

Do changes in the fundamentals have symmetric or asymmetric effects on house prices? Evidence from 52 states of the United States of America

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ABSTRACT

Time-series studies that have tried to establish the long-run relationship between house prices and economic fundamentals have been criticized due to low power of their cointegration tests. On the other hand, those who have used panel data and panel tests to increase the power have found mixed results. Both groups have assumed that changes in the fundamentals have symmetric effects on house prices. In this article, we use nonlinear ARDL approach to cointegration and error-correction modelling and quarterly data from each of the states in the US to show that changes in the fundamentals have asymmetric effects on house prices, in the short run as well as in the long run. Cointegration between house prices and fundamentals is established in 30 states and in District of Columbia.

KEYWORDS

House prices; fundamentals; nonlinear ARDL approach; asymmetry

JEL CLASSIFICATION

R13

1. Introduction

Recent fluctuations in the housing market and house prices which began with the financial crisis of 2008 clearly demonstrate that economic fundamentals such as overall economic activity, mortgage rates, consumer income, etc. play a major role in determining house prices. Yet empirical research is mixed on establishing a clear long-run relation between house prices and macroeconomic fundamentals. The mixed literature has been reviewed up until 1998 by Malpezzi (1999) and needs no repeat here. Post 1998, articles could be classified into those that have used only time-series data and those that have used panel data.

Concentrating on the time-series models, different authors have investigated the experiences of different countries or a major city in a country. These include Chen and Patel (1998) who investigated the behaviour of house prices in Taipei using Granger causality tests, variance decomposition and impulse response functions. Using quarterly data over the period 1973I–1994IV, they found that household income, short-run interest rates, stock price index, construction costs and housing completions Granger-cause house prices. The variance decomposition showed that current house prices disturbances result in greatest variability to future prices and the

remaining is explained by the five fundamentals mentioned. All variables were also found to be cointegrated using Johansen's test for cointegration. However, when the same test was used by Chen, Tsai and Chang (2007) using data from Taiwan, no cointegration was found. Chen, Tsai and Chang (2007) attribute lack of cointegration to structural breaks and when they use a stochastic break test which allows for temporary shocks during sample period, they find evidence in support of cointegration among house price and a few determinants. Similar cointegrating results were also found by Meen (2002) for the US and UK using aggregate level data, by Apergis (2003) in the housing market for Greece and by McQuinn and O'Reilly (2008) for Ireland.

Two studies have attributed lack of cointegration between house prices and economic fundamentals to ignoring nonlinearity in some of the cointegration approaches. Kim and Bhattacharya (2009) use a Smooth Transition Autoregressive (STAR) model based on nonlinear properties of housing prices in the entire US and four regions to show that housing prices reflect nonlinearity and within this nonlinearity context, a few fundamentals Granger cause house prices. Similar results are presented by Zhou (2010) when they use data from 10 US cities. When a

standard linear cointegration technique was used, they found evidence of cointegration among house prices and fundamentals only in one city. However, when a nonlinear cointegration method was used, they found support in favour of cointegration in six other cities.

Cointegration tests applied to time-series models are said to suffer from low power. In an effort to increase the power of cointegration tests, several studies have shifted to panel models and panel tests for cointegration between house prices and economic fundamentals. Malpezzi (1999) concentrates on house price to income ratio and identifies regulatory environment, some geographical variables, per capita income and its growth rate, population and its growth rate, and the nominal mortgage interest rate as determinants of the ratio. Using a panel model and annual data from 133 metropolitan areas in the US during 1979–1996 period, he shows that all variables are cointegrated and they all have significant effects on the house price to income ratio. In contrast to Malpezzi (1999), Gallin (2006) applied Pedroni (1999) and Maddala and Wu (1999) panel unit-root tests to the residuals of a model in which the dependent variable was Office of Federal Housing Enterprise Oversight's (OFHEO) weighted repeat-sales price index and independent variables were per capita personal income, population, user cost, a measure of wealth reflected by S and P 500 index, and personal consumption deflator to control for inflation. The panel model was estimated using cross-sectional data from 95 US cities and quarterly data over the period 1975I–2002II. While some of the variables were found to carry significant coefficient, the application of panel unit-root to the residuals of the estimated model supported nonstationary residuals, hence lack of cointegration or long-run relationship between house prices and economic fundamentals. Similar results in the US market are also reported by Mikhed and Zemcik (2009) but not by Holly, Pesaran and Yamagata (2010) and by Madsen (2012) in OECD countries.¹

All studies reviewed above, whether time-series or panel, and whether linear or nonlinear, have a common assumption that the effects of fundamentals on

house price is symmetric. For example, when household income rises, due to increased demand for housing, house prices rise and when household income declines, house prices decline. However, it is possible that when household income declines, rather than selling, some households may pay their mortgage out of their saving with the expectation that their financial situations will improve after a while. Selling in the short run and getting back to the market could be too costly and this may induce people to finance their mortgage out of saving. In this case, house prices may not decline as much as expected. The implication is that the effects of income changes on house prices could be asymmetric. The same could be true of other fundamentals. Thus, it is the main purpose of this article to test whether the changes in fundamentals have symmetric or asymmetric effects on house prices. When a standard linear cointegration method is used, not much support is found for cointegration between house prices and fundamentals. However, when nonlinear asymmetric cointegration method is used, strong evidence in favour of long-run relationship between house price and fundamentals is discovered. To demonstrate this we outline the model and the methods in Section II. Section III is dedicated to reporting the empirical results at the US states level that also includes District of Columbia (DC). Finally, Section IV concludes.

II. The models and methods

The two most common variables that have been identified by all studies as determinants of house prices are measures of household income and interest rate. Indeed, Case and Shiller (2003) used only these two factors to study the house prices in the US. They concluded that since 1995 house prices have been driven by fundamentals. As they wrote:

For more than forty states, income growth alone explains virtually the entire increase in housing prices, and falling interest rates have reduced financing costs sufficiently to keep the ratio of annual mortgage payments to income from rising even in the boom states of Massachusetts and California.

¹There is another strand of literature (mostly from the UK) pertaining to the debate about whether the apparent regional differences in UK house prices have a tendency to converge, diverge or simply reflect cyclical behaviour. Examples include Rosenthal (1986), MacDonald and Taylor (1993), Holmes and Grimes (2008), Holly, Pesaran and Yamagata (2011) and Abbott and De Vita (2012, 2013).

Thus, denoting the house prices by P , household income by I , and mortgage rates by M , we adopt the following log-linear specification:

$$\text{Ln}P_t = a + b\text{Ln}I_t + c\text{Ln}M_t + \varepsilon_t \quad (1)$$

The model outlined by Equation (1) is a long-run model and its estimate by any method will yield the long-run effects of income and interest rate on house prices. Furthermore, based on the theory, we expect an estimate of b to be positive and that of c to be negative. In order to infer the short-run effects of the exogenous variables, we now need to incorporate the short-run dynamic adjustment process into Equation (1). To that end, we rely upon Pesaran *et al.*'s (2001) bounds testing approach to error-correction modelling and cointegration and rewrite Equation (1) as:

$$\begin{aligned} \Delta \text{Ln}P_t = & \alpha + \sum_{k=1}^{n1} \beta_k \Delta \text{Ln}P_{t-k} + \sum_{k=0}^{n2} \delta_k \Delta \text{Ln}I_{t-k} \\ & + \sum_{k=0}^{n3} \pi_k \Delta \text{Ln}M_{t-k} + \lambda_0 \text{Ln}P_{t-1} + \lambda_1 \text{Ln}I_{t-1} \\ & + \lambda_2 \text{Ln}M_{t-1} + \mu_t \end{aligned} \quad (2)$$

In error-correction model (Equation (2)), short-run effects are now inferred by the estimates of coefficients attached to first-differenced variables and long-run effects are judged by the estimates of λ_1 and λ_2 normalized on λ_0 . However, for the long-run estimates to be valid, we must establish cointegration. Pesaran, Shin and Smith (2001) propose applying the standard F test for joint significance of linear combination of lagged level variables in Equation (2). However, they demonstrate that the F test in this application has new critical values that must account for integrating properties of variables. Hence, they report an upper bound critical value if all variables are $I(1)$ and a lower bound critical value if all variables are $I(0)$. They also argue that the upper bound critical value could be used in case variables are combination of $I(0)$ and $I(1)$. Therefore, on the assumption that almost all macro variables are either $I(0)$ or $I(1)$, there is no need for pre-unit-root testing under this approach. While this is a major advantage of this method, another

advantage is that short- and long-run estimates are obtained in one step by estimating Equation (2).²

As mentioned before, like any other method, even the Pesaran, Shin and Smith (2001) approach applied to Equation (2) includes an implicit assumption that exogenous variables have symmetric effects on house prices. In order to test this hypothesis, we separate increase in income and mortgage interest rate from decline in income and interest rate using partial sum concept as below:

$$\begin{aligned} \text{IPOS} &= \sum_{j=1}^t \Delta \text{Ln}I_j^+ = \sum_{j=1}^t \max(\Delta \text{Ln}I_j, 0), \text{ INEG} \\ &= \sum_{j=1}^t \Delta \text{Ln}I_j^- = \sum_{j=1}^t \min(\Delta \text{Ln}I_j, 0) \\ \text{MPOS} &= \sum_{j=1}^t \Delta \text{Ln}M_j^+ = \sum_{j=1}^t \max(\Delta \text{Ln}M_j, 0), \\ \text{MNEG} &= \sum_{j=1}^t \Delta \text{Ln}M_j^- = \sum_{j=1}^t \min(\Delta \text{Ln}M_j, 0) \end{aligned}$$

where IPOS is the cumulative sum of positive changes in income assuming negative changes are zero and INEG is cumulative sum of negative changes in income assuming positive changes are zero. Similarly, MPOS and MNEG are partial sums of positive and negative changes in mortgage rate.

The next step is to go back to Equation (2) and replace $\text{Ln} I$ by IPOS and INEG and $\text{Ln} M$ by MPOS and MNEG to arrive at a new specification (Equation (3)):

$$\begin{aligned} \Delta \text{Ln}P_t = & \alpha + \sum_{k=1}^{n1} \beta_k \Delta \text{Ln}P_{t-k} + \sum_{k=0}^{n2} \delta_k^+ \Delta \text{IPOS}_{t-k} \\ & + \sum_{k=0}^{n3} \delta_k^- \Delta \text{INEG}_{t-k} + \sum_{k=0}^{n4} \psi_k^+ \Delta \text{MPOS}_{t-k} \\ & + \sum_{k=0}^{n5} \psi_k^- \Delta \text{MNEG}_{t-k} + \rho_0 \text{Ln}P_{t-1} \\ & + \rho_1 \text{IPOS}_{t-1} + \rho_2 \text{INEG}_{t-1} \\ & + \rho_3 \text{MPOS}_{t-1} + \rho_4 \text{MNEG}_{t-1} + \xi_t + \end{aligned} \quad (3)$$

Shin, Yu and Greenwood-Nimmo (2014) label this specification as nonlinear ARDL model, due to

²For some other applications of this approach, see De Vita and Kyaw (2008) and Halicioglu (2007).

nature of constructing the four new variables and demonstrate that Pesaran *et al.*'s (2001) method is equally applicable to specification (Equation (3)). Hence, short-run symmetry versus asymmetry is judged by comparing estimates of δ_k^+ to δ_k^- and ψ_k^+ to ψ_k^- . Similarly, the long-run symmetry versus asymmetry is judged by comparing normalized estimate of ρ_1 to ρ_2 and normalized estimate of ρ_3 to ρ_4 .³

III. Results

In this section, we estimate both the linear ARDL model (Equation (2)), and nonlinear ARDL model (Equation (3)) for each of the 50 states and DC in the US using quarterly data over the 1975I–2014III period. 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 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 DC, 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.

Income data is Total Personal Income published by the US Bureau of Economic Analysis. Based on the BEA definition, personal income is the income received by all persons from all sources. It is the sum of net earnings by place of residence, property income and personal current transfer receipts. State Personal Income statistics can serve as a basis for decision making. For instance, they are used in forecasting models to project water and energy

consumption, state governments use them to project the need for public services and businesses use the statistics for market research. Here, we use real Total Personal Income which is seasonally adjusted figures deflated by Consumer Price Index. Finally, for the mortgage rates we use 30-year Conventional Mortgage Rate which comes from Board of Governors of the Federal Reserve System.⁴

In estimating either model, we impose a maximum of eight lags on each first-differenced variable and use Akaike's Information Criterion (AIC) to select the optimum lags.⁵ Results from each optimum model for each state are reported in Table 1. Due to volume of the results, for each case they are reported in three panels. While Panel A reports short-run coefficient estimates of only exogenous variables, Panel B reports the long-run estimates. All diagnostic statistics are then reported in Panel C.

Let us consider the results for the first state, Alaska. From the linear ARDL model and Panel A, since income carries at least one significant short-run coefficient, it has short-run effects on house prices. However, mortgage rate does not since the short-run coefficient is insignificant. None of these short-run effects, however, last into the long run since in Panel B, neither variable carries a significant coefficient. These long-run insignificant effects are further supported by insignificant F test for joint significance of lagged level variables or cointegration, since the reported value of 1.70 in Panel C is less than its critical value of 4.14.⁶

A few additional diagnostic statistics are also reported in Panel C. First, to determine the speed with which house prices, income and mortgage rates adjust towards their equilibrium values, we follow Pesaran, Shin and Smith (2001) and Bahmani-Oskooee and Tanku (2008) and use normalized long-run coefficient estimates and long-run model (Equation (1)) and generate an error term, usually called error-correction term denoted by ECM. We then replace the linear combination of lagged level variables in Equation (2) by ECM_{t-1} and estimate this new specification after imposing the same

³Suppose our time series variable is Z_t . We first generate ΔZ_t which includes positive and negative values. Intuitively, partial sum of positive changes is cumulative changes of ΔZ_t when negative values are replaced by zeros and partial sum of negative changes is cumulative changes of ΔZ_t when positive values are replaced by zeros. Due to space constraint, we do not plot the partial sums of income and interest rate changes. For more on this see Bahmani-Oskooee and Bahmani (2015), Bahmani-Oskooee and Fariditavana (2014), Bahmani-Oskooee and Fariditavana (2015) and Verheyen (2013).

⁴Note that the mortgage rates to Board of Governors of the Fed originate from Primary Mortgage Market Survey data that are provided by Freddie Mac.

⁵Note that the statistical package Microfit that is used here counts current value of a variable as one lag.

⁶This upper bound critical value comes from Pesaran, Shin and Smith (2001, Table CI(iii) Case III, p. 300) when there are two exogenous variables in the model.

Table 1. Full-information estimates of both linear and nonlinear ARDL models.

	Alaska		Alabama		Arkansas		Arizona	
	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL
Panel A: Short-run								
$\Delta \ln I_t$	.48 (1.70)		.54 (3.29)		.16 (1.78)		.51 (2.93)	
$\Delta \ln I_{t-1}$	.69 (2.28)		.16 (.96)		-.22 (-2.45)		-.10 (-.59)	
$\Delta \ln I_{t-2}$	.54 (1.88)		-.19 (-1.15)				-.31 (-1.75)	
$\Delta \ln I_{t-3}$	.19 (.72)		.19 (1.12)				.003 (.01)	
$\Delta \ln I_{t-4}$	-.13 (-.49)		-.31 (-1.81)				-.15 (-.93)	
$\Delta \ln I_{t-5}$	.76 (3.01)						.37 (2.25)	
$\Delta \ln I_{t-6}$	-.42 (-1.71)						.43 (2.72)	
$\Delta \ln I_{t-7}$	.34 (1.40)						-.33 (-1.98)	
$\Delta \ln M_t$	.07 (.95)						-.12 (-4.16)	
$\Delta \ln M_{t-1}$			-.10 (-3.93)		-.08 (-4.01)			
$\Delta \ln M_{t-2}$			-.08 (-3.08)		-.04 (-2.23)			
$\Delta \ln M_{t-3}$								
$\Delta \ln M_{t-4}$								
$\Delta \ln M_{t-5}$								
$\Delta \ln M_{t-6}$								
$\Delta \ln M_{t-7}$								
$\Delta \ln P_{S_t}$		.11 (.91)						
$\Delta \ln P_{S_{t-1}}$				.20 (.82)		-.23 (-1.68)		.51 (2.36)
$\Delta \ln P_{S_{t-2}}$				.14 (.57)				.28 (1.26)
$\Delta \ln P_{S_{t-3}}$				.57 (2.29)				.05 (.25)
$\Delta \ln P_{S_{t-4}}$								-.08 (-.37)
$\Delta \ln P_{S_{t-5}}$								-.15 (-.75)
$\Delta \ln P_{S_{t-6}}$								.27 (1.39)
$\Delta \ln P_{S_{t-7}}$								.62 (3.19)
$\Delta \ln EG_t$								
$\Delta \ln EG_{t-1}$		1.20 (1.78)		1.07 (3.15)		.85 (4.64)		.37 (.85)
$\Delta \ln EG_{t-2}$		-.61 (-.90)		-.16 (-.45)		-.66 (-3.64)		-.120 (-2.89)
$\Delta \ln EG_{t-3}$		.31 (.66)		-.127 (-3.43)				-.136 (-2.87)
$\Delta \ln EG_{t-4}$		-.23 (-.50)		.63 (1.89)				
$\Delta \ln EG_{t-5}$		-.125 (-2.69)		-.55 (-1.59)				
$\Delta \ln EG_{t-6}$		.84 (1.81)						
$\Delta \ln EG_{t-7}$		-.120 (-2.72)						
$\Delta \ln POS_t$		.23 (2.05)		-.02 (-.62)		-.001 (-.13)		-.07 (-1.31)
$\Delta \ln POS_{t-1}$		-.16 (-1.34)						
$\Delta \ln POS_{t-2}$		-.26 (-2.26)						
$\Delta \ln POS_{t-3}$								
$\Delta \ln POS_{t-4}$								
$\Delta \ln POS_{t-5}$								
$\Delta \ln POS_{t-6}$								
$\Delta \ln NEG_t$		.03 (.96)		-.20 (-4.10)		-.15 (-4.35)		-.21 (-3.83)
$\Delta \ln NEG_{t-1}$				-.12 (-2.60)		-.06 (-1.82)		.04 (.79)
$\Delta \ln NEG_{t-2}$								0.10 (1.88)
$\Delta \ln NEG_{t-3}$								.07 (1.39)
$\Delta \ln NEG_{t-4}$								
$\Delta \ln NEG_{t-5}$								
$\Delta \ln NEG_{t-6}$								

(Continued)

Table 1. (Continued).

	Alaska		Alabama		Arkansas		Arizona	
	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL
Panel B: Long-run estimates								
Constant	64.20 (.63)	6.10 (34.66)	2.61 (.33)	5.76 (43.52)	13.37 (1.31)	5.77 (24.49)	4.89 (.37)	5.84 (9.97)
$\Delta \ln I_t$	-3.24 (-.57)		.15 (.39)		-40 (-.77)		.06 (.09)	
$\Delta \ln M_t$	-1.97 (-.61)		-.001 (-.006)		-27 (-.74)		-.29 (-.42)	
$\Delta \ln S_t$		.40 (.99)		-1.45 (-2.22)		-.42 (-.30)		-4.10 (-1.84)
$\Delta \ln EG_t$		4.27 (9.98)		5.08 (4.26)		2.73 (2.34)		11.67 (2.49)
$\Delta \ln POS_t$		.61 (3.58)		.32 (2.15)		-.03 (-.13)		.23 (.32)
$\Delta \ln NEG_t$		.10 (1.00)		-.42 (-2.49)		-.31 (-.83)		-2.26 (-1.86)
Panel C: Diagnostic statistics								
F	1.70	4.20	1.43	2.96	1.64	2.25	3.61	6.13
ECM_{t-1}	-.02 (-2.27)	-.27 (-4.64)	-0.04 (-2.09)	-.11 (-3.91)	-.02 (-2.24)	-.04 (-3.40)	-.02 (-3.32)	-.04 (-5.63)
LM	5.07	2.63	1.32	3.61	4.09	6.20	3.52	3.83
QS (QS ²)	S (U)	S (U)	S (S)	S (S)	S (S)	S (S)	S (S)	S (S)
Adjusted R ²	.20	.30	.39	.49	.32	.42	.59	.63
Panel A: Short-run								
California			Colorado			Connecticut		
Linear ARDL			Linear ARDL			Linear ARDL		
Nonlinear ARDL			Nonlinear ARDL			Nonlinear ARDL		
$\Delta \ln I_t$	.009 (.50)		.25 (2.87)		.35 (3.30)		.009 (.49)	
$\Delta \ln I_{t-1}$			-.14 (-1.51)					
$\Delta \ln I_{t-2}$			-.02 (-.29)					
$\Delta \ln I_{t-3}$			.02 (.30)					
$\Delta \ln I_{t-4}$			.22 (2.41)					
$\Delta \ln I_{t-5}$			.05 (.56)					
$\Delta \ln I_{t-6}$			.15 (1.74)					
$\Delta \ln I_{t-7}$			-.20 (-2.10)					
$\Delta \ln M_t$	-.06 (-2.8)		-.05 (-3.02)		-.10 (-4.38)		-.10 (-2.88)	
$\Delta \ln M_{t-1}$	.05 (2.32)		.009 (.48)		-.03 (-1.67)		.01 (.49)	
$\Delta \ln M_{t-2}$			.04 (2.56)		.02 (.83)		-.05 (-1.62)	
$\Delta \ln M_{t-3}$					-.01 (-.79)		.08 (2.48)	
$\Delta \ln M_{t-4}$					-.02 (-.98)		-.09 (-2.70)	
$\Delta \ln M_{t-5}$					-.06 (-2.47)		.05 (1.36)	
$\Delta \ln M_{t-6}$								
$\Delta \ln M_{t-7}$								
$\Delta \ln POS_t$		.39 (2.38)		.35 (3.11)		.57 (3.46)		.04 (.44)
$\Delta \ln POS_{t-1}$		.43 (2.52)		.01 (.12)				
$\Delta \ln POS_{t-2}$				.001 (.01)				
$\Delta \ln POS_{t-3}$				-.04 (-.37)				
$\Delta \ln POS_{t-4}$				.18 (1.65)				
$\Delta \ln POS_{t-5}$				.17 (1.56)				
$\Delta \ln POS_{t-6}$				.22 (2.07)				
$\Delta \ln POS_{t-7}$				-.20 (-1.85)				
$\Delta \ln EG_t$		-.14 (-.49)		-.08 (-.40)		.12 (1.35)		.46 (1.08)
$\Delta \ln EG_{t-1}$		-1.07 (-3.71)		-.48 (-2.16)				.21 (.49)
$\Delta \ln EG_{t-2}$		-.77 (-2.68)						-.66 (-1.61)
$\Delta \ln EG_{t-3}$		-.43 (-1.41)						.13 (.33)
$\Delta \ln EG_{t-4}$		-.64 (-2.15)						.01 (.04)
$\Delta \ln EG_{t-5}$								-.94 (-2.34)

(Continued)

Table 1. (Continued).

	California		Colorado		Connecticut		Delaware	
	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL
ΔINEG_{t-6}								.92 (2.32)
ΔINEG_{t-7}								.81 (1.95)
ΔMPOS_t								-.10 (-1.70)
ΔMPOS_{t-1}		-.04 (-1.11)						
ΔMPOS_{t-2}		.09 (2.24)						
ΔMPOS_{t-3}		-.01 (-.28)						
ΔMPOS_{t-4}		.08 (2.20)						
ΔMPOS_{t-5}		.10 (2.52)						
ΔMPOS_{t-6}		.05 (1.21)						
ΔMPOS_{t-7}		.07 (1.68)						
ΔMNEG_t		-.19 (-4.57)						
ΔMNEG_{t-1}		.03 (.66)						
ΔMNEG_{t-2}		-.005 (-.10)						
ΔMNEG_{t-3}		-.03 (-.86)						
ΔMNEG_{t-4}		-.08 (-1.86)						
ΔMNEG_{t-5}		-.11 (-2.60)						
ΔMNEG_{t-6}		-.01 (-.29)						
ΔMNEG_{t-7}		-.09 (-2.49)						
Panel B: Long-run estimates								
Constant	-1.57 (-.10)	5.08 (8.08)	-6.84 (-1.11)	5.12 (27.18)	.34 (.05)	5.55 (28.59)	3.32 (.53)	5.85 (21.35)
$\text{Ln}I_t$	.38 (.55)		.65 (2.20)		.29 (.93)		.17 (.53)	
$\text{Ln}M_t$	-.30 (-.64)		.04 (.14)		-.04 (-.20)		-.23 (-.90)	
IPOS_t		1.94 (.80)		1.49 (2.76)				.74 (.48)
INEG_t		13.26 (2.28)		-1.08 (-.63)				1.16 (.30)
MPOS_t		-2.22 (-1.54)		-.24 (-.81)				-.34 (-.88)
MNEG_t		-1.61 (-1.47)		.30 (1.34)				-.17 (-.29)
Panel C: Diagnostic statistics								
F	4.25	4.93	3.37	2.50	6.11	2.74	3.58	2.17
ECM_{t-1}	-.02 (-3.60)	-.02 (-5.06)	-.02 (-3.20)	-.04 (-3.59)	-.03 (-4.31)	-.03 (-3.69)	-.05 (-3.30)	-.05 (-3.35)
LM	1.75	4.18	3.00	6.01	14.91	3.96	2.03	3.13
QS (QS ²)	S (S)	S (S)	S (S)	S (S)	S (S)	S (S)	S (U)	S (S)
Adjusted R ²	.75	.80	.49	.56	.61	.55	.44	.46
	Florida		Georgia		Hawaii		Iowa	
	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL
Panel A: Short-run								
$\Delta \text{Ln}I_t$	.22 (1.65)		.21 (2.13)		3.86 (7.86)		.06 (.69)	
$\Delta \text{Ln}I_{t-1}$					.19 (.33)		.18 (1.83)	
$\Delta \text{Ln}I_{t-2}$					-.57 (-.94)		-.04 (-.40)	
$\Delta \text{Ln}I_{t-3}$					-.41 (-.73)		.17 (1.89)	
$\Delta \text{Ln}I_{t-4}$					.86 (1.56)		.11 (1.22)	
$\Delta \text{Ln}I_{t-5}$					.62 (1.11)		.28 (3.02)	
$\Delta \text{Ln}I_{t-6}$					1.48 (2.69)		-.20 (-2.09)	
$\Delta \text{Ln}I_{t-7}$								
$\Delta \text{Ln}M_t$	-.12 (-5.25)		-.06 (-3.83)		-.009 (-.09)		-.10 (-3.46)	
$\Delta \text{Ln}M_{t-1}$					-.09 (-.97)			
$\Delta \text{Ln}M_{t-2}$					.05 (.57)			
$\Delta \text{Ln}M_{t-3}$					.01 (.14)			

(Continued)

Table 1. (Continued).

	Florida		Georgia		Hawaii		Iowa	
	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL
$\Delta \ln M_{t-4}$								
$\Delta \ln M_{t-5}$								
$\Delta \ln M_{t-6}$								
$\Delta \ln M_{t-7}$								
ΔIPOS_t		.47 (2.72)		.19 (1.46)		1.19 (1.83)		.05 (.36)
ΔIPOS_{t-1}		.04 (.27)				.90 (1.40)		.30 (2.09)
ΔIPOS_{t-2}		.53 (3.23)				.76 (1.23)		-.55 (-3.74)
ΔIPOS_{t-3}		-.20 (-1.29)				.78 (1.28)		
ΔIPOS_{t-4}						1.32 (2.15)		
ΔIPOS_{t-5}								
ΔIPOS_{t-6}								
ΔIPOS_{t-7}								
ΔINEG_t		-.20 (-.64)		.19 (2.21)		7.39 (6.77)		.14 (.74)
ΔINEG_{t-1}		-.37 (-1.22)				-3.31 (-2.57)		-.11 (-.59)
ΔINEG_{t-2}		-1.34 (-4.08)				-6.10 (-4.70)		.75 (3.90)
ΔINEG_{t-3}						-1.62 (-1.22)		.22 (1.17)
ΔINEG_{t-4}						-.96 (-.74)		.31 (1.65)
ΔINEG_{t-5}						1.07 (.89)		.64 (3.37)
ΔINEG_{t-6}						4.81 (4.40)		-1.16 (-5.91)
ΔINEG_{t-7}						-4.11 (-4.31)		
ΔMPOS_t		-.11 (-2.68)		-.0004 (-.04)		-.07 (-1.29)		-.03 (-1.48)
ΔMPOS_{t-1}		.001 (.02)						
ΔMPOS_{t-2}		.01 (.28)						
ΔMPOS_{t-3}		.08 (1.95)						
ΔMPOS_{t-4}		.07 (1.78)						
ΔMPOS_{t-5}		.06 (1.26)						
ΔMPOS_{t-6}		.07 (1.70)						
ΔMPOS_{t-7}								
ΔMNEG_t		-.18 (-4.13)		-.15 (-5.33)		.17 (1.33)		-.12 (-2.57)
ΔMNEG_{t-1}		-.006 (-.14)		.04 (1.36)		-.10 (-.81)		
ΔMNEG_{t-2}		.06 (1.33)				.07 (.53)		
ΔMNEG_{t-3}		-.02 (-.49)				.01 (.10)		
ΔMNEG_{t-4}		-.02 (-.46)				.14 (1.11)		
ΔMNEG_{t-5}		-.16 (-3.45)				.60 (4.61)		
ΔMNEG_{t-6}								
ΔMNEG_{t-7}								
Panel B: Long-run estimates								
Constant	12.99 (1.68)			5.69 (44.16)		5.31 (70.34)	19.98 (.88)	5.87 (7.15)
$\text{Ln} I_t$	-.30 (-.87)		8.90 (1.60)		-1.56 (-.11)		-.73 (-.63)	
$\text{Ln} M_t$	-.59 (-1.67)		-.14 (-.54)		.46 (.64)		-.53 (-.89)	
IPOS_t		.54 (.40)	-.26 (-1.06)		-.49 (-1.07)			
INEG_t		1.09 (.51)		-1.02 (-1.69)		2.47 (5.66)		.48 (.11)
MPOS_t		-.91 (-2.00)		3.54 (2.53)		2.80 (2.05)		-2.54 (-.28)
MNEG_t		-.51 (-1.26)		-.008 (-.04)		-.29 (-1.15)		-1.95 (-.49)
				-.57 (-2.09)		.03 (.23)		-.85 (-.41)

(Continued)



Table 1. (Continued).

	Florida		Georgia		Hawaii		Iowa	
	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL
Panel C: Diagnostic statistics								
F	5.96	7.06	5.21	3.51	4.80	5.68	2.86	1.28
ECM _{t-1}	-0.02 (-4.25)	-0.04 (-5.99)	-0.04 (-3.98)	-0.05 (-4.25)	-0.11 (-3.82)	-0.25 (-5.38)	-0.03 (-2.93)	-0.01 (-2.55)
LM	3.28	1.52	5.46	9.62	6.74	.97	5.89	15.97
QS (QS ²)	S (S)	S (S)	S (S)	S (S)	S (S)	S (S)	S (U)	S (S)
Adjusted R ²	.58	.67	.43	.48	.51	.71	.38	.52
Panel A: Short-run								
$\Delta \ln I_t$								
$\Delta \ln I_{t-1}$	.03 (1.47)		.19 (1.81)		.18 (2.52)		.03 (.59)	
$\Delta \ln I_{t-2}$			-.11 (-1.04)		.12 (1.66)		.01 (.25)	
$\Delta \ln I_{t-3}$			.12 (1.18)				-.02 (-.41)	
$\Delta \ln I_{t-4}$			-.19 (-1.91)				.16 (2.43)	
$\Delta \ln I_{t-5}$			-.16 (-1.55)				.10 (1.62)	
$\Delta \ln I_{t-6}$			-.18 (-1.79)					
$\Delta \ln I_{t-7}$			-.09 (-.87)					
$\Delta \ln M_t$			-.24 (-2.20)		-.09 (-6.22)		-.05 (-3.49)	
$\Delta \ln M_{t-1}$			-.03 (-2.13)				-.02 (-1.44)	
$\Delta \ln M_{t-2}$			.03 (2.02)				.04 (2.96)	
$\Delta \ln M_{t-3}$			.0007 (.03)				-.02 (-1.23)	
$\Delta \ln M_{t-4}$			-.01 (-.83)				-.002 (-.15)	
$\Delta \ln M_{t-5}$			-.03 (-1.71)				-.03 (-2.13)	
$\Delta \ln M_{t-6}$			-.01 (-1.00)				.05 (3.08)	
$\Delta \ln M_{t-7}$			.01 (1.01)					
$\Delta \ln M_{t-8}$			.03 (1.74)					
$\Delta \ln POS_t$		.52 (2.46)		.05 (1.12)		.05 (1.82)		-.004 (-.10)
$\Delta \ln POS_{t-1}$		.41 (1.98)						
$\Delta \ln POS_{t-2}$		.10 (.49)						
$\Delta \ln POS_{t-3}$		.25 (1.21)						
$\Delta \ln POS_{t-4}$		.02 (.10)						
$\Delta \ln POS_{t-5}$		-.04 (-.20)						
$\Delta \ln POS_{t-6}$		.59 (2.94)						
$\Delta \ln POS_{t-7}$								
$\Delta \ln NEG_t$		-.08 (-.20)				.51 (3.86)		.11 (2.01)
$\Delta \ln NEG_{t-1}$		-.73 (-1.87)		.29 (1.28)				
$\Delta \ln NEG_{t-2}$		.04 (.10)		-.15 (-.70)				
$\Delta \ln NEG_{t-3}$		-.15 (-3.73)		.60 (2.99)				
$\Delta \ln NEG_{t-4}$		.14 (.36)		-.29 (-1.52)				
$\Delta \ln NEG_{t-5}$		.39 (1.02)		-.39 (-2.06)				
$\Delta \ln NEG_{t-6}$		-.10 (-2.67)		-.44 (-2.32)				
$\Delta \ln NEG_{t-7}$		1.56 (4.21)						
$\Delta \ln POS_t$		.01 (.14)		.004 (.30)		-.03 (-1.52)		-.008 (-.92)
$\Delta \ln POS_{t-1}$		-.15 (-2.19)						
$\Delta \ln POS_{t-2}$		-.11 (-1.62)						
$\Delta \ln POS_{t-3}$								
$\Delta \ln POS_{t-4}$								
$\Delta \ln POS_{t-5}$								
$\Delta \ln POS_{t-6}$								

(Continued)

Table 1. (Continued).

	Idaho		Illinois		Indiana		Kansas	
	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL
$\Delta MNEG_t$		-.31 (-4.32)		-.10 (-3.31)		-.15 (-5.77)		-.11 (-3.93)
$\Delta MNEG_{t-1}$		-.04 (-.64)		.03 (.89)				-.02 (-.90)
$\Delta MNEG_{t-2}$		.01 (.22)		-.03 (-1.04)				.07 (2.61)
$\Delta MNEG_{t-3}$		-.04 (-.58)		-.03 (-.99)				
$\Delta MNEG_{t-4}$		.02 (.32)		-.08 (-2.65)				
$\Delta MNEG_{t-5}$		-.15 (-2.20)		-.07 (-2.32)				
$\Delta MNEG_{t-6}$		-.02 (-.35)						
$\Delta MNEG_{t-7}$		-.19 (-2.82)						
Panel B: Long-run estimates								
Constant	-2.22 (-.49)	5.35 (36.97)	-5.59 (-.92)	5.31 (18.34)	18.31 (.54)	5.69 (92.57)	14.85 (1.27)	5.82 (23.34)
LnI_t	.43 (1.84)		.56 (1.97)		-.64 (-.38)		-.47 (-.79)	
LnM_t	.11 (.56)		.003 (.02)		-.37 (-.42)		-.38 (-1.04)	
$IPOS_t$		.01 (.02)		1.12 (1.08)		.63 (2.01)		-.14 (-.10)
$INEG_t$		5.05 (3.23)		1.50 (.59)		3.09 (5.25)		3.57 (2.31)
$MPOS_t$		.59 (1.69)		.09 (.30)		-.03 (-.34)		-.25 (-.96)
$MNEG_t$		-.04 (-.24)		.14 (.36)		-.11 (-1.32)		-.46 (-1.32)
Panel C: Diagnostic statistics								
F	5.06	3.89	8.17	2.78	.52	4.39	2.35	2.73
ECM_{t-1}	-.08 (-3.90)	-.11 (-4.49)	-.06 (-4.99)	-.04 (-3.80)	-.009 (-1.26)	-.07 (-4.68)	-.01 (-2.67)	-.03 (-3.71)
LM	9.76	7.12	36.81	25.61	6.59	5.73	1.28	3.99
QS (QS^2)	U (S)	S (S)	S (S)	S (S)	S (S)	S (S)	S (S)	S (S)
Adjusted R^2	.43	.60	.53	.59	.43	.51	.39	.36
	Kentucky		Louisiana		Massachusetts		Maryland	
	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL
Panel A: Short-run								
ΔLnI_t	.32 (4.07)		.27 (3.00)		.22 (2.52)		.23 (1.67)	
ΔLnI_{t-1}	-.07 (-.77)		.13 (1.41)				.21 (1.50)	
ΔLnI_{t-2}	-.14 (-1.64)		-.05 (-.52)					
ΔLnI_{t-3}	-.09 (-1.15)		.01 (.21)					
ΔLnI_{t-4}	-.11 (-1.42)		.12 (1.42)					
ΔLnI_{t-5}	.17 (2.13)		.07 (.82)					
ΔLnI_{t-6}	.09 (1.09)		.21 (2.35)					
ΔLnI_{t-7}	-.20 (-2.52)		.23 (2.56)		-.07 (-4.56)		-.08 (-4.09)	
ΔLnM_t	-.06 (-4.34)		-.05 (-.45)					
ΔLnM_{t-1}			-.008 (-1.20)					
ΔLnM_{t-2}			.05 (2.87)					
ΔLnM_{t-3}			.01 (.59)					
ΔLnM_{t-4}			.004 (.27)					
ΔLnM_{t-5}			-.02 (-1.42)					
ΔLnM_{t-6}			.004 (.28)					
ΔLnM_{t-7}			.03 (2.26)					
$\Delta IPOS_t$		.20 (1.83)		.09 (.83)		.40 (2.92)		.09 (.52)
$\Delta IPOS_{t-1}$				.12 (.91)				.54 (2.99)
$\Delta IPOS_{t-2}$				-.05 (-.42)				
$\Delta IPOS_{t-3}$				-.24 (-1.95)				
$\Delta IPOS_{t-4}$				.03 (.30)				
$\Delta IPOS_{t-5}$				-.0003 (-.002)				
$\Delta IPOS_{t-6}$				.18 (1.57)				
$\Delta IPOS_{t-7}$				.24 (2.03)				

(Continued)

Table 1. (Continued).

	Kentucky		Louisiana		Massachusetts		Maryland	
	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL
$\Delta INEG_t$		.95 (5.23)		.81 (3.29)		-.08 (-.34)		.82 (2.11)
$\Delta INEG_{t-1}$		-.63 (-3.18)		-.31 (-1.33)		-.50 (-2.27)		-.81 (-2.14)
$\Delta INEG_{t-2}$		-.69 (-3.64)		-.41 (-1.58)				-.76 (-1.95)
$\Delta INEG_{t-3}$		.02 (1.1)						-.43 (-1.19)
$\Delta INEG_{t-4}$		-.42 (-2.24)						-.76 (-2.03)
$\Delta INEG_{t-5}$		.30 (1.72)						
$\Delta INEG_{t-6}$		.15 (.87)						
$\Delta INEG_{t-7}$		-.76 (-4.20)						
$\Delta MPOS_t$		.0002 (.009)		-.01 (-.40)		-.07 (-2.33)		-.09 (-2.60)
$\Delta MPOS_{t-1}$		-.02 (-1.00)		-.01 (-.64)				
$\Delta MPOS_{t-2}$		-.05 (-2.24)		.03 (1.31)				
$\Delta MPOS_{t-3}$				.02 (.71)				
$\Delta MPOS_{t-4}$				.05 (1.97)				
$\Delta MPOS_{t-5}$				-.02 (-.74)				
$\Delta MPOS_{t-6}$				-.002 (-.07)				
$\Delta MPOS_{t-7}$				.08 (3.28)		-.08 (-2.66)		
$\Delta MNEG_t$		-.10 (-4.13)		-.10 (-3.21)				-.08 (-2.22)
$\Delta MNEG_{t-1}$		-.009 (-.35)		.04 (1.30)				-.05 (-1.47)
$\Delta MNEG_{t-2}$		.04 (1.70)		.09 (2.81)				-.03 (-.98)
$\Delta MNEG_{t-3}$		-.04 (-1.68)		.04 (1.42)				-.05 (-1.41)
$\Delta MNEG_{t-4}$		.03 (1.41)						-.02 (-.68)
$\Delta MNEG_{t-5}$								-.09 (-2.80)
$\Delta MNEG_{t-6}$								
Panel B: Long-run estimates								
Constant	-3.05 (-.55)	5.74 (69.70)	208.8 (.19)	5.86 (14.81)	-7.56 (-.93)	5.65 (35.24)	13.24 (1.24)	5.56 (48.61)
LnI_t	.45 (1.63)		-10.29 (-.19)		.71 (1.82)		-.31 (-.61)	
$LnMt$	.07 (.46)		-6.27 (-.20)		-.07 (-.30)		-.72 (-1.80)	
$IPOS_t$		.01 (.06)		1.47 (1.41)		1.45 (.97)		-.02 (-.02)
$INEG_t$		3.57 (9.10)		8.22 (3.68)		-.31 (-.06)		3.41 (1.07)
$MPOS_t$		.12 (1.90)		-1.29 (-2.09)		-.24 (-.57)		-.34 (-1.11)
$MNEG_t$		-.12 (-1.88)		-.98 (-1.58)		.10 (.19)		-.48 (-1.98)
Panel C: Diagnostic statistics								
F	2.01	3.27	3.88	4.88	5.52	3.40	5.60	5.69
ECM_{t-1}	-.04 (-2.48)	-.16 (-4.12)	-.003 (-3.44)	-.04 (-5.04)	-.02 (-3.95)	-.02 (-4.07)	-.02 (-4.08)	-.04 (-5.42)
LM	4.99	5.07	9.89	2.91	11.96	6.38	5.01	1.13
QS (QS^2)	S (S)	S (S)	S (S)	S (S)	S (S)	S (S)	S (S)	S (S)
Adjusted R^2	.41	.58	.50	.58	.70	.72	.55	.61
			Maine		Michigan		Minnesota	
			Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL
Panel A: Short-run								
ΔLnI_t								
ΔLnI_{t-1}	.55 (2.04)		.07 (1.97)		.01 (.94)		.25 (3.14)	
ΔLnI_{t-2}								
ΔLnI_{t-3}								
ΔLnI_{t-4}								
ΔLnI_{t-5}								
ΔLnI_{t-6}								
ΔLnI_{t-7}								

(Continued)

Table 1. (Continued).

	Maine		Michigan		Minnesota		Missouri	
	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL
$\Delta \ln M_t$	-.11 (-2.22)							
$\Delta \ln M_{t-1}$	-.04 (-.78)		-.01 (-.68)		-.07 (-3.63)		-.03 (-2.66)	
$\Delta \ln M_{t-2}$	-.10 (-2.04)		-.03 (-1.15)					
$\Delta \ln M_{t-3}$	.01 (.22)		.02 (.97)					
$\Delta \ln M_{t-4}$	-.005 (-.10)		-.02 (-1.07)					
$\Delta \ln M_{t-5}$	-.06 (-1.15)		-.06 (-2.35)					
$\Delta \ln M_{t-6}$	.04 (.84)		-.05 (-2.04)					
$\Delta \ln M_{t-7}$	-.15 (-2.92)							
ΔPOS_t		.06 (.91)		.14 (2.60)		.02 (.46)		.29 (2.72)
ΔPOS_{t-1}								
ΔPOS_{t-2}								
ΔPOS_{t-3}								
ΔPOS_{t-4}								
ΔPOS_{t-5}								
ΔPOS_{t-6}								
ΔPOS_{t-7}								
ΔNEG_t		1.95 (3.10)		.30 (1.25)		.10 (.86)		.10 (2.03)
ΔNEG_{t-1}		-.10 (-.16)		-.14 (-.62)				
ΔNEG_{t-2}		-1.65 (-2.70)		-.23 (-.95)				
ΔNEG_{t-3}				.28 (1.15)				
ΔNEG_{t-4}				-.31 (-1.42)				
ΔNEG_{t-5}				-.45 (-2.10)				
ΔNEG_{t-6}				-.55 (-2.65)				
ΔNEG_{t-7}								
ΔMPOS_t		-.19 (-2.12)		-.02 (-.43)		-.001 (-.07)		.01 (1.09)
ΔMPOS_{t-1}				.11 (2.47)				
ΔMPOS_{t-2}				.09 (2.37)				
ΔMPOS_{t-3}				.06 (1.62)				
ΔMPOS_{t-4}								
ΔMPOS_{t-5}								
ΔMPOS_{t-6}								
ΔMPOS_{t-7}								
ΔMNEG_t		-.13 (-1.41)		-.09 (-2.02)		-.14 (-3.99)		-.08 (-3.70)
ΔMNEG_{t-1}		-.01 (-.16)		-.10 (-2.09)				
ΔMNEG_{t-2}		-.18 (-2.24)						
ΔMNEG_{t-3}		-.03 (-.38)						
ΔMNEG_{t-4}		-.13 (-1.57)						
ΔMNEG_{t-5}		-.14 (-1.71)						
ΔMNEG_{t-6}		.02 (.25)						
ΔMNEG_{t-7}		-.28 (-3.49)						
Panel B: Long-run estimates								
Constant	-6.12 (-.63)	5.84 (23.68)	-22.29 (-2.54)	5.91 (36.29)	-1.61 (-.21)	5.39 (25.84)	-5.73 (-.66)	5.52 (25.93)
$\text{Ln} l_t$	.67 (1.31)		1.39 (3.21)		.38 (1.06)		.57 (1.33)	
$\text{Ln} M_t$	.07 (.25)		.29 (1.86)		-.06 (-.25)		.19 (.90)	
IPOS_t		.65 (1.01)		1.12 (2.71)		.65 (.46)		-1.16 (-.85)
INEG_t		12.52 (3.40)		6.14 (8.56)		2.87 (.93)		2.99 (2.28)
MPOS_t		.09 (.36)		-.40 (-1.83)		-.03 (-.07)		.34 (1.14)
MNEG_t		-.76 (-2.12)		-.72 (-3.67)		-.12 (-.28)		-.25 (-.80)

(Continued)



Table 1. (Continued).

	Maine		Michigan		Minnesota		Missouri	
	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL
Panel C: Diagnostic statistics								
F	2.65	4.15		11.63	3.49	2.42	3.04	2.71
ECM _{t-1}	-0.06 (-2.84)	-0.09 (-4.60)	4.08	-0.12 (-7.75)	-0.02 (-3.24)	-0.03 (-3.51)	-0.03 (-2.95)	-0.04 (-3.61)
LM	8.32	1.52	7.42	5.52	6.39	6.36	9.19	8.08
QS (QS ²)	S (U)	S (U)	S (S)	S (S)	S (S)	S (S)	S (S)	S (S)
Adjusted R ²	.38	.69	.39	.47	.44	.45	.54	.56
Panel A: Short-run								
Mississippi								
$\Delta \ln I_t$	.48 (2.56)							
$\Delta \ln I_{t-1}$	.03 (.17)		.66 (5.12)		.23 (3.04)		.08 (.98)	
$\Delta \ln I_{t-2}$	-0.22 (-1.16)		-0.14 (-.95)				.01 (.12)	
$\Delta \ln I_{t-3}$	.37 (1.89)		.33 (2.25)				.20 (2.28)	
$\Delta \ln I_{t-4}$	-0.05 (-.29)		.12 (.80)					
$\Delta \ln I_{t-5}$	-0.34 (-1.89)		.34 (2.33)					
$\Delta \ln I_{t-6}$	.28 (1.54)		.18 (1.19)					
$\Delta \ln I_{t-7}$	.71 (3.87)		.24 (1.72)					
$\Delta \ln M_t$	-0.04 (-1.25)		-0.21 (-1.50)					
$\Delta \ln M_{t-1}$	-0.09 (-2.60)		-0.05 (-1.14)		-0.05 (-3.82)		-0.04 (-.69)	
$\Delta \ln M_{t-2}$	.06 (1.67)		-0.006 (-.14)				.11 (1.71)	
$\Delta \ln M_{t-3}$	-0.09 (-2.50)		.04 (1.00)				-0.01 (-.02)	
$\Delta \ln M_{t-4}$			.05 (1.20)				-0.04 (-.68)	
$\Delta \ln M_{t-5}$			-0.11 (-2.44)				-0.15 (-2.43)	
$\Delta \ln M_{t-6}$								
$\Delta \ln M_{t-7}$								
ΔIPOS_t		.28 (2.50)		.55 (3.32)		.22 (2.12)		.08 (1.47)
ΔIPOS_{t-1}				-0.46 (-2.26)		.03 (.35)		
ΔIPOS_{t-2}				.63 (3.19)		.19 (2.02)		
ΔIPOS_{t-3}				.07 (.38)				
ΔIPOS_{t-4}				.31 (1.65)				
ΔIPOS_{t-5}				.55 (3.03)				
ΔIPOS_{t-6}				-0.22 (-1.20)				
ΔIPOS_{t-7}				-0.51 (-2.98)				
ΔINEG_t		1.00 (2.90)		.56 (2.39)		.30 (1.49)		.20 (1.37)
ΔINEG_{t-1}		.49 (1.26)		.39 (1.69)		-0.46 (-2.27)		-0.44 (-2.92)
ΔINEG_{t-2}		-0.67 (-1.73)		-0.56 (-2.42)				.32 (2.13)
ΔINEG_{t-3}		.75 (1.94)		-0.35 (-1.46)				-0.44 (-3.13)
ΔINEG_{t-4}		.04 (.11)		.17 (.71)				-0.22 (-1.55)
ΔINEG_{t-5}		-0.29 (-.77)		-1.08 (-4.75)				-0.34 (-2.40)
ΔINEG_{t-6}		1.22 (3.15)		.92 (4.05)				-0.29 (-2.03)
ΔINEG_{t-7}		1.83 (4.55)						.42 (2.67)
ΔMPOS_t		-0.12 (-1.67)		.01 (.21)		.01 (1.55)		.04 (.87)
ΔMPOS_{t-1}		-0.03 (-.54)		-0.14 (-1.91)				
ΔMPOS_{t-2}		.09 (1.52)		-0.14 (-1.87)				
ΔMPOS_{t-3}		-0.06 (-.92)						
ΔMPOS_{t-4}		-0.009 (-.14)						
ΔMPOS_{t-5}		.02 (.39)						

(Continued)

Table 1. (Continued).

	Mississippi		Montana		North Carolina		North Dakota	
	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL
ΔMPOS_{t-6}		.17 (2.65)						
ΔMPOS_{t-7}		.05 (.79)						
ΔMNEG_t		-.12 (-1.65)						
ΔMNEG_{t-1}		.06 (.90)						
ΔMNEG_{t-2}		-.11 (-1.55)						
ΔMNEG_{t-3}		.10 (1.37)						
ΔMNEG_{t-4}		-.10 (-1.48)						
ΔMNEG_{t-5}								
ΔMNEG_{t-6}								
ΔMNEG_{t-7}								
Panel B: Long-run estimates								
Constant	-17.93 (-1.74)	4.28 (5.32)	-11.69 (-1.29)	5.40 (46.68)	-.33 (-.14)	5.38 (58.91)	.23 (.26)	5.76 (62.29)
$\text{Ln}I_t$	1.21 (2.28)		.98 (1.99)		.30 (2.70)		-.63 (-.66)	
$\text{Ln}M_t$	.67 (2.22)		.16 (.52)		.07 (.71)		-.074 (-0.81)	
IPOS_t		6.34 (1.28)		-.003 (-.002)		.005 (.01)		.29 (1.38)
INEG_t		-4.91 (-.86)		2.03 (5.03)		2.59 (1.59)		1.13 (8.97)
MPOS_t		-.45 (-.45)		.76 (1.97)		.22 (1.56)		.16 (.96)
MNEG_t		1.70 (1.42)		.11 (.61)		-.03 (-.24)		-.13 (-1.75)
Panel C: Diagnostic statistics								
F	2.47	1.91	2.16	3.97	5.25	3.98	2.13	4.45
ECM_{t-1}	-.06 (-2.74)	-.04 (-3.14)	-.06 (-2.56)	-.05 (-3.99)	-.004 (-3.22)	-.06 (-4.51)	-.03 (-2.47)	-.28 (-4.79)
LM	9.32	9.84	14.25	1.92	1.62	12.12	9.10	3.55
QS ($Q5^2$)	S (S)	S (S)	S (S)	S (S)	S (S)	S (S)	S (U)	S (U)
Adjusted R^2	.46	.54	.49	.48	0.46	.52	.22	.30
Panel A: Short-run								
$\Delta\text{Ln}I_t$								
$\Delta\text{Ln}I_{t-1}$	-.08 (-1.19)		.30 (2.53)		.18 (1.91)		.01 (.67)	
$\Delta\text{Ln}I_{t-2}$	.17 (2.53)		.16 (1.38)					
$\Delta\text{Ln}I_{t-3}$	-.07 (-1.00)							
$\Delta\text{Ln}I_{t-4}$	.10 (1.51)							
$\Delta\text{Ln}I_{t-5}$	-.03 (-.48)							
$\Delta\text{Ln}I_{t-6}$	.26 (3.63)							
$\Delta\text{Ln}I_{t-7}$	.14 (1.81)							
$\Delta\text{Ln}M_t$								
$\Delta\text{Ln}M_{t-1}$	-.06 (-3.01)		-.05 (-2.25)		-.05 (-3.32)		-.02 (-1.03)	
$\Delta\text{Ln}M_{t-2}$			-.07 (-2.58)				-.02 (-.94)	
$\Delta\text{Ln}M_{t-3}$			.03 (1.23)				.09 (3.46)	
$\Delta\text{Ln}M_{t-4}$			-.03 (-1.41)					
$\Delta\text{Ln}M_{t-5}$			.05 (2.14)					
$\Delta\text{Ln}M_{t-6}$			-.07 (-2.92)					
$\Delta\text{Ln}M_{t-7}$								
ΔIPOS_t								
ΔIPOS_{t-1}		-.002 (-.04)		.30 (1.92)		.34 (2.53)		.26 (3.57)
ΔIPOS_{t-2}								
ΔIPOS_{t-3}								
ΔIPOS_{t-4}								
ΔIPOS_{t-5}								

(Continued)



Table 1. (Continued).

	Nebraska		New Hampshire		New Jersey		New Mexico	
	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL
ΔIPOS_{t-6}								
ΔIPOS_{t-7}								
ΔINEG_t								
ΔINEG_{t-1}								
ΔINEG_{t-2}								
ΔINEG_{t-3}								
ΔINEG_{t-4}								
ΔINEG_{t-5}								
ΔINEG_{t-6}								
ΔINEG_{t-7}								
ΔMPOS_t								
ΔMPOS_{t-1}								
ΔMPOS_{t-2}								
ΔMPOS_{t-3}								
ΔMPOS_{t-4}								
ΔMPOS_{t-5}								
ΔMPOS_{t-6}								
ΔMPOS_{t-7}								
ΔMNEG_t								
ΔMNEG_{t-1}								
ΔMNEG_{t-2}								
ΔMNEG_{t-3}								
ΔMNEG_{t-4}								
ΔMNEG_{t-5}								
ΔMNEG_{t-6}								
ΔMNEG_{t-7}								
Panel B: Long-run estimates								
Constant	10.34 (.86)							
LnI_t	−24 (−39)	5.55 (13.13)	−9.25 (−.89)	4.86 (11.12)	3.40 (.30)	5.90 (19.50)	−62 (−.07)	5.72 (15.90)
LnM_t	−27 (−68)		.81 (1.50)	−12 (−2.47)	.16 (.30)		.33 (.81)	
IPOS_t			.30 (.78)		−33 (−1.14)		.11 (.38)	
INEG_t								
MPOS_t								
MNEG_t								
Panel C: Diagnostic statistics								
F	2.16	.62	4.69	3.62	5.49	3.42	2.20	5.82
ECM_{t-1}	−02 (−2.56)	−02 (−1.77)	−03 (−3.78)	−04 (−4.31)	−02 (−4.07)	−02 (−4.16)	−04 (−2.59)	−07 (−5.48)
LM	16.80	7.66	5.80	6.10	2.62	4.37	19.52	22.79
QS (QS ²)	S (S)	S (S)	S (S)	S (S)	S (S)	S (S)	S (S)	S (S)
Adjusted R ²	.31	.40	.62	.63	.71	.71	.30	.42
			New York		Ohio		Oklahoma	
			Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL
Panel A: Short-run								
ΔLnI_t								
ΔLnI_{t-1}	.01 (.93)		.06 (2.38)		.22 (2.50)		.30 (3.78)	
ΔLnI_{t-2}							−.07 (−1.01)	
ΔLnI_{t-3}							.09 (1.35)	
ΔLnI_{t-4}							.19 (2.76)	
ΔLnI_{t-5}							.10 (1.44)	
							.09 (1.39)	

(Continued)

Table 1. (Continued).

	Nevada		New York		Ohio		Oklahoma	
	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL
$\Delta \ln I_{t-6}$							.13 (1.87)	
$\Delta \ln I_{t-7}$								
$\Delta \ln M_t$	-.06 (-1.90)							
$\Delta \ln M_{t-1}$			-.10 (-3.22)					
$\Delta \ln M_{t-2}$			-.001 (-.03)					
$\Delta \ln M_{t-3}$			-.02 (-.88)					
$\Delta \ln M_{t-4}$			.04 (1.36)					
$\Delta \ln M_{t-5}$			-.08 (-2.69)					
$\Delta \ln M_{t-6}$			.003 (.11)					
$\Delta \ln M_{t-7}$			-.08 (-2.39)					
ΔIPOS_t		.34 (1.56)		.02 (.21)		.06 (1.39)		.13 (1.21)
ΔIPOS_{t-1}		.43 (1.93)						-.008 (-.07)
ΔIPOS_{t-2}								.0008 (.008)
ΔIPOS_{t-3}								.15 (1.4)
ΔIPOS_{t-4}								.24 (2.22)
ΔIPOS_{t-5}								
ΔIPOS_{t-6}								
ΔIPOS_{t-7}								
ΔINEG_t		-.04 (-.56)		.05 (.55)		.52 (2.90)		.57 (3.04)
ΔINEG_{t-1}		-.10 (-.25)						-.29 (-1.82)
ΔINEG_{t-2}		-.10 (-.29)						.13 (.80)
ΔINEG_{t-3}		-.50 (-1.34)						-.004 (-.02)
ΔINEG_{t-4}		-.97 (-2.77)						-.38 (-2.53)
ΔINEG_{t-5}		.77 (2.16)						
ΔINEG_{t-6}		.95 (2.11)						
ΔINEG_{t-7}								
ΔMPOS_t		-.01 (-.35)		-.08 (-1.44)		-.001 (-.18)		.05 (1.54)
ΔMPOS_{t-1}								
ΔMPOS_{t-2}								
ΔMPOS_{t-3}								
ΔMPOS_{t-4}								
ΔMPOS_{t-5}								
ΔMPOS_{t-6}								
ΔMPOS_{t-7}								
ΔMNEG_t		-.18 (-2.99)		-.12 (-1.95)		-.12 (-4.83)		-.18 (-5.40)
ΔMNEG_{t-1}			.006 (.11)			-.04 (-1.38)		
ΔMNEG_{t-2}			-.005 (-.09)					
ΔMNEG_{t-3}			.06 (1.09)					
ΔMNEG_{t-4}			-.14 (-2.35)					
ΔMNEG_{t-5}			-.005 (-.09)					
ΔMNEG_{t-6}			-.14 (-2.40)					
ΔMNEG_{t-7}								
Panel B: Long-run estimates								
Constant	.64 (.14)	5.11 (13.22)	-13.10 (-2.13)	5.66 (49.09)	-9.68 (-.72)	5.53 (33.82)	9.64 (.60)	5.25 (42.68)
$\ln I_t$	.24 (1.12)		.93 (3.26)		.74 (1.13)		-.24 (-.29)	
$\ln M_t$	.22 (.76)		.05 (.31)		.22 (.85)		-.11 (-.22)	
IPOS_t		1.46 (1.37)		.33 (.21)		1.33 (1.48)		1.00 (2.08)
INEG_t		-2.90 (-1.00)		.83 (.58)		3.80 (3.06)		2.67 (3.48)
MPOS_t		-.25 (-.34)		.05 (.24)		-.04 (-.18)		-.02 (-.12)
MNEG_t		.77 (1.49)		-.12 (-.24)		-.03 (-.16)		.09 (.61)

(Continued)

	Nevada		New York		Ohio		Oklahoma	
	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL
Panel C: Diagnostic statistics								
F	5.75	4.16	8.31	4.62	1.18	1.86	2.23	4.12
ECM _{t-1}	-0.04 (-4.14)	-0.04 (-4.63)	-0.06 (-5.03)	-0.06 (-4.87)	-0.01 (-1.89)	-0.04 (-3.09)	-0.01 (-2.36)	-0.06 (-4.43)
LM	3.58	3.64	3.23	3.24	2.47	3.78	3.83	9.03
OS (QS ²)	S (S)	S (U)	S (U)	S (U)	S (S)	S (S)	S (S)	S (S)
Adjusted R ²	.57	.63	.40	.40	.49	.52	.41	.50
	Oregon		Pennsylvania		Rhode Island		South Carolina	
	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL
Panel A: Short-run								
ΔlnI _t	.46 (2.47)							
ΔlnI _{t-1}	-.19 (-1.04)		.006 (.40)		.05 (2.27)		.32 (3.22)	
ΔlnI _{t-2}	-.19 (-1.03)							
ΔlnI _{t-3}	-.30 (-1.61)							
ΔlnI _{t-4}	-.28 (-1.62)							
ΔlnI _{t-5}	.30 (1.74)							
ΔlnI _{t-6}	.38 (2.15)							
ΔlnI _{t-7}	-.30 (-1.69)							
ΔlnM _t	-.05 (-1.93)		-.07 (-5.45)		-.07 (-2.57)		-.07 (-4.14)	
ΔlnM _{t-1}	-.01 (-.43)				-.03 (-1.32)		-.01 (-.89)	
ΔlnM _{t-2}	.04 (1.54)				-.02 (-.89)		.03 (1.64)	
ΔlnM _{t-3}	.08 (2.85)				-.05 (-1.94)		.02 (1.36)	
ΔlnM _{t-4}	-.02 (-.99)						-.02 (-1.18)	
ΔlnM _{t-5}	.07 (2.45)						.03 (1.57)	
ΔlnM _{t-6}	-.05 (-1.97)						.04 (2.47)	
ΔlnM _{t-7}	.06 (2.04)							
ΔIPO _{5t}		.21 (.91)		.008 (.27)		.28 (1.10)		.07 (.56)
ΔIPO _{5t-1}	.56 (2.44)					-.03 (-.13)		.30 (2.23)
ΔIPO _{5t-2}	-.47 (-2.02)					.62 (2.51)		
ΔIPO _{5t-3}						-.17 (-.75)		
ΔIPO _{5t-4}						-.40 (-1.73)		
ΔIPO _{5t-5}								
ΔIPO _{5t-6}								
ΔIPO _{5t-7}								
ΔINEG _t		1.02 (2.07)		.01 (.29)		.49 (1.26)		.95 (3.70)
ΔINEG _{t-1}		-1.92 (-4.10)				.40 (1.07)		-.42 (-1.61)
ΔINEG _{t-2}		.40 (.72)				-1.28 (-3.21)		
ΔINEG _{t-3}		-.23 (-.50)						
ΔINEG _{t-4}		-1.26 (-3.21)						
ΔINEG _{t-5}		.91 (2.44)						
ΔINEG _{t-6}		1.31 (3.76)						
ΔINEG _{t-7}		-1.64 (-4.56)						
ΔMPOS _t		.004 (.09)		-.007 (-.66)		-.10 (-2.23)		-.01 (-.37)
ΔMPOS _{t-1}		-.02 (-.44)						-.02 (-1.10)
ΔMPOS _{t-2}		-.04 (-.81)						.03 (1.40)
ΔMPOS _{t-3}		.01 (.28)						.03 (1.27)
ΔMPOS _{t-4}		.05 (1.04)						-.02 (-.94)
ΔMPOS _{t-5}		.14 (3.12)						.05 (1.90)
ΔMPOS _{t-6}		-.04 (-.99)						.07 (2.51)
ΔMPOS _{t-7}		.06 (1.43)						

(Continued)

Table 1. (Continued).

	Oregon		Pennsylvania		Rhode Island		South Carolina	
	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL
$\Delta MNEG_t$		-.15 (-3.06)		-.13 (-5.68)		-.05 (-1.98)		-.13 (-3.97)
$\Delta MNEG_{t-1}$		.08 (1.57)						
$\Delta MNEG_{t-2}$		.05 (1.02)						
$\Delta MNEG_{t-3}$		.22 (4.24)						
$\Delta MNEG_{t-4}$		-.12 (-2.16)						
$\Delta MNEG_{t-5}$								
$\Delta MNEG_{t-6}$								
$\Delta MNEG_{t-7}$								
Panel B: Long-run estimates								
Constant	-5.53 (-4.1)	2.28 (5.47)	2.99 (.37)	5.59 (21.74)	-12.26 (-1.80)	5.87 (24.94)	8.34 (1.37)	5.52 (45.93)
LnI_t	.63 (.96)		.16 (.42)		1.03 (2.81)		-.11 (-.37)	
LnM_t	-.24 (-.51)		-.21 (-1.22)		.06 (.33)		-.32 (-1.27)	
$IPOS_t$		-.23 (-.10)		.22 (.28)		-.36 (-.23)		.22 (.43)
$INEG_t$		8.32 (.96)		.38 (.29)		10.68 (2.49)		3.04 (1.54)
$MPOS_t$		-1.10 (-.79)		-.20 (-.65)		.006 (.01)		-.23 (-1.01)
$MNEG_t$		-1.38 (-1.12)		-.20 (-.80)		-1.06 (-1.72)		-.27 (-1.41)
Panel C: Diagnostic statistics								
F	3.60	3.26	5.33	2.72	7.18	3.38	4.13	2.81
ECM_{t-1}	-.04 (-3.31)	-.03 (-4.11)	-.04 (-4.03)	-.03 (-3.75)	-.05 (-4.67)	-.04 (-4.16)	-.03 (-3.54)	-.05 (-3.80)
LM	2.28	3.46	2.43	2.39	9.74	5.43	2.69	3.44
QS (QS^2)	S (S)	S (S)	S (S)	S (S)	S (S)	S (S)	S (S)	S (S)
Adjusted R^2	.51	.65	.63	.64	.59	.62	.41	.47
South Dakota								
Panel A: Short-run								
ΔLnI_t	.09 (.63)		.20 (1.33)		.11 (1.40)		.45 (3.43)	
ΔLnI_{t-1}	.39 (2.56)				-.09 (-1.15)			
ΔLnI_{t-2}	.07 (.49)				.06 (.78)			
ΔLnI_{t-3}	.15 (1.04)				.18 (2.23)			
ΔLnI_{t-4}	.05 (.36)							
ΔLnI_{t-5}	.07 (.50)							
ΔLnI_{t-6}	.34 (2.43)							
ΔLnI_{t-7}	.80 (5.65)							
ΔLnM_t	-.04 (-1.35)							
ΔLnM_{t-1}					-.04 (-2.31)		-.08 (-3.37)	
ΔLnM_{t-2}					.01 (.64)		.004 (.18)	
ΔLnM_{t-3}					.05 (3.28)		.07 (3.32)	
ΔLnM_{t-4}					-.02 (-1.50)			
ΔLnM_{t-5}					.02 (1.64)			
ΔLnM_{t-6}					-.01 (-.84)			
ΔLnM_{t-7}					.02 (1.20)			
ΔIPO_{5t}					.03 (1.79)			
ΔIPO_{5t-1}	.69 (3.09)			.06 (.32)		.12 (1.15)		.54 (3.35)
ΔIPO_{5t-2}	-.04 (-.18)			.25 (1.36)		-.11 (-.97)		.26 (1.54)
ΔIPO_{5t-3}	-.24 (-1.02)			.30 (1.66)		.009 (.08)		.28 (1.75)
ΔIPO_{5t-4}	-.09 (-.40)					.09 (.82)		
ΔIPO_{5t-5}	-.68 (-2.98)					.31 (2.64)		
ΔIPO_{5t-6}								
ΔIPO_{5t-7}								

(Continued)

Table 1. (Continued).

	South Dakota		Tennessee		Texas		Utah	
	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL
$\Delta INEG_t$		.008 (.03)		.96 (2.46)		.22 (1.02)		.12 (.33)
$\Delta INEG_{t-1}$		.21 (.76)		-1.18 (-2.83)		-.17 (-.83)		-.74 (-2.03)
$\Delta INEG_{t-2}$		-.29 (-1.09)		-1.39 (-3.30)		.31 (1.47)		
$\Delta INEG_{t-3}$		-.27 (-1.04)		-.18 (-.48)		.38 (1.79)		
$\Delta INEG_{t-4}$		.05 (.21)		-1.22 (-3.96)		-.53 (-2.39)		
$\Delta INEG_{t-5}$		-.29 (-1.18)		-1.14 (-3.63)				
$\Delta INEG_{t-6}$		.23 (1.00)						
$\Delta INEG_{t-7}$		1.39 (6.33)						
$\Delta MPOS_t$		-.12 (-1.01)		.04 (1.97)		-.0004 (-.04)		-.03 (-1.34)
$\Delta MPOS_{t-1}$								
$\Delta MPOS_{t-2}$								
$\Delta MPOS_{t-3}$								
$\Delta MPOS_{t-4}$								
$\Delta MPOS_{t-5}$								
$\Delta MPOS_{t-6}$								
$\Delta MPOS_{t-7}$								
$\Delta MNEG_t$		-.16 (-1.29)		-.13 (-3.30)		-.06 (-2.14)		-.14 (-3.80)
$\Delta MNEG_{t-1}$		-.02 (-.17)		-.07 (-1.81)		.006 (.23)		.008 (.19)
$\Delta MNEG_{t-2}$		-.04 (-.35)				.09 (3.15)		.16 (3.86)
$\Delta MNEG_{t-3}$		.06 (.58)				-.06 (-2.24)		
$\Delta MNEG_{t-4}$		-.12 (-1.09)						
$\Delta MNEG_{t-5}$		-.08 (-.75)						
$\Delta MNEG_{t-6}$		.01 (.16)						
$\Delta MNEG_{t-7}$		-.36 (-3.37)						
Panel B: Long-run estimates								
Constant	19.45 (.80)	5.93 (37.35)	10.86 (1.10)	5.91 (28.11)	-4.22 (-3.4)	4.89 (16.30)	.86 (.06)	5.44 (13.20)
$\text{Ln}I_t$	-.73 (-.55)		-.24 (-.50)		.46 (.82)		.28 (.40)	
$\text{Ln}M_t$	-.79 (-.80)		-.33 (-.93)		.05 (.09)		-.24 (-.31)	
IPOS_t		1.28 (2.61)		-1.08 (-2.25)		1.74 (1.80)		1.66 (1.50)
INEG_t		2.64 (6.06)		8.81 (3.45)		-.26 (-.11)		1.69 (.63)
MPOS_t		.28 (1.14)		.36 (2.28)		-.01 (-.04)		-.92 (-1.10)
MNEG_t		.28 (2.35)		-.44 (-2.18)		.63 (1.88)		-.10 (-.19)
Panel C: Diagnostic statistics								
F	1.18	4.97	3.65	5.00	3.23	1.54	2.29	2.47
ECM_{t-1}	-.04 (-1.90)	-.30 (-5.07)	-.05 (-3.34)	-.11 (-5.09)	-.01 (-3.14)	-.02 (-2.82)	-.02 (-2.58)	-.03 (-3.51)
LM	4.20	28.20	18.44	13.69	11.11	6.19	3.84	7.18
QS (QS^2)	S (U)	S (U)	S (S)	S (S)	S (S)	S (S)	S (S)	S (S)
Adjusted R^2	.41	.56	.27	.42	.44	.48	.48	.58
			Vermont		Washington		Wisconsin	
			Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL
Panel A: Short-run								
$\Delta \text{Ln}I_t$	.21 (1.65)		.99 (2.02)		.02 (1.09)		.40 (2.51)	
$\Delta \text{Ln}I_{t-1}$	-.05 (-.40)		.27 (.54)				-.13 (-.83)	
$\Delta \text{Ln}I_{t-2}$	-.16 (-1.22)		.27 (.55)				-.11 (-.72)	
$\Delta \text{Ln}I_{t-3}$	.37 (2.89)		-.15 (-.31)				.26 (1.75)	
$\Delta \text{Ln}I_{t-4}$	-.29 (-2.19)		-.64 (-1.37)				-.12 (-.81)	
$\Delta \text{Ln}I_{t-5}$			-.48 (-1.02)				-.20 (-1.41)	
$\Delta \text{Ln}I_{t-6}$			1.36 (2.90)				.30 (2.12)	
$\Delta \text{Ln}I_{t-7}$							.35 (2.36)	

(Continued)

Table 1. (Continued).

(Continued)

Table 1. (Continued).

	Virginia		Vermont		Washington		Wisconsin	
	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL
Panel C: Diagnostic statistics								
F	3.60	2.79	1.73	3.14	3.11	2.05	.84	1.72
ECM _{t-1}	-.03 (-3.31)	-.03 (-3.70)	-.10 (-2.29)	-.08 (-4.02)	-.03 (-3.08)	-.04 (-3.24)	-.04 (-1.60)	-.06 (-2.98)
LM	4.65	5.65	4.28	1.20	14.06	4.85	5.89	7.76
QS (QS ²)	S (S)	S (S)	S (U)	S (U)	S (S)	S (S)	S (S)	S (S)
Adjusted R ²	.50	.58	.43	.43	.48	.54	.30	.45
West Virginia								
District of Columbia								
Wyoming								
Panel A: Short-run								
Δlnl _t								
Δlnl _{t-1}	.58 (2.81)		.06 (.59)		.15 (1.16)			
Δlnl _{t-2}	.47 (2.23)		.28 (2.82)		.30 (2.23)			
Δlnl _{t-3}			.0008 (.007)					
Δlnl _{t-4}			.10 (.95)					
Δlnl _{t-5}			.28 (2.67)					
Δlnl _{t-6}								
Δlnl _{t-7}								
ΔlnM _t								
ΔlnM _{t-1}	-.01 (-.32)				-.02 (-1.69)			
ΔlnM _{t-2}	-.07 (-1.26)							
ΔlnM _{t-3}	.05 (.85)							
ΔlnM _{t-4}	.13 (2.27)							
ΔlnM _{t-5}								
ΔlnM _{t-6}								
ΔlnM _{t-7}								
ΔIPO _t								
ΔIPO _{t-1}		-.52 (-1.35)		-.01 (-.11)		.07 (1.21)		
ΔIPO _{t-2}		-.19 (-.48)		.25 (1.50)				
ΔIPO _{t-3}		-.85 (-2.19)						
ΔIPO _{t-4}		.81 (2.30)						
ΔIPO _{t-5}		-.65 (-1.79)						
ΔIPO _{t-6}		-.41 (-1.11)						
ΔIPO _{t-7}		-.76 (-2.13)						
ΔINEG _t		1.30 (3.45)		.27 (1.30)		-.43 (-1.35)		
ΔINEG _{t-1}		-.36 (-.67)		.09 (.47)		1.35 (4.42)		
ΔINEG _{t-2}		-.36 (-.71)		-.32 (-1.53)		-.61 (-1.99)		
ΔINEG _{t-3}		-1.32 (-2.59)		.02 (.11)		-.07 (-.26)		
ΔINEG _{t-4}		1.36 (2.79)		.37 (1.82)		.37 (1.31)		
ΔINEG _{t-5}		.92 (1.81)		-.29 (-1.44)		-.94 (-3.31)		
ΔINEG _{t-6}		.41 (.81)		.19 (.91)		.86 (2.98)		
ΔINEG _{t-7}		-.99 (-2.12)		-.46 (-2.13)				
ΔMPOS _t		-.09 (-2.33)		-.03 (-.65)		-.01 (-.43)		
ΔMPOS _{t-1}				.01 (.20)				
ΔMPOS _{t-2}				.01 (.31)				
ΔMPOS _{t-3}				-.02 (-.40)				
ΔMPOS _{t-4}				.05 (1.04)				
ΔMPOS _{t-5}				.16 (2.82)				

Table 1. (Continued).

	West Virginia		Wyoming		District of Columbia	
	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL	Linear ARDL	Nonlinear ARDL
ΔMPOS_{t-6}				.11 (2.10)		
ΔMPOS_{t-7}				-.06 (-1.17)		-.07 (-1.08)
ΔMNEG_t		.03 (.40)		-.03 (-.59)		-.09 (-1.35)
ΔMNEG_{t-1}		-.12 (-1.29)		.08 (1.37)		.04 (.62)
ΔMNEG_{t-2}		.14 (1.50)		.05 (.84)		-.17 (-2.70)
ΔMNEG_{t-3}		.22 (2.31)		-.02 (-.42)		
ΔMNEG_{t-4}				-.14 (-2.39)		
ΔMNEG_{t-5}						
ΔMNEG_{t-6}						
ΔMNEG_{t-7}						
Panel B: Long-run estimates						
Constant	226.07 (.71)	7.35 (2.76)	-8.43 (-1.91)	5.20 (28.58)	-4.73 (-.40)	5.28 (17.43)
$\text{Ln}I_t$	-11.87 (-.70)		.79 (3.26)		.67 (1.05)	
$\text{Ln}M_t$	-5.26 (-.70)		.18 (1.01)		-.51 (-1.28)	
IPOS_t		-3.84 (-.46)		.79 (4.09)		1.67 (1.37)
INEG_t		.04 (.01)		2.12 (6.65)		-.25 (-.07)
MPOS_t		-1.54 (-.62)		-.15 (-.61)		-.41 (-.42)
MNEG_t		-1.90 (-.63)		-.17 (-.95)		-.03 (-.09)
Panel C: Diagnostic statistics						
F	5.16	4.46	3.79	4.27	5.88	2.49
ECM_{t-1}	-.02 (-3.96)	-.06 (-4.80)	-.05 (-3.40)	-.14 (-4.72)	-0.05 (-4.22)	-.04 (-3.49)
LM	4.89	6.38	2.30	9.00	3.37	3.11
QS ($Q5^2$)	S (U)	S (U)	S (S)	S (S)	S (S)	S (S)
Adjusted R^2	.56	.67	.45	.53	.44	.52

Note: Numbers inside parentheses are t-ratios.

optimum lags on all first differenced variables. A significantly negative coefficient obtained for ECM_{t-1} will reflect adjustment towards long run and its absolute value will reflect adjustment speed. In Alaska, 2% of adjustment takes place in one quarter. Second, in order to make sure that the residuals are autocorrelation free, we rely upon the Lagrange Multiplier (LM) statistic which is distributed as χ^2 with four degrees of freedom. Our reported LM statistic of 5.07 is less than its critical value of 9.48 at the 5% significance level which supports lack of autocorrelation. Third, to establish stability of short- and long-run coefficient estimates, again we follow the literature and apply the CUSUM (denoted by QS) and CUSUMSQ (denoted by QS²) to the residuals of each optimum model. While stable coefficients are indicated by 'S', unstable ones are indicated by 'U'. As can be seen, at least one of the tests supports stability of all coefficients. Finally, we report the size of adjusted R^2 so that we can judge the goodness of fit.

If we are to summarize the results from the linear ARDL model, we conclude that in Alaska only income has short-run effects on housing prices and neither income nor mortgage rates have any long-run effects. Does this conclusion change if we shift to the results from nonlinear ARDL model? From the short-run estimates, we gather both income and mortgage rates do have short-run effects on house prices. However, the effects are asymmetric since only decline in income ($\Delta INEG$) and increase in mortgage rates ($\Delta MPOS$) carry at least one significant coefficient. Note that not only size of the coefficients are different, in Alaska it appears that decline in income has long-lasting effects on house prices compared to the rise in income which does not seem to have short-run effects. The opposite is true for mortgage rates. Increase in mortgage rates hurt house prices for too long as compared to decrease in rates which do not have any short-run significant effects. In this nonlinear model, it appears that short-run effects of both variables do last into the long run since both $INEG$ and $MPOS$ carry significant coefficients in Panel B. Clearly the long-run effects are also asymmetric. Once again, if these long-run estimates are to be valid, we must establish

cointegration. Our calculated F statistic of 4.05 is higher than its critical value of 3.52 at the 10% level and somewhat higher than its critical value of 4.01 at the 5% significance level.⁷ Therefore, it appears that once we separate changes in income and mortgage rates into their positive and negative changes, we find support for cointegration. Therefore, introducing nonlinearity into adjustment process improves the results in favour of economic theory.

Based on the above analysis for Alaska, we can now summarize our findings for all states. First, in the linear or nonlinear model, all exogenous variables have short-run effects on house prices because in almost all states each variable carries at least one significant coefficient. Second, in the nonlinear model short-run effects of changes in income and mortgage rate are asymmetric due to the fact that coefficient estimates of positive and negative changes in both variables differ in sign, size and duration. Third, from nonlinear model we also gather that the long-run effects of changes in income and interest rate are asymmetric. Again, the long-run coefficient estimates for positive changes as compared to negative changes differ in sign and size in most states. Fourth, the linear model supports cointegration among house prices, income and interest rate in 17 states and DC. The list includes California, Connecticut, Florida, Georgia, Hawaii, Idaho, Illinois, Massachusetts, Maryland, North Carolina, New Hampshire, New Jersey, Nevada, New York, Pennsylvania, Rhode Island, West Virginia and DC. Only in these cases, our calculated F statistic is above the upper bound critical value of 4.14. However, the nonlinear model supports cointegration in 24 states of Alaska, Arizona, California, Florida, Georgia, Hawaii, Idaho, Indiana, Louisiana, Maryland, Maine, Michigan, Montana, North Carolina, North Dakota, New Hampshire, New Mexico, Nevada, New York, Oklahoma, South Dakota, Tennessee, West Virginia and Wyoming. For these states, our calculated F statistic is greater than its upper bound critical value of 3.52. Putting our cointegration findings together from both models, cointegration is supported in 31 cases at least by one of the models and this supports the theory that in most states in

⁷Note that this time due to decomposition we have four exogenous variables. Therefore, the critical values from Pesaran, Shin and Smith (2001) are for the case of $k = 4$.

the US house prices are driven by fundamentals, though the effects of changes in the fundamentals are asymmetric.

IV. Summary and conclusion

The relation between house prices and fundamentals has been subject of investigation by many researchers who have used recent advances in econometric methods to establish the long-run relationship between house prices and economic fundamentals. Those who have used time-series models and have failed to find cointegration have been criticized for low power of the tests employed. To increase the power, some have used panel tests applied to pooled data. The findings are mixed at best.

Regardless of the models used, that is, time-series versus panel, all studies have one feature in common. They have all assumed that changes in the fundamentals have symmetric effects on housing prices. However, it is possible that reaction of buyers and sellers to be different to increase in fundamentals than to decrease in fundamentals. The same could be true for changes in the mortgage rates. Therefore, the main hypothesis we investigate in this article is whether changes in the fundamentals have symmetric or asymmetric effects on house prices in each of the states in the US. To that end, increases in income and interest rates are separated from decreases in income and interest rates, and using partial sum concept four new measures are constructed. These new measures are used in conjunction with an ARDL model, that is, a nonlinear ARDL approach to investigate the issue at hand.

The main findings could be best summarized by saying that both income and interest rate have short-run significant impact on house prices in almost all states. The short-run effects last into the long run in 30 states and DC since cointegration was established by either the linear ARDL approach of Pesaran, Shin and Smith (2001) or nonlinear ARDL approach of Shin, Yu and Greenwood-Nimmo (2014). Indeed, in more states, cointegration was established by nonlinear approach. Finally, the nonlinear model reveals that both income and interest rate changes have asymmetric effects on house prices in the short run as well as in the long run, in almost all states. This is our main finding in the article which was missing from previous studies related to the US states. These

findings do have major policy implications to policy makers as well as participants in the housing market. The finding that house prices are cointegrated with income and interest rate in most states assures the Fed that expansionary monetary policy to lower the interest rates clearly will stimulate the demand for housing over time and help economy grow. This is evidenced in post-2008 period here in the US. However, due to asymmetric effects of mortgage rate changes on house prices, the Fed should be cautious in implementing monetary policy. For example, if in a given state lower interest rates raises house price due to increased demand but higher rates do not hurt house prices, contractionary monetary policy will not be effective in fighting housing bubble in particular and inflation in general.

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