal Housing Enterprise Oversight. The major MSAs are LA (Los Angeles-Long Beach-Glendale); Ventura (Oxnard-Thousand Oaks-Ventura); Orange (Santa Ana-Anaheim-Irvine); and the Inland Empire (Riverside-San Bernardino).

Note: The price appreciation rate is defined as $\Delta P_t = \ln(P_t) - \ln(P_{t-4})$, where *P* is price index. In Panel B, t-values are in parentheses. ** and * indicate significance at the 0.01 level and 0.05 level, respectively.

Figure 3
Year-to-year Housing Price Appreciation in Four MSA within the LA Metropolitan Region



To avoid problems of spurious regression, it is important that a time series be stationary. Three tests are used to determine whether the time series is stationary. The first test is the augmented Dickey-Fuller (ADF) test. As represented in Equation 2, the null hypothesis is that the coefficient β_1 in Equation 2 is zero, i.e., time series y_t has a unit root. The number of optimal lags (*p*) is determined by minimizing the Schwarz information criterion.

$$\Delta y_t = \alpha + \delta t + \beta_1 y_{t-1} + \sum_{i=1}^{p} \beta_i \Delta y_{t-i} + \varepsilon_t \qquad (2)$$

The second test is the Phillips-Perron (PP) test, which is a nonparametric test. The third test is the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test. The null hypothesis in the KPSS test is that the time series is stationary. In contrast, the null hypothesis in both the ADF test and the PP test is that the time series has a unit root. It is conceivable that the null hypothesis in both tests will not be rejected unless there is overwhelming evidence against the null hypothesis. Therefore, the KPSS test is added as a robust check.

Table 3
Results from the Stationarity Tests

Panel A. Yearly Price Changes			
	ADF	PP	KPSS
LA	-2.55	-1.96	0.19
	(-3.45)	(-3.45)	(0.15)
Ventura	-2.41	-2.18	0.20
	(-3,45)	(-3.45)	(0.15)
Orange	-1.97	-2.55	0.19
	(-3.45)	(-3.45)	(0.15)
Inland Empire	-1.89	-2.33	0.21
	(-3.45)	(-3.45)	(0.15)
Panel B. First Difference in Yearly Price Changes			
	ADF	PP	KPSS
LA	-3.22	-5.85	0.07
	(-3.45)	(-3.45)	(0.15)
Ventura	-4.10	-7.77	0.11
	(-3.45)	(-3.45)	(0.15)
Orange	-4.54	-6.15	0.09
	(-3.45)	(-3.45)	(0.15)
Inland Empire	-6.637	-7.93	0.06
	(-3.45)	(-3.45)	(0.15)

Note: Yearly change in price index is the year-to-year logarithm difference, i.e., $\Delta P_t = \ln(P_t) - \ln(P_{t-4})$, to remove seasonality in quarterly data. For the Augmented Dickey-Fuller test (ADF) and the Phillips-Perron test (PP), the null hypothesis is that there is a unit root in the time series. In contrast, for the Kwiatkowski-Phillips-Schmidt-Shin test (KPSS), the null hypothesis is that the time series is stationary. The model includes a constant a deterministic time-trend. The optimal number of lags is selected with the Schwarz information criterion with maximum 8 lags. In parentheses are the critical values at the 5% level.

Table 3 presents the results from the unit root test with three methods. Panel A of Table 3 presents the unit root test at the appreciation rate level. For all four areas, results are consistent across the three methods. The null hypothesis of a unit root cannot be rejected for annual appreciation rate series in both the ADF test and the PP test. Similarly, the KPSS test rejects the null hypothesis of no unit root in the time series of housing price appreciation rates. As a result, the time series needs to be differenced to avoid spurious regression.

Panel B of Table 3 presents the unit root test results for the first difference in the housing price appreciation rate. Uniformly, the three tests reach the same conclusion. In both the ADF test and the PP test, the null hypothesis of the unit root is rejected for all four MSAs. Similarly, the KPSS cannot reject the null hypothesis that the time series is stationary.

Empirical Results

A ripple effect in prices between different areas can be reflected in two aspects. First, there is a causal relation in prices between different areas. Second, a long-run equilibrium relation exists in housing prices among the MSAs in the Los Angeles metropolitan region.

We used a VAR model to examine the lead-lag relationship in price appreciation rates between different areas. Equation 3 presents a VAR (*p*) model, in which the Schwarz information criterion is used to select the optimal number of lags (*p*).

$$\begin{bmatrix} y_t \\ x_t \end{bmatrix} = \begin{bmatrix} a_0 \\ b_0 \end{bmatrix} + \begin{bmatrix} a_1 \\ b_1 \end{bmatrix} \begin{bmatrix} y_{t-1} \\ x_{t-1} \end{bmatrix} + \cdots + \begin{bmatrix} a_p \\ b_p \end{bmatrix} \begin{bmatrix} y_{t-p} \\ x_{t-p} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1,t} \\ \varepsilon_{2,t} \end{bmatrix} \quad (3)$$

As shown in Table 4, three findings stand out. First, there is no Granger-causal relation in housing price appreciation rates between LA and Orange. The result seems to support the notion that housing markets are quite "on their own" between Los Angeles County and Orange County.

Such a result is consistent with the conventional wisdom that there are two relatively separate business centers in LA County and Orange County. These two centers trigger further development in peripheral areas. Second, a one-directional causal relation is found for two pairs, i.e., from LA to Ventura and from Orange to Ventura. Such a finding is consistent with the ripple effect hypothesis in that people move from business centers such as LA and Orange to a satellite city such as Ventura. Third, a bi-directional causal relation is found for three pairs: LA-the Inland Empire, Ventura-the Inland Empire, and Orange-the Inland Empire. Under the ripple effect hypothesis, one would expect LA, Ventura, and Orange to lead the Inland Empire in housing price appreciation. On the other hand, price appreciation in the Inland Empire reinforces that in coastal areas. Therefore, there is a feedback pattern in price appreciation between the coastal areas and the Inland Empire.

A long-run equilibrium relation implies that a run-up in housing prices in one MSA filters out to other MSAs so that price movements in MSAs do not deviate too much from one another. According to Eagle and Granger (1987), a cointegration test can be applied to detect such a long-run equilibrium relation. As in Equation 4, price appreciation rates in two neighboring areas, $\Delta P_{1,t}$ and $\Delta P_{2,t}$ are co-integrated if there is a linear relation β such that

$$\Delta P_{1,t} = \beta \Delta P_{2,t} + u_t \quad (4)$$

where u_t is white noise. Notice that the changes in the price index in the two areas do not drift away from each other over time since the error term u_t is stationary. The results from the Eagle

Table 4
Results from Granger-Causality Test

Panel A. LA and Orange (*p*=4)	
LA→Orange	5.06 (0.41)
Orange→LA	5.51 (0.36)
Panel B. LA and Ventura (*p*=5)	
LA→Ventura	10.30* (0.04)
Ventura→LA	4.67 (0.32)
Panel C. LA and Inland Empire (*p*=5)	
LA→Inland Empire	27.84** (0.00)
Inland Empire→LA	12.01* (0.04)
Panel D. Orange and Ventura (*p*=4)	
Orange→Ventura	11.48* (0.02)
Ventura→Orange	6.39 (0.18)
Panel E. Ventura and Inland Empire (*p*=8)	
Ventura→Inland Empire	59.68** (0.00)
Inland Empire→Ventura	15.66* (0.05)
Panel F. Orange and Inland Empire (*p*=8)	
Orange→Inland Empire	39.16** (0.00)
Inland Empire→Orange	19.89** (0.01)

Note: Granger-casual relation between two adjacent MSAs is tested. The statistics test the null hypothesis that the price in X does not Granger-cause (→) the price in Y. Optimal number of lag length is selected using Schwarz information criterion with maximum 8 lags. In parentheses are significance levels. ** and * indicate significance at the 0.01 level and 0.05 level, respectively.

Table 5
Results from the Co-integration Test

Paired MSA	Trace Test Statistics	Eigenvalue Test Statistics
LA & Ventura	29.16**	22.53**
LA & Orange	12.75	8.94
LA & Inland Empire	16.95	13.54
Orange & Inland Empire	21.27**	17.74*
Orange & Ventura	18.62	12.04
Ventura & Inland Empire	21.23*	15.89*

Note: In both trace test and eigenvalue test, it is assumed that there is no deterministic trend in the time series and a restricted constant in the co-integration relation. Optimal number of lag length is selected using Schwarz information criterion with maximum 8 lags. The null hypothesis is that there is the number of co-integration vector (r) is zero, i.e., H_0: r=0; H_1: r>0. ** and * indicate significance at 0.01 and 0.05 levels, respectively.

and Granger method depend on the dependent variables used in the test. As a result, we use the more robust method by Johansen (1991). We assume no deterministic trend in the time series and a restricted constant in the cointegration relation since Figure 3 shows no time trend in the price appreciation rates.

Table 5 presents the results of the cointegration test based on a trace test and a maximum eigenvalue test. The results from both the trace test and the eigenvalue test are consistent. The null hypothesis of no cointegration is rejected in three pairs of MSAs: 1) LA and Ventura, 2) Orange and the Inland Empire, and 3) Ventura and the Inland Empire. Therefore, a stable long-run relationship exists for housing prices between these three pair areas. However, there is no evidence for a stable long-run relation in housing prices in the other three pairs.

Compared with the results in Gallet (2004), our results offer both support and contradiction. Results in Gallet (2004) show that housing prices are converging between coastal counties but not between coastal areas and the Inland Empire. We find a long-run equilibrium relation in housing price appreciation rates between LA and Ventura. We also find that there is no cointegration relation between LA and the Inland Empire. Both findings are consistent with his conclusion. However, we do not find a cointegration relation between Orange and Ventura, both of which are coastal counties. Furthermore, we find a cointegration relation between the Inland Empire and the coastal counties of Orange and Ventura. We attribute these differences to different methodologies. In our study, we apply unit root tests on the level for each of the four time series and then conduct cointegration tests. In contrast, Gallet (2004) calculates the price differences for each pair of counties and tests for the existence of a unit root in the differenced price time series. A simple difference in time series, as in the case of Gallet (2004), can wash away rich dynamics only observable at the level. This is the motivation behind the cointegration test, which confirms long-run relationships at the level. The method in this study is more appropriate with regards to economic theory; consequently, the results are more robust.

Summary and Conclusions

This study examines the quarterly housing price index in six metropolitan statistical areas in the Los Angeles metropolitan region. Results show that housing price appreciation rates are co-integrated in three pairs: Los Angeles County and Ventura County, Orange County and the Inland Empire, and Ventura County and the Inland Empire. However, there is no evidence to support a stable long-run relation in housing price appreciation rates for the other pairs. It provides support for the use of error correction models to exploit such a cointegration relation in improving forecasting of price changes.

It is well known that both Los Angeles County and Orange County are business centers in this vast region. Results from a VAR model show that there is no Granger-causal relation in housing price appreciation rates between Los Angeles County and Orange County. This result supports the common wisdom that housing markets in both Los Angeles County and Orange County are distinguishing markets.

On the other hand, results from the VAR model show a feedback effect in price transmission between the coastal counties and the Inland Empire. There is diffusion in housing prices from the two business centers in Los Angeles and Orange counties to satellite areas in Ventura County and the Inland Empire. Overall, the results from the housing price index in the five Southern California counties support a ripple effect in housing price transmission as predicted in economic models.

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