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Asymmetric Causality and Asymmetric Cointegration between Income and House Prices in the United States of America

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When U.S. house prices were rising before the financial crisis of 2008, Case and Shiller (2003) argue that "income growth alone explains the pattern of recent home price increases in most states". Then can the decline in income after 2008 explain for the burst and abnormal decrease in house prices? Alternatively we ask whether the effects of income on house prices are symmetric or asymmetric. We employ quarterly data from each of the states in the U.S. and nonlinear autoregressive distributed lag modelling approach of Shin et al. (2014) to show that indeed, household income changes do have asymmetric effects on house prices in most of the states in the U.S. While adjustment asymmetry is borne out by the results in all states, asymmetric short-run impact is evidenced in 18 states and significant asymmetric long-run impact in 21 states.

Keywords:

House Prices, Household Income, Asymmetry, Nonlinear ARDL Approach.

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1. Introduction

Over the last three decades, the housing market in the U.S. has been subject to abnormal fluctuations. However, house prices in different states have fluctuated differently to changes in the overall economic conditions in the U.S. While many factors such as household income, interest rates, stock prices, construction costs, housing completions, and a measure of policy uncertainty are said to determine the house prices, Case and Shiller (2003, p. 300) argue that "income growth alone explains the pattern of recent home price increases in most states". If increase in income caused house prices to rise prior to 2003 - the period that was considered by Case and Shiller, did decline in income cause house prices to drop during post 2008? Furthermore, if the answer is affirmative, did income changes have symmetric or asymmetric effects on house prices?

Recent studies such as Chen and Patel (1998), Gallin (2006), Chen et al. (2007), McQuinn and O'Reilly (2008), Holmes and Grimes (2008), Kim and Bhattacharya (2009), Holly et al. (2011), Abbott and De Vita (2012 and 2013), and Katrakilidis and Tranchanas (2012) investigate the short-run causality or long-run relationships between house prices and income or some other variable in different countries.[2] While none of these studies have considered asymmetric short-run causality, Katrakilidis and Tranchanas (2012) consider asymmetric cointegration to investigate housing price dynamics in Greece. While our approach will be similar to that of Katrakilidis and Tranchanas (2012), we will modify their approach so that we can also investigate asymmetric short-run causality and engage in perhaps, the most comprehensive study that uses data from each of the 50 states and the District of Columbia in the U.S. To this end, we introduce the model and the method in Section II. The results are then reported and discussed in Section III and a concluding summary is provided in Section IV. Data definition and sources are cited in the Appendix.

2. Model and Methods

Following the literature, we begin with a log-linear relation between house prices (HP) and household income (HI) as follows:[3]

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[2] Previous literature is reviewed in Malpezzi (1999). For a detailed review of the recent literature see Bahmani-Oskooee and Ghodsi (2016).

[3] Some other studies have assessed the impact of other variables on house prices without engaging in asymmetric causality detection. Since our main goal is to investigate asymmetric causality between income and house prices, following Granger (1969), we restrict ourselves to a bivariate model. Example of studies that have included other variables without causality detection are: Mikhed and Zemcik (2007), Chen at al. (2007), Hatzius (2008), Wheaton and Nechayev (2009), Campbell et al. (2011), and Bahmani-Oskooee and Ghodsi (2016).

$$LnHP_t = a + bLnHI_t + \varepsilon_t \tag{1}$$

Specification (1) implies that household income determines house prices in the long run. But, do changes in household income cause house prices to change in the short run? Granger (1969) introduced his concept of causality by demonstrating that HI causes HP if after allowing for the past history of the dependent variable (HP), the current and past values of HI are jointly significant. The concept is only applied to stationary variables and since most of the time series variables are non-stationary, their first-differences are used for the Granger causality test below:

$$\Delta LnHP_t = \alpha + \sum_{i=1}^{n1} \beta_i \Delta LnHP_{t-i} + \sum_{i=0}^{n2} \delta_i \Delta LnHI_{t-i} + \mu_t \tag{2}$$

In (2), the household income is said to cause house prices if $\sum \delta_i \neq 0$ and this could be established either by the F or Wald test. However, later in 1987, Engle and Granger (1987) argue and demonstrate that if the two variables are adjusting in the short-run in a stable manner, we must ensure that they are also converging toward their long-run equilibrium values. If this is to be the case, the gap between two sides of (1) must decline in this process. This is tested by including a lagged error term from (1) into (2) as follows:

$$\Delta LnHP_t = \alpha + \sum_{i=1}^{n1} \beta_i \Delta LnHP_{t-i} + \sum_{i=0}^{n2} \delta_i \Delta LnHI_{t-i} + \lambda \varepsilon_{t-1} + \mu_t \tag{3}$$

Specification (3) is called an error-correction model in which estimates of λ must be negative and significant if adjustment is to be toward the long-run.

Three points related to Equations 1-3 deserve mention. First, according to Engle and Granger (1987) if the two variables in (1) are integrated of the same order d, and if they are to be cointegrated, ε_t should be integrated at an order less than d. For example, if both HP and HI are integrated of order one, ε_t should be stationary for cointegration. Second, Bahmani-Oskooee and Oyolola (2007) have argued that we can still use (3) to establish Granger causality from HI to HP by testing whether $\sum \delta_i \neq 0$ in (3). Finally, Banerjee et al. (1998) demonstrate that if the estimate of λ in (3) is negative and significant, that could be an indication of cointegration between two variables. However, they argue that the t-ratio that is used to judge its significance has a non-standard distribution, hence they provide new critical values.

In case one variable is I(1) and the other one is I(0) in Equation (1) or in any other linear model, none of the above tests are applicable. Pesaran et al. (2001) then introduce a unique procedure known as the autoregressive distributed lag modelling (ARDL) approach or a bounds testing approach. They solve Equation (1) for ε_t and lag the solution by one period to arrive at:

$$\varepsilon_{t-1} = LnHP_{t-1} + b' LnHI_{t-1} \tag{4}$$

The right-hand side of (4) replaces ε_{t-1} in (3) to arrive at another error-correction specification as follows:

$$\Delta LnHP_t = \alpha + \sum_{i=1}^{n1} \beta_i \Delta LnHP_{t-i} + \sum_{i=0}^{n2} \delta_i \Delta LnHI_{t-i} + \lambda_0 LnHP_{t-1} + \lambda_1 LnHI_{t-1} + \mu_t \quad (5)$$

Pesaran et al. (2001) then propose to apply the F test to establish joint significance of lagged level variables in (5) as a sign of cointegration. However, they tabulate that the F test in this context has new critical values. Since the critical values account for integrating properties of variables in a given mode, there is no need for pre-unit root testing and indeed, variables could be a combination of I(0) and I(1).[4] Once cointegration is established, the long-run effects of HI on HP are established by normalizing estimates of λ_1 on λ_0. The short-run effects are judged by the estimates of δ_is. Following Bahmani-Oskooee and Oyolola (2007), we apply the Wald test to determine whether $\sum \delta_i \neq 0$ is a sign of short-run causality.

One main assumption in estimating (5) is that changes in household income have symmetric effects on house prices. However, it is possible that the effects could be asymmetric. When household income rises, more people are working and they are more optimistic about the future, hence demand for housing increases, pushing the prices higher. However, when household income falls due to loss of a job, this could be considered a short-run phenomenon and some may continue financing their house by using their savings rather than selling their house and depressing the house price; hence asymmetric response of house prices to changes in household income. In order to assess the asymmetric effects of changes in household income, we follow Shin et al. (2014) and first form $\Delta Ln\ HI$ as changes in household income. We then use the partial sum of the positive changes (denoted by $\Delta Ln\ HI^+$) to generate a variable, POS, which indicates only increases in household income. Similarly, we use the partial sum of the negative changes (denoted by $\Delta Ln\ HI^-$) and generate a variable, NEG, which reflects only the decline in income as follows:

$$\begin{aligned} POS_t &= \sum_{j=1}^{t} \Delta LnHI_j^+ = \sum_{j=1}^{t} \max(\Delta LnHI_j, 0) \\ NEG_t &= \sum_{j=1}^{t} \Delta LnHI_j^- = \sum_{j=1}^{t} \min(\Delta LnHI_j, 0) \end{aligned} \quad (6)$$

Shin et al. (2014) then recommend replacing Ln HI in (5) with POS and NEG variables to arrive at the following specification:

[4] Indeed, we have made sure that there is no I(2) variable.

$$\Delta LnHP_t = \alpha + \sum_{i=1}^{n1} \beta_i \Delta LnHP_{t-i} + \sum_{i=0}^{n2} \delta_i^+ \Delta POS_{t-i} + \sum_{i=0}^{n3} \delta_i^- \Delta NEG_{t-i} + \rho_0 LnHP_{t-1} + \rho_1^+ POS_{t-1} + \rho_1^- NEG_{t-1} + \xi_t \quad (7)$$

Since the method of constructing the two variables, i.e., POS and NEG, introduce nonlinearity into the model, Shin et al. (2014) label this specification a nonlinear ARDL model so that Model (5) is referred to as a linear ARDL model. They show that the method and critical values in Pesaran et al. (2001) are equally applicable to (7).

Once (7) is estimated by using a set criterion, such as the Akaike information criterion (AIC), to select an optimum model, we shall engage in testing a few hypotheses. First, we shall infer that there is short-run ‘adjustment asymmetry’ if the number of lags obtained for the *ΔPOS* variable are different than those obtained for the *ΔNEG* variable. Second, in terms of the size of the impact, we will establish short-run ‘impact asymmetry’ if $\sum \delta_i^+ \neq \sum \delta_i^-$. This is done by applying the Wald test. Third, we will establish asymmetric short-run Granger causality if either $\sum \delta_i^+ \neq 0$ or $\sum \delta_i^- \neq 0$. If the first condition holds but the second condition does not, then we shall conclude that an increase in income causes house prices but decrease in income does not. Similarly, if the second condition is proven to hold but not the first one, we will conclude that a decline in income causes house prices but not an increase. Again the Wald test will be used to test these hypotheses. Fourth, cointegration between the Ln HP, POS and NEG variables will be established by applying the F test and using upper bound critical values from Pesaran et al. (2001). Note here that Shin et al. (2014, p. 291) recommend that POS and NEG should be treated as one variable and use the critical values for the case of k=1. This is mostly due to dependence between POS and NEG and the fact that critical values are higher for the case of one exogenous variable (k=1) compared to when k=2. Alternative testing for cointegration will be based on Banerjee et al. (1998). Within the linear or nonlinear ARDL approach, Pesaran et al. (2001) propose the use of long-run normalized estimates and long run models in either case to generate the error term. Denoting this error term with an error correction mechanism (ECM), the linear combination of the lagged level variables are then replaced by ECM_{t-1} and the new specification is estimated at optimum lags. Like the F test, the t-statistic that is used to judge the significance of ECM_{t-1} in the ARDL approach has upper and lower bound critical values that Pesaran et al. (2001, p. 303) supply. Finally, once cointegration is established, the asymmetric long-run effects of household income changes are tested by using the Wald test to determine if estimates of $\rho_1^+ \neq \rho_1^-$.[5]

[5] For some of the other applications of the linear model see Bahmani-Oskooee and Tanku (2008), and De Vita and Kyaw (2008). For the nonlinear model see Apergis (2003), Apergis and Miller (2006), Bahmani-Oskooee and Bahmani (2015), Bahmani-Oskooee and Fariditavana (2016), and Verheyen (2013).

3. Results

The linear model (5) and nonlinear model (7) are both estimated by using quarterly data over the period of 1975I-2014III from each of the states in the U.S. Details of the data are provided in the Appendix. We impose a maximum of eight lags on each-first differenced variable and use AIC to select the optimum lags. We then report the results from each optimum linear and nonlinear model and for each state in Table 1. For each model, after excluding the short-run estimates for the dependent variable, we report the short-run estimates in Panel A and long-run estimates in Panel B. All diagnostic statistics are then reported in Panel C. For ease of exposure and reading, a significant coefficient or statistic at the 10% (5%) level is indicated by one * (two **). These significant statistics are identified by using the critical values reported at the bottom of Table 1.

We begin reviewing the results for the state of Alaska, the first state in Table 1 and then summarize the results for the remaining states. In the linear model, since household income carries two significant coefficients, we can say that household income in Alaska has short-run effects on house prices. The sum of these short-run effects is significant, which implies short-run causality from household income to house prices. However, these short-run effects do not seem to last to the long run since the long-run coefficient obtained for LnHI is insignificant. It is no wonder why cointegration is not supported by neither the F test nor by ECM_{t-1}. Neither is significant in this linear model. The Lagrange multiplier (LM) statistic is also insignificant, thus implying autocorrelation free residuals but the coefficient estimate is unstable once the CUSUM (denoted by QS) and CUSUMSQ (denoted by QS^2) are applied to the residuals of the optimum model. While unstable estimates are denoted by “U”, stable ones are denoted by “S”.

How do our findings change if we shift to the estimate of the nonlinear model in Alaska? From the nonlinear ARDL model, we gather that both income increases (ΔPOS) and income decreases (ΔNEG) have short-run effects on house prices since each carries at least one significant coefficient. These short-run effects do last into the long run since both POS and NEG variables carry significant long-run coefficients as evidenced from Panel B. The long-run estimates are also meaningful due to the fact that cointegration is at least established by ECM_{t-1}. Since the nonlinear model produces evidence of cointegration between house prices and household income, this is preferred to the linear model. Additionally, the nonlinear model clearly produces evidence of asymmetric effects of income changes on house prices. First, since the number of lags are different, there is evidence of asymmetric short-run adjustment. Second, since the size and sign of some of the coefficients attached to ΔPOS are different than those attached to ΔNEG, there is also evidence of asymmetric short-run effects. However, the sum of these coefficients do not seem to be statistically different because the Wald statistic for testing whether

$\sum \delta_i^+ \neq \sum \delta_i^-$ is insignificant, thus implying lack of asymmetric short-run impact. However, this is not the case for long-run asymmetry due to the fact that the Wald statistic for testing long-run asymmetry is highly significant. Finally, since $\sum \delta_i^+$ is significant but not $\sum \delta_i^-$, we can say that in Alaska increases in income cause house prices but decreases in income do not, thus supporting asymmetric short-run causality.

We are now in the position to summarize our findings for all of the states. First, in the linear model, household income carries at least one short-run significant coefficient in all states except in Missouri and Nevada. The sum of these coefficients is significantly different from zero, i.e., $\sum \delta_i \neq 0$ by the Wald test in 36 states. Thus, in most states, household income causes house prices. Second, these short-run effects translate into significant long run effects only in 34 states which are meaningful in only 24 states since cointegration is supported by either the F or ECM_{t-1} test. How does the result change if we introduce nonlinear adjustment of household income and shift to the estimates of nonlinear models?

From the estimates of the nonlinear optimum models, we gather that first, income increases (ΔPOS) and income decreases (ΔNEG) have short-run effects in almost all states. However, the number of lags on ΔPOS are different than those on ΔNEG in 35 states, thus supporting adjustment asymmetry. Second, in almost all of the models, either the size or sign of these short-run estimates are different, thus supporting asymmetric short-run effects. Third, the sum of the short-run coefficient estimates attached to ΔPOS are significantly different than the sum of coefficients attached to ΔNEG, i.e., $\sum \delta_i^+ \neq \sum \delta_i^-$ in 18 states, thus supporting short-run asymmetric impacts. The list includes Arkansas, Arizona, California, Colorado, Florida, Indiana, Louisiana, Massachusetts, Mississippi, Ohio, Oklahoma, Oregon, South Carolina, South Dakota, Utah, Washington, Wisconsin, and West Virginia. Fourth, staying with short-run results, we also learn that increase in income causes house prices in 21 states but decrease in income causes house prices only in 15 states. The 21 states in which $\sum \delta_i^+ \neq 0$ is supported by significant Wald statistics are: Alaska, Arizona, Colorado, Connecticut, Florida, Hawaii, Idaho, Massachusetts, Maryland, Missouri, Montana, North Dakota, New Jersey, Oklahoma, South Dakota, Texas, Utah, Virginia, Vermont, Wisconsin, and West Virginia. The 15 states in which $\sum \delta_i^- \neq 0$ is supported by significant Wald statistics are: Arkansas, Arizona, California, Colorado, Connecticut, Florida, Indiana, Louisiana, Massachusetts, Mississippi, Ohio, Oregon, South Carolina, South Dakota, and Wisconsin.

Table 1 Estimates of Both Linear and Nonlinear ARDL Models for 52 States of U.S.

	Alaska		Alabama	
	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL
Panel A: Short-Run				
$\Delta LnHI_t$	0.44(1.72)*		0.68(3.9)**	
$\Delta LnHI_{t-1}$	0.27(1.05)		0.07(0.38)	
$\Delta LnHI_{t-2}$	0.24(0.92)		-0.15(.84)	
$\Delta LnHI_{t-3}$	0.03(0.11)		0.35(2.0)**	
$\Delta LnHI_{t-4}$	-0.32(1.32)			
$\Delta LnHI_{t-5}$	0.71 (2.9)**			
$\Delta LnHI_{t-6}$	-0.36(1.48)			
$\Delta LnHI_{t-7}$				
$\Delta LnHI_{t-8}$				
ΔPOS_t		0.66(1.64)*		0.03(1.63)
ΔPOS_{t-1}		0.54(1.35)		
ΔPOS_{t-2}				
ΔPOS_{t-3}				
ΔPOS_{t-4}				
ΔPOS_{t-5}				
ΔPOS_{t-6}				
ΔPOS_{t-7}				
ΔPOS_{t-8}				
ΔNEG_t		1.18(1.58)		1.27(3.7)**
ΔNEG_{t-1}		-0.37(0.51)		-0.13(0.34)
ΔNEG_{t-2}		0.49(1.03)		-0.95(2.6)**
ΔNEG_{t-3}		0.10(0.21)		1.09(2.9)*
ΔNEG_{t-4}		-0.96(2.0)**		
ΔNEG_{t-5}		1.11(2.3)**		
ΔNEG_{t-6}		-1.12(2.5)**		
ΔNEG_{t-7}				
ΔNEG_{t-8}				
Panel B: Long-Run				
Constant	3.07(0.45)	5.94(42.9)**	0.98(0.30)	5.56(90.5)**
$Ln\ HI_t$	0.14(0.35)		0.24(1.40)	
POS_t		1.24(6.49)**		0.41(2.0)**
NEG_t		3.66(6.02)**		1.60(1.36)
Panel C: Diagnostic				
F	1.48	4.20	3.06	2.50
ECM_{t-1}	-0.05(1.73)	-0.20(3.6)**	-0.04(2.48)	-0.07(2.75)
LM	5.22	1.79	0.91	2.20
QS ($QS^{2)}$)	U (U)	U (U)	S (U)	S (U)
Adjusted R^2	0.19	0.25	0.22	0.33
Wald Test				
$\sum \delta_{i\ i} = 0$	3.4482**		6.9598*	
$\sum \delta_i^{+} = 0$		6.0939**		1.4659
$\sum \delta_i^{-} = 0$		.15502		2.1497
$\sum \delta_i^{+} = \sum \delta_i^{-}$		.32377		.94146
$\rho_1^{+} = \rho_1^{-}$		7.8243**		1.1540

(Continued…)

(Table 1 Continued)

	Arkansas		Arizona	
	Linear ARDL	**Nonlinear ARDL**	**Linear ARDL**	**Nonlinear ARDL**
Panel A: Short-Run				
$\Delta LnHI_t$	0.35(3.7)**		0.55(3.1)**	
$\Delta LnHI_{t-1}$	-0.13(1.37)		0.09(0.56)	
$\Delta LnHI_{t-2}$	-0.01(0.12)		-0.34(1.9)**	
$\Delta LnHI_{t-3}$	-0.08(0.82)			
$\Delta LnHI_{t-4}$	0.14(1.48)			
$\Delta LnHI_{t-5}$	-0.01(.07)			
$\Delta LnHI_{t-6}$	0.31(3.4)**			
$\Delta LnHI_{t-7}$				
$\Delta LnHI_{t-8}$				
ΔPOS_t		0.02(1.58)		0.61(2.70)**
ΔPOS_{t-1}				
ΔPOS_{t-2}				
ΔPOS_{t-3}				
ΔPOS_{t-4}				
ΔPOS_{t-5}				
ΔPOS_{t-6}				
ΔPOS_{t-7}				
ΔPOS_{t-8}				
ΔNEG_t		0.84(4.7)**		0.24(0.52)
ΔNEG_{t-1}		-0.64(3.4)**		-0.82(1.90)*
ΔNEG_{t-2}		-0.16(0.86)		-1.09(2.34)**
ΔNEG_{t-3}		-0.02(0.11)		
ΔNEG_{t-4}		0.39(2.00)**		
ΔNEG_{t-5}		-0.01(0.05)		
ΔNEG_{t-6}		0.40(2.2)**		
ΔNEG_{t-7}				
ΔNEG_{t-8}				
Panel B: Long-Run				
Constant	4.22(1.17)	5.67(51.9)**	1.73(0.88)	5.19(49.5)**
Ln HI_t	0.06(0.31)		0.20(1.9)**	
POS_t		0.53(1.8)*		0.37(3.04)**
NEG_t		2.67(2.0)**		1.75(1.55)
Panel C: Diagnostic				
F	1.38	1.13	6.04**	6.07**
ECM_{t-1}	-0.02(1.67)	-0.03(1.83)	-0.04(3.4)**	-0.05(4.3)**
LM	13.67**	12.22**	3.19	5.63
QS (QS^2)	S (U)	S (U)	S (U)	U (U)
Adjusted R^2	0.24	0.34	0.50	0.54
Wald Test				
$\sum \delta_{i\ i} = 0$	6.5095*		1.1606	
$\sum \delta_i^{+} = 0$		.35402		6.3955*
$\sum \delta_i^{-} = 0$		3.5857*		4.7729*
$\sum \delta_i^{+} = \sum \delta_i^{-}$		3.7517*		7.3935*
$\rho_1^{+} = \rho_1^{-}$		2.9528*		1.2873

(Continued…)

(Table 1 Continued)

	California		**Colorado**	
	Linear ARDL	**Nonlinear ARDL**	**Linear ARDL**	**Nonlinear ARDL**
Panel A: Short-Run				
$\Delta LnHI_t$	0.02(3.3)**		0.30(3.3)**	
$\Delta LnHI_{t-1}$				
$\Delta LnHI_{t-2}$				
$\Delta LnHI_{t-3}$				
$\Delta LnHI_{t-4}$				
$\Delta LnHI_{t-5}$				
$\Delta LnHI_{t-6}$				
$\Delta LnHI_{t-7}$				
$\Delta LnHI_{t-8}$				
ΔPOS_t		0.02(2.27)**		0.33(2.6)**
ΔPOS_{t-1}				0.02(0.15)
ΔPOS_{t-2}				0.03(0.28)
ΔPOS_{t-3}				0.00(0.00)
ΔPOS_{t-4}				0.23(1.9)**
ΔPOS_{t-5}				0.18(1.52)
ΔPOS_{t-6}				0.25(2.0)**
ΔPOS_{t-7}				-0.17(1.36)
ΔPOS_{t-8}				
ΔNEG_t		-0.09(0.34)		0.08(0.34)
ΔNEG_{t-1}		-0.49(1.85)*		-0.71(3.0)**
ΔNEG_{t-2}		-0.45(1.70)*		
ΔNEG_{t-3}				
ΔNEG_{t-4}				
ΔNEG_{t-5}				
ΔNEG_{t-6}				
ΔNEG_{t-7}				
ΔNEG_{t-8}				
Panel B: Long-Run				
Constant	-10.90(3.9)**	5.33(45.9)**	-3.88(1.58)	4.94(24.3)**
Ln HI_t	0.80(6.09)**		0.51(3.8)**	
POS_t		0.91(2.9)**		0.66(2.5)**
NEG_t		1.95(1.17)		1.21(0.62)
Panel C: Diagnostic				
F	8.78**	5.11*	2.90	3.86
ECM_{t-1}	-0.03(4.2)**	-0.03(3.9)**	-0.02(2.39)	-0.02(3.43)*
LM	2.03	1.08	2.39	2.65
QS (QS^2)	S (S)	S (S)	S (S)	S (S)
Adjusted R^2	0.75	0.75	0.44	0.46
Wald Test				
$\sum \delta_{i\ i} = 0$	.04503		11.0041*	
$\sum \delta_i^{+} = 0$		.67933		13.1203*
$\sum \delta_i^{-} = 0$		5.1441*		4.0547*
$\sum \delta_i^{+} = \sum \delta_i^{-}$		5.0354*		13.1352*
$\rho_1^{+} = \rho_1^{-}$		.56194		.099549

(Continued…)

(Table 1 Continued)

	Connecticut		Delaware	
	Linear ARDL	**Nonlinear ARDL**	**Linear ARDL**	**Nonlinear ARDL**
Panel A: Short-Run				
$\Delta LnHI_t$	0.43(3.5)**		0.26(1.47)	
$\Delta LnHI_{t-1}$			0.31(1.8)*	
$\Delta LnHI_{t-2}$				
$\Delta LnHI_{t-3}$				
$\Delta LnHI_{t-4}$				
$\Delta LnHI_{t-5}$				
$\Delta LnHI_{t-6}$				
$\Delta LnHI_{t-7}$				
$\Delta LnHI_{t-8}$				
ΔPOS_t		0.63(3.9)**		0.04(1.63)
ΔPOS_{t-1}				
ΔPOS_{t-2}				
ΔPOS_{t-3}				
ΔPOS_{t-4}				
ΔPOS_{t-5}				
ΔPOS_{t-6}				
ΔPOS_{t-7}				
ΔPOS_{t-8}				
ΔNEG_t		0.06(1.25)		0.40(0.95)
ΔNEG_{t-1}				0.33(0.76)
ΔNEG_{t-2}				-0.58(1.46)
ΔNEG_{t-3}				0.15(0.38)
ΔNEG_{t-4}				0.47(1.18)
ΔNEG_{t-5}				-0.86(2.1)**
ΔNEG_{t-6}				0.77(1.9)*
ΔNEG_{t-7}				0.72(1.7)*
ΔNEG_{t-8}				
Panel B: Long-Run				
Constant	-1.80(0.47)	5.4(49.7)**	-2.59(1.10)	5.76(50.1)**
$Ln\ HI_t$	0.40(2.0)**		0.49(3.5)**	
POS_t		0.87(2.2)**		0.69(2.2)**
NEG_t		1.88(1.47)		1.54(1.01)
Panel C: Diagnostic				
F	4.47	3.74	2.98	2.56
ECM_{t-1}	-0.03(2.86)	-0.04(3.37)*	-0.04(2.45)	-0.05(2.79)
LM	6.49	4.01	0.32	1.59
QS (QS^2)	S (U)	S (U)	U (U)	S (U)
Adjusted R^2	0.47	0.49	0.41	0.40
Wald Test				
$\sum \delta_{i\ i} = 0$	9.3377*		4.4221*	
$\sum \delta_i^{+} = 0$		11.8314*		.32073
$\sum \delta_i^{-} = 0$		.025469*		1.0272
$\sum \delta_i^{+} = \sum \delta_i^{-}$		2.3499		.73983
$\rho_1^{+} = \rho_1^{-}$		1.0873		.48381

(Continued…)

(Table 1 Continued)

	Florida		Georgia	
	Linear ARDL	**Nonlinear ARDL**	**Linear ARDL**	**Nonlinear ARDL**
Panel A: Short-Run				
$\Delta LnHI_t$	0.29(1.9)*		0.22(1.87)*	
$\Delta LnHI_{t-1}$				
$\Delta LnHI_{t-2}$				
$\Delta LnHI_{t-3}$				
$\Delta LnHI_{t-4}$				
$\Delta LnHI_{t-5}$				
$\Delta LnHI_{t-6}$				
$\Delta LnHI_{t-7}$				
$\Delta LnHI_{t-8}$				
ΔPOS_t		0.54(2.9)**		0.25(1.88)*
ΔPOS_{t-1}		-0.08(0.40)		
ΔPOS_{t-2}		0.48(2.55)**		
ΔPOS_{t-3}				
ΔPOS_{t-4}				
ΔPOS_{t-5}				
ΔPOS_{t-6}				
ΔPOS_{t-7}				
ΔPOS_{t-8}				
ΔNEG_t		-0.30(0.84)		0.04(0.80)
ΔNEG_{t-1}		-0.12(0.35)		
ΔNEG_{t-2}		-0.88(2.5)**		
ΔNEG_{t-3}				
ΔNEG_{t-4}				
ΔNEG_{t-5}				
ΔNEG_{t-6}				
ΔNEG_{t-7}				
ΔNEG_{t-8}				
Panel B: Long-Run				
Constant	-0.80(0.28)	5.21(39.4)**	3.06(3.0)**	5.5(104)**
Ln HI_t	0.31(2.2)**		0.13(2.6)**	
POS_t		0.21(1.56)		0.20(2.2)**
NEG_t		-0.58(0.47)		0.75(0.88)
Panel C: Diagnostic				
F	4.63	7.27**	8.24**	4.61
ECM_{t-1}	-0.03(3.05)*	-0.04(4.6)**	-0.06(4.9)**	-0.05(3.75)**
LM	0.50	1.87	2.84	7.14
QS (QS^2)	S (U)	S (U)	S (S)	S (S)
Adjusted R^2	0.51	0.54	0.31	0.37
Wald Test				
$\sum \delta_i = 0$	3.6223*		3.4982*	
$\sum \delta_i^+ = 0$		4.2112*		2.4189
$\sum \delta_i^- = 0$		4.3185*		.81443
$\sum \delta_i^+ = \sum \delta_i^-$		6.7442*		.00017
$\rho_1^+ = \rho_1^-$		.57829		.26614

(Continued…)

(Table 1 Continued)

	Hawaii		**Iowa**	
	Linear ARDL	**Nonlinear ARDL**	**Linear ARDL**	**Nonlinear ARDL**
Panel A: Short-Run				
$\Delta LnHI_t$	4.03(7.9)**		0.12(1.29)	
$\Delta LnHI_{t-1}$			0.06(0.65)	
$\Delta LnHI_{t-2}$			-0.06(0.63)	
$\Delta LnHI_{t-3}$			0.18(1.95)*	
$\Delta LnHI_{t-4}$			0.14(1.40)	
$\Delta LnHI_{t-5}$			0.31(3.2)**	
$\Delta LnHI_{t-6}$			-0.24(2.3)**	
$\Delta LnHI_{t-7}$				
$\Delta LnHI_{t-8}$				
ΔPOS_t		1.05(1.57)		0.10(0.66)
ΔPOS_{t-1}		1.38(2.0)**		0.29(2.0)**
ΔPOS_{t-2}				-0.55(3.6)**
ΔPOS_{t-3}				
ΔPOS_{t-4}				
ΔPOS_{t-5}				
ΔPOS_{t-6}				
ΔPOS_{t-7}				
ΔPOS_{t-8}				
ΔNEG_t		8.6(8.4)**		0.20(1.02)
ΔNEG_{t-1}		-4.0(3.1)**		-0.28(-1.42)
ΔNEG_{t-2}		-4.8(3.9)**		0.69(3.56)**
ΔNEG_{t-3}		-0.35(0.28)		0.19(1.02)
ΔNEG_{t-4}		-0.74(0.59)		0.33(1.74)*
ΔNEG_{t-5}		0.45(0.37)		0.73(3.7)**
ΔNEG_{t-6}		4.9(4.3)**		-1.11(5.4)**
ΔNEG_{t-7}		-4.4(4.7)**		
ΔNEG_{t-8}				
Panel B: Long-Run				
Constant	-14.0(3.9)**	5.3(88.8)**	0.34(0.09)	5.54(42.6)**
$Ln\ HI_t$	1.12(5.4)**		0.27(1.39)	
POS_t		2.15(9.4)**		0.54(1.22)
NEG_t		4.97(6.0)*		0.96(0.96)
Panel C: Diagnostic				
F	3.14	5.82**	4.54	1.98
ECM_{t-1}	-0.11(2.51)	-0.22(4.2)**	-0.04(3.02)*	-0.04(2.46)
LM	2.32	1.44	8.96*	14.79**
QS (QS^2)	S (U)	S (U)	U (U)	S (U)
Adjusted R^2	0.44	0.67	0.33	0.49
Wald Test				
$\sum \delta_i = 0$	63.8448*		2.8806*	
$\sum \delta_i^{+} = 0$		7.9860*		.37981
$\sum \delta_i^{-} = 0$		.032648		1.6331
$\sum \delta_i^{+} = \sum \delta_i^{-}$		1.1745		2.2999
$\rho_1^{+} = \rho_1^{-}$		9.4791*		.32853

(Continued…)

(Table 1 Continued)

	Idaho		Illinois	
	Linear ARDL	**Nonlinear ARDL**	**Linear ARDL**	**Nonlinear ARDL**
Panel A: Short-Run				
$\Delta LnHI_t$	0.31(1.9)*		0.31(2.5)**	
$\Delta LnHI_{t-1}$			-0.13(1.04)	
$\Delta LnHI_{t-2}$			0.16(1.34)	
$\Delta LnHI_{t-3}$			-0.16(1.29)	
$\Delta LnHI_{t-4}$			-0.08(0.63)	
$\Delta LnHI_{t-5}$			-0.2(2.2)**	
$\Delta LnHI_{t-6}$				
$\Delta LnHI_{t-7}$				
$\Delta LnHI_{t-8}$				
ΔPOS_t		0.09(3.2)**		0.04(1.8)**
ΔPOS_{t-1}				
ΔPOS_{t-2}				
ΔPOS_{t-3}				
ΔPOS_{t-4}				
ΔPOS_{t-5}				
ΔPOS_{t-6}				
ΔPOS_{t-7}				
ΔPOS_{t-8}				
ΔNEG_t		0.35(0.89)		0.17(0.77)
ΔNEG_{t-1}		-0.42(1.10)		-0.1(0.6)**
ΔNEG_{t-2}		0.02(0.06)		0.59(2.8)**
ΔNEG_{t-3}		-0.91(2.4)**		-0.33(1.6)*
ΔNEG_{t-4}		-0.09(0.23)		-0.30(1.55)
ΔNEG_{t-5}		-0.06(0.17)		-0.5(2.5)**
ΔNEG_{t-6}		-1.12(3.0)**		
ΔNEG_{t-7}		1.09(2.8)**		
ΔNEG_{t-8}				
Panel B: Long-Run				
Constant	0.96(0.52)	5.48(76.0)**	-6.3(3.5)**	5.5(104)**
$Ln\ HI_t$	0.26(2.4)**		0.60(6.7)**	
POS_t		0.62(6.0)**		0.74(2.7)**
NEG_t		2.09(3.7)**		1.35(1.36)
Panel C: Diagnostic				
F	5.01*	3.07	10.54**	6.59**
ECM_{t-1}	-0.06(3.18)*	-0.12(2.99)	-0.06(4.6)*	-0.06(4.4)**
LM	1.54	6.78	12.60**	39.76**
QS (QS^2)	S (U)	S (U)	S (U)	S (U)
Adjusted R^2	0.38	0.51	0.42	0.51
Wald Test				
$\sum \delta_{i\ i} = 0$	3.5591*		.34184	
$\sum \delta_i^+ = 0$		2.6817*		.52049
$\sum \delta_i^- = 0$		.79628		1.1971
$\sum \delta_i^+ = \sum \delta_i^-$		1.3281		1.4207
$\rho_1^+ = \rho_1^-$		4.3471*		.50388

(Continued…)

(Table 1 Continued)

	Indiana		Kansas	
	Linear ARDL	**Nonlinear ARDL**	**Linear ARDL**	**Nonlinear ARDL**
Panel A: Short-Run				
$\Delta LnHI_t$	0.22(2.6)**		0.07(0.92)	
$\Delta LnHI_{t-1}$			-0.08(1.16)	
$\Delta LnHI_{t-2}$			-0.03(0.35)	
$\Delta LnHI_{t-3}$			0.16(2.1)**	
$\Delta LnHI_{t-4}$			0.14(1.9)**	
$\Delta LnHI_{t-5}$				
$\Delta LnHI_{t-6}$				
$\Delta LnHI_{t-7}$				
$\Delta LnHI_{t-8}$				
ΔPOS_t		0.09(4.5)**		0.03(1.92)*
ΔPOS_{t-1}				
ΔPOS_{t-2}				
ΔPOS_{t-3}				
ΔPOS_{t-4}				
ΔPOS_{t-5}				
ΔPOS_{t-6}				
ΔPOS_{t-7}				
ΔPOS_{t-8}				
ΔNEG_t		0.52(3.4)**		0.11(0.83)
ΔNEG_{t-1}				-0.15(1.11)
ΔNEG_{t-2}				-0.23(1.70)*
ΔNEG_{t-3}				0.28(2.0)**
ΔNEG_{t-4}				
ΔNEG_{t-5}				
ΔNEG_{t-6}				
ΔNEG_{t-7}				
ΔNEG_{t-8}				
Panel B: Long-Run				
Constant	3.21(1.32)	5.6(240)**	3.02(0.76)	5.53(60.9)**
$Ln\ HI_t$	0.12(0.93)		0.13(0.59)	
POS_t		0.79(8.4)**		0.87(2.6)**
NEG_t		2.51(8.4)**		3.11(2.5)**
Panel C: Diagnostic				
F	3.14	7.53**	2.57	2.93
ECM_{t-1}	-0.03(2.51)	-0.10(4.7)**	-0.02(2.26)	-0.03(2.98)
LM	6.21	4.34	2.25	4.04
QS (QS^{2})	S (U)	S (U)	S (U)	S (U)
Adjusted R^2	0.28	0.35	0.26	0.28
Wald Test				
$\sum \delta_{i\ i} = 0$	6.9393*		1.9095	
$\sum \delta_i^{+} = 0$		.27334		1.5619
$\sum \delta_i^{-} = 0$		10.7558*		.00046
$\sum \delta_i^{+} = \sum \delta_i^{-}$		3.7128*		.22360
$\rho_1^{+} = \rho_1^{-}$		18.9022*		3.0476*

(Continued…)

(Table 1 Continued)

	Kentucky		Louisiana	
	Linear ARDL	**Nonlinear ARDL**	**Linear ARDL**	**Nonlinear ARDL**
Panel A: Short-Run				
$\Delta LnHI_t$	0.42(5.05)**		0.38(3.7)**	
$\Delta LnHI_{t-1}$	0.07(0.74)		0.07(0.63)	
$\Delta LnHI_{t-2}$	-0.03(0.39)		0.10(0.94)	
$\Delta LnHI_{t-3}$	0.05(0.63)		0.09(0.92)	
$\Delta LnHI_{t-4}$	-0.01(0.07)		0.23(2.2)**	
$\Delta LnHI_{t-5}$	0.32(4.05)**		0.05(0.48)	
$\Delta LnHI_{t-6}$	0.24(2.80)**		0.15(1.49)	
$\Delta LnHI_{t-7}$			0.34(3.3)**	
$\Delta LnHI_{t-8}$				
ΔPOS_t		0.07(2.5)**		0.07(3.7)**
ΔPOS_{t-1}		0.91(5.3)**		
ΔPOS_{t-2}		-0.60(3.1)**		
ΔPOS_{t-3}		-0.56(3.0)**		
ΔPOS_{t-4}		0.24(1.49)		
ΔPOS_{t-5}		-0.01(0.06)		
ΔPOS_{t-6}		0.59(3.5)**		
ΔPOS_{t-7}		0.29(1.70)*		
ΔPOS_{t-8}		-0.45(2.5)**		
ΔNEG_t				0.68(3.2)**
ΔNEG_{t-1}				
ΔNEG_{t-2}				
ΔNEG_{t-3}				
ΔNEG_{t-4}				
ΔNEG_{t-5}				
ΔNEG_{t-6}				
ΔNEG_{t-7}				
ΔNEG_{t-8}				
Panel B: Long-Run				
Constant	-2.17(0.35)	5.63(144)**	0.62(0.13)	5.1(82.5)**
$Ln\ HI_t$	0.40(1.23)		0.23(0.90)	
POS_t		0.70(10.7)**		1.56(6.4)**
NEG_t		2.79(7.08)**		5.42(5.6)**
Panel C: Diagnostic				
F	0.91	2.47	3.44	4.75
ECM_{t-1}	-0.01(1.36)	-0.10(2.74)	-0.02(2.63)	-0.03(3.7)**
LM	0.83	4.43	2.12	5.13
QS (QS^2)	S (U)	S (U)	U (U)	S (U)
Adjusted R^2	0.30	0.46	0.40	0.41
Wald Test				
$\sum \delta_i = 0$	23.0855*		14.3721*	
$\sum \delta_i^+ = 0$		.30177		2.2996
$\sum \delta_i^- = 0$		.43751		9.5780*
$\sum \delta_i^+ = \sum \delta_i^-$		.28609		3.0764*
$\rho_1^+ = \rho_1^-$		5.5622*		9.5243*

(Continued…)

(Table 1 Continued)

	Massachusetts		**Maryland**	
	Linear ARDL	**Nonlinear ARDL**	**Linear ARDL**	**Nonlinear ARDL**
Panel A: Short-Run				
$\Delta LnHI_t$	0.23(2.4)**		0.27(1.87)*	
$\Delta LnHI_{t-1}$				
$\Delta LnHI_{t-2}$				
$\Delta LnHI_{t-3}$				
$\Delta LnHI_{t-4}$				
$\Delta LnHI_{t-5}$				
$\Delta LnHI_{t-6}$				
$\Delta LnHI_{t-7}$				
$\Delta LnHI_{t-8}$				
ΔPOS_t		0.38(2.8)**		0.04(0.24)
ΔPOS_{t-1}				0.51(2.6)**
ΔPOS_{t-2}				
ΔPOS_{t-3}				
ΔPOS_{t-4}				
ΔPOS_{t-5}				
ΔPOS_{t-6}				
ΔPOS_{t-7}				
ΔPOS_{t-8}				
ΔNEG_t		-0.06(0.24)		0.76(1.9)*
ΔNEG_{t-1}		-0.5(2.3)**		-0.97(2.4)**
ΔNEG_{t-2}				
ΔNEG_{t-3}				
ΔNEG_{t-4}				
ΔNEG_{t-5}				
ΔNEG_{t-6}				
ΔNEG_{t-7}				
ΔNEG_{t-8}				
Panel B: Long-Run				
Constant	-12.0(4.2)**	5.5(55.3)**	-5.90(3.0)**	5.47(44.5)**
$Ln\ HI_t$	0.94(6.4)**		0.61(6.0)**	
POS_t		0.96(1.9)*		0.83(3.5)**
NEG_t		1.15(0.52)		2.64(1.15)
Panel C: Diagnostic				
F	7.45**	4.22	7.09**	4.45
ECM_{t-1}	-0.03(3.8)**	-0.02(3.5)**	-0.03(3.7)**	-0.03(3.6)**
LM	11.41**	2.21	9.96**	4.01
QS (QS^2)	S (S)	S (S)	S (U)	S (U)
Adjusted R^2	0.68	0.70	0.51	0.54
Wald Test				
$\sum \delta_i = 0$	5.4973*		3.9240*	
$\sum \delta_i^+ = 0$		8.4992*		5.9712*
$\sum \delta_i^- = 0$		3.8386*		.15083
$\sum \delta_i^+ = \sum \delta_i^-$		6.9501*		1.5487
$\rho_1^+ = \rho_1^-$		.00399		.48234

(Continued…)

(Table 1 Continued)

	Maine		Michigan	
	Linear ARDL	**Nonlinear ARDL**	**Linear ARDL**	**Nonlinear ARDL**
Panel A: Short-Run				
$\Delta LnHI_t$	0.56(2.0)**		0.15(1.25)	
$\Delta LnHI_{t-1}$			0.23(1.91)*	
$\Delta LnHI_{t-2}$			0.16(1.30)	
$\Delta LnHI_{t-3}$			0.31(2.4)**	
$\Delta LnHI_{t-4}$				
$\Delta LnHI_{t-5}$				
$\Delta LnHI_{t-6}$				
$\Delta LnHI_{t-7}$				
$\Delta LnHI_{t-8}$				
ΔPOS_t		0.15(2.4)**		0.13(3.5)**
ΔPOS_{t-1}				
ΔPOS_{t-2}				
ΔPOS_{t-3}				
ΔPOS_{t-4}				
ΔPOS_{t-5}				
ΔPOS_{t-6}				
ΔPOS_{t-7}				
ΔPOS_{t-8}				
ΔNEG_t		1.37(2.1)**		0.23(3.2)**
ΔNEG_{t-1}		0.31(0.48)		
ΔNEG_{t-2}		-1.17(1.81)*		
ΔNEG_{t-3}				
ΔNEG_{t-4}				
ΔNEG_{t-5}				
ΔNEG_{t-6}				
ΔNEG_{t-7}				
ΔNEG_{t-8}				
Panel B: Long-Run				
Constant	-6.21(2.5)**	5.54(69.9)**	-10.81(1.38)	5.4(109)**
$Ln\ HI_t$	0.73(4.7)**		0.83(2.09)**	
POS_t		1.48(3.5)**		1.58(6.5)**
NEG_t		3.87(2.2)**		2.85(5.3)**
Panel C: Diagnostic				
F	3.55	3.27	2.01	6.39**
ECM_{t-1}	-0.07(2.66)	-0.10(3.15)	-0.02(2.01)	-0.08(4.4)**
LM	12.33**	3.86	3.90	0.95
QS (QS^2)	S (U)	S (U)	S (U)	U (U)
Adjusted R^2	0.38	0.34	0.38	0.38
Wald Test				
$\sum \delta_i = 0$	3.0835*		15.6101*	
$\sum \delta_i^+ = 0$		1.7967		1.9419
$\sum \delta_i^- = 0$		.14661		.00144
$\sum \delta_i^+ = \sum \delta_i^-$		.00361		.61573
$\rho_1^+ = \rho_1^-$		2.9861*		6.5663*

(Continued…)

(Table 1 Continued)

	Minnesota		Missouri	
	Linear ARDL	**Nonlinear ARDL**	**Linear ARDL**	**Nonlinear ARDL**
Panel A: Short-Run				
$\Delta LnHI_t$	0.01(2.54)**		0.15(1.54)	
$\Delta LnHI_{t-1}$				
$\Delta LnHI_{t-2}$				
$\Delta LnHI_{t-3}$				
$\Delta LnHI_{t-4}$				
$\Delta LnHI_{t-5}$				
$\Delta LnHI_{t-6}$				
$\Delta LnHI_{t-7}$				
$\Delta LnHI_{t-8}$				
ΔPOS_t		0.04(2.0)**		0.35(3.1)**
ΔPOS_{t-1}				
ΔPOS_{t-2}				
ΔPOS_{t-3}				
ΔPOS_{t-4}				
ΔPOS_{t-5}				
ΔPOS_{t-6}				
ΔPOS_{t-7}				
ΔPOS_{t-8}				
ΔNEG_t		0.10(1.34)		0.06(1.45)
ΔNEG_{t-1}				
ΔNEG_{t-2}				
ΔNEG_{t-3}				
ΔNEG_{t-4}				
ΔNEG_{t-5}				
ΔNEG_{t-6}				
ΔNEG_{t-7}				
ΔNEG_{t-8}				
Panel B: Long-Run				
Constant	-2.86(1.20)	5.4(68.0)**	2.43(1.04)	5.49(74.8)**
$Ln\ HI_t$	0.45(3.5)**		0.17(1.34)	
POS_t		0.91(2.6)**		0.53(2.3)**
NEG_t		2.45(1.55)		1.94(1.8)*
Panel C: Diagnostic				
F	5.44*	4.38	4.33	3.74
ECM_{t-1}	-0.03(3.3)**	-0.04(3.6)**	-0.03(2.9)*	-0.041(3.2)*
LM	1.79	5.92	5.60	14.52**
QS (QS^2)	S (U)	S (U)	S (U)	S (U)
Adjusted R^2	0.39	0.39	0.36	0.51
Wald Test				
$\sum \delta_i = 0$	.86027		2.4237	
$\sum \delta_i^{+} = 0$		1.4958		10.3282*
$\sum \delta_i^{-} = 0$		.01429		.15116
$\sum \delta_i^{+} = \sum \delta_i^{-}$		.25578		1.4148
$\rho_1^{+} = \rho_1^{-}$		1.1989		2.3106

(Continued…)

(Table 1 Continued)

	Mississippi		**Montana**	
	Linear ARDL	**Nonlinear ARDL**	**Linear ARDL**	**Nonlinear ARDL**
Panel A: Short-Run				
$\Delta LnHI_t$	0.60(2.9)**		0.70(5.24)**	
$\Delta LnHI_{t-1}$	0.12(0.58)		-0.17(1.10)	
$\Delta LnHI_{t-2}$	-0.01(0.03)		0.32(2.17)**	
$\Delta LnHI_{t-3}$	0.48(2.4)**		0.10(0.68)	
$\Delta LnHI_{t-4}$	0.09(0.45)		0.28(1.88)*	
$\Delta LnHI_{t-5}$	-0.13(0.64)		0.13(0.83)	
$\Delta LnHI_{t-6}$	0.24(1.27)		0.24(1.64)*	
$\Delta LnHI_{t-7}$	0.93(4.7)**		-0.21(1.40)	
$\Delta LnHI_{t-8}$				
ΔPOS_t		0.02(1.23)		0.74(4.6)**
ΔPOS_{t-1}				-0.5(3.0)**
ΔPOS_{t-2}				0.51(2.8)**
ΔPOS_{t-3}				0.08(0.46)
ΔPOS_{t-4}				0.46(2.7)**
ΔPOS_{t-5}				0.66(4.0)**
ΔPOS_{t-6}				-0.14(0.83)
ΔPOS_{t-7}				-0.3(2.0)**
ΔPOS_{t-8}				
ΔNEG_t		1.32(3.7)**		0.51(2.0)**
ΔNEG_{t-1}		0.12(0.33)		0.42(1.7)*
ΔNEG_{t-2}		-0.74(2.0)**		-0.27(1.19)
ΔNEG_{t-3}		0.72(2.0)**		-0.13(0.61)
ΔNEG_{t-4}		-0.12(0.34)		0.22(0.96)
ΔNEG_{t-5}		-0.55(1.58)		-1.1(4.7)**
ΔNEG_{t-6}		0.99(2.7)**		0.91(3.9)**
ΔNEG_{t-7}		1.61(4.4)**		
ΔNEG_{t-8}				
Panel B: Long-Run				
Constant	-4.49(0.37)	5.51(26.0)**	-5.39(1.44)	5.2(28.6)**
$Ln\ HI_t$	0.51(0.81)		0.63(2.8)**	
POS_t		0.77(1.01)		0.93(5.5)**
NEG_t		2.62(0.84)		1.15(2.2)**
Panel C: Diagnostic				
F	2.06	0.98	2.75	4.85*
ECM_{t-1}	-0.02(2.04)	-0.03(1.73)	-0.05(2.36)	-0.10(3.8)**
LM	6.34	23.51**	15.89**	9.14*
QS (QS^2)	U (U)	U (U)	S (U)	S (U)
Adjusted R^2	0.30	0.45	0.43	0.62
Wald Test				
$\sum \delta_i = 0$	9.8223*		3.8679*	
$\sum \delta_i^+ = 0$		.00783		3.9108*
$\sum \delta_i^- = 0$		10.2275*		.98594
$\sum \delta_i^+ = \sum \delta_i^-$		9.2551*		1.6923
$\rho_1^+ = \rho_1^-$		.48611		.27664

(Continued…)

(Table 1 Continued)

	North Carolina		North Dakota	
	Linear ARDL	**Nonlinear ARDL**	**Linear ARDL**	**Nonlinear ARDL**
Panel A: Short-Run				
$\Delta LnHI_t$	0.30(3.47)**		0.10(1.11)	
$\Delta LnHI_{t-1}$			-0.01(0.07)	
$\Delta LnHI_{t-2}$			0.25(2.7)**	
$\Delta LnHI_{t-3}$			-0.15(1.60)	
$\Delta LnHI_{t-4}$			-0.03(0.28)	
$\Delta LnHI_{t-5}$			-0.11(1.22)	
$\Delta LnHI_{t-6}$			-0.10(1.10)	
$\Delta LnHI_{t-7}$			0.22(2.3)**	
$\Delta LnHI_{t-8}$				
ΔPOS_t		0.20(1.74)*		0.17(4.6)**
ΔPOS_{t-1}		0.04(0.32)		
ΔPOS_{t-2}		0.19(1.81)*		
ΔPOS_{t-3}		0.04(0.32)		
ΔPOS_{t-4}		-0.21(1.9)*		
ΔPOS_{t-5}				
ΔPOS_{t-6}				
ΔPOS_{t-7}				
ΔPOS_{t-8}				
ΔNEG_t		0.35(1.64)*		0.17(1.15)
ΔNEG_{t-1}		-0.40(1.8)*		-0.40(2.6)**
ΔNEG_{t-2}				0.38(2.4)**
ΔNEG_{t-3}				-0.44(3.0)**
ΔNEG_{t-4}				-0.15(1.08)
ΔNEG_{t-5}				-0.29(2.0)**
ΔNEG_{t-6}				-0.23(1.64)*
ΔNEG_{t-7}				0.49(3.1)**
ΔNEG_{t-8}				
Panel B: Long-Run				
Constant	1.67(1.74)*	5.47(99)**	-8.32(1.21)	0.08(68.4)**
Ln HI_t	0.20(4.1)**		0.82(2.0)**	
POS_t		0.29(2.9)**		0.79(9.05)**
NEG_t		0.71(0.80)		1.12 (8.0)**
Panel C: Diagnostic				
F	4.73	6.72**	3.44	6.47**
ECM_{t-1}	-0.04(3.08)*	-0.07(4.52)	-0.06(2.63)	-0.21(4.43)**
LM	0.74	4.31	4.21	4.17
QS (QS^{2})	S (U)	S (U)	S (U)	S (U)
Adjusted R^2	0.37	0.44	0.20	0.29
Wald Test				
$\sum \delta_i = 0$	11.4500*		.23146	
$\sum \delta_i^{+} = 0$		1.2733		3.0462*
$\sum \delta_i^{-} = 0$		.016347		1.0248
$\sum \delta_i^{+} = \sum \delta_i^{-}$		.47142		2.1437
$\rho_1^{+} = \rho_1^{-}$		.29801		9.0860*

(Continued…)

(Table 1 Continued)

	Nebraska		New Hampshire	
	Linear ARDL	**Nonlinear ARDL**	**Linear ARDL**	**Nonlinear ARDL**
Panel A: Short-Run				
$\Delta LnHI_t$	-0.12(1.61)		0.39(2.9)**	
$\Delta LnHI_{t-1}$	0.14(1.92)*			
$\Delta LnHI_{t-2}$	-0.10(1.30)			
$\Delta LnHI_{t-3}$	0.11(1.41)			
$\Delta LnHI_{t-4}$	-0.06(0.73)			
$\Delta LnHI_{t-5}$	0.24(3.17)**			
$\Delta LnHI_{t-6}$				
$\Delta LnHI_{t-7}$				
$\Delta LnHI_{t-8}$				
ΔPOS_t		0.01(0.40)		0.35(2.1)**
ΔPOS_{t-1}				0.17(1.10)
ΔPOS_{t-2}				0.11(0.71)
ΔPOS_{t-3}				-0.3(1.9)**
ΔPOS_{t-4}				
ΔPOS_{t-5}				
ΔPOS_{t-6}				
ΔPOS_{t-7}				
ΔPOS_{t-8}				
ΔNEG_t		-0.33(2.3)**		-0.01(0.27)
ΔNEG_{t-1}		0.27(2.00)**		
ΔNEG_{t-2}		-0.38(2.7)**		
ΔNEG_{t-3}		0.41(2.7)**		
ΔNEG_{t-4}		0.10(0.66)		
ΔNEG_{t-5}		0.41(2.7)**		
ΔNEG_{t-6}		0.43(2.9)**		
ΔNEG_{t-7}		-0.37(2.4)**		
ΔNEG_{t-8}				
Panel B: Long-Run				
Constant	2.75(1.00)	5.52(25.6)**	-3.92(2.1)**	5.5(23.2)**
$Ln HI_t$	0.15(0.98)		0.55(5.2)**	
POS_t		0.23(0.52)		0.17(0.36)
NEG_t		0.44(0.30)		-0.52(0.27)
Panel C: Diagnostic				
F	3.10	1.21	8.51**	4.44
ECM_{t-1}	-0.03(2.50)	-0.03(1.92)	-0.05(4.1)**	-0.03(3.6)**
LM	1.71	6.19	6.69	1.60
QS (QS^{2})	S (U)	S (U)	S (U)	S (U)
Adjusted R^2	0.24	0.37	0.52	0.59
Wald Test				
$\sum \delta_i = 0$	1.3766		8.8982*	
$\sum \delta_i^{+} = 0$		.00049		.49335
$\sum \delta_i^{-} = 0$		1.7985		1.4377
$\sum \delta_i^{+} = \sum \delta_i^{-}$		1.6850		.09380
$\rho_1^{+} = \rho_1^{-}$		.03885		.32852

(Continued…)

(Table 1 Continued)

	New Jersey		**New Mexico**	
	Linear ARDL	**Nonlinear ARDL**	**Linear ARDL**	**Nonlinear ARDL**
Panel A: Short-Run				
$\Delta LnHI_t$	0.27(2.7)**		0.32(2.0)**	
$\Delta LnHI_{t-1}$			0.15(0.97)	
$\Delta LnHI_{t-2}$			-0.09(0.58)	
$\Delta LnHI_{t-3}$			0.30(1.92)*	
$\Delta LnHI_{t-4}$				
$\Delta LnHI_{t-5}$				
$\Delta LnHI_{t-6}$				
$\Delta LnHI_{t-7}$				
$\Delta LnHI_{t-8}$				
ΔPOS_t		0.2(1.97)**		0.01(0.90)
ΔPOS_{t-1}				
ΔPOS_{t-2}				
ΔPOS_{t-3}				
ΔPOS_{t-4}				
ΔPOS_{t-5}				
ΔPOS_{t-6}				
ΔPOS_{t-7}				
ΔPOS_{t-8}				
ΔNEG_t		-0.03(0.77)		0.04(0.37)
ΔNEG_{t-1}				
ΔNEG_{t-2}				
ΔNEG_{t-3}				
ΔNEG_{t-4}				
ΔNEG_{t-5}				
ΔNEG_{t-6}				
ΔNEG_{t-7}				
ΔNEG_{t-8}				
Panel B: Long-Run				
Constant	-10.9(4.0)**	5.6(47.5)**	1.42(0.69)	5.48(57.7)**
$Ln\ HI_t$	0.86(6.1)**		0.2(1.9)**	
POS_t		0.26(0.63)		0.23(0.92)
NEG_t		-1.16(0.72)		0.86(0.36)
Panel C: Diagnostic				
F	7.53**	4.99*	3.23	1.96
ECM_{t-1}	-0.03(3.8)**	-0.03(3.8)**	-0.04(2.55)	-0.04(2.43)
LM	9.10*	6.00	16.08**	42.38**
QS ($QS^{2)}$)	S (U)	S (S)	U (U)	U (S)
Adjusted R^2	0.58	0.69	0.26	0.22
Wald Test				
$\sum \delta_i = 0$	5.6759*		4.7739*	
$\sum \delta_i^{+} = 0$		5.1162*		.30469
$\sum \delta_i^{-} = 0$		.06723		.49504
$\sum \delta_i^{+} = \sum \delta_i^{-}$		1.5196		.13831
$\rho_1^{+} = \rho_1^{-}$		1.0392		.01580

(Continued…)

(Table 1 Continued)

	Nevada		New York	
	Linear ARDL	**Nonlinear ARDL**	**Linear ARDL**	**Nonlinear ARDL**
Panel A: Short-Run				
$\Delta LnHI_t$	0.08(1.57)		0.07(3.3)**	
$\Delta LnHI_{t-1}$				
$\Delta LnHI_{t-2}$				
$\Delta LnHI_{t-3}$				
$\Delta LnHI_{t-4}$				
$\Delta LnHI_{t-5}$				
$\Delta LnHI_{t-6}$				
$\Delta LnHI_{t-7}$				
$\Delta LnHI_{t-8}$				
ΔPOS_t		0.01(1.08)		0.34(1.58)
ΔPOS_{t-1}				
ΔPOS_{t-2}				
ΔPOS_{t-3}				
ΔPOS_{t-4}				
ΔPOS_{t-5}				
ΔPOS_{t-6}				
ΔPOS_{t-7}				
ΔPOS_{t-8}				
ΔNEG_t		0.002(0.03)		0.002(0.03)
ΔNEG_{t-1}		0.04(0.67)		
ΔNEG_{t-2}		-0.11(0.28)		
ΔNEG_{t-3}		-0.76(2.0)**		
ΔNEG_{t-4}		-0.82(2.2)**		
ΔNEG_{t-5}		0.86(2.38)**		
ΔNEG_{t-6}		0.67(1.53)		
ΔNEG_{t-7}				
ΔNEG_{t-8}				
Panel B: Long-Run				
Constant	4.07(3.7)**	5.45(53.5)**	-13.3(5.2)**	5.71(93)**
$Ln\ HI_t$	0.08(1.34)		0.95(7.7)**	
POS_t		0.12(1.23)		0.63(1.33)
NEG_t		0.65(0.63)		1.04(0.03)
Panel C: Diagnostic				
F	10.55**	6.50**	9.68**	6.72**
ECM_{t-1}	-0.05(4.6)**	-0.05(4.4)**	-0.06(4.4)**	-0.06(4.5)**
LM	0.34	4.14	4.65	2.30
QS (QS^{2})	S (U)	S (U)	S (U)	S (U)
Adjusted R^2	0.54	0.60	0.32	0.33
Wald Test				
$\sum \delta_{i\ i} = 0$	2.4715		2.3386	
$\sum \delta_i{}^{+}{}_{i} = 0$		.72828		2.1228
$\sum \delta_i{}^{-} = 0$		.00926		.00117
$\sum \delta_i{}^{+} = \sum \delta_i{}^{-}$		.01033		.61703
$\rho_1^{+} = \rho_1^{-}$		.60769		.63624

(Continued…)

(Table 1 Continued)

	Ohio		Oklahoma	
	Linear ARDL	**Nonlinear ARDL**	**Linear ARDL**	**Nonlinear ARDL**
Panel A: Short-Run				
$\Delta LnHI_t$	0.26(2.8)**		0.24(3.1)**	
$\Delta LnHI_{t-1}$			-0.01(0.21)	
$\Delta LnHI_{t-2}$			0.10(1.31)	
$\Delta LnHI_{t-3}$			0.20(2.7)**	
$\Delta LnHI_{t-4}$				
$\Delta LnHI_{t-5}$				
$\Delta LnHI_{t-6}$				
$\Delta LnHI_{t-7}$				
$\Delta LnHI_{t-8}$				
ΔPOS_t		0.11(0.63)		0.25(2.0)**
ΔPOS_{t-1}		0.10(0.63)		-0.18(1.56)
ΔPOS_{t-2}		-0.23(1.49)		0.08(0.80)
ΔPOS_{t-3}		-0.41(2.6)*		0.24(2.4)**
ΔPOS_{t-4}				0.25(2.3)**
ΔPOS_{t-5}				0.13(1.28)
ΔPOS_{t-6}				0.14(1.35)
ΔPOS_{t-7}				
ΔPOS_{t-8}				
ΔNEG_t		0.66(3.2)**		0.39(2.0)**
ΔNEG_{t-1}				
ΔNEG_{t-2}				
ΔNEG_{t-3}				
ΔNEG_{t-4}				
ΔNEG_{t-5}				
ΔNEG_{t-6}				
ΔNEG_{t-7}				
ΔNEG_{t-8}				
Panel B: Long-Run				
Constant	1.66(0.34)	5.6(137)**	8.05(1.9)*	5.28(50.1)**
$Ln\ HI_t$	0.19(0.80)		-0.16(0.73)	
POS_t		1.24(6.2)**		0.61(2.4)**
NEG_t		3.39(5.8)**		2.43(2.9)**
Panel C: Diagnostic				
F	2.20	5.92**	4.08	6.42**
ECM_{t-1}	-0.02(2.10)	-0.07(4.2)**	-0.02(2.87)	-0.05(4.3)**
LM	2.12	6.33	10.81**	2.10
QS (QS^2)	S (U)	S (U)	U (U)	U (U)
Adjusted R^2	0.41	0.45	0.38	0.38
Wald Test				
$\sum \delta_i{}_i = 0$	7.9031*		17.8665*	
$\sum \delta_i{}^+{}_i = 0$		2.3158		17.0875*
$\sum \delta_i{}^- = 0$		10.8189*		.00659
$\sum \delta_i{}^+ = \sum \delta_i{}^-$		8.0951*		11.0538*
$\rho_1^+ = \rho_1^-$		11.2470*		5.1656*

(Continued…)

(Table 1 Continued)

	Oregon		Pennsylvania	
	Linear ARDL	**Nonlinear ARDL**	**Linear ARDL**	**Nonlinear ARDL**
Panel A: Short-Run				
$\Delta LnHI_t$	0.65(3.6)**		0.24(2.4)**	
$\Delta LnHI_{t-1}$	-0.46(2.4)**			
$\Delta LnHI_{t-2}$	-0.05(0.28)			
$\Delta LnHI_{t-3}$	-0.16(0.84)			
$\Delta LnHI_{t-4}$	-0.10(0.53)			
$\Delta LnHI_{t-5}$	0.23(1.29)			
$\Delta LnHI_{t-6}$	0.41(2.3)**			
$\Delta LnHI_{t-7}$	-0.38(2.1)**			
$\Delta LnHI_{t-8}$				
ΔPOS_t		0.07(2.8)*		0.02(1.50)
ΔPOS_{t-1}				
ΔPOS_{t-2}				
ΔPOS_{t-3}				
ΔPOS_{t-4}				
ΔPOS_{t-5}				
ΔPOS_{t-6}				
ΔPOS_{t-7}				
ΔPOS_{t-8}				
ΔNEG_t		1.53(3.2)**		-0.01(0.10)
ΔNEG_{t-1}		-1.64(3.4)**		
ΔNEG_{t-2}		-0.46(0.91)		
ΔNEG_{t-3}		-0.24(0.49)		
ΔNEG_{t-4}		-0.77(1.9)**		
ΔNEG_{t-5}		0.78(2.0)**		
ΔNEG_{t-6}		1.14(3.0)**		
ΔNEG_{t-7}		-1.56(4.0)**		
ΔNEG_{t-8}				
Panel B: Long-Run				
Constant	-11.3(3.8)**	5.20(43.1)**	-5.91(3.2)**	5.49(69)**
$Ln\ HI_t$	0.92(5.8)**		0.59(6.4)**	
POS_t		1.27(6.04)**		0.44(1.68)*
NEG_t		3.25(2.14)**		-0.09(0.10)
Panel C: Diagnostic				
F	5.69*	3.66	9.16**	4.63
ECM_{t-1}	-0.04(3.3)**	-0.05(3.34)*	-0.06(4.2)**	-0.05(3.7)**
LM	3.28	3.34	6.06	8.57*
QS (QS^2)	S (S)	S (U)	S (U)	S (S)
Adjusted R^2	0.47	0.54	0.37	0.55
Wald Test				
$\sum \delta_{i\ i} = 0$	.14573		5.8224*	
$\sum \delta_i^+ = 0$		1.4210		.62880
$\sum \delta_i^- = 0$		2.9040*		.08936
$\sum \delta_i^+ = \sum \delta_i^-$		3.4153*		.35814
$\rho_1^+ = \rho_1^-$		1.6678		.50372

(Continued…)

(Table 1 Continued)

	Rhode Island		South Carolina	
	Linear ARDL	**Nonlinear ARDL**	**Linear ARDL**	**Nonlinear ARDL**
Panel A: Short-Run				
$\Delta LnHI_t$	0.05(3.8)**		0.31(2.8)**	
$\Delta LnHI_{t-1}$				
$\Delta LnHI_{t-2}$				
$\Delta LnHI_{t-3}$				
$\Delta LnHI_{t-4}$				
$\Delta LnHI_{t-5}$				
$\Delta LnHI_{t-6}$				
$\Delta LnHI_{t-7}$				
$\Delta LnHI_{t-8}$				
ΔPOS_t		0.38(1.47)		0.04(2.4)**
ΔPOS_{t-1}		0.02(0.09)		
ΔPOS_{t-2}		0.58(2.2)**		
ΔPOS_{t-3}		-0.24(0.99)		
ΔPOS_{t-4}		-0.4(1.8)*		
ΔPOS_{t-5}				
ΔPOS_{t-6}				
ΔPOS_{t-7}				
ΔPOS_{t-8}				
ΔNEG_t		0.25(0.68)		1.12(4.3)**
ΔNEG_{t-1}		0.54(1.44)		-0.49(1.82)*
ΔNEG_{t-2}		-0.9(2.3)**		
ΔNEG_{t-3}				
ΔNEG_{t-4}				
ΔNEG_{t-5}				
ΔNEG_{t-6}				
ΔNEG_{t-7}				
ΔNEG_{t-8}				
Panel B: Long-Run				
Constant	-11.3(4.8)**	5.4(48.9)**	1.75(1.05)	5.57(148)**
$Ln\ HI_t$	0.10(7.4)**		0.21(2.3)**	
POS_t		2.1(4.5)**		0.67(3.7)**
NEG_t		5.40(3.0)**		3.98(2.7)**
Panel C: Diagnostic				
F	8.70**	4.63	3.36	3.95
ECM_{t-1}	-0.05(4.1)**	-0.05(3.7)**	-0.04(2.60)	-0.07(3.47)*
LM	4.10	2.45	3.26	3.01
QS (QS^2)	S (U)	S (U)	S (U)	S (U)
Adjusted R^2	0.54	0.60	0.27	0.34
Wald Test				
$\sum \delta_{i\ i} = 0$	2.3199		8.7438*	
$\sum \delta_i^{+} = 0$		.31709		.03189
$\sum \delta_i^{-} = 0$		.03929		3.0886*
$\sum \delta_i^{+} = \sum \delta_i^{-}$		.20329		2.5988*
$\rho_1^{+} = \rho_1^{-}$		5.0756*		4.1534*

(Continued…)

(Table 1 Continued)

	South Dakota		Tennessee	
	Linear ARDL	**Nonlinear ARDL**	**Linear ARDL**	**Nonlinear ARDL**
Panel A: Short-Run				
$\Delta LnHI_t$	0.17(1.11)		0.23(1.61)	
$\Delta LnHI_{t-1}$	0.35(2.2)**		0.03(0.22)	
$\Delta LnHI_{t-2}$	0.13(0.90)		0.02(0.16)	
$\Delta LnHI_{t-3}$	0.13(0.92)		0.15(2.4)**	
$\Delta LnHI_{t-4}$	-0.04(0.30)			
$\Delta LnHI_{t-5}$	0.02(0.15)			
$\Delta LnHI_{t-6}$	0.30(2.0)**			
$\Delta LnHI_{t-7}$	0.79(5.5)**			
$\Delta LnHI_{t-8}$				
ΔPOS_t		0.49(2.3)**		0.02(1.32)
ΔPOS_{t-1}				
ΔPOS_{t-2}				
ΔPOS_{t-3}				
ΔPOS_{t-4}				
ΔPOS_{t-5}				
ΔPOS_{t-6}				
ΔPOS_{t-7}				
ΔPOS_{t-8}				
ΔNEG_t		-0.07(0.30)		0.93(2.9)**
ΔNEG_{t-1}		0.23(0.99)		-0.05(0.16)
ΔNEG_{t-2}		-0.03(0.16)		-0.35(1.10)
ΔNEG_{t-3}		0.002(.013)		1.17(3.7)**
ΔNEG_{t-4}		0.29(1.36)		-0.7(2.2)**
ΔNEG_{t-5}		-0.02(0.12)		-0.6(1.9)**
ΔNEG_{t-6}		0.54(2.6)**		0.52(1.60)
ΔNEG_{t-7}		1.45(7.0)**		
ΔNEG_{t-8}				
Panel B: Long-Run				
Constant	1.32(0.34)	6.09(27.9)**	1.38(0.77)	5.4(78.9)**
$Ln\ HI_t$	0.24(1.04)		0.22(2.3)**	
POS_t		0.90(5.4)**		0.24(1.67)*
NEG_t		2.23(4.2)**		0.59(0.46)
Panel C: Diagnostic				
F	0.95	6.22**	3.23	2.70
ECM_{t-1}	-0.06(1.39)	-0.17(4.35)**	-0.05(2.55)	-0.07(2.87)
LM	10.14**	30.89**	1.52	15.52**
QS (QS^{2})	S (U)	U (U)	S (U)	S (U)
Adjusted R^2	0.38	0.52	0.18	0.32
Wald Test				
$\sum \delta_i = 0$	10.9179*		6.1629*	
$\sum \delta_i^{+} = 0$		5.3064*		.36229
$\sum \delta_i^{-} = 0$		12.1536*		1.0747
$\sum \delta_i^{+} = \sum \delta_i^{-}$		7.4340*		1.2609
$\rho_1^{+} = \rho_1^{-}$		17.6862*		.06771

(Continued…)

(Table 1 Continued)

	Texas		Utah	
	Linear ARDL	**Nonlinear ARDL**	**Linear ARDL**	**Nonlinear ARDL**
Panel A: Short-Run				
$\Delta LnHI_t$	0.19(2.2)**		0.55(3.7)**	
$\Delta LnHI_{t-1}$	-0.12(1.39)			
$\Delta LnHI_{t-2}$	0.11(1.29)			
$\Delta LnHI_{t-3}$	0.25(2.94)**			
$\Delta LnHI_{t-4}$	0.12(1.45)			
$\Delta LnHI_{t-5}$				
$\Delta LnHI_{t-6}$				
$\Delta LnHI_{t-7}$				
$\Delta LnHI_{t-8}$				
ΔPOS_t		0.06(0.54)		0.38(2.0)**
ΔPOS_{t-1}		-0.16(1.37)		0.22(1.20)
ΔPOS_{t-2}		0.10(0.85)		0.42(2.5)**
ΔPOS_{t-3}		0.19(1.64)		0.27(1.55)
ΔPOS_{t-4}		0.3(2.9)**		
ΔPOS_{t-5}		0.19(1.46)		
ΔPOS_{t-6}				
ΔPOS_{t-7}				
ΔPOS_{t-8}				
ΔNEG_t		0.32(1.34)		0.55(1.38)
ΔNEG_{t-1}		-0.17(0.70)		-0.80(1.95)*
ΔNEG_{t-2}		0.18(0.77)		
ΔNEG_{t-3}		0.5(2.1)**		
ΔNEG_{t-4}		-0.44(1.8)*		
ΔNEG_{t-5}		-0.39(1.63)		
ΔNEG_{t-6}				
ΔNEG_{t-7}				
ΔNEG_{t-8}				
Panel B: Long-Run				
Constant	1.13(0.16)	4.7(10.2)**	-1.22(0.71)	5.00(32.9)**
$Ln\ HI_t$	0.19(0.56)		0.38(3.9)**	
POS_t		0.50(0.87)		0.64(4.6)**
NEG_t		2.43(0.66)		3.39(1.9)**
Panel C: Diagnostic				
F	1.69	2.64	5.01*	3.50
ECM_{t-1}	-0.01(1.83)	-0.02(2.84)	-0.04(3.1)*	-0.04(3.2)*
LM	11.22**	6.10	3.01	3.74
QS (QS^{2})	S (S)	S (U)	S (S)	S (U)
Adjusted R^2	0.40	0.40	0.38	0.44
Wald Test				
$\sum \delta_i = 0$	13.2822*		14.2188*	
$\sum \delta_i^{+} = 0$		8.9412*		13.2764*
$\sum \delta_i^{-} = 0$		.00295		1.5062
$\sum \delta_i^{+} = \sum \delta_i^{-}$		1.4905		8.3084*
$\rho_1^{+} = \rho_1^{-}$		.34687		2.9720*

(Continued…)

(Table 1 Continued)

	Virginia		Vermont	
	Linear ARDL	**Nonlinear ARDL**	**Linear ARDL**	**Nonlinear ARDL**
Panel A: Short-Run				
$\Delta LnHI_t$	0.32(2.50)**		1.00(2.0)**	
$\Delta LnHI_{t-1}$	-0.04(0.33)			
$\Delta LnHI_{t-2}$	-0.08(0.63)			
$\Delta LnHI_{t-3}$	0.40(2.9)**			
$\Delta LnHI_{t-4}$	-0.26(1.93)*			
$\Delta LnHI_{t-5}$				
$\Delta LnHI_{t-6}$				
$\Delta LnHI_{t-7}$				
$\Delta LnHI_{t-8}$				
ΔPOS_t		0.47(2.4)**		1.18(1.85)*
ΔPOS_{t-1}				
ΔPOS_{t-2}				
ΔPOS_{t-3}				
ΔPOS_{t-4}				
ΔPOS_{t-5}				
ΔPOS_{t-6}				
ΔPOS_{t-7}				
ΔPOS_{t-8}				
ΔNEG_t		-0.11(0.34)		0.71(2.2)**
ΔNEG_{t-1}		-0.14(4.4)**		
ΔNEG_{t-2}		-0.05(0.16)		
ΔNEG_{t-3}		0.69(2.2)**		
ΔNEG_{t-4}		-1.12(3.5)**		
ΔNEG_{t-5}				
ΔNEG_{t-6}				
ΔNEG_{t-7}				
ΔNEG_{t-8}				
Panel B: Long-Run				
Constant	-4.62(2.0)**	5.26(37.5)**	-5.53(2.1)**	5.31(44)**
$Ln\ HI_t$	0.54(4.5)**		0.67(4.4)**	
POS_t		0.54(1.6)*		1.66(2.4)**
NEG_t		0.11(0.04)		5.24(1.6)*
Panel C: Diagnostic				
F	3.91	3.30	3.32	4.30
ECM_{t-1}	-0.03(2.80)	-0.03(3.17)	-0.12(2.59)	-0.13(3.62)**
LM	4.06	2.93	4.31	4.12
QS (QS^{2})	S (S)	S (S)	S (U)	U (U)
Adjusted R^2	0.40	0.44	0.34	0.37
Wald Test				
$\sum \delta_i = 0$	1.4338		4.0163*	
$\sum \delta_i^{+} = 0$		5.1839*		2.6746*
$\sum \delta_i^{-} = 0$		1.0216		.29361
$\sum \delta_i^{+} = \sum \delta_i^{-}$		2.2997		.02956
$\rho_1^{+} = \rho_1^{-}$		.05824		3.6476*

(Continued…)

(Table 1 Continued)

	Washington		Wisconsin	
	Linear ARDL	**Nonlinear ARDL**	**Linear ARDL**	**Nonlinear ARDL**
Panel A: Short-Run				
$\Delta LnHI_t$	0.03(3.5)**		0.35(2.2)**	
$\Delta LnHI_{t-1}$			-0.03(0.19)	
$\Delta LnHI_{t-2}$			0.05(0.33)	
$\Delta LnHI_{t-3}$			0.30(2.0)**	
$\Delta LnHI_{t-4}$			0.01(0.04)	
$\Delta LnHI_{t-5}$			-0.20(1.36)	
$\Delta LnHI_{t-6}$			0.40(2.7)**	
$\Delta LnHI_{t-7}$			0.37(2.4)**	
$\Delta LnHI_{t-8}$				
ΔPOS_t		0.11(1.02)		0.08(0.37)
ΔPOS_{t-1}		0.32(2.2)**		-0.62(2.8)**
ΔPOS_{t-2}		-0.21(1.49)		0.12(0.54)
ΔPOS_{t-3}				-0.50(2.3)**
ΔPOS_{t-4}				-0.44(1.9)**
ΔPOS_{t-5}				-0.09(0.40)
ΔPOS_{t-6}				-0.53(2.4)**
ΔPOS_{t-7}				
ΔPOS_{t-8}				
ΔNEG_t		0.24(1.17)		0.76(2.0)**
ΔNEG_{t-1}		-0.5(2.8)**		0.52(1.41)
ΔNEG_{t-2}				-0.47(1.26)
ΔNEG_{t-3}				1.54(4.0)**
ΔNEG_{t-4}				0.69(2.0)**
ΔNEG_{t-5}				-0.69(2.1)**
ΔNEG_{t-6}				1.12(3.3)**
ΔNEG_{t-7}				
ΔNEG_{t-8}				
Panel B: Long-Run				
Constant	-7.13(5.3)**	5.2(60.8)**	-6.97(1.14)	5.59(71.4)**
$Ln\ HI_t$	0.68(9.6)**		0.65(2.0)**	
POS_t		0.66(3.4)**		0.98(6.68)**
NEG_t		0.69(0.81)		2.53(3.17)**
Panel C: Diagnostic				
F	6.38**	3.43	1.42	3.24
ECM_{t-1}	-0.04(3.5)**	-0.04(3.24)*	-0.02(1.69)	-0.08(3.06)
LM	3.55	10.48**	4.29	13.62**
QS (QS^2)	S (S)	S (S)	S (U)	U (S)
Adjusted R^2	0.49	0.50	0.26	0.40
Wald Test				
$\sum \delta_i = 0$	1.7456		11.2823*	
$\sum \delta_i^+ = 0$		1.0190		10.0943*
$\sum \delta_i^- = 0$		1.8001		12.4751*
$\sum \delta_i^+ = \sum \delta_i^-$		4.5046*		16.4647*
$\rho_1^+ = \rho_1^-$		.00097		2.6117*

(Continued…)

(Table 1 Continued)

	West Virginia		Wyoming	
	Linear ARDL	**Nonlinear ARDL**	**Linear ARDL**	**Nonlinear ARDL**
Panel A: Short-Run				
$\Delta LnHI_t$	0.81(3.7)**		0.02(0.17)	
$\Delta LnHI_{t-1}$	0.35(1.49)		0.24(2.0)**	
$\Delta LnHI_{t-2}$	0.11(0.47)		0.27(2.3)**	
$\Delta LnHI_{t-3}$	0.02(0.09)		0.24(2.0)**	
$\Delta LnHI_{t-4}$	0.05(0.22)		0.30(2.5)**	
$\Delta LnHI_{t-5}$	0.58(2.6)**		-0.10(0.82)	
$\Delta LnHI_{t-6}$	0.46(2.1)**		0.23(2.0)**	
$\Delta LnHI_{t-7}$				
$\Delta LnHI_{t-8}$				
ΔPOS_t		-0.05(0.13)		0.11(3.1)**
ΔPOS_{t-1}		-0.35(0.96)		
ΔPOS_{t-2}		-0.80(2.2)**		
ΔPOS_{t-3}		0.88(2.4)**		
ΔPOS_{t-4}		-0.96(3.3)**		
ΔPOS_{t-5}				
ΔPOS_{t-6}				
ΔPOS_{t-7}				
ΔPOS_{t-8}				
ΔNEG_t		1.64(4.3)**		0.13(0.68)
ΔNEG_{t-1}		-0.26(0.48)		0.37(1.8)*
ΔNEG_{t-2}		-0.43(0.87)		-0.19(0.94)
ΔNEG_{t-3}		-1.28(2.6)**		0.03(0.13)
ΔNEG_{t-4}		1.28(2.5)**		0.47(2.4)**
ΔNEG_{t-5}				-0.22(1.08)
ΔNEG_{t-6}				0.29(1.45)
ΔNEG_{t-7}				-0.5(2.5)**
ΔNEG_{t-8}				
Panel B: Long-Run				
Constant	2.23(0.23)	5.72(68.7)**	-2.86(0.94)	5.1(116)**
$Ln\ HI_t$	0.16(0.29)		0.48(2.6)**	
POS_t		1.09(6.4)**		0.9(14.3)**
NEG_t		2.76(7.3)**		1.90(7.9)**
Panel C: Diagnostic				
F	1.62	4.19	5.21*	5.09*
ECM_{t-1}	-0.04(1.80)	-0.20(3.5)**	-0.03(-3.2)**	-0.12(3.9)**
LM	14.05**	7.03	4.12	10.95**
QS (QS^2)	S (U)	S (U)	U (U)	U (S)
Adjusted R^2	0.52	0.62	0.31	0.48
Wald Test				
$\sum \delta_i = 0$	8.2670*		21.1042*	
$\sum \delta_i^+ = 0$		3.0192*		.00281
$\sum \delta_i^- = 0$		.81059		.36031
$\sum \delta_i^+ = \sum \delta_i^-$		4.1153*		.32953
$\rho_1^+ = \rho_1^-$		12.1085*		5.6330*

(Continued…)

(Table 1 Continued)

	District of Columbia	
	Linear ARDL	**Nonlinear ARDL**
Panel A: Short-Run		
$\Delta LnHI_t$	0.19(1.38)	
$\Delta LnHI_{t-1}$	0.27(1.98)**	
$\Delta LnHI_{t-2}$		
$\Delta LnHI_{t-3}$		
$\Delta LnHI_{t-4}$		
$\Delta LnHI_{t-5}$		
$\Delta LnHI_{t-6}$		
$\Delta LnHI_{t-7}$		
$\Delta LnHI_{t-8}$		
ΔPOS_t		0.06(2.38)**
ΔPOS_{t-1}		
ΔPOS_{t-2}		
ΔPOS_{t-3}		
ΔPOS_{t-4}		
ΔPOS_{t-5}		
ΔPOS_{t-6}		
ΔPOS_{t-7}		
ΔPOS_{t-8}		
ΔNEG_t		-0.37(1.17)
ΔNEG_{t-1}		1.26(4.21)**
ΔNEG_{t-2}		-0.67(2.1)**
ΔNEG_{t-3}		-0.003(0.01)
ΔNEG_{t-4}		0.40(1.35)
ΔNEG_{t-5}		-0.93(3.2)**
ΔNEG_{t-6}		0.99(3.4)**
ΔNEG_{t-7}		
ΔNEG_{t-8}		
Panel B: Long-Run		
Constant	-19.4(8.7)**	5.43(24.4)**
$Ln\ HI_t$	1.47(11.3)**	
POS_t		1.23(4.22)**
NEG_t		0.63(0.72)
Panel C: Diagnostic		
F	5.86**	4.07
ECM_{t-1}	-0.07(4.1)**	-0.05(3.46)*
LM	3.89	2.74
QS (QS^2)	S (U)	U (S)
Adjusted R^2	0.43	0.49
Wald Test		
$\sum \delta_i = 0$	2.2045	
$\sum \delta_i^{+} = 0$		.93387
$\sum \delta_i^{-} = 0$		2.2609
$\sum \delta_i^{+} = \sum \delta_i^{-}$		.96676
$\rho_1^{+} = \rho_1^{-}$		.17827

(Continued…)

(Table 1 Continued)

Notes: a. Numbers inside the parentheses next to coefficient estimates are absolute value of t-ratios. *, ** indicate significance at the 10% and 5% levels respectively.

b. The upper bound critical value of the F-test for cointegration when there is one exogenous variable (k=1) is 4.78 (5.73) at the 10% (5%) level of significance. These come from Pesaran et al. (2001, Table CI, Case III, p. 300).

c. The upper bound critical value of the t-test for significance of ECM_{t-1} is -2.91 (-3.22) at the 10% (5%) level when k =1. The comparable figures when k = 2 in the nonlinear model are -3.21 and -3.53 respectively. These come from Pesaran et al. (2001, Table CII, Case III, p. 303).

d. LM is the Lagrange multiplier statistic to test for autocorrelation. It is distributed as χ^2 with 4 degrees of freedom. The critical value is 7.78 (9.48) at the 10% (5%) level.

e. All Wald tests are distributed as χ^2 with one degree of freedom. The critical value is 2.71 (3.84) at the 10% (5%) level.

Once again, we ask in how many states do asymmetric short-run effects last into the long run? From Panel B we gather that either the POS or NEG variable carries a significant long-run coefficient in 41 states. The comparable figure from the linear model was 34 where household income carried a significant long-run coefficient. Thus, introducing nonlinear adjustment yields more significant results. These significant long-run estimates are meaningful in 33 states since either the F statistic or ECM_{t-1} is significant. The comparable figure for cointegration in the linear model is 24. Again, this is an indication of the superiority of the nonlinear specification. Therefore, more support is obtained for cointegration between house prices and household income. Finally, we ask whether asymmetric long-run effects are significantly different. Here we test if $\rho_1^+ \neq \rho_1^-$. The Wald test appears to be significant in 21 states only.[6]

4. Summary and Conclusion

The financial crisis of 2008 that shook the world in general and the U.S. in particular was mostly attributed to the real estate bubble that burst in the U.S. Specifically, house prices that rose abnormally in the U.S. prior to 2008, declined abnormally after 2008. However, changes were disproportionate and differed from one state to another. While there are many factors that contributed to the fluctuations in house prices, Case and Shiller (2003, p. 300) argue that "income growth alone explains the pattern of recent home price increases in

[6] Note that just like the linear model in which the LM statistic is significant in 14 states, it is still significant in 14 states in the nonlinear model. Thus, autocorrelation does not seem to be an issue in most models. Estimated coefficients are also stable, at least by either using the CUSUM or CUSUMSQ test in most models.

most states”. If income increase explains most of the increase in housing prices prior to 2008, does decline in income explain most of the decline in housing prices in post 2008? In other words, do income changes have symmetric or asymmetric effects on house prices?

The main purpose of this paper is to investigate whether changes in household income have symmetric or asymmetric effects on the housing prices in each state of the U.S. Indeed, previous research assumed that the effects are asymmetric and included household income in their model and estimated a linear model. Following the recent trend in applied research, we separate household income increases from decreases by using partial sums. We then estimate the linear ARDL model by first using the bounds testing approach in Pesaran et al. (2001) and next, the nonlinear ARDL approach in Shin et al. (2014) . The latter approach allows testing to see if changes in income have symmetric or asymmetric effects on house prices. We do this by using quarterly data over the period of 1975I-2014III from each and every state of the U.S.

Our finding could be best summarized by saying that a nonlinear model performs better than a linear model in that more support is provided for cointegration between house prices and household income. Given that previous studies have not been able to find much support for cointegration, nonlinear models that may even include other factors should be given serious consideration. Second, we find support for the adjustment asymmetry in almost all states, implying that the speed in which increases in income affects house prices is different than that in which decreases in income affects house prices. Third, since the size and sign of short-run effects are different due to increases in income as compared to decreases in income, the short-run effects of income changes are asymmetric in almost all states. However, asymmetric short-run impact is only found in 18 states. Finally, while the asymmetric short-run effects lasted into the long-run in 41 states, the long-run effects are significantly asymmetric in only 21 states. These asymmetric effects could be attributed to the reaction of the households to an increase in their income as compared to a decrease in their income. When household income rises, the demand for housing rises too, thus pushing the prices up. However, when income declines, if this is considered a short-run phenomenon, they may finance their mortgage by using savings rather than selling. All in all, our findings are state-specific and show the importance of using disaggregated data state by state.

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Appendix

Data Sources and Definitions
Quarterly data over the 1975I-2014III period are used to carry out the empirical exercise.

HP = House Price. House price data is House Price Index (HPI) which is a weighted repeat sales index that measures the average price changes of repeat sales or re-financings on the same single-family house. This information is obtained by studying repeat mortgage transactions on single-family properties in which the mortgages have been securitized or purchased by Fannie Mae or Freddie Mac since 1975. The HPI provides an accurate indicator of house price trends at different geographic levels. The breadth of this sample provides more information than other house price indexes. These data are available for the nine Census Bureau divisions, the 50 states and District of Columbia, and for Metropolitan Statistical Areas and Divisions. The Federal Housing Finance Agency publishes monthly and quarterly HPI data. In this study, we use seasonally adjusted real HPI by adjusting the HPI with the consumer price index.

HI = Household income; defined as total personal income published by the U.S. Bureau of Economic Analysis. Here we use real total personal income which are seasonally adjusted figures deflated by the consumer price index.