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"Housing Prices and Fundamentals: The Role of a Supply Shifter."

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Abstract

The present paper empirically investigates the cointegrating relation between housing prices and economic fundamental variables in the US housing market. Employing simple yet rigorous econometric techniques, the present paper finds strong evidence in favor of cointegrating relations in most US states when both demand and supply side fundamental variables are included in the cointegrating regression. This result casts doubt on previous empirical work that reports a lack of cointegrating relations of housing prices with mostly demand-side fundamental variables. The previous literature may suffer a misspecification problem. Further, the present cointegrating vector estimates seem consistent with economic theory only when both demand and supply variables are included.

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I. Introduction

The present paper examines cointegrating relation between housing prices and economic fundamental variables in single family occupied US housing market. Cointegration refers to comovements of economic variables in the long run. If housing prices and economic fundamental variables are found to be cointegrated, then they would have a stable long run relationship. The stability implies that when a shock happens, reversibility occurs reaching the steady state. Regarding the cointegration implication in the conclusion, (last sentence) the reversibility or reversion to equilibrium appears as a new empirical result (but this is an important implication of cointegration). Most of the conventional tests focus on the demand side of this relationship. Summers (1981) and Poterba (1985) argue that the outward shift in the demand curve for housing is due to the impact of high levels of inflation that increase the interest rate subsidy on home mortgages. Glaeser (2004) points out that demand-side analysis has dominated the housing literature. In order to understand booms and busts in housing prices then we need to understand housing supply. He furthers that the common combination of rising real housing prices since the late '70s and amounts of construction forces us to consider the housing supply. Therefore, the housing market model in this study includes building cost as a supply shifter with an annual data from 1975 to 2009. Other fundamentals used as explanatory variables across states are real income per capita and population.

The data show that population has been growing steadily in all states and real income per capita has been increasing in nearly all of the states. The impact of building cost on housing prices is visible in the data as well. Although real housing prices vary in most states, there has been a steady increase in almost all populous states starting from 1997, which has been referred as a "bubble". In some of the populous states, the bubble has averaged a lot more. Housing price increases averaged 11% in California, 9% in Florida, 7% in New York, 4% in Pennsylvania, 3.5% in Illinois, and 2% in Texas.

The importance of the present study lies in finding cointegration from a single equation. However, Banarjee (1999) points out that especially in small samples cointegration tests are considered to have relatively low test power. The present study demonstrates that the issue of power may not be critical to finding cointegration, rather it is a correctly specified model. Gallin (2006) uses both univariate and more powerful panel-data tests for cointegration and rejects it, employing to construction wage as a supply shifter. Wages are highly correlated with income, however, and may include only demand side information. In addition, wages add little to the explanation and may hide the supply side information. In the present study, we use a building cost index. Building costs are assumed competitive between states. This is more helpful in reflecting supply side information such as, oil price movements than construction wages.

Moreover, the paper underlines the significance of obtaining the correct signs of the estimated coefficients from univariate cointegration tests. Persistent movement among these cointegrating variables with correct signs suggests that, in the long run the housing market will reach a dynamic equilibrium. The relation among the states without cointegration may be considered as short-run phenomenon that may be a possible misalignment due to cyclical revaluation/devaluation process around the long-run relationship. The organization of the paper is as follows. Section two presents past literature review on housing market. In section three, we explain the model and econometric methods for the cointegration. Section four reports the regression results and interpretation. Finally, section five is the conclusion.

II. Literature Review

The previous studies (Abraham and Hendershott 1996, Capozza, Hendershott, Mack, and Mayer 2002, Meen 2002) indicate a common thought in the housing market; even if housing prices and income move in different directions in the short-run, the steady relationship between the two variables will eventually push them toward their long-run equilibrium. Most of the studies focus on finding cointegration by using powerful tests, such as panel regression or different sample sets. Further, these studies have not mentioned the significance of obtaining correct signs in the coefficients of cointegrating variables. Although the importance of building costs has been discussed slightly in the literature, the correct definition as a supply shifter has not been explained sufficiently well. There are many variables that contribute to building costs from land prices to steel, and from transportation cost to labor cost. If housing prices increase with general prices, then real housing prices in the long-run are expected to be stationary. [1]

As Meen (2002) points out, in the short-run with inelastic housing supply, a positive demand shock will temporarily increase housing prices. However, when prices go above the equilibrium, this relation will follow the change in the building cost levels. Most of the following literature report cointegration only from demand side. Malpezzi (1999) tests and formulates two-equation models of housing prices in many different ways, and confirms that changes in housing prices are cointegrated with income. Abraham and Hendershott (1996) estimate 30 MSAs and confirm cointegration between housing prices and income. In another MSA study, Mikhed and Zemick (2009) use several fundamental variables to explain housing prices, and find that prior to 2006 there had been a price bubble. Their univariate tests also indicate a decline in the prices for these MSAs. Holly, Pesaran, and Yamagata (2006) find in their panel study for 49 states over 29 years that housing prices are cointegrated with fundamentals (real income). Another study on dynamics of housing prices outside of US in Singapore by Hin and Cuervo (1999) find that, there is a cointegration between housing prices, and fundamentals such as real GDP and the prime lending rate.

Since 2000, there have been a quite increased number of studies done on supply side of housing market. However, there are some disagreements on the significance of some supply shifters. Phang, Kim, and Watcher (2010) report that in comparative studies, if countries have restrictive land use regulations and/or a high degree of government intervention in housing markets, then restriction and/or intervention typically decreases supply elasticities. Applying long historical data for seven industrialized countries, Madsen (2011) shows that in the US and other countries, primarily house prices are driven by land prices and construction costs in the very long run. Nevertheless, he points out that in the UK due to long-term restrictions on the development of new land and acquisition costs, building costs and agricultural land prices do not completely determine house prices in the long run. As a result, housing prices are responsive to demography and income. Also in an earlier study Malpezzi and Maclennan (2001) find that the elasticity of supply in the UK is less than the elasticity of supply in the US. The two countries show different results in prewar and postwar eras. Authors estimate supply elasticities in the UK for prewar are between 1 and 4 and for postwar are between 0 and less than 1. On the other hand, estimates in the US are to be between 4 and 10 in prewar and between 6 and 13 in postwar.

Capozza, Hendershott, Mack, and Mayer (2002) is one of the earlier studies where construction cost is used as a supply shifter in a city-level panel study for 62 Metropolitan Statistical Areas (MSA) in the US. Authors test real housing price dynamics and find correlation

[1] Here Meen (2002) states that changes in house prices can be forecasted partly and they are not random walk.

with the fundamentals, such as city size, real income growth, population growth, and real construction costs. In a very recent work, Zhou (2010) uses construction cost and mortgage rates as supply shifters, and tests the cointegration for 10 US cities. Then the author finds that only one city shows evidence of linear cointegration whereas yields evidence of non-linear cointegration for six other cities (in all, 7 cities out of 10). Galin (2006) is the only study where housing prices are not cointegrated with income in a city-level panel of 95 MSAs over 23 years. The author states that even powerful tests are not significant enough to reject the null hypothesis of no cointegration.

The univariate regression results from state level sample in the present paper noticeably demonstrate that in the US housing market there is cointegration between house prices and fundamentals in some states when we incorporate both demand and supply shifters. The approach in this study is confirming these results without relying on panel study which requires stronger assumptions. We simply finalize the results by only single equation in all states. Furthermore, our findings not only support cointegration in most states, but also explain the significance of obtaining the correct signs in the equation. However, there is no significant evidence when we employ only the demand shifters income and population.

III. The Housing Market Model

The relationship of the housing price and fundamentals can be seen by analyzing housing supply and demand. The proposed quantity of owner-occupied housing demand depends on the real price of house P, real income per capita Y, population POP, and other stochastic demand shifters ε_d. The housing supply depends on the real price of house P, building cost C, population POP, and other stochastic supply shifters ε_s:

$$Q_d = D(P, Y, POP;\ \varepsilon_d) \tag{1}$$

$$Q_s = S(P, C;\ \varepsilon_s) \tag{2}$$

The housing price and the quantity of house demanded can be written as a function of exogenous variables:

$$P = P(Y, POP, C;\ \varepsilon_d;\ \varepsilon_s) \tag{3}$$

Solution for the proposed model will be log-linearized where the log of housing price is related to the logs of the rest of the derived variables. Coefficients of this log-linearized model are assumed unchanged, and other unobserved components of the model are assumed stationary. Housing price and fundamentals in the proposed model are cointegrated with unit roots. Nonetheless, there may be many reasons why such a cointegrating relationship may not exist. The first reason may be that unstable price elasticities of supply and rapid changes in demographics may affect the price elasticity of demand. Another reason may be that local taxes may not be stationary.

A straightforward approach to explain the structural model of the housing market is the present-value model where the amount of rent should equal the user cost of housing. A long-run equilibrium relationship between the housing prices and fundamentals such as, income, would require cointegration. To elaborate the theory, we follow Poterba (1984) and Topel and Rosen (1988).

Based on this theory, we can continue with cointegration tests for state-level housing prices and fundamentals. The hypothesized regression is:

$$x_{0,t} = \alpha + \delta t + \sum_{m=1}^{M} \beta_m x_{m,t} + e_t, \quad (4)$$

where $m = 1, \dots, M$ indexes $I(1)$ variables and $t = 1, \dots, T$ indexes time. If the residuals e_t are stationary, then it can be concluded that the x's are cointegrated. We follow augmented Engle-Granger (AEG) τ test for cointegration as in Engle and Granger (1987), a two-step procedure. First, estimated residuals e_t are obtained by estimating (4) with ordinary least squares. The next step is to do an ADF τ test on the residuals.

IV. Data & Empirical Results

Annual data begin with the earliest available state data from 1975 and extend through 2009. Real housing prices, real income per capita, and population for all states come from St. Louis FRED database. The sample is single family housing price index, which is selected for the 50 states and DC. Average national building cost is obtained from Robert J. Shiller's website. Regarding the time horizon, Shiller and Perron (1985) argue more observations holding the time span fixed does not increase the power of tests. Our results, therefore, should satisfy the reader in having a finite sample of 36 observations for this time series empirical study.

The building cost index mixes 20-city average steel, cement, and lumber prices as a materials component, and includes 20-city average skilled and unskilled labor wages. Over the sample period, the building cost index has an average of 84.5 and standard error of 1.23.

Table 1 reports results of three different AEG τ tests that are run for three different models. The first model's results are displayed in the first column. In this model, income is used as a single explanatory variable, and cointegration is confirmed only in five states; California, Hawaii, Maine, Maryland, and South Dakota. In the middle column, the second model's results are displayed. Two demand shifter fundamentals income and population are incorporated in this model. Here, the results do not change as expected when one more demand shifter is added in the equation. California, DC, Iowa, Maryland, and South Dakota are the significant states with cointegration and no other state is reported as significant. Finally, in the third model population is dropped and the supply shifter building cost is added with the demand shifter income. These results are shown in the last column. When cointegration tests for the third model are compared to other one-variable and two-variable demand side models, one can see that results change dramatically. Cointegration is now confirmed in twenty states, including populous states, such as Arizona, Florida, Georgia, and North Carolina.

Table – 1 Augmented Engle/Granger Cointegration Test Results

STATES	Y	Y-POP	Y-BC	STATES	Y	Y-POP	Y-BC
Alabama	-1.17	-1.28	-4.97***	**Montana**	-2.77	-2.97	-4.13**
Alaska	-3.10	-3.11	-3.27	**North Carolina**	-1.16	-3.45	-4.36**
Arkansas	-1.25	-2.18	-4.49**	**North Dakota**	-1.23	-1.79	-5.44***
Arizona	-1.82	-1.51	-3.93*	**Nebraska**	-1.22	-2.08	-2.28
California	-3.52**	-3.68*	-3.51	**Nevada**	-3.00	-2.65	-3.38
Colorado	-1.62	-1.62	-3.73*	**New Hampshire**	-2.54	-2.40	-2.78
Connecticut	-2.46	-2.72	-2.43	**New Jersey**	-2.76	-2.75	-2.76
Delaware	-2.37	-2.82	-3.08	**New Mexico**	-1.84	-2.02	-2.60
D.C.	-3.03	-3.94*	-2.84	**New York**	-2.21	-2.16	-2.39
Florida	-2.91	-2.04	-4.08**	**Ohio**	-1.96	-3.06	-2.28
Georgia	-0.62	-2.36	-3.91*	**Oklahoma**	-1.51	-1.82	-2.94
Hawaii	-3.80**	-3.82*	-3.77*	**Oregon**	-1.90	-2.01	-3.30
Idaho	-1.15	-1.24	-3.96*	**Pennsylvania**	-2.52	-2.76	-2.95
Illinois	-1.56	-2.60	-2.83	**Rhode Island**	-2.94	-3.02	-2.65
Indiana	-1.64	-2.28	-2.94	**South Carolina**	-1.52	-2.80	-3.33
Iowa	-2.63	-4.13**	-2.21	**South Dakota**	-3.97**	-4.52**	-7.11***
Kansas	-1.89	-1.46	-2.61	**Tennessee**	-1.35	-2.90	-4.83***
Kentucky	-1.49	-2.11	-4.82***	**Texas**	-1.52	-1.49	-2.02
Louisiana	-1.70	-1.74	-3.05	**Utah**	-1.97	-1.90	-3.76*
Maine	-3.29*	-3.30	-3.06	**Virginia**	-2.24	-2.14	-3.21
Maryland	-3.87**	-3.91*	-3.55	**Vermont**	-1.79	-2.29	-2.56
Massachusetts	-3.03	-3.04	-3.05	**Washington**	-2.39	-2.39	-2.92
Michigan	-2.60	-2.84	-3.95*	**Wisconsin**	-1.76	-1.75	-4.15**
Minnesota	-1.49	-1.98	-3.20	**West Virginia**	-1.07	-2.49	-3.66*
Missouri	-1.34	-3.13	-4.41**	**Wyoming**	-1.56	-1.56	-3.52
Mississippi	-1.10	-1.23	-5.37***				

Notes: Critical Values for 35 sample-size are calculated from MacKinnon (2010); for 2 variables -4.228, -3.516, -3.168, for 3 variables -4.732, -3.994, -3.633, for 1%, 5%, and 10% respectively.

Canonical Cointegrating Regression (CCR)

Park's (1992) CCR method estimates the cointegrating vector with a number of advantages. The main idea of CCR is to implement least square estimation via transformed variables using the long-run covariance matrix of $\eta_t = [\varepsilon_t\, u_t]$, so that the LS estimator is asymptotically efficient. CCR is as efficient as the ML procedure of Johansen (1988) but is robust to distributional assumptions because it is nonparametric.[2]

[2] Johansen Test was also employed for this study. Cointegration is confirmed at least in one variable in 32 states only.

Table – 2 Model 1 – CCR Results with Single Demand Variable

	Coeff. (St. Err.)	H(p,q)		Coeff. (St. Err.)	H(p,q)
STATES	**Y**	**Stat (p-value)**	**STATES**	**Y**	**Stat (p-value)**
Alabama	-0.14(0.19)	1.60(0.21)***	**Montana**	1.59(0.49)	0.15(0.70) ***
Alaska	2.24(0.31)	0.24(0.63)***	**North Carolina**	0.34(0.04)	0.06(0.80) ***
Arkansas	-0.36(0.34)	4.26(0.04)	**North Dakota**	0.73(0.45)	2.56(0.11) ***
Arizona	0.10(0.55)	0.52(0.47)***	**Nebraska**	0.13(0.42)	2.47(0.12) ***
California	2.15(0.17)	0.46(0.50)***	**Nevada**	0.59(0.29)	0.55(0.46) ***
Colorado	0.79(0.28)	1.05(0.31)***	**New Hampshire**	0.33(0.17)	1.48(0.22) ***
Connecticut	0.53(0.46)	0.56(0.45)***	**New Jersey**	0.90(0.26)	0.13(0.72) ***
Delaware	1.09(0.25)	0.05(0.82) ***	**New Mexico**	0.50(0.52)	0.41(0.52) ***
DC	1.55(0.62)	0.58(0.45) ***	**New York**	1.83(0.36)	1.81(0.18) ***
Florida	-0.07(0.27)	1.41(0.24) ***	**Ohio**	-0.14(0.31)	2.43(0.12) ***
Georgia	0.30(0.04)	1.46(0.23) ***	**Oklahoma**	-0.70(1.51)	3.94(0.05)
Hawaii	2.80(0.43)	0.68(0.41) ***	**Oregon**	1.81(0.09)	0.65(0.42) ***
Idaho	0.58(0.14)	0.05(0.81) ***	**Pennsylvania**	0.70(0.33)	0.00(0.95) ***
Illinois	0.85(0.17)	0.03(0.87) ***	**Rhode Island**	1.27(0.25)	1.16(0.28) ***
Indiana	-0.05(0.17)	0.48(0.49) ***	**South Carolina**	0.39(0.00)	0.86(0.35) ***
Iowa	0.20(0.97)	6.40(0.01)	**South Dakota**	0.53(0.15)	4.22(0.04)
Kansas	-0.40(0.97)	2.27(0.13) ***	**Tennessee**	-0.05(0.15)	2.52(0.11) ***
Kentucky	0.20(0.26)	0.73(0.39) ***	**Texas**	-1.13(0.44)	0.03(0.87) ***
Louisiana	-0.35(0.56)	1.16(0.28) ***	**Utah**	0.67(0.40)	0.83(0.36) ***
Maine	0.94(0.23)	0.00(0.97) ***	**Virginia**	0.63(0.10)	0.06(0.81) ***
Maryland	0.92(0.12)	0.00(0.98) ***	**Vermont**	0.57(0.21)	0.15(0.70) ***
Massachusetts	1.14(0.23)	0.50(0.48) ***	**Washington**	1.61(0.19)	0.03(0.86) ***
Michigan	0.91(0.20)	0.02(0.89) ***	**Wisconsin**	0.75(0.37)	0.10(0.75) ***
Minnesota	0.65(0.16)	0.14(0.71) ***	**West Virginia**	-0.13(0.68)	3.05(0.08)
Missouri	-0.16(0.21)	10.06(0.00)	**Wyoming**	0.65(0.58)	1.88(0.17) ***
Mississippi	-0.37(0.35)	0.20(0.65) ***			

Notes: Stat and p-values in H(p,q) column with three asterisks indicate significant critical values for the corresponding states. (Under the null hypothesis of cointegration p-values > 10% are significant)

Table 2 reports the CCR estimates and the cointegration tests for the first model where housing price is defined as a function of only one demand shifter income. CCR cointegration test is displayed in H(p,q) column under the null hypothesis of cointegragtion. In this model, cointegration is confirmed in almost all states except that in Arkansas, Iowa, Missouri, Oklahoma, South Dakota, and West Virginia. However, it is seen in the coefficient column that the demand shifter income is either insignificant in nine states or has the wrong sign in thirteen states. This outcome is not expected in this study regardless of the significant cointegrating results.

Table – 3 Model 2 – CCR Results with Two Demand Variables

	Coeff. (St. Err.)		H(p,q)		Coeff. (St. Err.)		H(p,q)
STATES	**Y**	**POP**	**Stat (p-value)**	**STATES**	**Y**	**POP**	**Stat (p-value)**
Alabama	-2.17(0.89)	5.35(2.21)	1.32(0.25)***	**Montana**	2.77(0.54)	-2.76(0.94)	10.14(0.00)
Alaska	2.25(0.24)	0.18(0.08)	0.00(0.95) ***	**North Carolina**	-1.12(0.18)	1.50(0.18)	1.30(0.26) ***
Arkansas	-3.78(0.83)	6.58(1.54)	0.01(0.93) ***	**North Dakota**	0.53(0.41)	2.58(2.15)	4.99(0.03)
Arizona	2.69(0.41)	-0.83(0.40)	0.09(0.77) ***	**Nebraska**	-2.58(0.68)	8.54(2.23)	10.86(0.00)
California	0.84(0.37)	0.53(0.29)	1.44(0.23) ***	**Nevada**	2.06(0.39)	-0.42(0.10)	5.59(0.02)
Colorado	3.54(0.85)	-2.36(0.82)	3.37(0.07)	**New Hampshire**	4.12(1.36)	-5.81(2.36)	5.50(0.02)
Connecticut	-0.91(0.74)	10.23(3.66)	0.06(0.81) ***	**New Jersey**	2.12(0.22)	-1.43(0.68)	1.68(0.20) ***
Delaware	0.72(0.74)	0.23(0.85)	0.70(0.40) ***	**New Mexico**	2.78(0.66)	-2.14(0.59)	0.97(0.33) ***
DC	1.88(0.20)	2.59(0.54)	0.38(0.54) ***	**New York**	1.99(0.26)	0.41(1.41)	0.06(0.81) ***
Florida	6.54(1.17)	-4.05(0.94)	7.08(0.01)	**Ohio**	-1.42(0.36)	6.94(1.58)	5.05(0.03)
Georgia	-1.00(0.36)	0.92(0.32)	2.21(0.14) ***	**Oklahoma**	1.40(0.73)	-2.94(1.20)	15.43(0.00)
Hawaii	3.51(0.55)	-0.14(0.48)	0.22(0.64) ***	**Oregon**	1.68(1.01)	-0.50(1.46)	0.13(0.72) ***
Idaho	0.58(0.91)	-0.04(0.70)	0.24(0.63) ***	**Pennsylvania**	-0.49(0.40)	7.56(3.05)	0.02(0.88) ***
Illinois	-0.20(0.49)	2.99(1.57)	0.64(0.42) ***	**Rhode Island**	0.69(0.50)	2.91(1.64)	0.00(0.97) ***
Indiana	-1.02(0.49)	2.19(1.09)	0.02(0.88) ***	**South Carolina**	-1.81(0.36)	2.62(0.47)	0.70(0.40) ***
Iowa	-0.69(0.17)	7.27(0.79)	10.37(0.00)	**South Dakota**	-0.29(0.53)	3.02(1.95)	4.82(0.03)
Kansas	6.24(1.07)	-13.20(2.27)	3.09(0.08)	**Tennessee**	-1.73(0.48)	2.99(0.71)	5.58(0.02)
Kentucky	-1.09(0.39)	3.40(0.98)	1.36(0.24) ***	**Texas**	2.57(0.61)	-2.24(0.48)	2.07(0.15) ***
Louisiana	0.52(0.53)	-0.10(1.03)	2.31(0.13) ***	**Utah**	2.42(0.80)	-0.88(0.54)	0.54(0.46) ***
Maine	2.03(1.22)	-3.23(3.65)	0.23(0.63) ***	**Virginia**	1.58(0.09)	-1.16(0.33)	1.65(0.20) ***
Maryland	1.28(0.55)	-0.33(0.93)	1.44(0.23) ***	**Vermont**	2.74(0.41)	-5.43(1.03)	1.02(0.31) ***
Massachusetts	2.18(0.14)	0.04(1.16)	1.22(0.27) ***	**Washington**	1.80(0.89)	-0.21(0.85)	0.28(0.59) ***
Michigan	-1.38(0.39)	6.25(0.96)	0.11(0.74) ***	**Wisconsin**	1.45(1.11)	-0.71(2.35)	0.43(0.51) ***
Minnesota	-0.05(1.11)	1.65(2.06)	7.22(0.01)	**West Virginia**	0.93(0.12)	7.12(0.45)	4.34(0.04)
Missouri	-2.18(0.57)	4.46(1.15)	3.11(0.08)	**Wyoming**	0.88(0.23)	-0.94(0.40)	3.48(0.06)
Mississippi	-0.90(1.19)	1.78(3.61)	0.97(0.33) ***				

Notes: Stat and p-values in H(p,q) column with three asterisks indicate significant critical values for the corresponding states. (Under the null hypothesis of cointegration p-values > 10% are significant)

In the second model, two demand shifters income and population are employed, and the results are reported in Table 3. Even though one more demand side variable is added in the model, cointegration is still not confirmed in seventeen states. Under the coefficient column, in thirty eight states, demand shifters both or separately has the wrong sign(s). Populous states like Pennsylvania, Georgia, Michigan, and Illinois are some of the examples. While coefficient for income per capita is expected to have positive sign in the second model, in these mentioned states income has negative sign although cointegration is confirmed. These results refer that some information is still hidden in this model when two demand shifters are used.

Table – 4 Model 3 – CCR Results with Supply & Demand Variables

	Coeff. (St. Err.)		H(p,q)		Coeff. (St. Err.)		H(p,q)
STATES	**Y**	**BC**	**Stat (p-value)**	**STATES**	**Y**	**BC**	**Stat (p-value)**
Alabama	0.66(0.04)	1.49(0.09)	0.26(0.61) ***	**Montana**	1.41(0.21)	0.86(0.29)	0.49(0.48) ***
Alaska	1.87(0.42)	0.30(0.34)	0.00(0.95) ***	**North Carolina**	0.82(0.04)	1.25(0.08)	0.01(0.94) ***
Arkansas	0.50(0.06)	1.55(0.12)	0.10(0.76) ***	**North Dakota**	0.54(0.05)	2.17(0.09)	0.74(0.39) ***
Arizona	1.72(0.21)	1.98(0.36)	0.07(0.79) ***	**Nebraska**	0.63(0.22)	1.71(0.41)	0.00(0.99) ***
California	1.90(0.13)	-0.15(0.25)	5.19(0.02)	**Nevada**	0.55(0.48)	0.52(0.64)	1.16(0.28) ***
Colorado	2.12(0.23)	2.46(0.42)	0.32(0.57) ***	**New Hampshire**	0.14(0.46)	-0.08(0.86)	0.50(0.48) ***
Connecticut	1.17(0.63)	0.20(1.27)	0.03(0.86) ***	**New Jersey**	2.07(0.97)	1.77(2.19)	0.08(0.78) ***
Delaware	0.93(0.36)	0.07(0.48)	0.01(0.92) ***	**New Mexico**	0.93(0.14)	1.28(0.23)	0.17(0.68) ***
DC	2.35(0.30)	3.71(0.80)	0.01(0.93) ***	**New York**	2.74(0.52)	2.08(0.97)	0.75(0.39) ***
Florida	1.82(0.22)	2.90(0.40)	1.17(0.28) ***	**Ohio**	-0.01(0.23)	0.53(0.15)	1.55(0.21) ***
Georgia	0.98(0.10)	1.79(0.24)	0.08(0.77) ***	**Oklahoma**	0.75(0.20)	2.53(0.29)	0.19(0.66) ***
Hawaii	3.02(0.47)	0.41(0.61)	1.27(0.26) ***	**Oregon**	2.08(0.22)	1.34(0.34)	0.43(0.51) ***
Idaho	1.16(0.06)	1.50(0.12)	0.80(0.37) ***	**Pennsylvania**	0.09(0.45)	-0.11(0.29)	0.01(0.93) ***
Illinois	0.86(0.14)	0.65(0.09)	1.46(0.23) ***	**Rhode Island**	1.04(0.51)	-0.36(0.96)	0.31(0.58) ***
Indiana	0.23(0.12)	0.39(0.19)	1.62(0.20) ***	**South Carolina**	0.89(0.05)	1.39(0.11)	0.16(0.69) ***
Iowa	0.90(0.28)	2.07(0.38)	0.11(0.75) ***	**South Dakota**	0.85(0.08)	1.16(0.16)	3.69(0.06)
Kansas	0.65(0.16)	1.99(0.26)	0.04(0.85) ***	**Tennessee**	0.88(0.05)	1.60(0.11)	0.03(0.87) ***
Kentucky	0.73(0.07)	1.01(0.13)	1.95(0.16) ***	**Texas**	0.33(0.14)	1.91(0.22)	3.32(0.07)
Louisiana	0.80(0.12)	2.30(0.23)	0.19(0.66) ***	**Utah**	2.01(0.22)	2.13(0.38)	1.16(0.28) ***
Maine	1.12(0.29)	0.22(0.64)	0.02(0.90) ***	**Virginia**	0.92(0.17)	1.06(0.18)	0.00(0.99) ***
Maryland	1.30(0.23)	0.97(0.35)	0.42(0.52) ***	**Vermont**	0.69(0.21)	0.68(0.43)	0.05(0.82) ***
Massachusetts	1.86(1.08)	1.08(2.60)	0.11(0.75) ***	**Washington**	1.43(0.23)	0.00(0.42)	0.43(0.51) ***
Michigan	1.36(0.22)	0.63(0.32)	4.00(0.05)	**Wisconsin**	1.44(0.10)	1.42(0.17)	2.98(0.08)
Minnesota	1.24(0.12)	1.63(0.27)	0.11(0.74) ***	**West Virginia**	0.65(0.09)	2.12(0.14)	2.04(0.15) ***
Missouri	0.76(0.07)	1.21(0.11)	0.54(0.46) ***	**Wyoming**	0.88(0.13)	2.11(0.26)	0.23(0.63) ***
Mississippi	0.53(0.08)	1.87(0.17)	1.84(0.18) ***				

Notes: Stat and p-values in H(p,q) column with three asterisks indicate significant critical values for the corresponding states. (Under the null hypothesis of cointegration p-values > 10% are significant)

Finally in the last table we employ one demand shifter income and one supply shifter building cost when explaining house prices. We can see that again the results change dramatically in this model similar to the Augmented Engle Granger test. Cointegration is confirmed for almost all states except in California, Michigan, South Dakota, Texas, and Wisconsin. Also, coefficients are now significant and have the correct signs for the most states. Failing to confirm cointegration especially in California and Texas is expected because of the large housing markets in metropolitan cities like Los Angeles, San Francisco, Houston, and Dallas. This evidently suggests bubbles in these housing markets. However, without relying on panel study which requires stronger assumptions, the third model as a whole explains this hidden information by including the building cost index in a single equation for each state.

V. Conclusion

Choosing the right supply and demand shifters is a critical part of the study of housing market dynamics. In order to reflect more supply information, the current study incorporates building cost index as a supply shifter to test the relationship between housing prices and fundamentals in single family occupied US housing market at the state level. This study confirms that housing prices and fundamentals are linked by a long-run equilibrium relationship in most states. Cointegration is tested both with Augmented Engle Granger and canonical cointegrating regression tests for the analysis in three different models for each of the states.

There is no significant evidence to support cointegration when only demand shifters are employed in the housing market model. The present paper reveals that even with low power univariate regression methods; there is cointegration between housing prices and fundamentals in most states when both supply and demand shifters are incorporated. The previous literature has been improved with deterministic and correctly specified work by using a finite small sample. In addition, persistent movements among variables have provided much stronger cointegration results determined by the fundamentals.

When the model including both demand and supply shifters is specified more correctly, cointegration is confirmed in most states. In the states, such as California, Michigan, South Dakota, Texas, and Wisconsin with no cointegration, the relationship between housing prices and fundamentals may be considered as short-run phenomenon that may be a possible misalignment due to cyclical revaluation/devaluation process around the long-run relationship. Finally, the present paper suggests that the housing market will eventually reach equilibrium in the long run.

VI. References

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