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On the Link between House Prices and House Permits: Asymmetric Evidence from 51 States of the United States of America

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Increased issuance of housing permits is said to move house prices in either direction. If perceived as an indication of a growing housing supply, house prices are expected to decline (supply hypothesis). However, a larger number of housing permits can also reflect positive expectations about future housing demand which would drive house prices upwards (demand hypothesis). We test these two competing hypotheses by using data from each state in the United States. We estimate linear and non-linear models to test if housing permit issuance determines house prices. The results show support for both the supply and demand hypotheses in the short run for most states but only for the demand hypothesis in the long run. We also uncover asymmetric short-run and long-run effects in 21 states.

Keywords:

House Prices, House Permits, Nonlinear ARDL Approach, Asymmetry

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1. Introduction

In identifying the determinants of house prices in any country, researchers have included mortgage rates and household income as the two main determinants. These are considered the "fundamentals" (Case and Shiller 2003) and are found to determine the demand for housing. As household income rises and mortgage rates decline, consumers demand more housing, which pushes house prices higher. Studies that have considered supply-side factors that affect house prices include Chen and Patel (1998), Chen *et al.* (2007), Mikhed and Zemcik (2009), Adams and Fuss (2010), and Zhou (2010). All of these studies utilize construction costs as an additional determinant of house prices. Madsen (2012), however, shows that acquisition costs also matter in the long run. Others such as Abelson *et al*. (2005) and Gallin (2006) emphasize the effects of housing stocks or building permits on house prices (Rapach and Strauss 2009).[1] Additionally, Glaeser et al. (2008) show that supply elasticity is a relevant factor. They find that places that are more elastic in housing supply had built slightly more during the 1980s, which impacted the housing prices. Large albeit fleeting increases in housing prices followed in these more elastic places. Later, Saiz (2010) uses satellite-generated data on terrain elevation to estimate the amount of developable land in U.S. metropolitan areas. The data show that residential development is effectively curtailed by the presence of steep-sloped terrain. Saiz (2010) argues that supply elasticities can be well characterized as functions of both physical and regulatory constraints, which in turn, are endogenous to price and demographic growth. This argument is further supported by Davidoff (2016) who argues that the relationship between supply constraints and price volatility is much weaker after accounting for observable demand factors.

One of the ways to account for the impact of housing supply on house prices is to include issued house permits to measure potential housing quantity, as in Rapach and Strauss (2009). An increase in house permits may reflect rising housing quantity, which could depress house prices (supply hypothesis). As Quigley and Rosenthal (2005) argue, caps on development, zoning limits on allowable densities, and long permit-processing delays result in fewer permits and may lead to increased housing prices. However, Famiglietti *et al.* (2019) argue that housing permits may reflect expectations around future housing construction, thus implying that housing permits lead house prices as these permits are forward-looking (demand hypothesis). Using aggregate and regional data from the United States (US) and a graphical approach, we confirm that a decline in housing permits is occurring throughout much of the country,

[1] Some studies have also included other factors such as inflation, unemployment, policy uncertainty, etc. See Apergis (2003), Apergis and Rezitis (2003), Antonakakis *et al*. (2015), Bahmani-Oskooee and Ghodsi (2017), and Bahmani-Oskooee *et al*. (2021).

potentially signaling a decline in expectations for future housing demand and prices.[2]

The primary purpose of this paper is to test these two competing hypotheses about the relationship between house prices and housing permits in the US by using state-level data. Our empirical results show support for the forward-looking demand hypothesis, i.e., higher issuance of housing permits drives the growth in house prices. To show our results, we introduce the models and methods in Section 2, followed by our empirical results in Section 3. We conclude in Section 4. The appendix contains detailed definitions of the variables and data sources.

2. The Models and Methods

As mentioned in the introduction, almost every study on house prices includes household income (I) and mortgage rates (M) as the two main determinants of house prices. We closely follow them and use these two fundamental variables in our model in addition to housing permits (H) as follows: [3]

$$LnP_t = a + bLnI_t + cLnM_t + dLnH_t + \varepsilon_t \quad (1)$$

Based on the economic theory and housing literature, we expect house prices to be positively related to household income and negatively to the mortgage rate. Therefore, we expect the estimate of *b* to be positive and the estimate of *c* to be negative. As discussed above, since housing permits could portend negative or positive effects on house prices depending on whether the demand or supply channel prevails, an estimate of *d* could be negative or positive.

Equation (1) is a long-run model, and the coefficient estimates reflect the long-run effects of exogenous variables on house prices. To also assess their short-run effects, we convert Equation (1) into an error-correction model. We follow Pesaran *et al*. (2001) and modify Equation (1) as:

$$\begin{aligned}\Delta LnP_t = \alpha &+ \textstyle\sum_{k=1}^{n1}\beta_k \Delta LnP_{t-k} + \sum_{k=0}^{n2}\delta_k \Delta LnI_{t-k} + \sum_{k=0}^{n3}\pi_k \Delta LnM_{t-k} \\ &+ \textstyle\sum_{k=0}^{n4}\theta_k \Delta LnH_{t-k} + \lambda_0 LnP_{t-1} + \lambda_1 LnI_{t-1} + \lambda_2 LnM_{t-1} \\ &+ \lambda_3 LnH_{t-1} + \mu_t \end{aligned} \quad (2)$$

[2] See Federal Reserve Bank of St. Louis: https://research.stlouisfed.org/publications/economic-synopses/2019/12/20/construction-permits-and-future-housing-supply-implications-for-2020

[3] Examples of other studies that include income and mortgage rates but not house permits are: Meen (2002), McQuinn and O'Reilly (2008), Kim and Bhattacharya (2009), Holly *et al.* (2010), Apergis *et al.* (2015), Lai and Van Order (2017), Alexiou and Vogiazas (2019), Baghestani and Viriyavipart (2019), Alola (2020), De Albuquerquemello, and Bessarria (2021), and Cuesta and Kukk (2021).

Equation (2) is an error-correction model in which the lagged error term from Equation (1) is replaced by the linear combination of lagged level variables as its proxy.[4] The main advantage of Equation (2) is that both short-run and long-run effects could be inferred in one step. Coefficients attached to the first-differenced variables reflect the short-run effects, and estimates of λ_1 - λ_3 normalized on -λ_0, reflect the long-run effects. However, for the long-run effects to be valid, Pesaran *et al.* (2001) recommend two tests for cointegration. One is the F test to establish the joint significance of the linear combination of lagged level variables as a proxy for the lagged error-correction term in Engle and Granger (1987). The other test is the t-test to establish the significance of λ_0, which is also a test of the lagged error-correction term in Engle and Granger (1987).[5] However, since the distribution of both tests in this context is not standardized, Pesaran *et al*. (2001) provide new critical values that account for the integrating properties of variables. They argue that their critical values are valid even if there are combinations of I(0) and I(1) variables, which is another advantage of this method.[6]

The central assumption behind Equation (2) is that all exogenous variables have symmetric effects on house prices. Bahmani-Oskooee and Ghodsi (2016) first argue that fundamentals could have asymmetric effects. As they discuss and demonstrate, an increase in income or mortgage rate could affect house prices at a different rate than a similar decrease in income or mortgage rate. For example, assume that an x% increase in income is followed by a y% rise in house prices. This result does not imply that an x% decrease in income will similarly drive house prices down by y%. One reason might be that households finance their mortgage out of their savings. The same holds for mortgage rates and house permits. Thus, to estimate the differential impact of an increase vs. a decrease in permits on house prices, we use an asymmetric analysis. We follow Shin *et al.* (2014) closely and differentiate between a rise and a decline in a variable by using the partial sum approach described here. Using house permits *H* as an example, this approach amounts to constructing *ΔLnH*, and then generating two new time series that consist of the positive and negative changes of *ΔLnH*, as follows:

$$H_t^+ = \sum_{j=1}^{t} \max(\Delta LnH_j, 0), \qquad and \qquad H_t^- = \sum_{j=1}^{t} \min(\Delta LnH_j, 0) \qquad (3)$$

H_t^+ is the partial sum of positive changes that reflects only increases in house permits. Similarly, H_t^- is the partial sum of negative changes that reflects only declines in house permits. We also construct the partial sum of changes in household income and mortgage rate and record them as I_t^+ , I_t^-, M_t^+ , and M_t^-,

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[4] Indeed, the two terms are the same if we solve Equation (1) for the error term and lag both sides by one period.

[5] For demonstration of this point, see Bahmani-Oskooee and Ghodsi (2018).

[6] Since almost all macro variables are either I(0) or I(1), there is no need for pre-unit root testing.

respectively. Lastly, we replace our three exogenous variables in Equation (2) by their partial sums to arrive at:

$$\Delta LnP_t = a + \sum_{j=1}^{n1} b_j \Delta LnP_{t-j} + \sum_{j=0}^{n2} c_j^{+} \Delta I_{t-j}^{+} + \sum_{j=0}^{n3} c_j^{-} \Delta I_{t-j}^{-}$$
$$+\sum_{j=0}^{n4} d_j^{+} \Delta M_{t-j}^{+} + \sum_{j=0}^{n5} d_j^{-} \Delta M_{t-j}^{-} + \sum_{j=0}^{n6} e_j^{+} \Delta H_{t-j}^{+}$$
$$+\sum_{j=0}^{n7} e_j^{-} \Delta H_{t-j}^{-} + \rho_0 LnP_{t-1} + \rho_1^{+} I_{t-1}^{+} + \rho_1^{-} I_{t-1}^{-} \quad (4)$$
$$+\rho_2^{+} M_{t-1}^{+} + \rho_2^{-} M_{t-1}^{-} + \rho_3^{+} H_{t-1}^{+} + \rho_3^{-} H_{t-1}^{-} + \mu_t$$

Shin *et al*. (2014) label the specification in Equation (4) as a non-linear autoregressive distributed lag (ARDL) model, whereas the specification in Equation (2) is known as a linear ARDL model. The nonlinearity in Equation (4) is due to the method of constructing the partial sum variables. Shin *et al*. (2014) show that both models are subjected to the same diagnostic tests and the same ordinary least square (OLS) estimation method. Furthermore, Shin *et al*. (2014, p. 290) point out that such non-linear models "correct perfectly for the weak endogeneity of any non-stationary variables and that the choice of an appropriate lag structure will render the model free from serial correlation."[7]

We estimate Equation (4) by using OLS while testing for the potential asymmetric effects of housing permits on house prices by using multiple tests. The short-run effects of house permits will be asymmetric if, at any given lag order j, the estimate of e_j^{+} happens to be different from that of e_j^{-}. However, if the Wald test rejects the null hypothesis of $\sum e_j^{+} = \sum e_j^{-}$, that will be an indication of cumulative asymmetric short-run effects. Finally, the long-run effects of house permit issuance on house prices will be asymmetric if the Wald test rejects the null of $\rho_3^{+}/-\rho_0 = \rho_3^{-}/-\rho_0$.

3. Empirical Results

We estimate the linear ARDL model, that is, Equation (2), and the non-linear ARDL model, that is, Equation (4), for each of the 50 states and Washington DC in the US by using quarterly data over the 1988QI-2019QI period.[8]

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[7] Shin *et al*. (2014, p. 291) also argue that in applying the F test, critical values should stay at the same high and conservative levels when we move from the linear to nonlinear model, even though the nonlinear model has more variables.

[8] Balcilar et al. (2020) also use state level data to show that state-level regressions can recover a large degree of heterogeneity that country-level exercises typically ignore. Such heterogeneity is prominent not only in terms of consumption smoothing behavior, but also with regards to housing return predictability. Sheng et al. (2021) also uses state level data to assess the impact of oil shocks on the synchronization in housing price movements across all the US states plus Washington DC. They find that "oil-specific supply and consumption demand shocks are most important in driving the national factor. Moreover, as observed from the regime-specific local projection model, these

Table 1 Estimates of the Linear ARDL Model

Linear ARDL	Alaska	Alabama	Arkansas	Arizona
Panel A: Short-run				
ΔLnH_t	0.00(0.14)[a]	0.01(1.59)	0.02(4.05)**	0.00(0.29)
ΔLnH_{t-1}	0.00(0.58)			-0.02(1.5)
ΔLnH_{t-2}	0.00(0.04)			
ΔLnH_{t-3}	-0.01(1.54)			
ΔLnH_{t-4}	0.01(1.07)			
ΔLnH_{t-5}	0.01(1.34)			
ΔLnH_{t-6}	-0.01(2.04)**			
ΔLnH_{t-7}				
ΔLnI_t	0.09(0.89)	0.21(2.43)**	0.02(0.28)	0.08(0.5)
ΔLnI_{t-1}	-0.01(0.09)	-0.2(2.27)**	-0.21(3.13)**	-0.1(0.6)
ΔLnI_{t-2}	0.24(2.27)**			0.11(0.62)
ΔLnI_{t-3}	0.24(2.45)**			0.19(1.18)
ΔLnI_{t-4}				-0.35(2.22)**
ΔLnI_{t-5}				
ΔLnI_{t-6}				
ΔLnI_{t-7}				
ΔLnM_t	-0.05(2.24)**	-0.1(7.13)**	-0.07(5.36)**	-0.11(3.91)**
ΔLnM_{t-1}	0.06(2.76)**	0.02(1.37)	-0.01(0.34)	0.05(1.78)*
ΔLnM_{t-2}	-0.05(2.32)**	0.01(0.68)	0.03(2.36)**	
ΔLnM_{t-3}	0.06(2.77)**	-0.02(1.35)	-0.01(0.99)	
ΔLnM_{t-4}		0.00(0.18)		
ΔLnM_{t-5}		-0.01(0.46)		
ΔLnM_{t-6}		0.05(2.96)**		
ΔLnM_{t-7}				
Panel B: Long-run				
Constant	1.2(1.94)*	0.34(0.81)	0.34(1.37)	0.84(2.16)**
$(H)_t$	0.01(2.85)**	0.01(3.4)**	0.02(5.64)**	0.02(4.06)**
$(I)_t$	-0.06(1.48)	0.02(0.69)	0.01(0.71)	-0.02(0.85)
$(M)_t$	-0.05(2.3)**	0.00(0.21)	0.00(0.24)	-0.05(2.8)**
Panel C: Diagnostic				
F^b	4.12*	5.56**	5.81**	6.06**
$\hat{\lambda}_0$ (t-ratio)[c]	-0.02(0.61)	-0.06(2.58)	-0.06(3.22)	-0.03(2)
LM^d	2.99*	0.57	0.27	0
QS (QS^2)	S(S)	S(S)	S(S)	S(S)
Adjusted R^2	0.34	0.63	0.47	0.74

(Continued…)

two shocks are found to have a relatively stronger impact in a bearish rather than a bullish national housing market" (Sheng et al., 2021).

(Table 1 Continued)

Linear ARDL	California	Colorado	Connecticut	Delaware
Panel A: Short-run				
ΔLnH_t	0.02(1.73)*	0.00(0.67)	0.00(0.31)	0.01(0.6)
ΔLnH_{t-1}		0.00(0.56)		
ΔLnH_{t-2}		0.01(1.07)		
ΔLnH_{t-3}				
ΔLnH_{t-4}				
ΔLnH_{t-5}				
ΔLnH_{t-6}				
ΔLnH_{t-7}				
ΔLnI_t	0.08(0.76)	0.06(0.99)	0.16(2.66)**	0.09(1.39)
ΔLnI_{t-1}			-0.06(1.03)	
ΔLnI_{t-2}			-0.09(1.43)	
ΔLnI_{t-3}			0.09(1.4)	
ΔLnI_{t-4}			-0.12(1.9)*	
ΔLnI_{t-5}			-0.21(3.35)**	
ΔLnI_{t-6}			-0.12(1.86)*	
ΔLnI_{t-7}				
ΔLnM_t	-0.06(2.68)**	-0.03(2.06)**	-0.07(4.89)**	-0.09(4.79)**
ΔLnM_{t-1}	0.06(2.5)**	0.02(1.41)	0.01(0.49)	
ΔLnM_{t-2}			-0.01(0.68)	
ΔLnM_{t-3}			-0.02(1.41)	
ΔLnM_{t-4}			-0.02(1.53)	
ΔLnM_{t-5}			0.01(0.53)	
ΔLnM_{t-6}			0.02(1.34)	
ΔLnM_{t-7}				
Panel B: Long-run				
Constant	0.07(0.17)	0.1(0.51)	-0.32(0.92)	-0.56(2.67)**
$(H)_t$	0.02(3.44)**	0.01(2.63)**	0.01(1.51)	0.03(6.61)**
$(I)_t$	0.00(0.27)	0.02(1.61)	0.03(1.83)*	0.02(1.91)*
$(M)_t$	-0.03(2.23)**	-0.01(1.21)	0.01(1.02)	0.01(1.01)
Panel C: Diagnostic				
F^b	4.25*	3.9*	5.77**	14.06**
$\hat{\lambda}_0$ (t-ratio)^c	-0.02(3.17)	-0.04(3.76)*	-0.03(4.32)**	-0.02(2.88)
LM^d	0.12	0.38	0.86	0.84
QS (QS^2)	S(S)	S(S)	S(S)	S(S)
Adjusted R^2	0.81	0.74	0.76	0.59

(Continued…)

(Table 1 Continued)

Linear ARDL	**Florida**	**Georgia**	**Hawaii**	**Iowa**
Panel A: <u>Short-run</u>				
ΔLnH_t	0.01(0.97)	-0.01(0.83)	0.01(2.35)**	0.01(1.67)*
ΔLnH_{t-1}	-0.03(2.38)**	-0.02(2.12)**		-0.01(2.73)**
ΔLnH_{t-2}		0.02(2.98)**		-0.01(1.93)*
ΔLnH_{t-3}				0.00(0.64)
ΔLnH_{t-4}				-0.01(2.93)**
ΔLnH_{t-5}				-0.01(2.31)**
ΔLnH_{t-6}				
ΔLnH_{t-7}				
ΔLnI_t	0.15(1.33)	0.18(2.62)**	0.26(1.72)*	0.04(1.1)
ΔLnI_{t-1}	0.01(0.07)	-0.29(3.82)**	-0.22(1.38)	-0.07(1.76)*
ΔLnI_{t-2}	-0.02(0.16)	-0.01(0.08)		
ΔLnI_{t-3}	0.23(2.34)**	0.01(0.11)		
ΔLnI_{t-4}	-0.17(1.75)*	-0.16(2.03)**		
ΔLnI_{t-5}				
ΔLnI_{t-6}				
ΔLnI_{t-7}				
ΔLnM_t	-0.12(6.27)**	-0.06(4.78)**	-0.08(3.28)**	-0.04(3.52)**
ΔLnM_{t-1}	0.07(3.14)**	0.03(1.98)*	0.05(2.16)**	0.02(1.96)*
ΔLnM_{t-2}	-0.01(0.25)			-0.02(1.52)
ΔLnM_{t-3}	0.00(0.17)			
ΔLnM_{t-4}	0.00(0.08)			
ΔLnM_{t-5}	0.01(0.33)			
ΔLnM_{t-6}	0.06(3.01)**			
ΔLnM_{t-7}	-0.04(1.97)*			
Panel B: <u>Long-run</u>				
Constant	0.3(0.77)	0.37(1.72)*	0.00(0.00)	0.24(0.94)
$(H)_t$	0.04(5.73)**	0.01(3.83)**	0.02(4.58)**	0.02(4.85)**
$(I)_t$	-0.01(0.58)	0.01(0.67)	0.04(1.12)	0.01(0.98)
$(M)_t$	-0.05(3.55)**	-0.01(1)	-0.03(1.99)**	0.00(0.27)
Panel C: <u>Diagnostic</u>				
F^b	7.73**	5.02**	9.62**	7.46**
$\hat{\lambda}_0$ (t-ratio)^c	-0.02(2.03)	-0.05(3.72)*	-0.06(4.18)**	-0.06(4.22)**
LM^d	2.44	0.45	2.07	0.26
QS (QS^2)	S(S)	S(S)	S(S)	S(S)
Adjusted R^2	0.87	0.79	0.69	0.47

(Continued…)

(Table 1 Continued)

Linear ARDL	Idaho	Illinois	Indiana	Kansas
Panel A: <u>Short-run</u>				
ΔLnH_t	-0.01(0.64)	0.01(1.84)*	0.00(0.26)	0.00(0.78)
ΔLnH_{t-1}	-0.02(1.78)*	-0.01(1.88)*	0.00(0.71)	-0.01(2.13)**
ΔLnH_{t-2}			-0.01(0.96)	-0.01(3.43)**
ΔLnH_{t-3}			-0.01(2)**	
ΔLnH_{t-4}			-0.01(2.73)**	
ΔLnH_{t-5}			-0.01(1.98)*	
ΔLnH_{t-6}				
ΔLnH_{t-7}				
ΔLnI_t	0.1(0.94)	0.15(2.18)**	0.12(2.21)**	-0.01(0.27)
ΔLnI_{t-1}		-0.12(1.81)*	-0.2(3.79)**	-0.17(3.84)**
ΔLnI_{t-2}		0.00(0.02)	-0.04(0.78)	-0.11(2.29)**
ΔLnI_{t-3}		-0.1(1.4)	0.21(3.79)**	
ΔLnI_{t-4}		-0.09(1.32)	-0.05(0.81)	
ΔLnI_{t-5}		-0.15(2.19)**	-0.22(3.86)**	
ΔLnI_{t-6}				
ΔLnI_{t-7}				
ΔLnM_t	-0.08(3.45)**	-0.05(4.31)**	-0.04(3.84)**	-0.03(2.98)**
ΔLnM_{t-1}		0.02(1.99)**	0.02(1.53)	0.02(1.89)*
ΔLnM_{t-2}			-0.01(1.33)	0.01(1.3)
ΔLnM_{t-3}				0.00(0.15)
ΔLnM_{t-4}				-0.01(0.8)
ΔLnM_{t-5}				0.01(0.74)
ΔLnM_{t-6}				0.04(3.83)**
ΔLnM_{t-7}				
Panel B: <u>Long-run</u>				
Constant	0.4(1.19)	0.26(1.09)	0.21(0.89)	0.46(1.91)*
$(H)_t$	0.03(4.3)**	0.02(4.67)**	0.01(3.95)**	0.02(4.18)**
$(I)_t$	0.01(0.42)	0.01(1.08)	0.03(2.41)**	0.00(0.02)
$(M)_t$	-0.02(1.45)	-0.02(2.89)**	0.00(0.51)	-0.02(2.32)**
Panel C: <u>Diagnostic</u>				
F^b	8.52**	8.56**	6.77**	7.18**
$\hat{\lambda}_0$ (t-ratio)^c	-0.07(3.73)*	-0.05(5.24)**	-0.08(5.06)**	-0.04(4.16)**
LM^d	0	0.54	0.84	0.07
QS (QS^2)	S(S)	S(S)	S(S)	S(S)
Adjusted R^2	0.61	0.74	0.69	0.59

(Continued…)

(Table 1 Continued)

Linear ARDL	**Kentucky**	**Louisiana**	**Massachusetts**	**Maryland**
Panel A: <u>Short-run</u>				
ΔLnH_t	0.00(0.46)	0.00(0.09)	0.00(0.53)	0.00(0.05)
ΔLnH_{t-1}	-0.02(3.11)**	-0.01(2.22)**		
ΔLnH_{t-2}	-0.02(2.39)**			
ΔLnH_{t-3}	-0.02(2.27)**			
ΔLnH_{t-4}	-0.01(1.93)*			
ΔLnH_{t-5}	-0.02(2.74)**			
ΔLnH_{t-6}	-0.02(3.6)**			
ΔLnH_{t-7}	-0.01(2.57)**			
ΔLnI_t	0.21(2.82)**	0.17(2.26)**	0.15(1.98)*	0.22(1.47)
ΔLnI_{t-1}	-0.31(3.79)**		-0.16(1.98)*	0.01(0.09)
ΔLnI_{t-2}			-0.16(1.85)*	0.02(0.16)
ΔLnI_{t-3}				
ΔLnI_{t-4}				
ΔLnI_{t-5}				
ΔLnI_{t-6}				
ΔLnI_{t-7}				
ΔLnM_t	-0.04(3.18)**	-0.06(3.79)**	-0.06(4.07)**	-0.04(2.11)**
ΔLnM_{t-1}		0.00(0.23)	0.03(1.88)*	0.06(2.69)**
ΔLnM_{t-2}		0.04(2.09)**		
ΔLnM_{t-3}		-0.02(1.27)		
ΔLnM_{t-4}		0.01(0.91)		
ΔLnM_{t-5}		-0.02(0.93)		
ΔLnM_{t-6}		0.04(2.73)**		
ΔLnM_{t-7}		-0.02(1.24)		
Panel B: <u>Long-run</u>				
Constant	0.63(2.11)**	0.54(1)	0.06(0.19)	0.71(1.46)
$(H)_t$	0.03(6.02)**	0.01(2.67)**	0.00(0.23)	0.00(0.16)
$(I)_t$	0.04(2.24)**	0.00(0.08)	0.01(0.93)	-0.04(1.91)*
$(M)_t$	-0.02(2.1)**	-0.01(1)	0.00(0.33)	-0.02(1.61)
Panel C: <u>Diagnostic</u>				
F^b	10.6**	3.57	3.69	4.31*
$\hat{\lambda}_0$ (t-ratio)^c	-0.12(5.54)**	-0.05(1.57)	-0.02(3.28)	-0.03(3.52)*
LM^d	1.27	0.01	0.4	0.32
QS (QS^2)	S(S)	S(S)	S(S)	S(S)
Adjusted R^2	0.58	0.34	0.75	0.25

(Continued…)

(Table 1 Continued)

Linear ARDL	Maine	Michigan	Minnesota	Missouri
Panel A: <u>Short-run</u>				
ΔLnH_t	0.00(0.46)	0.00(0.72)	0.01(2.11)**	0.00(1.1)
ΔLnH_{t-1}	-0.01(0.81)	-0.01(1.92)*	0.01(0.75)	-0.01(1.53)
ΔLnH_{t-2}	0.00(0.32)		0.01(1.61)	
ΔLnH_{t-3}	0.00(0.16)		0.02(3.23)**	
ΔLnH_{t-4}	0.00(0.72)		0.01(1.23)	
ΔLnH_{t-5}			0.01(0.95)	
ΔLnH_{t-6}			0.02(3.37)**	
ΔLnH_{t-7}			0.01(1.51)	
ΔLnI_t	0.03(0.29)	0.05(0.86)	-0.07(1.1)	0.13(2.04)**
ΔLnI_{t-1}	-0.18(1.74)*	-0.15(2.4)**	-0.08(1.13)	-0.19(2.76)**
ΔLnI_{t-2}	-0.16(1.66)*	-0.08(1.33)	-0.08(1.21)	-0.07(1.15)
ΔLnI_{t-3}		0.00(0.03)		
ΔLnI_{t-4}		-0.19(3.04)**		
ΔLnI_{t-5}		-0.24(4.27)**		
ΔLnI_{t-6}				
ΔLnI_{t-7}				
ΔLnM_t	-0.07(4.95)**	-0.03(3.05)**	-0.04(3.22)**	-0.03(3.21)**
ΔLnM_{t-1}			0.01(0.84)	
ΔLnM_{t-2}			-0.01(0.83)	
ΔLnM_{t-3}			-0.03(1.9)*	
ΔLnM_{t-4}				
ΔLnM_{t-5}				
ΔLnM_{t-6}				
ΔLnM_{t-7}				
Panel B: <u>Long-run</u>				
Constant	-0.34(0.99)	-1.43(4.76)**	-0.96(2.82)**	-0.4(1.89)*
$(H)_t$	0.02(2.61)**	0.02(7.99)**	0.01(2.3)**	0.01(6.05)**
$(I)_t$	0.05(2.48)**	0.12(6.2)**	0.05(3.27)**	0.04(3.16)**
$(M)_t$	-0.01(0.62)	0.00(0.94)	0.02(2.12)**	0.00(0.81)
Panel C: <u>Diagnostic</u>				
F^b	6.01**	19.89**	3.68	11.84**
$\hat{\lambda}_0$ (t-ratio)^c	-0.06(4.88)**	-0.1(8.38)**	-0.03(3.21)	-0.05(4.76)**
LM^d	0	0.27	3.84**	0.27
QS (QS^2)	S(S)	S(S)	S(S)	S(S)
Adjusted R^2	0.71	0.84	0.79	0.65

(Continued…)

(Table 1 Continued)

Linear ARDL	**Mississippi**	**Montana**	**North Carolina**	**North Dakota**
Panel A: <u>Short-run</u>				
ΔLnH_t	0.01(1.53)	0.01(1.31)	-0.01(2.25)**	0.00(0.08)
ΔLnH_{t-1}		-0.02(2.84)**	0.00(0.25)	
ΔLnH_{t-2}		-0.01(1.65)	0.01(1.38)	
ΔLnH_{t-3}				
ΔLnH_{t-4}				
ΔLnH_{t-5}				
ΔLnH_{t-6}				
ΔLnH_{t-7}				
ΔLnI_t	0.23(2.54)**	0.12(1.42)	0.06(1.41)	0.02(0.6)
ΔLnI_{t-1}			-0.12(2.74)**	
ΔLnI_{t-2}			0.01(0.2)	
ΔLnI_{t-3}			0.14(3.43)**	
ΔLnI_{t-4}				
ΔLnI_{t-5}				
ΔLnI_{t-6}				
ΔLnI_{t-7}				
ΔLnM_t	-0.06(3.34)**	-0.04(1.87)*	-0.03(3.14)**	-0.03(2)**
ΔLnM_{t-1}	-0.02(0.95)		0.02(1.78)*	
ΔLnM_{t-2}	0.05(2.81)**		0.01(0.99)	
ΔLnM_{t-3}	-0.03(1.55)		0.00(0.22)	
ΔLnM_{t-4}			0.01(1.06)	
ΔLnM_{t-5}			0.00(0.28)	
ΔLnM_{t-6}			0.03(2.63)**	
ΔLnM_{t-7}				
Panel B: <u>Long-run</u>				
Constant	0.29(0.78)	-0.09(0.24)	0.41(1.95)*	0.53(2.08)**
$(H)_t$	0.02(5.05)**	0.03(7.57)**	0.01(3.26)**	0.01(3.91)**
$(I)_t$	0.03(1.19)	0.04(1.73)*	0.00(0.01)	-0.01(0.6)
$(M)_t$	0.00(0.24)	0.01(0.7)	-0.01(1.22)	-0.02(1.93)*
Panel C: <u>Diagnostic</u>				
F^b	6.94**	19.29**	3.28	9.15**
$\hat{\lambda}_0$ (t-ratio)^c	-0.09(3.09)	-0.08(4.63)**	-0.03(1.78)	-0.03(2.32)
LM^d	0.05	0.9	0.08	0.07
QS (QS^2)	S(S)	S(S)	S(S)	S(S)
Adjusted R^2	0.32	0.38	0.75	0.26

(Continued…)

(Table 1 Continued)

Linear ARDL	**Nebraska**	**New Hampshire**	**New Jersey**	**New Mexico**
Panel A: <u>Short-run</u>				
ΔLnH_t	-0.01(2.62)**	0.01(2.1)**	0.00(0.36)	0.01(1.32)
ΔLnH_{t-1}	-0.01(1.6)	-0.01(2.74)**		
ΔLnH_{t-2}	-0.02(3.27)**			
ΔLnH_{t-3}	-0.01(1.51)			
ΔLnH_{t-4}	-0.01(2.46)**			
ΔLnH_{t-5}				
ΔLnH_{t-6}				
ΔLnH_{t-7}				
ΔLnI_t	-0.03(0.52)	0.1(1.87)*	0.14(1.66)*	0.12(1.18)
ΔLnI_{t-1}		-0.14(2.51)**	-0.17(1.96)*	
ΔLnI_{t-2}		-0.09(1.56)	-0.09(0.99)	
ΔLnI_{t-3}		0.04(0.77)		
ΔLnI_{t-4}		-0.13(2.49)**		
ΔLnI_{t-5}				
ΔLnI_{t-6}				
ΔLnI_{t-7}				
ΔLnM_t	-0.04(3.57)**	-0.05(4.27)**	-0.06(3.84)**	-0.06(3.36)**
ΔLnM_{t-1}	0.04(3.01)**	0.02(1.59)	0.03(1.63)	
ΔLnM_{t-2}				
ΔLnM_{t-3}				
ΔLnM_{t-4}				
ΔLnM_{t-5}				
ΔLnM_{t-6}				
ΔLnM_{t-7}				
Panel B: <u>Long-run</u>				
Constant	0.82(3.36)**	-0.33(1.88)*	0.1(0.34)	0.35(1.11)
$(H)_t$	0.01(2.22)**	0.02(5.59)**	0.00(0.23)	0.01(2.8)**
$(I)_t$	-0.02(1.23)	0.04(3.42)**	0.01(0.53)	0.01(0.49)
$(M)_t$	-0.02(2.49)**	0.00(0.81)	0.00(0.4)	-0.01(1.12)
Panel C: <u>Diagnostic</u>				
F^b	4.85**	9.01**	2.79	4.57**
$\hat{\lambda}_0$ (t-ratio)^c	-0.03(2.26)	-0.04(5.25)**	-0.02(2.79)	-0.05(2.94)
LM^d	0.17	1.06	0.09	0.02
QS (QS^2)	S(S)	S(S)	S(S)	S(S)
Adjusted R^2	0.49	0.82	0.73	0.5

(Continued…)

(Table 1 Continued)

Linear ARDL	Nevada	New York	Ohio	Oklahoma
Panel A: Short-run				
$\mathbf{\Delta LnH_t}$	-0.01(0.82)	0.00(1.06)	0.00(0.14)	0.01(2.25)**
ΔLnH_{t-1}	-0.01(1.69)*		0.00(0.35)	
ΔLnH_{t-2}			0.00(0.26)	
ΔLnH_{t-3}			-0.01(1.39)	
ΔLnH_{t-4}			-0.02(3.41)**	
ΔLnH_{t-5}			-0.01(1.34)	
ΔLnH_{t-6}				
ΔLnH_{t-7}				
$\mathbf{\Delta LnI_t}$	0.22(1.65)	0.14(1.88)*	0.17(2.5)**	0.00(0.07)
ΔLnI_{t-1}		-0.13(1.66)	-0.25(3.7)**	
ΔLnI_{t-2}			-0.05(0.71)	
ΔLnI_{t-3}			0.19(2.82)**	
ΔLnI_{t-4}			-0.12(1.78)*	
ΔLnI_{t-5}			-0.27(4.06)**	
ΔLnI_{t-6}				
ΔLnI_{t-7}				
$\mathbf{\Delta LnM_t}$	-0.1(2.87)**	-0.09(4.83)**	-0.04(4.23)**	-0.05(3.39)**
ΔLnM_{t-1}	0.07(2.03)**			-0.02(1.23)
ΔLnM_{t-2}				0.03(2.34)**
ΔLnM_{t-3}				-0.02(1.7)*
ΔLnM_{t-4}				
ΔLnM_{t-5}				
ΔLnM_{t-6}				
ΔLnM_{t-7}				
Panel B: Long-run				
Constant	0.87(2.74)**	0.41(1.03)	0.04(0.16)	0.1(0.43)
$(H)_t$	0.02(3.69)**	0.00(0.6)	0.01(4.07)**	0.01(3.25)**
$(I)_t$	-0.02(1.04)	0.01(0.45)	0.03(2.37)**	0.02(1.53)
$(M)_t$	-0.05(2.77)**	-0.01(1.23)	0.00(0.23)	0.01(1.01)
Panel C: Diagnostic				
F^b	7.12**	3.66	8.63**	2.63
$\hat{\lambda}_0$ (t-ratio)^c	-0.03(3.03)	-0.03(3.66)*	-0.07(5.72)**	-0.06(2.7)
LM^d	0.77	0.64	0.1	1.06
QS (QS^2)	S(S)	U(S)	S(S)	S(S)
Adjusted R^2	0.75	0.58	0.73	0.22

(Continued…)

(Table 1 Continued)

Linear ARDL	**Oregon**	**Pennsylvania**	**Rhode Island**	**South Carolina**
Panel A: <u>Short-run</u>				
ΔLnH_t	0.01(1.68)*	0.00(1.05)	0.01(1.79)*	-0.01(1.72)*
ΔLnH_{t-1}				-0.03(3.58)**
ΔLnH_{t-2}				
ΔLnH_{t-3}				
ΔLnH_{t-4}				
ΔLnH_{t-5}				
ΔLnH_{t-6}				
ΔLnH_{t-7}				
ΔLnI_t	0.16(2.35)**	0.11(1.47)	0.18(1.79)*	0.09(1.13)
ΔLnI_{t-1}	-0.23(3.09)**	-0.24(3.09)**	-0.08(0.76)	-0.25(3.21)**
ΔLnI_{t-2}		-0.06(0.74)	-0.02(0.18)	-0.07(0.91)
ΔLnI_{t-3}		0.01(0.12)	0.04(0.36)	
ΔLnI_{t-4}		-0.16(2.17)**	-0.25(2.34)**	
ΔLnI_{t-5}			-0.23(2.2)**	
ΔLnI_{t-6}				
ΔLnI_{t-7}				
ΔLnM_t	-0.04(3.19)**	-0.05(4.77)**	-0.08(4.24)**	-0.09(6.22)**
ΔLnM_{t-1}	0.04(3.31)**			
ΔLnM_{t-2}				
ΔLnM_{t-3}				
ΔLnM_{t-4}				
ΔLnM_{t-5}				
ΔLnM_{t-6}				
ΔLnM_{t-7}				
Panel B: <u>Long-run</u>				
Constant	0.22(0.93)	-0.66(2.95)**	-0.68(1.75)*	0.65(2.67)**
$(H)_t$	0.01(3.38)**	0.02(4.83)**	0.01(2)**	0.03(7.25)**
$(I)_t$	0.00(0.34)	0.04(3.43)**	0.06(2.66)**	0.00(0.27)
$(M)_t$	-0.02(2.64)**	-0.01(1.09)	-0.01(0.53)	-0.01(1.35)
Panel C: <u>Diagnostic</u>				
F^b	7.26**	7.75**	5.18**	15.43**
$\hat{\lambda}_0$ (t-ratio)^c	-0.02(3.09)	-0.02(3.24)	-0.03(4.44)**	-0.08(5.67)**
LM^d	0.06	0.32	0.67	0.68
QS (QS^2)	S(S)	S(S)	S(S)	S(S)
Adjusted R^2	0.85	0.71	0.8	0.67

(Continued…)

(Table 1 Continued)

Linear ARDL	**South Dakota**	**Tennessee**	**Texas**	**Utah**
Panel A: <u>Short-run</u>				
ΔLnH_t	0.00(1.08)	0.00(0.5)	-0.01(1.05)	0.01(1.58)
ΔLnH_{t-1}	-0.02(2.56)**			
ΔLnH_{t-2}	-0.01(1.1)			
ΔLnH_{t-3}	-0.01(0.98)			
ΔLnH_{t-4}	0.00(1.06)			
ΔLnH_{t-5}				
ΔLnH_{t-6}				
ΔLnH_{t-7}				
ΔLnI_t	0.03(0.53)	0.18(2.95)**	0.1(2.11)**	0.09(0.94)
ΔLnI_{t-1}		-0.21(3.33)**	-0.09(1.82)*	-0.15(1.53)
ΔLnI_{t-2}		0.02(0.3)	-0.03(0.54)	0.26(2.55)**
ΔLnI_{t-3}		0.03(0.48)	0.12(2.42)**	
ΔLnI_{t-4}		-0.07(1.24)		
ΔLnI_{t-5}		0.01(0.12)		
ΔLnI_{t-6}		-0.01(0.11)		
ΔLnI_{t-7}		-0.16(2.67)**		
ΔLnM_t	-0.05(3.01)**	-0.05(4.45)**	-0.05(4.32)**	-0.05(2.21)**
ΔLnM_{t-1}		0.03(2.17)**	0.04(3.81)**	0.04(1.76)*
ΔLnM_{t-2}			0.01(0.72)	
ΔLnM_{t-3}			-0.01(0.61)	
ΔLnM_{t-4}			0.01(0.6)	
ΔLnM_{t-5}			0.02(1.61)	
ΔLnM_{t-6}			0.03(2.28)**	
ΔLnM_{t-7}				
Panel B: <u>Long-run</u>				
Constant	0.78(2.72)**	0.1(0.52)	0.65(3.54)**	-0.12(0.4)
$(H)_t$	0.02(3.43)**	0.02(6.15)**	0.00(1.89)*	0.02(4.43)**
$(I)_t$	-0.01(0.25)	0.01(0.98)	-0.01(0.94)	0.04(1.78)*
$(M)_t$	-0.02(1.97)*	-0.01(0.97)	-0.02(3.08)**	0.01(0.5)
Panel C: <u>Diagnostic</u>				
F^b	5.4**	10.05**	2.93	9.56**
$\hat{\lambda}_0$ (t-ratio)^c	-0.07(2.3)	-0.04(2.79)	-0.02(2.1)	-0.07(4.22)**
LM^d	0.5	0.71	0.62	1.33
QS (QS^2)	S(S)	S(S)	S(S)	S(S)
Adjusted R^2	0.14	0.65	0.66	0.73

(Continued…)

(Table 1 Continued)

Linear ARDL	**Virginia**	**Vermont**	**Washington**	**Wisconsin**
Panel A: <u>Short-run</u>				
ΔLnH_t	0.01(1.41)	0.01(2.06)**	0.00(0.34)	-0.01(1.35)
ΔLnH_{t-1}		-0.01(2.34)**	0.00(0.59)	-0.04(4.96)**
ΔLnH_{t-2}		-0.01(1.85)*	0.01(1.58)	-0.02(2.56)**
ΔLnH_{t-3}			-0.01(1.35)	-0.01(1.59)
ΔLnH_{t-4}			-0.01(1.25)	-0.02(2.87)**
ΔLnH_{t-5}				-0.01(1.93)*
ΔLnH_{t-6}				-0.02(2.21)**
ΔLnH_{t-7}				-0.01(1.78)*
ΔLnI_t	0.11(0.95)	0.2(1.84)*	-0.05(1.19)	0.18(2.6)**
ΔLnI_{t-1}				
ΔLnI_{t-2}				
ΔLnI_{t-3}				
ΔLnI_{t-4}				
ΔLnI_{t-5}				
ΔLnI_{t-6}				
ΔLnI_{t-7}				
ΔLnM_t	-0.1(5.2)**	-0.07(3.81)**	-0.04(3.09)**	-0.03(2.76)**
ΔLnM_{t-1}	0.03(1.35)		0.04(3)**	0.04(3.47)**
ΔLnM_{t-2}				
ΔLnM_{t-3}				
ΔLnM_{t-4}				
ΔLnM_{t-5}				
ΔLnM_{t-6}				
ΔLnM_{t-7}				
Panel B: <u>Long-run</u>				
Constant	-0.28(0.87)	-0.7(2.54)**	0.07(0.34)	0.11(0.41)
$(H)_t$	0.02(3.19)**	0.03(7.54)**	0.02(3.81)**	0.03(6.89)**
$(I)_t$	0.01(0.76)	0.04(2.35)**	0.00(0.08)	0.03(2.28)**
$(M)_t$	-0.02(1.66)	-0.01(0.7)	-0.02(2.19)**	-0.03(3.43)**
Panel C: <u>Diagnostic</u>				
F^b	3.44	20.19**	4.81**	12.86**
$\hat{\lambda}_0$ (t-ratio)^c	-0.01(1.37)	-0.02(2.07)	-0.02(1.97)	-0.08(5.57)**
LM^d	1.14	0.06	3.73*	0.13
QS (QS^2)	S(S)	S(S)	S(S)	S(S)
Adjusted R^2	0.62	0.42	0.82	0.64

(Continued…)

(Table 1 Continued)

Linear ARDL	**West Virginia**	**Wyoming**	**DC**
Panel A: <u>Short-run</u>			
ΔLnH_t	0.01(1.08)	0.01(1.35)	0.00(0.75)
ΔLnH_{t-1}	-0.02(2.6)**		0.00(0.59)
ΔLnH_{t-2}	-0.01(1.09)		0.00(1.74)*
ΔLnH_{t-3}	0.00(0.47)		
ΔLnH_{t-4}	-0.01(1.68)*		
ΔLnH_{t-5}			
ΔLnH_{t-6}			
ΔLnH_{t-7}			
ΔLnI_t	0.39(3.93)**	0.06(0.82)	0.03(0.28)
ΔLnI_{t-1}			
ΔLnI_{t-2}			
ΔLnI_{t-3}			
ΔLnI_{t-4}			
ΔLnI_{t-5}			
ΔLnI_{t-6}			
ΔLnI_{t-7}			
ΔLnM_t	-0.1(5.71)**	-0.05(2.59)**	-0.06(2.08)**
ΔLnM_{t-1}			
ΔLnM_{t-2}			
ΔLnM_{t-3}			
ΔLnM_{t-4}			
ΔLnM_{t-5}			
ΔLnM_{t-6}			
ΔLnM_{t-7}			
Panel B: <u>Long-run</u>			
Constant	2.06(4.42)**	0.13(0.53)	0.47(1.03)
$(H)_t$	0.02(5.05)**	0.02(2.81)**	0.00(1.12)
$(I)_t$	-0.07(2.53)**	0.04(2.32)**	0.01(0.33)
$(M)_t$	-0.04(4.22)**	0.00(0.31)	-0.03(1.92)*
Panel C: <u>Diagnostic</u>			
F^b	11.16**	6.14**	2.73
$\hat{\lambda}_0$ (t-ratio)^c	-0.06(2.28)	-0.1(4.43)**	-0.03(3.12)
LM^d	0.07	1.88	1.31
QS (QS^2)	S(S)	S(S)	S(S)
Adjusted R^2	0.38	0.38	0.53

Notes: a. Numbers in parentheses are absolute values of the t-ratios, and * (**) indicates significance at the 10% (5%) confidence level.

b. At the 10% (5%) significance level when there are three exogenous variables (k=3), the critical value of the F test is 3.77 (4.35). This comes from Pesaran *et al*. (2001, Table CI-Case III, page 300).

c. At the 10% (5%) significance level when there are three exogenous variables (k=3), the critical value of the t-test for cointegration is -3.46 (-3.78). This comes from Pesaran *et al*. (2001, Table CII-Case III, page 303).
d. LM is the Lagrange multiplier test of residual serial correlation. It is distributed as $\chi2$ with one degree of freedom since we test for first-order serial correlation. Its critical value at the 10% (5%) level is 2.71 (3.84).

We impose a maximum of eight lags on each first-differenced variable in both models and use the Akaike information criterion (AIC) to select the optimum lags. All critical values are reported in the notes below each table and used to identify significant estimates or used in diagnostic tests. We review the estimates of the linear and non-linear models in Tables 1 and 2, respectively. Due to the large volume of data, we report the results in three panels in each table. Panel A reports the short-run coefficient estimates of only the exogenous variables, while Panel B reports the long-run estimates. Panel C reports the results of the diagnostic tests. We first turn to the linear model estimates in Table 1.

Our primary variable of interest is housing permit issuance, *H*. Panel A of Table 1 shows that in 29 states and Washington, DC, the *ΔLnH* variable carries at least one significant coefficient, which supports the short-run effects of house permits on house prices. In some states such as West Virginia, the short-run effects are negative, while in others like Washington, DC, the effects are positive. These findings imply that there is support for both positive (demand hypothesis) and negative (supply hypothesis) impacts of increased issuance of housing permits on house prices in the short run.

A more critical question is to ask in how many states do the short-run effects last into the long run? Panel B reveals that in all but 11 states, the *LnH* variable carries a significant coefficient also supported by at least one of the cointegration tests reported in Panel C. The 11 states with no long-run effects are Connecticut, Louisiana, Massachusetts, Minnesota, North Carolina, New Jersey, New York, Oklahoma, Texas, Virginia, and Washington, DC. In the remaining 40 states, housing permits have significant long-run effects on house prices. Moreover, the coefficient estimate is positive in all 40 states. These findings support the conclusion in Famiglietti *et al.* (2019) that housing permits reflect expectations on the future of newly constructed housing units and that house permits are forward-looking.[9] Since the linear model is assumed to be symmetric, our finding also implies that fewer housing permits depress house prices. This outcome could happen if builders or residents in an area perceive

[9] In addition to the two cointegration tests in Panel C, we also report two other diagnostics. To check for autocorrelation, we report the Lagrange multiplier test which is distributed as χ^2 with one degree of freedom. Since it is insignificant in all models, there is lack of serial correlation. To establish stability of all coefficient estimates, we apply and report the CUSUM and CYSUMSQ tests as QS and QS^2. Stable estimates are indicated by “S” and unstable estimates by “US”. Clearly, all of the estimates are stable.

the decline in permits as a bad sign and begin to move out of that area. How does the outcome change if we differentiate between an increase and a decrease in housing permits? The estimates of the non-linear model, Equation (4), shed light on the asymmetric effect. We report the results in Table 2.

Table 2 Estimates of the Non-linear ARDL Model

Non-Linear ARDL	Alaska	Alabama	Arkansas	Arizona
Panel A: <u>Short-run</u>				
$\boldsymbol{\Delta H_t^+}$	0.01(0.54)[a]	0.00(0.13)	0.04(4.63)**	-0.01(0.28)
ΔH_{t-1}^+	-0.04(2.73)**		-0.03(2.95)**	
ΔH_{t-2}^+	-0.02(1.36)		-0.02(1.91)*	
ΔH_{t-3}^+	-0.04(3.4)**		-0.02(1.59)	
ΔH_{t-4}^+			-0.02(2.05)**	
ΔH_{t-5}^+			0.00(0.46)	
ΔH_{t-6}^+			-0.01(0.64)	
ΔH_{t-7}^+			-0.01(2.04)**	
$\boldsymbol{\Delta H_t^-}$	-0.01(0.62)	0.02(1.42)	-0.02(1.97)*	0.03(1.24)
ΔH_{t-1}^-	0.02(1.61)		-0.03(2.29)**	-0.01(0.26)
ΔH_{t-2}^-	-0.01(0.65)		-0.02(1.77)*	0.05(2.52)**
ΔH_{t-3}^-	0.02(1.49)		-0.02(1.83)*	0.03(1.55)
ΔH_{t-4}^-			0.00(0.09)	0.04(2.03)**
ΔH_{t-5}^-	0.02(1.66)		-0.03(2.47)**	
ΔH_{t-6}^-	-0.02(2.72)**		-0.02(2.32)**	
ΔH_{t-7}^-	0.01(1.5)			
Panel B: <u>Long-run</u>				
Constant	-0.14(0.33)	0.98(2.41)**	1.73(3.25)**	0.56(2.05)**
H_t^+	0.03(2.59)**	0.02(2.12)**	0.05(5.23)**	0.00(0.36)
H_t^-	0.03(3.11)**	0.03(3.51)**	0.04(4.8)**	0.02(0.91)
I_t^+	0.08(0.93)	-0.17(1.89)*	-0.08(0.98)	-0.09(1.39)
I_t^-	-0.15(0.85)	-0.06(0.55)	0.03(0.43)	0.31(1.02)
M_t^+	-0.05(1.6)	0.03(1.82)*	-0.04(1.9)*	-0.05(1.73)*
M_t^-	0.00(0.04)	-0.04(1.85)*	-0.01(0.79)	-0.15(2.76)**
Panel C: <u>Diagnostic</u>				
F[b]	4.77**	8.22**	7.81**	3.12
$\hat{\rho}_0$ (t-ratio)[c]	-0.03(1.21)	-0.08(2.34)	-0.15(3.83)	-0.05(2.69)
LM[d]	1.57	1.03	0.25	0.51
QS (QS^2)	S(S)	S(S)	S(S)	S(S)
Adjusted R^2	0.57	0.76	0.64	0.81
Wald-S[e]	5.38**	0.7	2.1	4.3**
Wald-L	0.01	0.55	6.3**	0.8

(Continued…)

(Table 2 Continued)

Non-Linear ARDL	California	Colorado	Connecticut	Delaware
Panel A: Short-run				
$\boldsymbol{\Delta H_t^+}$	0.03(1.04)	0.01(0.78)	-0.01(0.96)	0.02(1.27)
ΔH_{t-1}^+	-0.04(1.76)*		-0.02(2.47)**	-0.03(1.98)*
ΔH_{t-2}^+				
ΔH_{t-3}^+				
ΔH_{t-4}^+				
ΔH_{t-5}^+				
ΔH_{t-6}^+				
ΔH_{t-7}^+				
$\boldsymbol{\Delta H_t^-}$	0.02(1.02)	-0.01(1.36)	0.00(0.42)	0.00(0.23)
ΔH_{t-1}^-		0.01(0.62)	0.02(1.97)*	
ΔH_{t-2}^-		0.02(2.23)**		
ΔH_{t-3}^-		0.01(0.78)		
ΔH_{t-4}^-		0.02(1.72)*		
ΔH_{t-5}^-				
ΔH_{t-6}^-				
ΔH_{t-7}^-				
Panel B: Long-run				
Constant	0.4(3.72)**	0.52(3.3)**	0.54(4.33)**	0.63(3.19)**
H_t^+	0.00(0.3)	0.00(0.68)	0.00(0.31)	0.04(3.55)**
H_t^-	0.04(4.75)**	0.00(0.52)	0.01(1.16)	0.05(7.19)**
I_t^+	0.00(0.02)	0.01(0.67)	0.02(0.53)	0.09(3.21)**
I_t^-	-0.26(1.93)*	0.11(0.84)	-0.05(0.55)	-0.01(0.16)
M_t^+	-0.01(0.44)	0.01(0.46)	0.02(1.28)	-0.01(0.47)
M_t^-	-0.07(3.47)**	-0.01(0.48)	0.01(0.55)	0.02(0.69)
Panel C: Diagnostic				
F^b	3.67**	1.97	4.78**	34.83**
$\hat{\rho}_0$ (t-ratio)^c	-0.02(2.96)	-0.04(3.18)	-0.03(4.17)*	-0.05(3.37)
LM^d	0.01	0.01	0.3	1.42
QS (QS^2)	S(S)	S(S)	S(S)	S(S)
Adjusted R^2	0.85	0.79	0.78	0.73
Wald-S^e	0.63	0.95	4.89**	0.28
Wald-L	7.92**	0	0.96	0.04

(Continued…)

(Table 2 Continued)

Non-Linear ARDL	**Florida**	**Georgia**	**Hawaii**	**Iowa**
Panel A: <u>Short-run</u>				
$\boldsymbol{\Delta H_t^+}$	0.05(2.69)**	0.04(3.53)**	0.00(0.48)	0.02(2.25)**
ΔH_{t-1}^+	0.07(2.9)**	0.01(0.97)		-0.04(3.56)**
ΔH_{t-2}^+	0.06(2.43)**	0.03(2.62)**		-0.03(3.14)**
ΔH_{t-3}^+	0.04(1.94)*			-0.02(2.38)**
ΔH_{t-4}^+	0.03(1.39)			-0.01(1.35)
ΔH_{t-5}^+	0.07(2.89)**			-0.02(2.68)**
ΔH_{t-6}^+	0.01(0.69)			-0.01(1.13)
ΔH_{t-7}^+	0.06(2.97)**			
$\boldsymbol{\Delta H_t^-}$	0.00(0.06)	-0.01(0.98)	0.00(0.15)	-0.01(1.56)
ΔH_{t-1}^-	-0.06(2.83)**	-0.02(1.87)*		-0.03(2.64)**
ΔH_{t-2}^-	0.01(0.55)	0.02(1.61)		-0.03(3.11)**
ΔH_{t-3}^-	0.02(1.03)	0.04(3.47)**		-0.02(2.24)**
ΔH_{t-4}^-	-0.05(2.24)**	0.02(2.02)**		-0.03(4.29)**
ΔH_{t-5}^-	-0.06(2.6)**	0.02(1.66)		
ΔH_{t-6}^-				
ΔH_{t-7}^-				
Panel B: <u>Long-run</u>				
Constant	-0.12(0.92)	0.28(1.65)	0.77(2.46)**	1.8(4.16)**
H_t^+	-0.04(2.6)**	0.02(3)**	0.01(1.89)*	0.04(4.99)**
H_t^-	0.09(6.04)**	0.04(5.61)**	0.01(1.92)*	0.02(2.71)**
I_t^+	0.1(1.63)	0.02(0.91)	-0.47(5)**	0.06(1.59)
I_t^-	-0.89(5.46)**	-0.33(3.86)**	0.96(3.55)**	0.02(0.21)
M_t^+	0.05(1.86)*	0.04(2.01)**	0.01(0.48)	-0.02(1.28)
M_t^-	-0.07(2.52)**	0.03(2.94)**	-0.18(6.1)**	0.04(2.44)**
Panel C: <u>Diagnostic</u>				
F[b]	7.72**	8.02**	21.72**	6.26**
$\hat{\rho}_0$ (t-ratio)[c]	0.01(0.53)	-0.02(1.68)	-0.06(2.4)	-0.15(4.49)**
LM[d]	0.3	1.59	0.15	0.12
QS (QS^2)	S(S)	S(S)	S(S)	S(S)
Adjusted R^2	0.92	0.87	0.75	0.59
Wald-S[e]	22.61**	0.18	0.15	0.05
Wald-L	31.95**	1.14	0.02	3.83*

(Continued…)

(Table 2 Continued)

Non-Linear ARDL	**Idaho**	**Illinois**	**Indiana**	**Kansas**
Panel A: <u>Short-run</u>				
$\boldsymbol{\Delta H_t^+}$	0.02(1.37)	0.00(0.36)	0.00(0.04)	0.00(0.58)
ΔH_{t-1}^+	-0.04(2.74)**		-0.01(0.6)	-0.01(1.72)*
ΔH_{t-2}^+			-0.02(2.07)**	-0.02(3.03)**
ΔH_{t-3}^+			-0.03(2.89)**	-0.02(2.75)**
ΔH_{t-4}^+			-0.01(1.17)	
ΔH_{t-5}^+			-0.01(1.73)*	
ΔH_{t-6}^+			-0.02(2.5)**	
ΔH_{t-7}^+				
$\boldsymbol{\Delta H_t^-}$	-0.02(1.41)	0.03(3.16)**	0.01(0.59)	0.00(0.54)
ΔH_{t-1}^-		0.00(0.17)	0.00(0.23)	-0.02(2.91)**
ΔH_{t-2}^-		0.02(1.86)*	0.01(0.82)	-0.02(3.29)**
ΔH_{t-3}^-			0.01(0.86)	
ΔH_{t-4}^-			-0.01(1.2)	
ΔH_{t-5}^-			0.00(0.47)	
ΔH_{t-6}^-			0.02(2)**	
ΔH_{t-7}^-				
Panel B: <u>Long-run</u>				
Constant	0.26(1.09)	0.91(4.48)**	1.19(5.06)**	0.5(2.69)**
H_t^+	0.04(2.24)**	0.02(2.35)**	0.02(3.92)**	0.02(3.97)**
H_t^-	0.04(4.64)**	0.03(3.4)**	0.00(0.1)	0.01(2.57)**
I_t^+	-0.12(1.67)*	0.00(0.08)	-0.07(1.7)*	-0.06(2.45)**
I_t^-	-0.2(0.85)	-0.1(0.72)	0.38(3.04)**	0.03(0.48)
M_t^+	-0.01(0.57)	0.01(0.31)	0.01(0.45)	-0.01(1.27)
M_t^-	-0.06(1.39)	-0.01(0.53)	0.00(0.16)	0.00(0.19)
Panel C: <u>Diagnostic</u>				
F[b]	8.3**	6.31**	7.33**	4.89**
$\hat{\rho}_0$ (t-ratio)[c]	-0.02(0.98)	-0.08(5.22)**	-0.09(5.18)**	-0.05(2.94)
LM[d]	0.06	0.39	5.72**	2.24
QS (QS^2)	S(S)	S(S)	S(S)	S(S)
Adjusted R^2	0.74	0.77	0.76	0.67
Wald-S[e]	0.01	3.8*	5.1**	0.36
Wald-L	0.15	2.05	11.79**	2.84*

(Continued…)

(Table 2 Continued)

Non-Linear ARDL	**Kentucky**	**Louisiana**	**Massachusetts**	**Maryland**
Panel A: Short-run				
$\boldsymbol{\Delta H_t^+}$	0.01(1.24)	0.00(0.12)	-0.01(0.51)	0.01(0.64)
ΔH_{t-1}^+	-0.06(4.71)**	-0.02(1.5)		-0.01(0.81)
ΔH_{t-2}^+	-0.03(2.29)**	0.00(0.14)		0.01(0.56)
ΔH_{t-3}^+	-0.03(2.97)**	-0.02(2.09)**		0.02(1.03)
ΔH_{t-4}^+	-0.02(1.76)*	-0.02(2.37)**		-0.01(0.37)
ΔH_{t-5}^+	0.00(0.11)	-0.01(1.17)		0.02(1.56)
ΔH_{t-6}^+	-0.02(2.17)**			
ΔH_{t-7}^+	-0.02(2)**			
$\boldsymbol{\Delta H_t^-}$	0.01(0.74)	0.01(1.19)	0.00(0.44)	-0.01(0.79)
ΔH_{t-1}^-	0.00(0.09)			0.03(1.65)
ΔH_{t-2}^-	-0.04(3.1)**			0.02(1.53)
ΔH_{t-3}^-	-0.03(2.55)**			
ΔH_{t-4}^-	-0.02(1.67)*			
ΔH_{t-5}^-	-0.04(3.43)**			
ΔH_{t-6}^-	-0.03(2.91)**			
ΔH_{t-7}^-	-0.04(3.66)**			
Panel B: Long-run				
Constant	1.72(3.96)**	0.19(0.46)	0.34(2.63)**	-0.05(0.26)
H_t^+	0.03(6.75)**	0.00(0.29)	0.00(0.54)	-0.01(0.75)
H_t^-	0.05(5.69)**	0.02(2.03)**	0.00(0.88)	-0.01(0.43)
I_t^+	0.12(1.88)*	-0.06(1.05)	0.01(0.34)	-0.01(0.28)
I_t^-	-0.21(1.55)	0.02(0.14)	0.03(0.28)	-0.2(0.99)
M_t^+	0.00(0.31)	0.00(0.12)	0.01(0.65)	0.02(0.78)
M_t^-	-0.01(0.73)	-0.05(2.14)**	0.00.00(0.00)	0.02(0.98)
Panel C: Diagnostic				
F[b]	13.93**	3.94**	2.29	4.78**
$\hat{\rho}_0$ (t-ratio)[c]	-0.14(4.37)*	-0.02(0.61)	-0.03(2.83)	-0.06(5.18)**
LM[d]	0.59	0.47	2.74*	1.18
QS (QS^2)	S(S)	S(S)	S(S)	S(S)
Adjusted R^2	0.7	0.61	0.78	0.41
Wald-S[e]	0.05	5.11**	0.33	0
Wald-L	4.18**	3.62*	0.08	0.05

(Continued…)

(Table 2 Continued)

Non-Linear ARDL	**Maine**	**Michigan**	**Minnesota**	**Missouri**
Panel A: <u>Short-run</u>				
$\boldsymbol{\Delta H_t^+}$	-0.01(0.74)	0.00(0.13)	0.01(1.13)	0.00(0.04)
ΔH_{t-1}^+				
ΔH_{t-2}^+				
ΔH_{t-3}^+				
ΔH_{t-4}^+				
ΔH_{t-5}^+				
ΔH_{t-6}^+				
ΔH_{t-7}^+				
$\boldsymbol{\Delta H_t^-}$	0.02(2.14)**	0.01(0.93)	0.02(1.9)*	0.00(0.38)
ΔH_{t-1}^-	-0.02(2.15)**	0.01(0.97)	0.01(0.73)	
ΔH_{t-2}^-		0.03(2.39)**	0.02(2.58)**	
ΔH_{t-3}^-		0.03(1.92)*	0.03(3.19)**	
ΔH_{t-4}^-		0.00(0.23)		
ΔH_{t-5}^-		0.02(1.3)		
ΔH_{t-6}^-		0.03(2.9)**		
ΔH_{t-7}^-		0.03(2.99)**		
Panel B: <u>Long-run</u>				
Constant	1.19(7.4)**	0.97(2.58)**	0.71(4.56)**	0.75(4.13)**
H_t^+	0.02(2.32)**	0.02(2.84)**	0.01(3.05)**	0.01(3.34)**
H_t^-	0.06(6.45)**	0.00(0.15)	0.03(3.93)**	0.02(3.9)**
I_t^+	0.16(3.62)**	-0.04(0.78)	0.07(2.19)**	0.03(0.92)
I_t^-	0.07(0.78)	0.53(5.14)**	-0.06(0.68)	0.04(0.55)
M_t^+	0.02(1.68)*	0.00(0.08)	0.01(0.74)	0.02(1.52)
M_t^-	-0.05(2.79)**	-0.05(3.05)**	-0.01(0.73)	0.00(0.17)
Panel C: <u>Diagnostic</u>				
F^b	7.76**	6.91**	4.53**	7.98**
$\hat{\rho}_0$ (t-ratio)^c	-0.09(7.01)**	-0.1(4.21)*	-0.05(4.44)**	-0.07(4.84)**
LM^d	0.02	0.05	2.55	0.03
QS (QS^2)	S(S)	S(S)	S(S)	S(S)
Adjusted R^2	0.78	0.89	0.82	0.68
Wald-S^e	0.1	7.55**	3.98**	0.05
Wald-L	23.39**	2.45	6.72**	0.28

(Continued…)

(Table 2 Continued)

Non-Linear ARDL	**Mississippi**	**Montana**	**North Carolina**	**North Dakota**
Panel A: <u>Short-run</u>				
$\boldsymbol{\Delta H_t^+}$	0.00(0.2)	0.01(1.54)	0.00(0.26)	0.00(0.56)
ΔH_{t-1}^+	0.02(0.94)	-0.02(1.88)*		0.00(0.47)
ΔH_{t-2}^+	0.03(1.56)			-0.01(1.63)
ΔH_{t-3}^+	0.03(2.07)**			
ΔH_{t-4}^+	0.04(2.47)**			
ΔH_{t-5}^+	0.02(1.24)			
ΔH_{t-6}^+	-0.01(0.36)			
ΔH_{t-7}^+	0.02(1.24)			
$\boldsymbol{\Delta H_t^-}$	-0.01(1.02)	0.00(0.46)	-0.01(1.03)	0.00(0.55)
ΔH_{t-1}^-	0.00(0.17)	-0.01(1.36)	0.01(1.03)	-0.01(2.45)**
ΔH_{t-2}^-	0.01(0.39)	-0.02(2.64)**	0.02(1.8)*	-0.01(1.39)
ΔH_{t-3}^-	0.01(0.39)		0.01(0.92)	-0.01(1.53)
ΔH_{t-4}^-	0.00(0.07)			-0.01(2.22)**
ΔH_{t-5}^-	-0.03(2.71)**			
ΔH_{t-6}^-	0.00(0.38)			
ΔH_{t-7}^-	-0.02(1.93)*			
Panel B: <u>Long-run</u>				
Constant	2.72(3.26)**	0.93(3.55)**	0.61(2.48)**	0.95(2.79)**
H_t^+	-0.02(1.74)*	0.03(7.36)**	0.01(1.57)	0.02(4.71)**
H_t^-	-0.03(1.49)	0.03(5.19)**	0.01(0.5)	0.02(5.19)**
I_t^+	-0.08(1.54)	-0.05(0.92)	-0.07(2.34)**	-0.02(0.69)
I_t^-	1.02(2.81)**	0.28(2.55)**	0.05(0.42)	-0.03(0.83)
M_t^+	-0.01(0.55)	0.03(1.33)	0.01(0.82)	0.01(0.74)
M_t^-	-0.11(3.91)**	-0.02(0.96)	-0.01(0.84)	-0.01(0.96)
Panel C: <u>Diagnostic</u>				
F[b]	4.63**	13.67**	6.82**	7.94**
$\hat{\rho}_0$ (t-ratio)[c]	-0.22(3.97)	-0.07(3.52)	-0.05(3.11)	-0.09(3.27)
LM[d]	0.45	0.29	1.49	0
QS (QS^2)	S(S)	S(S)	S(S)	S(S)
Adjusted R^2	0.56	0.55	0.78	0.37
Wald-S[e]	7.6**	1.29	1.07	2.09
Wald-L	0.05	0.14	0.71	1.29

(Continued…)

(Table 2 Continued)

Non-Linear ARDL	**Nebraska**	**New Hampshire**	**New Jersey**	**New Mexico**
Panel A: <u>Short-run</u>				
$\boldsymbol{\Delta H_t^+}$	0.02(2.04)**	0.00(0.59)	0.00(0.54)	0.03(1.99)*
ΔH_{t-1}^+		-0.03(3.75)**		-0.01(0.44)
ΔH_{t-2}^+				0.02(1.4)
ΔH_{t-3}^+				-0.01(0.68)
ΔH_{t-4}^+				-0.04(2.64)**
ΔH_{t-5}^+				-0.02(1.51)
ΔH_{t-6}^+				-0.02(1.92)*
ΔH_{t-7}^+				
$\boldsymbol{\Delta H_t^-}$	-0.01(1.39)	0.00(0.19)	0.00(0.26)	0.02(1.34)
ΔH_{t-1}^-		-0.01(0.74)		0.02(1.27)
ΔH_{t-2}^-		-0.01(1)		0.01(0.51)
ΔH_{t-3}^-		0.01(1.99)*		0.03(2.41)**
ΔH_{t-4}^-				0.02(1.54)
ΔH_{t-5}^-				-0.04(2.36)**
ΔH_{t-6}^-				
ΔH_{t-7}^-				
Panel B: <u>Long-run</u>				
Constant	-0.05(0.18)	0.54(3.71)**	0.48(4.08)**	0.13(0.42)
H_t^+	0.01(1.96)*	0.03(3.35)**	-0.01(1.08)	0.03(3.06)**
H_t^-	0.01(0.94)	0.02(2.75)**	0.00(0.39)	0.02(2.83)**
I_t^+	-0.01(0.29)	0.1(3.19)**	-0.05(1.16)	0.00(0.04)
I_t^-	-0.23(2.17)**	-0.11(1.33)	0.28(1.63)	-0.15(1.08)
M_t^+	-0.04(2.26)**	-0.01(0.79)	0.00(0.08)	-0.05(1.87)*
M_t^-	0.01(0.47)	0.04(2.43)**	-0.05(1.82)*	-0.01(0.36)
Panel C: <u>Diagnostic</u>				
F[b]	3.02	4.46**	4.48**	3.07
$\hat{\rho}_0$ (t-ratio)[c]	0.00(0.17)	-0.04(3.6)	-0.03(4.07)*	-0.03(1.27)
LM[d]	0	1.55	0.24	0.84
QS (QS^2)	S(S)	S(S)	S(S)	S(S)
Adjusted R^2	0.6	0.86	0.77	0.68
Wald-S[e]	4.37**	1.99	0.01	3.81*
Wald-L	0.97	3.15*	1.15	1.86

(Continued…)

(Table 2 Continued)

Non-Linear ARDL	**Nevada**	**New York**	**Ohio**	**Oklahoma**
Panel A: <u>Short-run</u>				
$\boldsymbol{\Delta H_t^+}$	0.00(0.21)	-0.02(2.08)**	-0.01(0.8)	0.00(0.15)
ΔH_{t-1}^+	-0.02(1.12)	-0.02(1.01)	-0.01(0.76)	
ΔH_{t-2}^+	-0.01(0.4)	0.00(0.08)	-0.04(3.18)**	
ΔH_{t-3}^+	0.03(1.55)	0.01(0.82)	-0.01(1.25)	
ΔH_{t-4}^+	0.04(2.13)**	-0.04(2.18)**	-0.02(2.01)**	
ΔH_{t-5}^+				
ΔH_{t-6}^+				
ΔH_{t-7}^+				
$\boldsymbol{\Delta H_t^-}$	0.00(0.25)	-0.02(1.67)	0.01(0.62)	0.02(2.02)**
ΔH_{t-1}^-	-0.01(0.38)	-0.01(0.49)	-0.01(0.61)	
ΔH_{t-2}^-	0.00(0.16)	0.02(1.08)	0.04(3.16)**	
ΔH_{t-3}^-	-0.02(1.36)	-0.02(1.72)*	0.00(0.45)	
ΔH_{t-4}^-	-0.03(2.61)**		-0.01(0.78)	
ΔH_{t-5}^-			0.00(0.19)	
ΔH_{t-6}^-			0.01(1.06)	
ΔH_{t-7}^-				
Panel B: <u>Long-run</u>				
Constant	1(5.18)**	0.34(1.6)	1.02(3.67)**	1.17(4.01)**
H_t^+	-0.01(1.06)	0.00(0.38)	0.02(3.16)**	0.01(1.77)*
H_t^-	0.06(5.42)**	0.01(0.67)	0.01(1.92)*	0.00(0.19)
I_t^+	0.03(0.53)	0.09(0.71)	0.02(0.57)	-0.02(0.79)
I_t^-	-0.32(1.72)*	0.32(1.25)	0.21(1.6)	0.05(1.38)
M_t^+	-0.01(0.16)	-0.08(1.59)	0.01(1.14)	0.01(0.82)
M_t^-	-0.19(4.45)**	-0.08(1.52)	0.01(0.49)	0.02(0.87)
Panel C: <u>Diagnostic</u>				
F[b]	5.39**	2.69	8.43**	3.37*
$\hat{\rho}_0$ (t-ratio)[c]	-0.07(4.89)**	-0.04(2.69)	-0.1(5.96)**	-0.08(3.42)
LM[d]	1.01	1.5	0.42	1.84
QS (QS^2)	S(S)	S(S)	S(S)	S(S)
Adjusted R^2	0.82	0.66	0.82	0.36
Wald-S[e]	3.34*	0.75	3.96*	1.29
Wald-L	17**	0.47	3.68*	4.01**

(Continued…)

(Table 2 Continued)

Non-Linear ARDL	**Oregon**	**Pennsylvania**	**Rhode Island**	**South Carolina**
Panel A: <u>Short-run</u>				
$\boldsymbol{\Delta H_t^+}$	0.01(1.4)	0.00(0.26)	0.02(1.42)	0.03(1.88)*
ΔH_{t-1}^+	0.00(0.18)	-0.01(1.61)	0.00(0.23)	-0.11(2.95)**
ΔH_{t-2}^+	0.00(0.45)		0.04(2.47)**	-0.09(2.8)**
ΔH_{t-3}^+	0.03(2.59)**		0.03(2.02)**	-0.08(2.64)**
ΔH_{t-4}^+	-0.01(0.71)		0.02(1.15)	-0.07(2.24)**
ΔH_{t-5}^+	-0.02(2.14)**		-0.01(0.83)	-0.02(0.6)
ΔH_{t-6}^+			0.02(1.86)*	-0.03(1.42)
ΔH_{t-7}^+			0.01(0.95)	-0.05(3.23)**
$\boldsymbol{\Delta H_t^-}$	0.01(1.03)	0.00(0.62)	0.02(1.59)	0.00(0.1)
ΔH_{t-1}^-	0.01(1.25)		0.02(1.07)	-0.02(1.14)
ΔH_{t-2}^-	0.03(2.91)**		-0.02(1.49)	-0.01(0.74)
ΔH_{t-3}^-			-0.01(0.91)	0.03(1.67)
ΔH_{t-4}^-			-0.01(0.4)	0.01(1.05)
ΔH_{t-5}^-			-0.01(0.55)	-0.03(2.36)**
ΔH_{t-6}^-			-0.03(2.66)**	-0.04(3.31)**
ΔH_{t-7}^-				-0.01(1.32)
Panel B: <u>Long-run</u>				
Constant	0.39(2.79)**	0.34(3.11)**	0.73(2.47)**	-0.41(0.5)
H_t^+	0.01(0.84)	0.03(2.67)**	0.00(0.15)	0.15(2.98)**
H_t^-	0.00(0.47)	0.02(3.3)**	0.01(0.83)	0.01(0.33)
I_t^+	-0.06(1.28)	0.04(0.94)	0.13(2.01)**	-0.5(1.48)
I_t^-	0.24(1.8)*	-0.09(1.71)*	0.08(0.32)	-0.39(3.29)**
M_t^+	0.01(0.67)	0.00(0.24)	0.00(0.13)	-0.11(3.04)**
M_t^-	-0.03(2.69)**	0.02(1.2)	-0.02(0.66)	0.03(1.7)*
Panel C: <u>Diagnostic</u>				
F[b]	2.63	4.61**	4.35**	10.3**
$\hat{\rho}_0$ (t-ratio)[c]	-0.03(3.22)	-0.02(2.37)	-0.06(2.92)	-0.08(2.16)
LM[d]	0.98	1.52	1.18	0.49
QS (QS^2)	S(S)	S(S)	S(S)	S(S)
Adjusted R^2	0.9	0.8	0.85	0.82
Wald-S[e]	1.41	1.62	5.6**	2.92*
Wald-L	0.14	0.61	0.38	3.13*

(Continued…)

(Table 2 Continued)

Non-Linear ARDL	**South Dakota**	**Tennessee**	**Texas**	**Utah**
Panel A: <u>Short-run</u>				
$\boldsymbol{\Delta H_t^+}$	0.00(0.12)	0.02(2.95)**	0.02(1.99)*	0.01(0.74)
ΔH_{t-1}^+		-0.04(4.22)**	0.00(0.28)	
ΔH_{t-2}^+		-0.04(4.58)**	-0.03(1.71)*	
ΔH_{t-3}^+		-0.03(3.49)**	-0.01(0.39)	
ΔH_{t-4}^+		-0.02(2.03)**	0.02(1.65)	
ΔH_{t-5}^+		-0.01(1.55)	0.00(0.2)	
ΔH_{t-6}^+		-0.01(1.89)*	-0.02(1.37)	
ΔH_{t-7}^+		-0.01(1.8)*	0.03(2.41)**	
$\boldsymbol{\Delta H_t^-}$	0.01(0.94)	0.01(0.96)	-0.01(0.55)	0.01(0.86)
ΔH_{t-1}^-	-0.02(2.69)**		-0.01(0.44)	
ΔH_{t-2}^-	-0.01(1.25)		0.01(0.81)	
ΔH_{t-3}^-	-0.01(2.01)**		0.01(0.73)	
ΔH_{t-4}^-	-0.01(1.77)*		-0.03(1.77)*	
ΔH_{t-5}^-	-0.01(1)		-0.02(0.92)	
ΔH_{t-6}^-			0.04(2.52)**	
ΔH_{t-7}^-				
Panel B: <u>Long-run</u>				
Constant	0.8(1.91)*	0.58(3.54)**	-0.24(0.7)	0.99(3.98)**
H_t^+	0.02(3.78)**	0.05(8.84)**	0.02(1.58)	0.03(4.58)**
H_t^-	0.02(3.72)**	0.04(7.71)**	0.03(2.06)**	0.02(3.02)**
I_t^+	-0.12(3.18)**	0.01(0.53)	0.09(1.58)	0.07(1.63)
I_t^-	0.02(0.22)	-0.4(3.83)**	-0.28(1.95)*	0.08(0.85)
M_t^+	0.02(0.96)	-0.02(2.01)**	-0.02(1.29)	-0.02(0.85)
M_t^-	-0.03(1.87)*	0.02(2.35)**	0.03(1.22)	0.01(0.53)
Panel C: <u>Diagnostic</u>				
F[b]	4.58**	17.08**	1.74	8.57**
$\hat{\rho}_0$ (t-ratio)[c]	-0.05(1.64)	-0.05(3.4)	0.04(1.43)	-0.09(4.7)**
LM[d]	1.5	2.39	0	0
QS (QS^2)	S(S)	S(S)	S(S)	S(S)
Adjusted R^2	0.23	0.83	0.75	0.78
Wald-S[e]	3.7*	12.35**	0.07	0.01
Wald-L	0.2	3.83*	1.08	0.24

(Continued…)

(Table 2 Continued)

Non-Linear ARDL	**West Virginia**	**Wyoming**	**DC**
Panel A: Short-run			
$\boldsymbol{\Delta H_t^+}$	-0.01(1.08)	0.00(0.03)	0.00(1.83)*
ΔH_{t-1}^+	-0.02(2.14)**		0.00(1.77)*
ΔH_{t-2}^+	0.00(0.43)		-0.01(3.21)**
ΔH_{t-3}^+	0.03(3.3)**		
ΔH_{t-4}^+			
ΔH_{t-5}^+			
ΔH_{t-6}^+			
ΔH_{t-7}^+			
$\boldsymbol{\Delta H_t^-}$	0.01(0.69)	0.00(0.07)	0.00(0.28)
ΔH_{t-1}^-		-0.03(3.26)**	
ΔH_{t-2}^-		-0.02(1.89)*	
ΔH_{t-3}^-			
ΔH_{t-4}^-			
ΔH_{t-5}^-			
ΔH_{t-6}^-			
ΔH_{t-7}^-			
Panel B: Long-run			
Constant	2.11(5.1)**	2.21(5.35)**	0.58(3.42)**
H_t^+	0.00(0.37)	0.01(1.21)	0.00(2)**
H_t^-	0.04(6.33)**	0.03(3.48)**	0.00(2.29)**
I_t^+	0.36(3.71)**	0.13(3.84)**	-0.07(0.78)
I_t^-	-0.27(2.51)**	0.16(3.21)**	-0.24(1.26)
M_t^+	-0.03(1.61)	0.00(0.15)	0.02(0.98)
M_t^-	-0.04(1.93)*	-0.07(3.8)**	-0.01(0.28)
Panel C: Diagnostic			
F[b]	12.21**	4.71**	3.36*
$\hat{\rho}_0$ (t-ratio)[c]	-0.2(5.94)**	-0.18(4.9)**	-0.05(3.82)
LM[d]	0.19	2.76*	0.28
QS (QS^2)	S(S)	S(S)	S(S)
Adjusted R^2	0.61	0.46	0.62
Wald-S[e]	0.1	5.54**	0.09
Wald-L	14.03**	16.7**	0.52

Notes: a. Numbers the parentheses are absolute values of the t-ratios, and * (**) indicates significance at the 10% (5%) confidence level.
b. At the 10% (5%) significance level when there are three exogenous variables (k=3), the critical value of the F test is 3.77 (4.35). This comes from Pesaran *et al*. (2001, Table CI-Case III, page 300).
c. At the 10% (5%) significance level when there are six exogenous variables in the non-linear model (k=6), the critical value of the t-test for significance of $\hat{\rho}_0$ is -4.04 (-4.38). This comes from Pesaran *et al*. (2001, Table CII-Case III, page 303).

d. LM is the Lagrange multiplier test of residual serial correlation. It is distributed as $\chi 2$ with one degree of freedom since we test for first-order serial correlation. Its critical value at the 10% (5%) level is 2.71 (3.84).
e. All Wald tests are distributed as $\chi 2$ with one degree of freedom, and its critical value at the 10% (5%) level is 2.71 (3.84).

From Panel A of Table 2, we gather that in 44 states, either the ΔH^+ or ΔH^- carry at least one significant lagged coefficient, thus supporting the short-run effects of housing permits on house prices. This increase in the number of states where house permits have short-run effects on house prices from 29 in the linear model to 44 in the non-linear model must be attributed to the non-linear adjustment of house permits. Furthermore, we find that at any lag j, the estimated coefficient attached to ΔH_{t-j}^{+} is different from the estimate attached to ΔH_{t-j}^{-}, which implies that the short-run effects are asymmetric in most states. However, we observe cumulative asymmetric short-run effects in only 20 states, based on a significant Wald-S test reported in Panel C. A significant Wald test implies that we reject the equality between the sum of the ΔH_{t-j}^{+} coefficients and that of the ΔH_{t-j}^{-} coefficients. These 20 states include Alaska, Arizona, Connecticut, Florida, Illinois, Indiana, Louisiana, Michigan, Minnesota, Mississippi, Nebraska, New Mexico, Nevada, Ohio, Rhode Island, South Carolina, South Dakota, Tennessee, Washington, and Wyoming.[10]

Next, we test whether asymmetric short-run effects translate into long run effects in any state. Panel B of Table 2 reports the asymmetric long-run results. We learn that either H^+ or H^- carry a significant coefficient supported by at least one cointegration test (Panel C) in 38 states. In almost all of the states, both variables take positive coefficients, consistent with the results from the linear models. An increase in permits portends negative effects on house prices only in Florida and Mississippi since the $H+$ variable carries a negative coefficient in these two states. The results show that the relationship between house permits and house prices is state-specific. For example, in Florida, both an increase and a decrease in house permits have negative long-run effects on house prices, a clear sign of asymmetric long-run effects. This result is also supported by the Wald-L test reported in Panel C. Indeed, asymmetric long-run effects are supported in 21 states. We consider the two models as complements rather than substitutes. Thus, we recommend estimating the linear model first, and in the case of an insignificant result, estimating the non-linear model. Consider the case of Maryland as an example. The linear model predicts that house permits have no long-run effects on house prices. The non-linear model also predicts no long-run impact on prices following an increase in permits; however, we find that a decrease in permits in Maryland portends a negative

[10] Note that for brevity we only report short-run estimates attached to the ΔH_{t-j}^{+} and the ΔH_{t-j}^{-} variables. The original submission included full information estimates which are available upon request from the corresponding author.

effect on house prices. Thus, introducing non-linear adjustments of house permits yields significant findings in Maryland. We also recommend estimating the non-linear model even if the linear model predicts a significant outcome. The non-linear model helps to determine if the significant relationship between house permits and house prices results from an increase or a decrease in house permits. California serves as an excellent example, as the linear model predicts a significant long-run link between house prices and house permits; however, the non-linear model shows that this link is solely due to a decrease in permits.[11]

4. Summary and Conclusion

Fundamental economic indicators such as household income and mortgage rates are known to determine house prices. However, the recent literature has also identified some supply-side factors such as construction costs or more straightforward supply proxies such as housing stocks or housing permits. Two competing theories aim to explain the effects of housing supply on house prices. Following the law of demand and supply, increased housing supply is expected to depress house prices (supply hypothesis). However, if increased housing supply, as measured by house permits, reflects expectations about the new construction of housing units in the future, the demand for housing may increase, thus pushing prices higher (demand hypothesis).

Although our goal in this paper is to test the abovementioned competing hypotheses, we also argue and demonstrate that the effects of housing permits on house prices could be asymmetric. We use the non-linear ARDL approach in Shin *et al.* (2014) to test the asymmetric impact of housing permits on house prices. For comparison, we also assume the effects to be symmetric and apply the linear ARDL approach in Pesaran *et al.* (2001). We use quarterly data over the 1988QI-2019QI period from each state in the US to carry out our empirical analysis.

Our findings are easily summarized. We find short-run linear effects of house permits on house prices in 29 states. In some of the states, this relationship is negative, thus implying house permits have a supply-side impact on house prices. In contrast, we find positive effects in the remaining states, thus supporting the forward-looking demand hypothesis. Moreover, we find that the linear short-run impact transforms into long-run positive effects in 40 states. However, when we estimate a non-linear model for each state, we find significant asymmetric short-run effects in 44 states. These non-linear short-

[11] Other diagnostics are similar to those of the linear model and need no repeating here. Short-run estimates from both the linear and nonlinear models reveal that the demand side factors, i.e., income and mortgage rates, take a different lag structure than the supply side factor, i.e., house permits in every state. This implies that the two hypotheses assume different future time points as to the anticipated effects in terms of their realization.

run effects spill over into the long run in 38 states. The non-linear model shows support for the demand hypothesis in 36 states. In contrast, more house permits issued have adverse effects on house prices in Florida and Mississippi. All in all, it appears that in most states, increased issuance of house permits is a signal of future growth in the housing markets, which increases the optimism of the future of the economy while creating more demand for housing in the present.

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Appendix

Data Definition and Sources

All data are quarterly over the period of 1988QI-2019QI. The sample starts in 1988 because the house permit measure was introduced in that year.

Variables:

H = House Permits: number of new housing units authorized by building permits. Data are available monthly, year-to-date, and annually at the national, state, selected metropolitan area, county, and place levels. The data are from the Building Permits Survey.

"The United States Code, Title 13, authorizes this survey, provides for voluntary responses, and provides an exception to confidentiality for public records...(Coverage is) (a)ll places issuing building permits for privately-owned residential structures. Over 98 percent of all privately-owned residential buildings constructed are in permit-issuing places…(Special features) provides a designated principal economic indicator, and the only source of current and consistent small area data on new authorizations for residential construction.

A monthly survey of 9,000 selected permit-issuing places; and an annual census of an additional 11,000 permit places that are not in the above monthly sample constitutes the full sample of house permits. The monthly sample of permit-issuing places is selected using a stratified systematic sample procedure. All permit places located in the selected large metropolitan areas are selected with certainty. The remaining places are stratified by state. Places that exceed a cutoff value, which varies by state, are selected with certainty. The remaining places are sampled at a rate of 1 in 10. Monthly estimates represent all permit-issuing places nationwide. If a survey report is not received, missing data on permits for new construction are imputed except for places selected for the Survey of Construction (SOC). For these places, SOC permit data are used.

The Conference Board uses this data for developing its index of leading economic indicators. The Federal Reserve Board uses the data to analyze national and regional economic conditions. The Department of Housing and Urban Development uses the data to evaluate housing programs. Financial institutions use these statistics to estimate mortgage demand. Private businesses use them for market planning, material use, and investment analysis" (US Census Bureau, 2021).

New Private Housing Units Authorized by Building Permits for each state of the United States, retrieved from Federal Reserve Economic Data (FRED) and Federal Reserve Bank of St. Louis.

P = House Price. The house price index (HPI) is based on repeat mortgage transactions on single-family properties with mortgages that have been securitized or purchased by Fannie Mae or Freddie Mac since 1975. The Federal Housing Finance Agency publishes monthly and quarterly HPI data. We use seasonally adjusted HPI data, adjusted for inflation by using the consumer price index (CPI). All data are also available from FRED provided by the Federal Reserve Bank of St. Louis.

I = Measure of household income. We use the total personal income of each state published by the US Bureau of Economic Analysis. This measure of income accounts for population growth in each state, which is a determinant of the housing demand. Again, the data is seasonally adjusted and deflated by the CPI. All data are available from FRED of the Federal Reserve Bank of St. Louis.

M = Mortgage rate. We use a 30-year conventional mortgage rate in each state. The main source is the primary mortgage market survey data from Freddie Mac, which provided the data to the Federal Reserve's Board of Governors. Again, the data are available from FRED of the Federal Reserve Bank of St. Louis.