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

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ABSTRACT

When the U.S. house prices were rising before the Financial Crisis of 2008, Case and Shiller (2003) argued that “income growth alone explains the pattern of recent home price increases in most states”. Can then the decline in income after 2008 explain 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 ARDL 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, short-run impact asymmetry is evidenced in 18 states and significant long-run asymmetry in 21 states.

JEL Classification: R13

Key words: House Prices, Household income, Asymmetry, Nonlinear ARDL Approach.

*. Valuable comments of an anonymous referee and those of the editor are greatly appreciated. Any remaining error, however, is our own responsibility.

I. Introduction

Over the last three decades housing market in the U.S. has been subject to abnormal fluctuations. However, house prices in different states have fluctuated differently to changes in overall economic conditions in the United States. 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 which was considered by Case and Shiller, did decline in income cause house prices to drop during post 2008? Furthermore, if the answer is in the affirmative, did income changes cause house prices symmetrically or asymmetrically?

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) have investigated short-run causality or long-run relationship between house prices and income or some other variables in different countries.[1] While none of these studies have considered asymmetry short-run causality, Katrakilidis and Tranchanas (2012) considered asymmetry cointegration to investigate housing price dynamics in only Greece. While our approach will be similar to Katrakilidis and Tranchanas (2012), we will modify their approach so that we can also investigate the short-run asymmetry causality and engage in perhaps, the most comprehensive study that uses data from each of the 52 states of the United States of America. To this end, we introduce the

[1] Old literature is reviewed by Malpezzi (1999). For detailed review of recent literature see Bahmani-Oskooee and Ghodsi (2016).

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.

II. The Model and Methods

Following the literature we begin with a log-linear relation between house prices (HP) and household income (HI) as follows:[2]

$$LnHP_t = a + bLnHI_t + \varepsilon_t \qquad (1)$$

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

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

In (2), 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) argued and demonstrated that if the two variables are adjusting in the short-run in a stable manner, we must make sure they are also converging toward their long-run equilibrium values. If this is to be the

[2] Some other studies have assessed the impact of other variables on house prices without engaging in asymmetry causality detection. Since our main goal is to investigate asymmetric causality between income and hose 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).

case, the gap between two sides of (1) must decline in this process. This is tested by including lagged error term from (1) into (2) as follows:

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

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

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, 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, for cointegration ε_t should stationary. 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*. (1989) have demonstrated that if an 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 ARDL bounds testing approach. They solve equation (1) for , ε_t and lag the solution by one period to arrive at:

$$\varepsilon_{t-1} = LnHP_{t-1} + b' LnHI_{t-1} \quad (4)$$

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

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

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, the F test in this context has new critical values that they tabulate. Since their critical values do account for integrating properties of variables in a given mode, there is no need for pre-unit root testing and indeed, variables could be combination of I(0) and I(1).[3] Once cointegration is established, long-run effects of household income on house prices are established by normalizing estimate of λ_1 on λ_0. The short-run effects are judged by the estimates of δ_i's. Following Bahmani-Oskooee and Oyolola (2007) we apply the Wald test to determine whether $\sum \delta_i \neq 0$ as a sign of short-run causality.

One main assumption in estimating (5) is that changes in household income has 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 house hold income falls due to loss of a job, this could be considered a short-run phenomenon and some may continue financing their house using their saving rather than selling their houses and depressing house prices, hence asymmetry response of house prices to changes in household income. In order to assess asymmetry 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 partial sum of positive changes (denoted by $\Delta Ln\ HI^+$) to generate a variable, POS, which indicates only increases in household income. Similarly, we use partial sum of negative changes (denoted by $\Delta Ln\ HI^-$) and generate a variable, NEG, which reflects only the decline in income as follows:

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

$$POS_t = \sum_{j=1}^{t} \Delta LnHI_j^+ = \sum_{j=1}^{t} \max(\Delta LnHI_j, 0),$$

$$NEG_t = \sum_{j=1}^{t} \Delta LnHI_j^- = \sum_{j=1}^{t} \min(\Delta LnHI_j, 0) \qquad (6)$$

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

$$\Delta LnHP_t = \alpha + \sum_{i=1}^{n1} \beta_i \Delta LnHP_{t-i} + \sum_{i=0}^{n2} \delta_i^+ \Delta POS_{t-i} + \sum_{i=0}^{n3} \delta_i^- \Delta NEG_{t-i}$$

$$+ \rho_0 LnHP_{t-1} + \rho_1^+ POS_{t-1} + \rho_1^- NEG_{t-1} + \xi_t \qquad (7)$$

Since 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 whereas, model (5) is referred to as the linear ARDL model. They show that Pesaran *et al*'s (2001) method and critical values are equally applicable to specification (7).

Once (7) is estimated using a set criterion such as AIC to select an optimum model, we shall engage in a few hypothesis testing. First, we shall infer short-run 'adjustment asymmetry' if number of lags obtained for *ΔPOS* variable are different than those obtained for *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 short-run asymmetry 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 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 hypothesis. Fourth, cointegration between 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 that here Shin *et al*. (2014, p. 291) recommend treating POS and NEG as one variable and using the critical values for the case of k=1. This is mostly due to dependency 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 test for cointegration will be based Banerjee *et al.* (1998). Within the linear or nonlinear ARDL approach, Pesaran et al. (2001) propose using the long-run normalized estimates and long run model in either case to generate the error tem. Denoting this error term by ECM, the linear combination of 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 significance of ECM_{t-1} within ARDL approach has an upper bound and a lower bound critical value that Pesaran *et al*. (2001, p. 303) supply. Finally, once cointegration is established, long-run asymmetry effects of household income changes is tested by using the Wald test to determine if estimate of $\rho_1^+ \neq \rho_1^-$.[4]

III. The Results

The linear model (5) and nonlinear model (7) are both estimated using quarterly data over the period 1975I-2014III from each of states in the United States of America. Details of the data are provided in the Appendix. We impose a maximum of eight lags on each-first differenced variable and use Akaike's Information Criterion (AIC) to select the optimum lags. We then report the results from each optimum linear and nonlinear models 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

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

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.

Table 1 goes here

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. Sum of these short-run effects are significant, implying short-run causality form household income to house prices. However, these short-run effects does not seem to last into the long run since the long-run coefficient obtained for LnHI is insignificant. No wonder why cointegration is not supported neither by the F test nor by ECM_{t-1}. Neither is significant in this linear model. The Lagrange Multiplier (LM) statistic is also insignificant, implying autocorrelation free residuals but the coefficient estimate are 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", stables 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 established at least 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 number of lags are different, there is evidence of short-run adjustment asymmetry. Second, since size and sign of some of the coefficients attached to ΔPOS are different than those attached to ΔNEG, there is also evidence of short-run asymmetry effects. However, 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, implying lack of short-run impact asymmetry. 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 $\sum \delta_i^-$ is not, we can say that in Alaska increases in income causes house prices but decreases in income does not, supporting short-run asymmetry causality.

We are now in a position to summarize our findings for all 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 the long run significant effects only in 34 states and these long run effects are meaningful in only 24 states since cointegration is supported either by the F or ECM_{t-1} test. How do the result change if we introduce nonlinear adjustment of household income and shift to the estimates of nonlinear models?

From the estimates of nonlinear optimum models we gather that: First, income increases (ΔPOS) and income decreases (ΔNEG) have short-run effects in almost all states. However, number of lags on ΔPOS are different than those on ΔNEG in 35 states, supporting adjustment asymmetry. Second, in almost all models either the size or sign of these short-run estimates are different, supporting short-run asymmetry effects. Third, 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, supporting short-run impact asymmetry. 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 $\sum \delta_i^+ \neq 0$ that is supported by significant Wald statistic 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. In the 15 states in which $\sum \delta_i^- \neq 0$ is supported by significant Wald statistic are: Arkansas, Arizona, California, Colorado, Connecticut, Florida, Indiana, Louisiana, Massachusetts, Mississippi, Ohio, Oregon, South Carolina, South Dakota, and Wisconsin.

Once again we ask in how many states short-run asymmetry effects last into the long run? From Panel B we gather that either the POS or NEG variable carry 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 was 24. Again, this is an indication of superiority of the nonlinear specification. It yield more support for cointegration between house prices and household income. Finally, we ask whether long-run asymmetric effects are significantly different. Here we test if $\rho_1^+ \neq \rho_1^-$. The Wald test appears to be significant in 21 states only.[5]

IV. Summary and Conclusion

The financial crisis of 2008 that shook the world in general and the United States in particular was mostly attributed to the real estate bubble that burst in the United States. Specifically, house prices that rose abnormally in the United States prior to 2008, declined abnormally after 2008. However, changes were disproportionate and differed from one state to another. While there are many factors contributing to fluctuations in house prices, Case and Shiller (2003, p. 300) argued that "income growth alone explains the pattern of recent home price increases in 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 during post 2008? In other word, do income changes have symmetric or asymmetric effects on house prices?

The main purpose of this paper was to investigate whether changes in household income have symmetric or asymmetric effects on the housing prices in each state of the United States. Indeed, previous research assumed 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 using partial sum concept. We then estimate the linear ARDL model using Pesaran *et al.* (2001) bounds testing approach first and Shin et al. (2014) nonlinear ARDL approach next. The latter approach allows us also to test if changes in

[5] Note that just like the linear model in which the LM statistic was 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 either by the CUSUM or CUSUMSQ tests in most models.

income have symmetric or asymmetric effects on house prices. We do this using quarterly data over the period 1975I-2014III from each and every states of the United States.

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

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

HI = Household income. It is defined as Total Personal Income published by the U.S. Bureau of Economic Analysis. Here we use real Total Personal Income which is seasonally adjusted figures deflated by Consumer Price Index.

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Table 1: Estimates of Both the Linear and Nonlinear ARDL Models for 52 States of the United States of America								
	Alaska		Alabama		Arkansas		Arizona	
Panel A: Short-Run	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL
$\Delta LnHI_t$	0.44(1.72)*		0.68(3.9)**		0.35(3.7)**		0.55(3.1)**	
$\Delta LnHI_{t-1}$	0.27(1.05)		0.07(0.38)		-0.13(1.37)		0.09(0.56)	
$\Delta LnHI_{t-2}$	0.24(0.92)		-0.15(.84)		-0.01(0.12)		-0.34(1.9)**	
$\Delta LnHI_{t-3}$	0.03(0.11)		0.35(2.0)**		-0.08(0.82)			
$\Delta LnHI_{t-4}$	-0.32(1.32)				0.14(1.48)			
$\Delta LnHI_{t-5}$	0.71 (2.9)**				-0.01(.07)			
$\Delta LnHI_{t-6}$	-0.36(1.48)				0.31(3.4)**			
$\Delta LnHI_{t-7}$								
$\Delta LnHI_{t-8}$								
ΔPOS_t		0.66(1.64)*		0.03(1.63)		0.02(1.58)		0.61(2.70)**
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)**		0.84(4.7)**		0.24(0.52)
ΔNEG_{t-1}		-0.37(0.51)		-0.13(0.34)		-0.64(3.4)**		-0.82(1.90)*
ΔNEG_{t-2}		0.49(1.03)		-0.95(2.6)**		-0.16(0.86)		-1.09(2.34)**
ΔNEG_{t-3}		0.10(0.21)		1.09(2.9)*		-0.02(0.11)		
ΔNEG_{t-4}		-0.96(2.0)**				0.39(2.00)**		
ΔNEG_{t-5}		1.11(2.3)**				-0.01(0.05)		
ΔNEG_{t-6}		-1.12(2.5)**				0.40(2.2)**		
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)**	4.22(1.17)	5.67(51.9)**	1.73(0.88)	5.19(49.5)**
$Ln\ HI_t$	0.14(0.35)		0.24(1.40)		0.06(0.31)		0.20(1.9)**	
POS_t		1.24(6.49)**		0.41(2.0)**		0.53(1.8)*		0.37(3.04)**
NEG_t		3.66(6.02)**		1.60(1.36)		2.67(2.0)**		1.75(1.55)
Panel C: Diagnostic								
F	1.48	4.20	3.06	2.50	1.38	1.13	6.04**	6.07**
ECM_{t-1}	-0.05(1.73)	-0.20(3.6)**	-0.04(2.48)	-0.07(2.75)	-0.02(1.67)	-0.03(1.83)	-0.04(3.4)**	-0.05(4.3)**
LM	5.22	1.79	0.91	2.20	13.67**	12.22**	3.19	5.63
QS (QS^2)	U (U)	U (U)	S (U)	S (U)	S (U)	S (U)	S (U)	U (U)
Adjusted R^2	0.19	0.25	0.22	0.33	0.24	0.34	0.50	0.54
Wald Tests:								
$\sum \delta_{i\ i} = 0$	3.4482**		6.9598*		6.5095*		1.1606	
$\sum \delta_i^+ = 0$		6.0939**		1.4659		.35402		6.3955*
$\sum \delta_i^- = 0$		.15502		2.1497		3.5857*		4.7729*
$\sum \delta_i^+ = \sum \delta_i^-$		.32377		.94146		3.7517*		7.3935*
$\rho_1^+ = \rho_1^-$		7.8243**		1.1540		2.9528*		1.2873

Notes: See end of the Table.

	California		Colorado		Connecticut		Delaware	
Panel A: Short-Run	**Linear ARDL**	**Nonlinear ARDL**	**Linear ARDL**	**Nonlinear ARDL**	**Linear ARDL**	**Nonlinear ARDL**	**Linear ARDL**	**Nonlinear ARDL**
$\Delta LnHI_t$	0.02(3.3)**		0.30(3.3)**		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		0.02(2.27)**		0.33(2.6)**		0.63(3.9)**		0.04(1.63)
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)		0.06(1.25)		0.40(0.95)
ΔNEG_{t-1}		-0.49(1.85)*		-0.71(3.0)**				0.33(0.76)
ΔNEG_{t-2}		-0.45(1.70)*						-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	-10.90(3.9)**	5.33(45.9)**	-3.88(1.58)	4.94(24.3)**	-1.80(0.47)	5.4(49.7)**	-2.59(1.10)	5.76(50.1)**
$Ln\ HI_t$	0.80(6.09)**		0.51(3.8)**		0.40(2.0)**		0.49(3.5)**	
POS_t		0.91(2.9)**		0.66(2.5)**		0.87(2.2)**		0.69(2.2)**
NEG_t		1.95(1.17)		1.21(0.62)		1.88(1.47)		1.54(1.01)
Panel C: Diagnostic								
F	8.78**	5.11*	2.90	3.86	4.47	3.74	2.98	2.56
ECM_{t-1}	-0.03(4.2)**	-0.03(3.9)**	-0.02(2.39)	-0.02(3.43)*	-0.03(2.86)	-0.04(3.37)*	-0.04(2.45)	-0.05(2.79)
LM	2.03	1.08	2.39	2.65	6.49	4.01	0.32	1.59
QS ($QS^{2)}$)	S (S)	S (S)	S (S)	S (S)	S (U)	S (U)	U (U)	S (U)
Adjusted R^2	0.75	0.75	0.44	0.46	0.47	0.49	0.41	0.40
Wald Tests:								
$\sum \delta_{i\ i} = 0$	.04503		11.0041*		9.3377*		4.4221*	
$\sum \delta_i^{+} = 0$		.67933		13.1203*		11.8314*		.32073
$\sum \delta_i^{-} = 0$		5.1441*		4.0547*		.025469*		1.0272
$\sum \delta_i^{+} = \sum \delta_i^{-}$		5.0354*		13.1352*		2.3499		.73983
$\rho_1^{+} = \rho_1^{-}$		.56194		.099549		1.0873		.48381

	Florida		Georgia		Hawaii		Iowa	
Panel A: Short-Run	**Linear ARDL**	**Nonlinear ARDL**	**Linear ARDL**	**Nonlinear ARDL**	**Linear ARDL**	**Nonlinear ARDL**	**Linear ARDL**	**Nonlinear ARDL**
$\Delta LnHI_t$	0.29(1.9)*		0.22(1.87)*		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		0.54(2.9)**		0.25(1.88)*		1.05(1.57)		0.10(0.66)
ΔPOS_{t-1}		-0.08(0.40)				1.38(2.0)**		0.29(2.0)**
ΔPOS_{t-2}		0.48(2.55)**						-0.55(3.6)**
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)		8.6(8.4)**		0.20(1.02)
ΔNEG_{t-1}		-0.12(0.35)				-4.0(3.1)**		-0.28(-1.42)
ΔNEG_{t-2}		-0.88(2.5)**				-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	-0.80(0.28)	5.21(39.4)**	3.06(3.0)**	5.5(104)**	-14.0(3.9)**	5.3(88.8)**	0.34(0.09)	5.54(42.6)**
$Ln HI_t$	0.31(2.2)**		0.13(2.6)**		1.12(5.4)**		0.27(1.39)	
POS_t		0.21(1.56)		0.20(2.2)**		2.15(9.4)**		0.54(1.22)
NEG_t		-0.58(0.47)		0.75(0.88)		4.97(6.0)*		0.96(0.96)
Panel C: Diagnostic								
F	4.63	7.27**	8.24**	4.61	3.14	5.82**	4.54	1.98
ECM_{t-1}	-0.03(3.05)*	-0.04(4.6)**	-0.06(4.9)**	-0.05(3.75)**	-0.11(2.51)	-0.22(4.2)**	-0.04(3.02)*	-0.04(2.46)
LM	0.50	1.87	2.84	7.14	2.32	1.44	8.96*	14.79**
QS (QS^2)	S (U)	S (U)	S (S)	S (S)	S (U)	S (U)	U (U)	S (U)
Adjusted R^2	0.51	0.54	0.31	0.37	0.44	0.67	0.33	0.49
Wald Tests:								
$\sum \delta_i = 0$	3.6223*		3.4982*		63.8448*		2.8806*	
$\sum \delta_i^+ = 0$		4.2112*		2.4189		7.9860*		.37981
$\sum \delta_i^- = 0$		4.3185*		.81443		.032648		1.6331
$\sum \delta_i^+ = \sum \delta_i^-$		6.7442*		.00017		1.1745		2.2999
$\rho_1^+ = \rho_1^-$		.57829		.26614		9.4791*		.32853

	Idaho		Illinois		Indiana		Kansas	
Panel A: Short-Run	**Linear ARDL**	**Nonlinear ARDL**	**Linear ARDL**	**Nonlinear ARDL**	**Linear ARDL**	**Nonlinear ARDL**	**Linear ARDL**	**Nonlinear ARDL**
$\Delta LnHI_t$	0.31(1.9)*		0.31(2.5)**		0.22(2.6)**		0.07(0.92)	
$\Delta LnHI_{t-1}$			-0.13(1.04)				-0.08(1.16)	
$\Delta LnHI_{t-2}$			0.16(1.34)				-0.03(0.35)	
$\Delta LnHI_{t-3}$			-0.16(1.29)				0.16(2.1)**	
$\Delta LnHI_{t-4}$			-0.08(0.63)				0.14(1.9)**	
$\Delta LnHI_{t-5}$			-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)**		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		0.35(0.89)		0.17(0.77)		0.52(3.4)**		0.11(0.83)
ΔNEG_{t-1}		-0.42(1.10)		-0.1(0.6)**				-0.15(1.11)
ΔNEG_{t-2}		0.02(0.06)		0.59(2.8)**				-0.23(1.70)*
ΔNEG_{t-3}		-0.91(2.4)**		-0.33(1.6)*				0.28(2.0)**
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)**	3.21(1.32)	5.6(240)**	3.02(0.76)	5.53(60.9)**
$Ln\ HI_t$	0.26(2.4)**		0.60(6.7)**		0.12(0.93)		0.13(0.59)	
POS_t		0.62(6.0)**		0.74(2.7)**		0.79(8.4)**		0.87(2.6)**
NEG_t		2.09(3.7)**		1.35(1.36)		2.51(8.4)**		3.11(2.5)**
Panel C: Diagnostic								
F	5.01*	3.07	10.54**	6.59**	3.14	7.53**	2.57	2.93
ECM_{t-1}	-0.06(3.18)*	-0.12(2.99)	-0.06(4.6)*	-0.06(4.4)**	-0.03(2.51)	-0.10(4.7)**	-0.02(2.26)	-0.03(2.98)
LM	1.54	6.78	12.60**	39.76**	6.21	4.34	2.25	4.04
QS (QS^2)	S (U)	S (U)	S (U)	S (U)	S (U)	S (U)	S (U)	S (U)
Adjusted R^2	0.38	0.51	0.42	0.51	0.28	0.35	0.26	0.28
Wald Tests:								
$\sum \delta_{i\ i} = 0$	3.5591*		.34184		6.9393*		1.9095	
$\sum \delta_i^+ = 0$		2.6817*		.52049		.27334		1.5619
$\sum \delta_i^- = 0$		.79628		1.1971		10.7558*		.00046
$\sum \delta_i^+ = \sum \delta_i^-$		1.3281		1.4207		3.7128*		.22360
$\rho_1^+ = \rho_1^-$		4.3471*		.50388		18.9022*		3.0476*

	Kentucky		Louisiana		Massachusetts		Maryland	
Panel A: Short-Run	**Linear ARDL**	**Nonlinear ARDL**	**Linear ARDL**	**Nonlinear ARDL**	**Linear ARDL**	**Nonlinear ARDL**	**Linear ARDL**	**Nonlinear ARDL**
$\Delta LnHI_t$	0.42(5.05)**		0.38(3.7)**		0.23(2.4)**		0.27(1.87)*	
$\Delta LnHI_{t-1}$	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)**		0.38(2.8)**		0.04(0.24)
ΔPOS_{t-1}		0.91(5.3)**						0.51(2.6)**
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)**		-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	-2.17(0.35)	5.63(144)**	0.62(0.13)	5.1(82.5)**	-12.0(4.2)**	5.5(55.3)**	-5.90(3.0)**	5.47(44.5)**
$Ln\ HI_t$	0.40(1.23)		0.23(0.90)		0.94(6.4)**		0.61(6.0)**	
POS_t		0.70(10.7)**		1.56(6.4)**		0.96(1.9)*		0.83(3.5)**
NEG_t		2.79(7.08)**		5.42(5.6)**		1.15(0.52)		2.64(1.15)
Panel C: Diagnostic								
F	0.91	2.47	3.44	4.75	7.45**	4.22	7.09**	4.45
ECM_{t-1}	-0.01(1.36)	-0.10(2.74)	-0.02(2.63)	-0.03(3.7)**	-0.03(3.8)**	-0.02(3.5)**	-0.03(3.7)**	-0.03(3.6)**
LM	0.83	4.43	2.12	5.13	11.41**	2.21	9.96**	4.01
QS (QS^2)	S (U)	S (U)	U (U)	S (U)	S (S)	S (S)	S (U)	S (U)
Adjusted R^2	0.30	0.46	0.40	0.41	0.68	0.70	0.51	0.54
Wald Tests:								
$\sum \delta_i = 0$	23.0855*		14.3721*		5.4973*		3.9240*	
$\sum \delta_i^+ = 0$		.30177		2.2996		8.4992*		5.9712*
$\sum \delta_i^- = 0$		.43751		9.5780*		3.8386*		.15083
$\sum \delta_i^+ = \sum \delta_i^-$		.28609		3.0764*		6.9501*		1.5487
$\rho_1^+ = \rho_1^-$		5.5622*		9.5243*		.00399		.48234

	Maine		Michigan		Minnesota		Missouri	
Panel A: Short-Run	**Linear ARDL**	**Nonlinear ARDL**	**Linear ARDL**	**Nonlinear ARDL**	**Linear ARDL**	**Nonlinear ARDL**	**Linear ARDL**	**Nonlinear ARDL**
$\Delta LnHI_t$	0.56(2.0)**		0.15(1.25)		0.01(2.54)**		0.15(1.54)	
$\Delta LnHI_{t-1}$			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)**		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		1.37(2.1)**		0.23(3.2)**		0.10(1.34)		0.06(1.45)
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)**	-2.86(1.20)	5.4(68.0)**	2.43(1.04)	5.49(74.8)**
$Ln\ HI_t$	0.73(4.7)**		0.83(2.09)**		0.45(3.5)**		0.17(1.34)	
POS_t		1.48(3.5)**		1.58(6.5)**		0.91(2.6)**		0.53(2.3)**
NEG_t		3.87(2.2)**		2.85(5.3)**		2.45(1.55)		1.94(1.8)*
Panel C: Diagnostic								
F	3.55	3.27	2.01	6.39**	5.44*	4.38	4.33	3.74
ECM_{t-1}	-0.07(2.66)	-0.10(3.15)	-0.02(2.01)	-0.08(4.4)**	-0.03(3.3)**	-0.04(3.6)**	-0.03(2.9)*	-0.041(3.2)*
LM	12.33**	3.86	3.90	0.95	1.79	5.92	5.60	14.52**
QS ($QS^{2)}$)	S (U)	S (U)	S (U)	U (U)	S (U)	S (U)	S (U)	S (U)
Adjusted R^2	0.38	0.34	0.38	0.38	0.39	0.39	0.36	0.51
Wald Tests:								
$\sum \delta_i = 0$	3.0835*		15.6101*		.86027		2.4237	
$\sum \delta_i^+ = 0$		1.7967		1.9419		1.4958		10.3282*
$\sum \delta_i^- = 0$		.14661		.00144		.01429		.15116
$\sum \delta_i^+ = \sum \delta_i^-$		.00361		.61573		.25578		1.4148
$\rho_1^+ = \rho_1^-$		2.9861*		6.5663*		1.1989		2.3106

	Mississippi		Montana		North Carolina		North Dakota	
Panel A: Short-Run	**Linear ARDL**	**Nonlinear ARDL**	**Linear ARDL**	**Nonlinear ARDL**	**Linear ARDL**	**Nonlinear ARDL**	**Linear ARDL**	**Nonlinear ARDL**
$\Delta LnHI_t$	0.60(2.9)**		0.70(5.24)**		0.30(3.47)**		0.10(1.11)	
$\Delta LnHI_{t-1}$	0.12(0.58)		-0.17(1.10)				-0.01(0.07)	
$\Delta LnHI_{t-2}$	-0.01(0.03)		0.32(2.17)**				0.25(2.7)**	
$\Delta LnHI_{t-3}$	0.48(2.4)**		0.10(0.68)				-0.15(1.60)	
$\Delta LnHI_{t-4}$	0.09(0.45)		0.28(1.88)*				-0.03(0.28)	
$\Delta LnHI_{t-5}$	-0.13(0.64)		0.13(0.83)				-0.11(1.22)	
$\Delta LnHI_{t-6}$	0.24(1.27)		0.24(1.64)*				-0.10(1.10)	
$\Delta LnHI_{t-7}$	0.93(4.7)**		-0.21(1.40)				0.22(2.3)**	
$\Delta LnHI_{t-8}$								
ΔPOS_t		0.02(1.23)		0.74(4.6)**		0.20(1.74)*		0.17(4.6)**
ΔPOS_{t-1}				-0.5(3.0)**		0.04(0.32)		
ΔPOS_{t-2}				0.51(2.8)**		0.19(1.81)*		
ΔPOS_{t-3}				0.08(0.46)		0.04(0.32)		
ΔPOS_{t-4}				0.46(2.7)**		-0.21(1.9)*		
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)**		0.35(1.64)*		0.17(1.15)
ΔNEG_{t-1}		0.12(0.33)		0.42(1.7)*		-0.40(1.8)*		-0.40(2.6)**
ΔNEG_{t-2}		-0.74(2.0)**		-0.27(1.19)				0.38(2.4)**
ΔNEG_{t-3}		0.72(2.0)**		-0.13(0.61)				-0.44(3.0)**
ΔNEG_{t-4}		-0.12(0.34)		0.22(0.96)				-0.15(1.08)
ΔNEG_{t-5}		-0.55(1.58)		-1.1(4.7)**				-0.29(2.0)**
ΔNEG_{t-6}		0.99(2.7)**		0.91(3.9)**				-0.23(1.64)*
ΔNEG_{t-7}		1.61(4.4)**						0.49(3.1)**
ΔNEG_{t-8}								
Panel B: Long-Run								
Constant	-4.49(0.37)	5.51(26.0)**	-5.39(1.44)	5.2(28.6)**	1.67(1.74)*	5.47(99)**	-8.32(1.21)	0.08(68.4)**
$Ln\ HI_t$	0.51(0.81)		0.63(2.8)**		0.20(4.1)**		0.82(2.0)**	
POS_t		0.77(1.01)		0.93(5.5)**		0.29(2.9)**		0.79(9.05)**
NEG_t		2.62(0.84)		1.15(2.2)**		0.71(0.80)		1.12 (8.0)**
Panel C: Diagnostic								
F	2.06	0.98	2.75	4.85*	4.73	6.72**	3.44	6.47**
ECM_{t-1}	-0.02(2.04)	-0.03(1.73)	-0.05(2.36)	-0.10(3.8)**	-0.04(3.08)*	-0.07(4.52)	-0.06(2.63)	-0.21(4.43)**
LM	6.34	23.51**	15.89**	9.14*	0.74	4.31	4.21	4.17
QS (QS^2)	U (U)	U (U)	S (U)	S (U)	S (U)	S (U)	S (U)	S (U)
Adjusted R^2	0.30	0.45	0.43	0.62	0.37	0.44	0.20	0.29
Wald Tests:								
$\sum \delta_i = 0$	9.8223*		3.8679*		11.4500*		.23146	
$\sum \delta_i^+ = 0$		.00783		3.9108*		1.2733		3.0462*
$\sum \delta_i^- = 0$		10.2275*		.98594		.016347		1.0248
$\sum \delta_i^+ = \sum \delta_i^-$		9.2551*		1.6923		.47142		2.1437
$\rho_1^+ = \rho_1^-$		.48611		.27664		.29801		9.0860*

	Nebraska		New Hampshire		New Jersey		New Mexico	
Panel A: Short-Run	**Linear ARDL**	**Nonlinear ARDL**	**Linear ARDL**	**Nonlinear ARDL**	**Linear ARDL**	**Nonlinear ARDL**	**Linear ARDL**	**Nonlinear ARDL**
$\Delta LnHI_t$	-0.12(1.61)		0.39(2.9)**		0.27(2.7)**		0.32(2.0)**	
$\Delta LnHI_{t-1}$	0.14(1.92)*						0.15(0.97)	
$\Delta LnHI_{t-2}$	-0.10(1.30)						-0.09(0.58)	
$\Delta LnHI_{t-3}$	0.11(1.41)						0.30(1.92)*	
$\Delta LnHI_{t-4}$	-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)**		0.2(1.97)**		0.01(0.90)
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)		-0.03(0.77)		0.04(0.37)
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)**	-10.9(4.0)**	5.6(47.5)**	1.42(0.69)	5.48(57.7)**
$Ln\ HI_t$	0.15(0.98)		0.55(5.2)**		0.86(6.1)**		0.2(1.9)**	
POS_t		0.23(0.52)		0.17(0.36)		0.26(0.63)		0.23(0.92)
NEG_t		0.44(0.30)		-0.52(0.27)		-1.16(0.72)		0.86(0.36)
Panel C: Diagnostic								
F	3.10	1.21	8.51**	4.44	7.53**	4.99*	3.23	1.96
ECM_{t-1}	-0.03(2.50)	-0.03(1.92)	-0.05(4.1)**	-0.03(3.6)**	-0.03(3.8)**	-0.03(3.8)**	-0.04(2.55)	-0.04(2.43)
LM	1.71	6.19	6.69	1.60	9.10*	6.00	16.08**	42.38**
QS ($QS^{2)}$)	S (U)	S (U)	S (U)	S (U)	S (U)	S (S)	U (U)	U (S)
Adjusted R^2	0.24	0.37	0.52	0.59	0.58	0.69	0.26	0.22
Wald Tests:								
$\sum \delta_i = 0$	1.3766		8.8982*		5.6759*		4.7739*	
$\sum \delta_i^+ = 0$		.00049		.49335		5.1162*		.30469
$\sum \delta_i^- = 0$		1.7985		1.4377		.06723		.49504
$\sum \delta_i^+ = \sum \delta_i^-$		1.6850		.09380		1.5196		.13831
$\rho_1^+ = \rho_1^-$		.03885		.32852		1.0392		.01580

	Nevada		New York		Ohio		Oklahoma	
Panel A: Short-Run	**Linear ARDL**	**Nonlinear ARDL**	**Linear ARDL**	**Nonlinear ARDL**	**Linear ARDL**	**Nonlinear ARDL**	**Linear ARDL**	**Nonlinear ARDL**
$\Delta LnHI_t$	0.08(1.57)		0.07(3.3)**		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		0.01(1.08)		0.34(1.58)		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		0.002(0.03)		0.002(0.03)		0.66(3.2)**		0.39(2.0)**
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)**	1.66(0.34)	5.6(137)**	8.05(1.9)*	5.28(50.1)**
$Ln\ HI_t$	0.08(1.34)		0.95(7.7)**		0.19(0.80)		-0.16(0.73)	
POS_t		0.12(1.23)		0.63(1.33)		1.24(6.2)**		0.61(2.4)**
NEG_t		0.65(0.63)		1.04(0.03)		3.39(5.8)**		2.43(2.9)**
Panel C: Diagnostic								
F	10.55**	6.50**	9.68**	6.72**	2.20	5.92**	4.08	6.42**
ECM_{t-1}	-0.05(4.6)**	-0.05(4.4)**	-0.06(4.4)**	-0.06(4.5)**	-0.02(2.10)	-0.07(4.2)**	-0.02(2.87)	-0.05(4.3)**
LM	0.34	4.14	4.65	2.30	2.12	6.33	10.81**	2.10
QS (QS^2)	S (U)	S (U)	S (U)	S (U)	S (U)	S (U)	U (U)	U (U)
Adjusted R^2	0.54	0.60	0.32	0.33	0.41	0.45	0.38	0.38
Wald Tests:								
$\sum \delta_{i\ i} = 0$	2.4715		2.3386		7.9031*		17.8665*	
$\sum \delta_i^{+}{}_i = 0$		.72828		2.1228		2.3158		17.0875*
$\sum \delta_i^{-} = 0$		.00926		.00117		10.8189*		.00659
$\sum \delta_i^{+} = \sum \delta_i^{-}$		.01033		.61703		8.0951*		11.0538*
$\rho_1^{+} = \rho_1^{-}$		.60769		.63624		11.2470*		5.1656*

	Oregon		Pennsylvania		Rhode Island		South Carolina	
Panel A: Short-Run	**Linear ARDL**	**Nonlinear ARDL**	**Linear ARDL**	**Nonlinear ARDL**	**Linear ARDL**	**Nonlinear ARDL**	**Linear ARDL**	**Nonlinear ARDL**
$\Delta LnHI_t$	0.65(3.6)**		0.24(2.4)**		0.05(3.8)**		0.31(2.8)**	
$\Delta LnHI_{t-1}$	-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)		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		1.53(3.2)**		-0.01(0.10)		0.25(0.68)		1.12(4.3)**
ΔNEG_{t-1}		-1.64(3.4)**				0.54(1.44)		-0.49(1.82)*
ΔNEG_{t-2}		-0.46(0.91)				-0.9(2.3)**		
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)**	-11.3(4.8)**	5.4(48.9)**	1.75(1.05)	5.57(148)**
$Ln\ HI_t$	0.92(5.8)**		0.59(6.4)**		0.10(7.4)**		0.21(2.3)**	
POS_t		1.27(6.04)**		0.44(1.68)*		2.1(4.5)**		0.67(3.7)**
NEG_t		3.25(2.14)**		-0.09(0.10)		5.40(3.0)**		3.98(2.7)**
Panel C: Diagnostic								
F	5.69*	3.66	9.16**	4.63	8.70**	4.63	3.36	3.95
ECM_{t-1}	-0.04(3.3)**	-0.05(3.34)*	-0.06(4.2)**	-0.05(3.7)**	-0.05(4.1)**	-0.05(3.7)**	-0.04(2.60)	-0.07(3.47)*
LM	3.28	3.34	6.06	8.57*	4.10	2.45	3.26	3.01
QS (QS^2)	S (S)	S (U)	S (U)	S (S)	S (U)	S (U)	S (U)	S (U)
Adjusted R^2	0.47	0.54	0.37	0.55	0.54	0.60	0.27	0.34
Wald Tests:								
$\sum \delta_{i\ i} = 0$	.14573		5.8224*		2.3199		8.7438*	
$\sum \delta_i^+ = 0$		1.4210		.62880		.31709		.03189
$\sum \delta_i^- = 0$		2.9040*		.08936		.03929		3.0886*
$\sum \delta_i^+ = \sum \delta_i^-$		3.4153*		.35814		.20329		2.5988*
$\rho_1^+ = \rho_1^-$		1.6678		.50372		5.0756*		4.1534*

	South Dakota		Tennessee		Texas		Utah	
Panel A: Short-Run	**Linear ARDL**	**Nonlinear ARDL**	**Linear ARDL**	**Nonlinear ARDL**	**Linear ARDL**	**Nonlinear ARDL**	**Linear ARDL**	**Nonlinear ARDL**
$\Delta LnHI_t$	0.17(1.11)		0.23(1.61)		0.19(2.2)**		0.55(3.7)**	
$\Delta LnHI_{t-1}$	0.35(2.2)**		0.03(0.22)		-0.12(1.39)			
$\Delta LnHI_{t-2}$	0.13(0.90)		0.02(0.16)		0.11(1.29)			
$\Delta LnHI_{t-3}$	0.13(0.92)		0.15(2.4)**		0.25(2.94)**			
$\Delta LnHI_{t-4}$	-0.04(0.30)				0.12(1.45)			
$\Delta LnHI_{t-5}$	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)		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		-0.07(0.30)		0.93(2.9)**		0.32(1.34)		0.55(1.38)
ΔNEG_{t-1}		0.23(0.99)		-0.05(0.16)		-0.17(0.70)		-0.80(1.95)*
ΔNEG_{t-2}		-0.03(0.16)		-0.35(1.10)		0.18(0.77)		
ΔNEG_{t-3}		0.002(.013)		1.17(3.7)**		0.5(2.1)**		
ΔNEG_{t-4}		0.29(1.36)		-0.7(2.2)**		-0.44(1.8)*		
ΔNEG_{t-5}		-0.02(0.12)		-0.6(1.9)**		-0.39(1.63)		
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)**	1.13(0.16)	4.7(10.2)**	-1.22(0.71)	5.00(32.9)**
$Ln\ HI_t$	0.24(1.04)		0.22(2.3)**		0.19(0.56)		0.38(3.9)**	
POS_t		0.90(5.4)**		0.24(1.67)*		0.50(0.87)		0.64(4.6)**
NEG_t		2.23(4.2)**		0.59(0.46)		2.43(0.66)		3.39(1.9)**
Panel C: Diagnostic								
F	0.95	6.22**	3.23	2.70	1.69	2.64	5.01*	3.50
ECM_{t-1}	-0.06(1.39)	-0.17(4.35)**	-0.05(2.55)	-0.07(2.87)	-0.01(1.83)	-0.02(2.84)	-0.04(3.1)*	-0.04(3.2)*
LM	10.14**	30.89**	1.52	15.52**	11.22**	6.10	3.01	3.74
QS (QS^2)	S (U)	U (U)	S (U)	S (U)	S (S)	S (U)	S (S)	S (U)
Adjusted R^2	0.38	0.52	0.18	0.32	0.40	0.40	0.38	0.44
Wald Tests:								
$\sum \delta_i = 0$	10.9179*		6.1629*		13.2822*		14.2188*	
$\sum \delta_i^+ = 0$		5.3064*		.36229		8.9412*		13.2764*
$\sum \delta_i^- = 0$		12.1536*		1.0747		.00295		1.5062
$\sum \delta_i^+ = \sum \delta_i^-$		7.4340*		1.2609		1.4905		8.3084*
$\rho_1^+ = \rho_1^-$		17.6862*		.06771		.34687		2.9720*

	Virginia		Vermont		Washington		Wisconsin	
Panel A: Short-Run	**Linear ARDL**	**Nonlinear ARDL**	**Linear ARDL**	**Nonlinear ARDL**	**Linear ARDL**	**Nonlinear ARDL**	**Linear ARDL**	**Nonlinear ARDL**
$\Delta LnHI_t$	0.32(2.50)**		1.00(2.0)**		0.03(3.5)**		0.35(2.2)**	
$\Delta LnHI_{t-1}$	-0.04(0.33)						-0.03(0.19)	
$\Delta LnHI_{t-2}$	-0.08(0.63)						0.05(0.33)	
$\Delta LnHI_{t-3}$	0.40(2.9)**						0.30(2.0)**	
$\Delta LnHI_{t-4}$	-0.26(1.93)*						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		0.47(2.4)**		1.18(1.85)*		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		-0.11(0.34)		0.71(2.2)**		0.24(1.17)		0.76(2.0)**
ΔNEG_{t-1}		-0.14(4.4)**				-0.5(2.8)**		0.52(1.41)
ΔNEG_{t-2}		-0.05(0.16)						-0.47(1.26)
ΔNEG_{t-3}		0.69(2.2)**						1.54(4.0)**
ΔNEG_{t-4}		-1.12(3.5)**						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	-4.62(2.0)**	5.26(37.5)**	-5.53(2.1)**	5.31(44)**	-7.13(5.3)**	5.2(60.8)**	-6.97(1.14)	5.59(71.4)**
$Ln\ HI_t$	0.54(4.5)**		0.67(4.4)**		0.68(9.6)**		0.65(2.0)**	
POS_t		0.54(1.6)*		1.66(2.4)**		0.66(3.4)**		0.98(6.68)**
NEG_t		0.11(0.04)		5.24(1.6)*		0.69(0.81)		2.53(3.17)**
Panel C: Diagnostic								
F	3.91	3.30	3.32	4.30	6.38**	3.43	1.42	3.24
ECM_{t-1}	-0.03(2.80)	-0.03(3.17)	-0.12(2.59)	-0.13(3.62)**	-0.04(3.5)**	-0.04(3.24)*	-0.02(1.69)	-0.08(3.06)
LM	4.06	2.93	4.31	4.12	3.55	10.48**	4.29	13.62**
QS (QS^{2})	S (S)	S (S)	S (U)	U (U)	S (S)	S (S)	S (U)	U (S)
Adjusted R^2	0.40	0.44	0.34	0.37	0.49	0.50	0.26	0.40
Wald Tests:								
$\sum \delta_i = 0$	1.4338		4.0163*		1.7456		11.2823*	
$\sum \delta_i^{+} = 0$		5.1839*		2.6746*		1.0190		10.0943*
$\sum \delta_i^{-} = 0$		1.0216		.29361		1.8001		12.4751*
$\sum \delta_i^{+} = \sum \delta_i^{-}$		2.2997		.02956		4.5046*		16.4647*
$\rho_1^{+} = \rho_1^{-}$		.05824		3.6476*		.00097		2.6117*

	West Virginia		Wyoming		District of Columbia			
Panel A: Short-Run	**Linear ARDL**	**Nonlinear ARDL**	**Linear ARDL**	**Nonlinear ARDL**	**Linear ARDL**	**Nonlinear ARDL**		
$\Delta LnHI_t$	0.81(3.7)**		0.02(0.17)		0.19(1.38)			
$\Delta LnHI_{t-1}$	0.35(1.49)		0.24(2.0)**		0.27(1.98)**			
$\Delta LnHI_{t-2}$	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)**		0.06(2.38)**		
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)		-0.37(1.17)		
ΔNEG_{t-1}		-0.26(0.48)		0.37(1.8)*		1.26(4.21)**		
ΔNEG_{t-2}		-0.43(0.87)		-0.19(0.94)		-0.67(2.1)**		
ΔNEG_{t-3}		-1.28(2.6)**		0.03(0.13)		-0.003(0.01)		
ΔNEG_{t-4}		1.28(2.5)**		0.47(2.4)**		0.40(1.35)		
ΔNEG_{t-5}				-0.22(1.08)		-0.93(3.2)**		
ΔNEG_{t-6}				0.29(1.45)		0.99(3.4)**		
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)**	-19.4(8.7)**	5.43(24.4)**		
$Ln\ HI_t$	0.16(0.29)		0.48(2.6)**		1.47(11.3)**			
POS_t		1.09(6.4)**		0.9(14.3)**		1.23(4.22)**		
NEG_t		2.76(7.3)**		1.90(7.9)**		0.63(0.72)		
Panel C: Diagnostic								
F	1.62	4.19	5.21*	5.09*	5.86**	4.07		
ECM_{t-1}	-0.04(1.80)	-0.20(3.5)**	-0.03(-3.2)**	-0.12(3.9)**	-0.07(4.1)**	-0.05(3.46)*		
LM	14.05**	7.03	4.12	10.95**	3.89	2.74		
QS (QS^2)	S (U)	S (U)	U (U)	U (S)	S (U)	U (S)		
Adjusted R^2	0.52	0.62	0.31	0.48	0.43	0.49		
Wald Tests:								
$\sum \delta_i = 0$	8.2670*		21.1042*		2.2045			
$\sum \delta_i^+ = 0$		3.0192*		.00281		.93387		
$\sum \delta_i^- = 0$		.81059		.36031		2.2609		
$\sum \delta_i^+ = \sum \delta_i^-$		4.1153*		.32953		.96676		
$\rho_1^+ = \rho_1^-$		12.1085*		5.6330*		.17827		

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 on 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.