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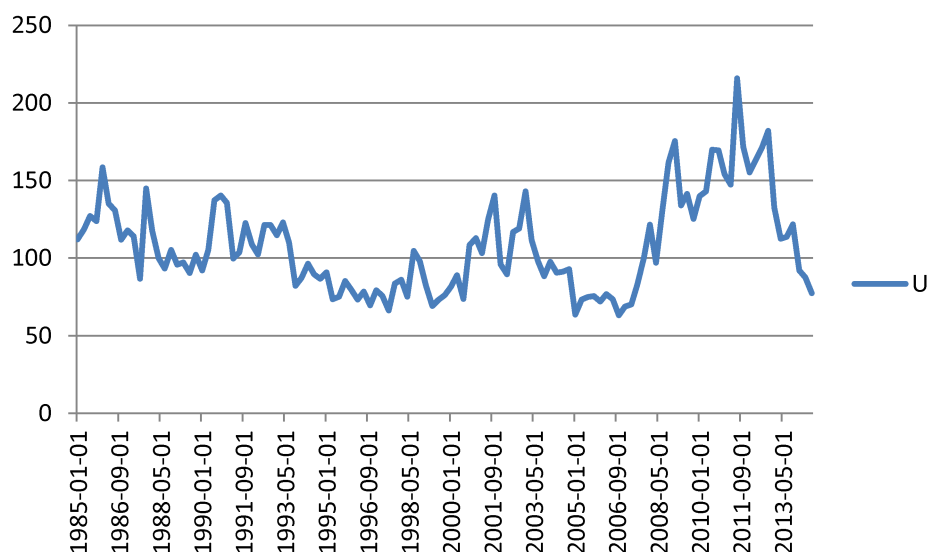
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# POLICY UNCERTAINTY AND HOUSE PRICES IN THE UNITED STATES

**Executive Summary.** Previous research has either relied on a time series model or a panel model to establish cointegration between house prices and their main determinants, such as a measure of household income and a measure of interest rates. The findings are mixed but mostly lean toward rejecting cointegration between house prices and economic fundamentals. None of the studies included a measure policy uncertainty in their models. We include a measure of policy uncertainty in our model and use the bounds testing approach for cointegration and error-correction modeling. We find that policy uncertainty has short-run and mostly negative effects on house prices in 24 states. The short-run effects last into the long run in 17 states. Furthermore, cointegration is established in 35 states.

**Mohsen Bahmani-Oskooee**  
**Seyed Hesam Ghodsi**

When the U.S. Congress engages in discussion concerning the federal government budget, at times the process is prolonged, mostly due to ideological differences between democrats and republicans. The prolonged process generates uncertainty and uneasiness among the public, which could affect their decision to spend or save. Of course such decisions are also affected by other factors that contribute to an uncertain environment. Newspapers are full of such stories and today they are used by Economic Uncertainty Policy Group to construct a measure of economic uncertainty. In constructing such a measure, the Group searches news covering economic policy uncertainty issues from highly circulated newspapers so that they can capture policy-oriented news. To that end, they search for such words as “policy,” “uncertainty,” “budget,” “tax,” “deficit,” “regulation,” “spending,” etc. Policy uncertainty news is captured by including the word “uncertain” or “uncertainty” in all searches. From these papers, a normalized index of the volume of news articles is constructed as a measure of economic policy uncertainty. This is perhaps the most comprehensive measure of uncertainty that is constructed, mostly due to the fact that the words that are searched reflect changes in most macro variables that could be affected by changes in expectations, economic conditions, political conditions, etc. In order to gain some insight to the behavior of this measure for the United States, we plot it in Exhibit 1. As can be seen,

**Exhibit 1** | Plot of Policy Uncertainty Measure ( $U$ ) in the U.S.

clearly the uncertainty measure reflects the reality in the U.S. It has jumped due to terrorism that took place on the September 11, 2001 and the financial crisis that began in 2007. However, in more recent years when the U.S. economy has improved, the uncertainty measure has declined.<sup>1</sup>

Assessing the impact of any measure of uncertainty on macro variables is a common practice in economics and house prices are no exception. Our main goal in this paper is to determine whether house prices in the U.S. react to this policy uncertainty measure. Our search of the literature on the impact of any uncertainty measure on house prices was futile. A large number of studies have been concerned with establishing a long-run relation between house prices and fundamental macro variables, such as income, mortgage rates, debt, stock prices, construction cost, etc. We can basically divide more recent studies into two groups. The first group includes studies that used time series data. Examples include Chen and Patel (1998), who considered the housing market in Taipei; Meen (2002), who concentrated on the housing market in the U.S. and U.K.; Apergis (2003), who was concerned with the market in Greece; Chen, Tsai, and Chang (2007), who used data from Taiwan; McQuinn and O'Reilly (2008), who dealt with the experience of Ireland; and Kim and Bhattacharya (2009) and Zhou (2010), who examined the U.S. market. The second group includes

studies that have used time series and cross-sectional data combined in a panel setting. Examples include Malpezzi (1999), Gallin (2006), Mikhed and Zemcik (2009), Holly, Pesaran, and Yamagata (2010), and Madsen (2012), who have mostly used data from large U.S. cities over time. The findings from both groups are inconclusive and mostly lean toward finding a lack of a long-run relation between house prices and fundamentals.

As mentioned above, none of the studies in the literature has looked at the possible impact of an uncertainty measure on house prices. Now that a policy uncertainty measure is available, we investigate its short- and long-run effects on house prices in each U.S. state. We begin by introducing the model and estimation method. Since our approach is a time series, we next report the results for each state. Finally, we provide concluding remarks. Variable definitions and sources of data are in the Appendix.

## THE MODEL AND THE METHOD

Clearly in specifying any model we wish to include all determinants of the dependent variable. However, this is not possible since data on all variables are not available in every state. Thus, to increase the number of case studies (states) and degrees of freedom, we include the most important determinants. The two most important determinants of house

prices, which have been used by all studies, are a measure of household income and a measure of interest rate. As a matter of fact, these were the only factors that Case and Shiller (2003) considered to study house prices in the U.S. They concluded that since 1995 house prices have been driven mostly by these two factors. Therefore, we too include a measure of income and interest rate in our model, in addition to the measure of policy uncertainty, as outlined in equation (1):

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

where  $P$  denotes house prices,  $I$  denotes a measure of household income,  $M$  signifies the mortgage rate, and  $U$  denotes the policy uncertainty. While we expect an estimate of  $b$  to be positive and that of  $c$  to be negative, an estimate of  $d$  could be negative or positive. If an increase in uncertainty induces the public to become cautious and spend less, part of which could fall on mortgage payments, which could eventually reduce the demand for housing and reduce house prices, hence a negative  $d$ . However, if an increase in uncertainty induces the public to adjust their portfolio toward safer real assets like housing, then an estimate of  $d$  could be positive. This could be the case if inflation uncertainty is a main contributing factor to economic uncertainty. During an uncertain inflationary environment, the public simply hedges against inflation by not saving and shifting toward real assets.

Equation (1) is usually referred to as a long-run model and coefficient estimates reflect the long-run effects of exogenous variables. In order to assess their short-run effects, we need to specify equation (1) in an error-correction modeling format. The specification here follows Pesaran, Shin, and Smith's (2001) bounds testing approach, as follows:

$$\begin{aligned} \Delta \text{Ln}P_t = & \alpha + \sum_{k=1}^{n1} \beta_k \Delta \text{Ln}P_{t-k} + \sum_{k=0}^{n2} \delta_k \Delta \text{Ln}I_{t-k} \\ & + \sum_{k=0}^{n3} \pi_k \Delta \text{Ln}M_{t-k} + \sum_{k=0}^{n4} \theta_k \Delta \text{Ln}U_{t-k} \\ & + \lambda_0 \text{Ln}P_{t-1} + \lambda_1 \text{Ln}I_{t-1} + \lambda_2 \text{Ln}M_{t-1} \\ & + \lambda_3 \text{Ln}U_{t-1} + \mu_t. \end{aligned} \quad (2)$$

In spirit, equation (2) carries the same concept as Engle and Granger (1987) representation theorem. The difference is that linear combination of lagged level variables has replaced lagged error term from (1). Pesaran, Shin, and Smith (2001) propose applying the familiar F-test to establish the joint significance of lagged level variables as a sign of cointegration among the variables. However, they demonstrate that the F-test in this application has new critical values that they tabulate. Since the critical values account for the integrating properties of variables in a given model, there is no need to engage in pre-unit root testing. Indeed, they demonstrate that their upper bound critical values could be used even if we have a combination of  $I(0)$  and  $I(1)$  variables. This is one of the main advantages of this method since almost all macro variables are either  $I(0)$  or  $I(1)$ . Another advantage of this method is that short- and long-run estimates are obtained in one step by applying ordinary least squares (OLS) to equation (2). Furthermore, Panopoulou and Pittis (2004) demonstrate that in small samples this approach performs better than other approaches.

Once cointegration is established, the long-run effects are derived by normalizing estimates of  $\lambda_1 - \lambda_3$  on  $\lambda_0$ . This is done by setting the estimate of the error-correction component of (2) equal to zero first:

$$\hat{\lambda}_0 \text{Ln}P_{t-1} + \hat{\lambda}_1 \text{Ln}I_{t-1} + \hat{\lambda}_2 \text{Ln}M_{t-1} + \hat{\lambda}_3 \text{Ln}U_{t-1} = 0 \quad (3)$$

and solving (3) for  $\text{Ln}P_{t-1}$  next:

$$\text{Ln}P_{t-1} = -\frac{\hat{\lambda}_1}{\hat{\lambda}_0} \text{Ln}I_{t-1} - \frac{\hat{\lambda}_2}{\hat{\lambda}_0} \text{Ln}M_{t-1} - \frac{\hat{\lambda}_3}{\hat{\lambda}_0} \text{Ln}U_{t-1}. \quad (4)$$

Comparing normalized coefficients from (4) to those in equation (1), we infer:

$$\hat{b} = -\frac{\hat{\lambda}_1}{\hat{\lambda}_0}; \hat{c} = -\frac{\hat{\lambda}_2}{\hat{\lambda}_0}; \hat{d} = -\frac{\hat{\lambda}_3}{\hat{\lambda}_0}.$$

Note that the short-run effects are inferred by the estimates of coefficients attached to first-differenced variables.

## THE RESULTS

In this section, we estimate error-correction model outlined by equation (2) for each of the 50 U.S. states and Washington, DC.<sup>2</sup> Quarterly data for the 1985:Q1–2014:Q3 period are used for our empirical analysis.<sup>3</sup> We begin with 1985 due to the fact that the policy uncertainty measure is published beginning 1985. Following the literature, we impose a maximum of eight lags on each first-differenced variable and use Akaike's information criterion (AIC) to select the optimum lags. We then report the results for each optimum model and for each state in Exhibit 2. As can be seen, while the short-run coefficient estimates of only exogenous variables are reported in Panel A, the normalized long-run estimates are reported in Panel B. Diagnostic statistics are reported in Panel C.<sup>4</sup>

From Panel A we gather that the measure of income ( $I$ ) and mortgage rates ( $M$ ) carry at least one significant coefficient at the 10% significance level in almost all states, supporting the notion that indeed income and interest rates have significant short-run effects on house prices. As for our newly introduced policy uncertainty variable ( $U$ ), it carries at least one short-run significant coefficient in 23 states and Washington, DC and in most cases the coefficient is negative. Thus, it appears that the policy uncertainty variable does have a significantly negative effect on house prices in almost half of the states. Do these short-run effects last into the long run?

The long-run estimates that are reported in Panel B indicate that while household income carries significant and positive coefficient in 25 states, the mortgage rate carries a significantly negative coefficient in only two states, North Dakota and Utah. This evidence supports Case and Shiller (2003), who concluded that house prices in the U.S. are mostly driven by income. As for the uncertainty variable,  $U$ , it has a significant coefficient in 17 states and the estimate is negative in all 17 states except one. Thus, it appears that policy uncertainty plays relatively more of a long-run role than mortgage rates. This may explain why the U.S. Great Recession in 2008 was so prolonged despite low interest rates.

The above long-run estimates will be valid only if we establish cointegration. To that end, we turn to Panel C and the results of the F-test along with other diagnostics. Given the upper bound critical value of 3.77, our calculated F-statistic is significant in 35 states, supporting cointegration between house prices and fundamentals.<sup>5</sup> These are mostly cases in which at least one of the determinants has a long-run significant coefficient. For example, the income and policy uncertainty measure for Alaska has significant long-run coefficients; the F-statistic is 6.75 and significant, implying that the coefficients are meaningful. This support for cointegration in almost 70% of the models is unique and could be due to new data, a new model, and a new method.

In addition to F-statistics, we also report several other diagnostics. The first is whether variables are adjusting toward their long-run equilibrium values. If yes, at what speed. To answer this question, we use normalized long-run coefficient estimates from Panel B and equation (4) or (1) and calculate the error-correction ( $ECM$ ) term. 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 optimum lags used for the estimations in Panel A. A significantly negative coefficient obtained for  $ECM_{t-1}$  signifies adjustment toward long-run equilibrium values and the size of the coefficient in absolute value measures the adjustment speed.<sup>6</sup> Given its new critical value of  $-3.47$ , clearly  $ECM_{t-1}$  exhibits a significantly negative coefficient for 40 states, although adjustment speed differs somewhat from one state to another.<sup>7</sup> The third diagnostic statistic is the Lagrange multiplier (LM) statistic, which is used to test for autocorrelation among the residuals of each error-correction model. This statistic is distributed as chi-square with four degrees of freedom. Given its critical value of 9.48, it is insignificant in almost all models, supporting autocorrelation free residuals.

How stable are short- and long-run coefficient estimates in each model? We test for the stability of all coefficients by applying the well-known CUSUM (denoted by QS) and CUSUMSQ (denoted by QS<sup>2</sup>) to the residuals of each optimum model.<sup>8</sup> We denote

**Exhibit 2** | Estimates of Model (2) for Each State

|                                | Alaska        | Alabama       | Arkansas      | Arizona        | California     | Colorado      | Connecticut    | Delaware      |
|--------------------------------|---------------|---------------|---------------|----------------|----------------|---------------|----------------|---------------|
| Panel A: Short-Run Estimates   |               |               |               |                |                |               |                |               |
| $\Delta \ln I_t$               | -0.17 (-0.75) | 0.27 (2.82)   | 0.09 (1.16)   | 0.30 (1.92)    | 0.05 (2.61)    | 0.04 (3.17)   | 0.15 (1.75)    | 0.24 (2.50)   |
| $\Delta \ln I_{t-1}$           | -0.07 (-0.28) | -0.14 (-1.50) | -0.14 (-1.79) |                |                |               |                | 0.15 (1.58)   |
| $\Delta \ln I_{t-2}$           | -0.53 (-2.14) |               |               |                |                |               |                |               |
| $\Delta \ln I_{t-3}$           | 0.05 (0.21)   |               |               |                |                |               |                |               |
| $\Delta \ln I_{t-4}$           | -0.73 (-2.84) |               |               |                |                |               |                |               |
| $\Delta \ln I_{t-5}$           | -0.37 (-1.47) |               |               |                |                |               |                |               |
| $\Delta \ln I_{t-6}$           | -0.70 (-2.81) |               |               |                |                |               |                |               |
| $\Delta \ln I_{t-7}$           |               |               |               |                |                |               |                |               |
| $\Delta \ln I_{t-8}$           |               |               |               |                |                |               |                |               |
| $\Delta \ln M_t$               | -0.08 (-1.53) | -0.08 (-5.13) | -0.07 (-4.28) | -0.10 (-3.49)  | -0.04 (-1.47)  | -0.03 (-2.11) | -0.08 (-3.98)  | -0.09 (-4.99) |
| $\Delta \ln M_{t-1}$           | 0.05 (0.80)   |               |               |                |                | 0.01 (0.57)   |                |               |
| $\Delta \ln M_{t-2}$           | -0.10 (-1.63) |               |               |                |                | 0.001 (0.09)  |                |               |
| $\Delta \ln M_{t-3}$           | 0.11 (1.81)   |               |               |                |                | 0.01 (0.49)   |                |               |
| $\Delta \ln M_{t-4}$           | -0.10 (-1.50) |               |               |                |                | -0.05 (-2.85) |                |               |
| $\Delta \ln M_{t-5}$           |               |               |               |                |                |               |                |               |
| $\Delta \ln M_{t-6}$           |               |               |               |                |                |               |                |               |
| $\Delta \ln M_{t-7}$           |               |               |               |                |                |               |                |               |
| $\Delta \ln M_{t-8}$           |               |               |               |                |                |               |                |               |
| $\Delta \ln U_t$               | -0.02 (-1.18) | -0.01 (-0.99) | -0.01 (-0.99) | -0.003 (-0.35) | -0.01 (-1.52)  | -0.01 (-2.22) | -0.002 (-0.50) | -0.01 (-2.61) |
| $\Delta \ln U_{t-1}$           | 0.05 (2.45)   | 0.01 (2.05)   | 0.01 (1.76)   | -0.02 (-1.79)  | -0.02 (-2.44)  |               |                | -0.01 (-1.97) |
| $\Delta \ln U_{t-2}$           | 0.02 (1.18)   | -0.01 (-1.48) | -0.01 (-1.70) | -0.01 (-1.74)  | -0.03 (-3.43)  |               |                | -0.01 (-1.97) |
| $\Delta \ln U_{t-3}$           | 0.06 (2.87)   |               |               | -0.02 (-2.78)  | -0.01 (-2.00)  |               |                | -0.01 (-1.53) |
| $\Delta \ln U_{t-4}$           | 0.04 (2.22)   |               |               |                |                |               |                | 0.01 (1.16)   |
| $\Delta \ln U_{t-5}$           | 0.03 (1.76)   |               |               |                |                |               |                | 0.001 (0.30)  |
| $\Delta \ln U_{t-6}$           |               |               |               |                |                |               |                | 0.01 (3.20)   |
| $\Delta \ln U_{t-7}$           |               |               |               |                |                |               |                |               |
| $\Delta \ln U_{t-8}$           |               |               |               |                |                |               |                |               |
| Panel B: Long-Run Estimates    |               |               |               |                |                |               |                |               |
| Constant                       | -9.83 (-1.35) | -2.08 (-0.41) | 7.43 (0.79)   | -14.41 (-1.32) | -41.31 (-2.63) | -7.72 (-2.98) | -1.70 (-0.14)  | -0.17 (-0.02) |
| $\ln I_t$                      | 0.96 (2.45)   | 0.43 (1.83)   | 0.01 (0.04)   | 0.92 (1.99)    | 2.06 (3.05)    | 0.74 (6.23)   | 0.43 (0.73)    | 0.36 (0.86)   |
| $\ln M_t$                      | -0.01 (-0.04) | 0.02 (0.18)   | -0.28 (-0.77) | 0.56 (1.02)    | 0.91 (1.87)    | 0.04 (0.33)   | -0.09 (-0.27)  | -0.24 (-0.72) |
| $\ln U_t$                      | -0.23 (-2.67) | -0.10 (-0.90) | -0.38 (-1.84) | 0.29 (0.83)    | 0.47 (1.79)    | -0.15 (-2.32) | -0.09 (-0.48)  | 0.04 (0.33)   |
| Panel C: Diagnostic Statistics |               |               |               |                |                |               |                |               |
| $F$                            | 6.75          | 3.73          | 3.11          | 2.84           | 4.12           | 4.63          | 3.09           | 4.67          |
| $ECM_{t-1}$                    | -0.19 (-5.29) | -0.05 (-3.89) | -0.02 (-3.49) | -0.03 (-3.41)  | -0.02 (-4.12)  | -0.05 (-4.36) | -0.02 (-3.47)  | -0.03 (-4.39) |
| $LM$                           | 12.85         | 2.28          | 2.65          | 1.75           | 4.06           | 1.27          | 5.82           | 2.03          |
| QS (QS <sup>2</sup> )          | S (S)         | S (S)         | S (S)         | S (S)          | S (S)          | S (S)         | S (S)          | S (S)         |
| Adj. R <sup>2</sup>            | 0.49          | 0.52          | 0.37          | 0.69           | 0.79           | 0.62          | 0.73           | 0.69          |

**Exhibit 2** (continued) | Estimates of Model (2) for Each State

|                                | Florida       | Georgia        | Hawaii         | Iowa          | Idaho         | Illinois       | Indiana       | Kansas        |
|--------------------------------|---------------|----------------|----------------|---------------|---------------|----------------|---------------|---------------|
| Panel A: Short-Run Estimates   |               |                |                |               |               |                |               |               |
| $\Delta \ln I_t$               | 0.003 (0.16)  | 0.31 (3.36)    | 0.50 (3.25)    | -0.03 (-2.09) | 0.16 (1.54)   | 0.21 (2.33)    | 0.11 (1.80)   | 0.02 (0.34)   |
| $\Delta \ln I_{t-1}$           |               |                | -0.08 (-0.48)  |               |               | -0.07 (-0.77)  |               | -0.10 (-1.42) |
| $\Delta \ln I_{t-2}$           |               |                | 0.17 (1.07)    |               |               | -0.02 (-0.25)  |               | -0.11 (-1.64) |
| $\Delta \ln I_{t-3}$           |               |                | -0.001 (-0.01) |               |               | 0.22 (-2.51)   |               | 0.12 (1.73)   |
| $\Delta \ln I_{t-4}$           |               |                | 0.30 (1.94)    |               |               | -0.01 (-0.05)  |               |               |
| $\Delta \ln I_{t-5}$           |               |                | 0.35 (2.26)    |               |               | -0.19 (-1.99)  |               |               |
| $\Delta \ln I_{t-6}$           |               |                | 0.29 (1.78)    |               |               |                |               |               |
| $\Delta \ln I_{t-7}$           |               |                |                |               |               |                |               |               |
| $\Delta \ln I_{t-8}$           |               |                |                |               |               |                |               |               |
| $\Delta \ln M_t$               | -0.09 (-3.69) | -0.08 (-4.31)  | -0.07 (-2.97)  | -0.06 (-4.68) | -0.06 (-2.45) | -0.04 (-2.54)  | -0.06 (-5.19) | -0.05 (-3.70) |
| $\Delta \ln M_{t-1}$           | 0.03 (1.40)   |                |                |               | -0.02 (-1.07) |                | 0.001 (0.09)  | 0.001 (0.07)  |
| $\Delta \ln M_{t-2}$           |               |                |                |               | 0.04 (1.84)   |                | -0.02 (-1.80) | 0.004 (0.27)  |
| $\Delta \ln M_{t-3}$           |               |                |                |               |               |                | 0.01 (1.00)   | -0.01 (-0.70) |
| $\Delta \ln M_{t-4}$           |               |                |                |               |               |                | -0.04 (-2.75) | -0.02 (-1.55) |
| $\Delta \ln M_{t-5}$           |               |                |                |               |               |                |               | -0.04 (-2.36) |
| $\Delta \ln M_{t-6}$           |               |                |                |               |               |                |               | 0.04 (2.78)   |
| $\Delta \ln M_{t-7}$           |               |                |                |               |               |                |               | -0.03 (-2.03) |
| $\Delta \ln M_{t-8}$           |               |                |                |               |               |                |               |               |
| $\Delta \ln U_t$               | 0.003 (0.46)  | -0.001 (-0.31) | -0.01 (-0.95)  | -0.01 (-1.96) | 0.01 (1.10)   | -0.004 (-1.10) | -0.01 (-2.01) | -0.01 (-2.06) |
| $\Delta \ln U_{t-1}$           |               |                | -0.01 (-1.22)  | 0.01 (3.19)   | 0.01 (1.37)   |                |               |               |
| $\Delta \ln U_{t-2}$           |               |                | -0.02 (-2.69)  |               |               |                |               |               |
| $\Delta \ln U_{t-3}$           |               |                | -0.01 (-2.29)  |               |               |                |               |               |
| $\Delta \ln U_{t-4}$           |               |                |                |               |               |                |               |               |
| $\Delta \ln U_{t-5}$           |               |                |                |               |               |                |               |               |
| $\Delta \ln U_{t-6}$           |               |                |                |               |               |                |               |               |
| $\Delta \ln U_{t-7}$           |               |                |                |               |               |                |               |               |
| $\Delta \ln U_{t-8}$           |               |                |                |               |               |                |               |               |
| Panel B: Long-Run Estimates    |               |                |                |               |               |                |               |               |
| Constant                       | 2.88 (0.16)   | 1.32 (0.23)    | -15.36 (-1.43) | 86.64 (0.55)  | 1.34 (0.24)   | -0.71 (-0.11)  | -4.37 (-0.88) | -2.96 (-0.42) |
| $\ln I_t$                      | 0.13 (0.17)   | 0.23 (0.92)    | 1.21 (2.15)    | -3.78 (-0.50) | 0.29 (1.15)   | 0.36 (1.29)    | 0.53 (2.28)   | 0.50 (1.42)   |
| $\ln M_t$                      | -0.31 (-0.47) | -0.10 (-0.39)  | 0.04 (0.15)    | -2.51 (-0.57) | -0.17 (-0.67) | -0.22 (-1.37)  | 0.15 (1.22)   | 0.02 (0.12)   |
| $\ln U_t$                      | 0.13 (0.46)   | -0.03 (-0.30)  | -0.09 (-0.88)  | -1.43 (-0.64) | -0.15 (-1.13) | -0.08 (-1.11)  | -0.15 (-1.73) | -0.21 (-1.88) |
| Panel C: Diagnostic Statistics |               |                |                |               |               |                |               |               |
| $F$                            | 1.89          | 4.59           | 6.75           | 4.51          | 4.95          | 5.83           | 1.63          | 3.51          |
| $ECM_{t-1}$                    | -0.02 (-2.78) | -0.03 (-4.33)  | -0.05 (-5.27)  | -0.01 (-4.19) | -0.06 (-4.51) | -0.05 (-4.90)  | -0.04 (-2.58) | -0.04 (-3.79) |
| $LM$                           | 1.73          | 1.56           | 4.37           | 2.40          | 2.02          | 8.07           | 1.22          | 1.98          |
| QS (QS <sup>2</sup> )          | S (U)         | S (U)          | S (S)          | S (S)         | S (S)         | S (U)          | S (S)         | S (S)         |
| Adj. R <sup>2</sup>            | 0.75          | 0.61           | 0.75           | 0.24          | 0.56          | 0.61           | 0.50          | 0.43          |

Exhibit 2 (continued) | Estimates of Model (2) for Each State

|                                | Kentucky       | Louisiana     | Massachusetts  | Maryland       | Maine         | Michigan       | Minnesota      | Missouri       |
|--------------------------------|----------------|---------------|----------------|----------------|---------------|----------------|----------------|----------------|
| Panel A: Short-Run Estimates   |                |               |                |                |               |                |                |                |
| $\Delta \ln I_t$               | 0.36 (4.17)    | 0.20 (2.23)   | -1.19 (2.79)   | 0.35 (2.57)    | 0.18 (1.61)   | 0.04 (1.62)    | 0.02 (1.37)    | 0.29 (4.08)    |
| $\Delta \ln I_{t-1}$           | -0.12 (-1.37)  |               | -0.18 (-2.01)  |                | -0.14 (-1.27) |                |                |                |
| $\Delta \ln I_{t-2}$           |                |               | -0.23 (-2.47)  |                | -0.28 (-2.59) |                |                |                |
| $\Delta \ln I_{t-3}$           |                |               |                |                |               |                |                |                |
| $\Delta \ln I_{t-4}$           |                |               |                |                |               |                |                |                |
| $\Delta \ln I_{t-5}$           |                |               |                |                |               |                |                |                |
| $\Delta \ln I_{t-6}$           |                |               |                |                |               |                |                |                |
| $\Delta \ln I_{t-7}$           |                |               |                |                |               |                |                |                |
| $\Delta \ln I_{t-8}$           |                |               |                |                |               |                |                |                |
| $\Delta \ln M_t$               | 0.05 (-4.02)   | -0.06 (-3.50) | -0.07 (-4.05)  | -0.08 (-4.03)  | -0.10 (-5.15) | -0.03 (-1.73)  | -0.07 (-3.36)  | -0.03 (-2.72)  |
| $\Delta \ln M_{t-1}$           |                | -0.03 (-2.03) |                |                |               |                | 0.002 (0.10)   |                |
| $\Delta \ln M_{t-2}$           |                | 0.03 (1.76)   |                |                |               |                | -0.01 (-0.56)  |                |
| $\Delta \ln M_{t-3}$           |                | -0.02 (-1.12) |                |                |               |                | 0.01 (0.49)    |                |
| $\Delta \ln M_{t-4}$           |                | -0.02 (-1.39) |                |                |               |                | -0.04 (-2.28)  |                |
| $\Delta \ln M_{t-5}$           |                | -0.04 (-2.04) |                |                |               |                | -0.04 (-1.97)  |                |
| $\Delta \ln M_{t-6}$           |                |               |                |                |               |                |                |                |
| $\Delta \ln M_{t-7}$           |                |               |                |                |               |                |                |                |
| $\Delta \ln M_{t-8}$           |                |               |                |                |               |                |                |                |
| $\Delta \ln U_t$               | -0.003 (-1.03) | -0.01 (-1.15) | -0.004 (-1.25) | -0.01 (-2.02)  | -0.01 (-2.02) | 0.001 (0.11)   | -0.003 (-0.72) | -0.001 (-0.56) |
| $\Delta \ln U_{t-1}$           |                |               |                | -0.01 (-1.81)  |               |                |                |                |
| $\Delta \ln U_{t-2}$           |                |               |                | -0.01 (-2.74)  |               |                |                |                |
| $\Delta \ln U_{t-3}$           |                |               |                |                |               |                |                |                |
| $\Delta \ln U_{t-4}$           |                |               |                |                |               |                |                |                |
| $\Delta \ln U_{t-5}$           |                |               |                |                |               |                |                |                |
| $\Delta \ln U_{t-6}$           |                |               |                |                |               |                |                |                |
| $\Delta \ln U_{t-7}$           |                |               |                |                |               |                |                |                |
| $\Delta \ln U_{t-8}$           |                |               |                |                |               |                |                |                |
| Panel B: Long-Run Estimates    |                |               |                |                |               |                |                |                |
| Constant                       | 0.73 (0.08)    | -6.30 (-1.09) | -13.13 (-1.69) | -12.98 (-1.30) | -3.52 (-0.41) | -18.74 (-1.84) | -6.14 (-0.82)  | -3.23 (-0.44)  |
| $\ln I_t$                      | 0.29 (0.73)    | 0.70 (2.46)   | 1.03 (2.81)    | 0.90 (1.90)    | 0.58 (1.31)   | 1.23 (2.52)    | 0.65 (1.79)    | 0.47 (1.34)    |
| $\ln M_t$                      | -0.13 (-0.47)  | -0.06 (-0.32) | -0.01 (-0.07)  | 0.11 (0.34)    | -0.15 (-0.58) | 0.01 (0.04)    | -0.09 (-0.36)  | -0.01 (-0.07)  |
| $\ln U_t$                      | -0.10 (-0.81)  | -0.31 (-2.58) | -0.15 (-1.19)  | 0.25 (1.41)    | -0.08 (-0.69) | 0.01 (0.11)    | -0.09 (-0.72)  | -0.05 (-0.53)  |
| Panel C: Diagnostic Statistics |                |               |                |                |               |                |                |                |
| $F$                            | 1.61           | 4.74          | 5.83           | 3.89           | 4.87          | 3.97           | 4.20           | 2.63           |
| $ECM_{t-1}$                    | -0.03 (-2.58)  | -0.05 (-4.42) | -0.03 (-4.88)  | -0.03 (-4.00)  | -0.03 (-4.47) | -0.03 (-4.02)  | -0.04 (-4.16)  | -0.02 (-3.24)  |
| $LM$                           | 7.46           | 13.75         | 2.56           | 4.29           | 7.65          | 5.49           | 7.50           | 3.94           |
| QS (QS <sup>2</sup> )          | S (S)          | S (S)         | S (S)          | S (U)          | S (S)         | S (U)          | S (U)          | S (S)          |
| Adj. R <sup>2</sup>            | 0.39           | 0.53          | 0.75           | 0.73           | 0.64          | 0.65           | 0.61           | 0.58           |

**Exhibit 2** (continued) | Estimates of Model (2) for Each State

|                                | Mississippi   | Montana       | North Carolina | North Dakota  | Nebraska       | New Hampshire  | New Jersey     | New Mexico     |
|--------------------------------|---------------|---------------|----------------|---------------|----------------|----------------|----------------|----------------|
| Panel A: Short-Run Results     |               |               |                |               |                |                |                |                |
| $\Delta \ln I_t$               | 0.05 (2.33)   | 0.07 (2.16)   | 0.17 (2.42)    | 0.02 (0.71)   | 0.01 (0.77)    | 0.33 (3.68)    | 0.14 (1.54)    | 0.18 (1.68)    |
| $\Delta \ln I_{t-1}$           |               |               | -0.10 (-1.47)  | -0.08 (-2.13) |                |                | -0.11 (-1.26)  |                |
| $\Delta \ln I_{t-2}$           |               |               |                | -0.08 (-2.04) |                |                | -0.14 (-1.51)  |                |
| $\Delta \ln I_{t-3}$           |               |               |                | -0.01 (-0.41) |                |                | -0.17 (-1.94)  |                |
| $\Delta \ln I_{t-4}$           |               |               |                | -0.01 (-0.49) |                |                |                |                |
| $\Delta \ln I_{t-5}$           |               |               |                | 0.01 (0.28)   |                |                |                |                |
| $\Delta \ln I_{t-6}$           |               |               |                | -0.12 (-3.10) |                |                |                |                |
| $\Delta \ln I_{t-7}$           |               |               |                |               |                |                |                |                |
| $\Delta \ln I_{t-8}$           |               |               |                |               |                |                |                |                |
| $\Delta \ln M_t$               | -0.07 (-3.47) | -0.01 (-1.21) | -0.04 (-3.29)  | -0.02 (-2.54) | -0.03 (-1.89)  | -0.06 (-2.77)  | -0.07 (-3.61)  | -0.06 (-2.83)  |
| $\Delta \ln M_{t-1}$           | -0.04 (-2.37) |               |                |               |                | -0.05 (-2.52)  |                |                |
| $\Delta \ln M_{t-2}$           | 0.03 (1.64)   |               |                |               |                |                |                |                |
| $\Delta \ln M_{t-3}$           | -0.04 (-2.41) |               |                |               |                |                |                |                |
| $\Delta \ln M_{t-4}$           | 0.004 (0.20)  |               |                |               |                |                |                |                |
| $\Delta \ln M_{t-5}$           | -0.06 (-2.97) |               |                |               |                |                |                |                |
| $\Delta \ln M_{t-6}$           |               |               |                |               |                |                |                |                |
| $\Delta \ln M_{t-7}$           |               |               |                |               |                |                |                |                |
| $\Delta \ln M_{t-8}$           |               |               |                |               |                |                |                |                |
| $\Delta \ln U_t$               | -0.01 (-2.09) | -0.01 (-0.82) | 0.0001 (0.03)  | 0.002 (0.44)  | 0.003 (0.69)   | -0.01 (-1.87)  | -0.003 (-0.92) | -0.002 (-0.46) |
| $\Delta \ln U_{t-1}$           |               | 0.02 (2.94)   | 0.01 (1.77)    |               |                | -0.01 (-1.65)  |                |                |
| $\Delta \ln U_{t-2}$           |               |               |                |               |                | -0.01 (-2.71)  |                |                |
| $\Delta \ln U_{t-3}$           |               |               |                |               |                |                |                |                |
| $\Delta \ln U_{t-4}$           |               |               |                |               |                |                |                |                |
| $\Delta \ln U_{t-5}$           |               |               |                |               |                |                |                |                |
| $\Delta \ln U_{t-6}$           |               |               |                |               |                |                |                |                |
| $\Delta \ln U_{t-7}$           |               |               |                |               |                |                |                |                |
| $\Delta \ln U_{t-8}$           |               |               |                |               |                |                |                |                |
| Panel B: Long-Run Results      |               |               |                |               |                |                |                |                |
| Constant                       | -6.46 (-1.46) | -6.56 (-1.48) | 4.63 (0.69)    | -0.95 (-0.33) | -0.01 (-0.001) | -20.66 (-2.56) | -6.14 (-0.62)  | -0.86 (-0.16)  |
| $\ln I_t$                      | 0.72 (3.35)   | 0.77 (3.37)   | 0.12 (0.44)    | 0.44 (2.98)   | 0.33 (0.96)    | 1.44 (3.53)    | 0.66 (1.44)    | 0.37 (1.46)    |
| $\ln M_t$                      | 0.20 (1.31)   | -0.19 (-1.07) | -0.17 (-0.66)  | -0.32 (-1.99) | -0.04 (-0.19)  | 0.43 (1.48)    | -0.16 (-0.62)  | -0.03 (-0.14)  |
| $\ln U_t$                      | -0.36 (-2.58) | -0.13 (-1.63) | -0.22 (-1.25)  | -0.10 (-1.99) | -0.08 (-0.78)  | 0.02 (0.17)    | -0.13 (-0.87)  | -0.04 (-0.45)  |
| Panel C: Diagnostic Statistics |               |               |                |               |                |                |                |                |
| $F$                            | 8.91          | 6.46          | 4.62           | 8.92          | 2.28           | 6.59           | 4.24           | 4.44           |
| $ECM_{t-1}$                    | -0.06 (-6.02) | -0.09 (-5.15) | -0.03 (-4.35)  | -0.09 (-6.06) | -0.04 (-3.07)  | -0.03 (-5.21)  | -0.02 (-3.99)  | -0.05 (-4.19)  |
| $LM$                           | 0.58          | 13.88         | 2.17           | 1.56          | 7.29           | 0.73           | 7.96           | 2.20           |
| QS (QS <sup>2</sup> )          | S (S)         | S (S)         | S (U)          | U (S)         | S (S)          | S (S)          | S (S)          | S (S)          |
| Adj. R <sup>2</sup>            | 0.33          | 0.40          | 0.57           | 0.46          | 0.32           | 0.73           | 0.75           | 0.49           |

Exhibit 2 (continued) | Estimates of Model (2) for Each State

|                                | Nevada           | New York      | Ohio           | Oklahoma      | Oregon         | Pennsylvania   | Rhode Island   | South Carolina |
|--------------------------------|------------------|---------------|----------------|---------------|----------------|----------------|----------------|----------------|
| Panel A: Short-Run Estimates   |                  |               |                |               |                |                |                |                |
| $\Delta \ln I_t$               | 0.08 (1.92)      | 0.03 (0.44)   | 0.22 (2.46)    | 0.05 (3.41)   | 0.27 (2.12)    | 0.27 (3.11)    | 0.41 (3.29)    | 0.27 (3.12)    |
| $\Delta \ln I_{t-1}$           | 0.22 (1.63)      | -0.20 (-2.47) | -0.14 (-1.65)  |               | -0.21 (-1.67)  |                | -0.10 (-0.79)  |                |
| $\Delta \ln I_{t-2}$           |                  | -0.11 (-1.48) | -0.13 (-1.50)  |               |                |                | -0.29 (-2.21)  |                |
| $\Delta \ln I_{t-3}$           |                  |               |                |               |                |                |                |                |
| $\Delta \ln I_{t-4}$           |                  |               |                |               |                |                |                |                |
| $\Delta \ln I_{t-5}$           |                  |               |                |               |                |                |                |                |
| $\Delta \ln I_{t-6}$           |                  |               |                |               |                |                |                |                |
| $\Delta \ln I_{t-7}$           |                  |               |                |               |                |                |                |                |
| $\Delta \ln I_{t-8}$           |                  |               |                |               |                |                |                |                |
| $\Delta \ln M_t$               | -0.07 (-2.16)    | -0.10 (-4.56) | -0.06 (-4.40)  | -0.07 (-4.56) | -0.08 (4.00)   | -0.07 (-4.15)  | -0.09 (-3.90)  | -0.08 (-4.88)  |
| $\Delta \ln M_{t-1}$           |                  |               |                | -0.05 (-3.09) | 0.01 (0.82)    |                |                |                |
| $\Delta \ln M_{t-2}$           |                  |               |                | 0.01 (1.04)   | -0.01 (-0.42)  |                |                |                |
| $\Delta \ln M_{t-3}$           |                  |               |                | -0.03 (-2.01) | 0.03 (1.59)    |                |                |                |
| $\Delta \ln M_{t-4}$           |                  |               |                | -0.01 (-0.73) | -0.05 (-2.97)  |                |                |                |
| $\Delta \ln M_{t-5}$           |                  |               |                | -0.03 (-2.18) |                |                |                |                |
| $\Delta \ln M_{t-6}$           |                  |               |                |               |                |                |                |                |
| $\Delta \ln M_{t-7}$           |                  |               |                |               |                |                |                |                |
| $\Delta \ln M_{t-8}$           |                  |               |                |               |                |                |                |                |
| $\Delta \ln U_t$               | -0.0001 (-0.004) | -0.01 (-1.92) | -0.001 (-0.43) | -0.01 (-3.76) | -0.004 (-0.58) | -0.001 (-0.40) | -0.004 (-0.99) | -0.004 (-0.94) |
| $\Delta \ln U_{t-1}$           | -0.02 (-1.88)    | 0.01 (0.73)   |                |               |                |                |                |                |
| $\Delta \ln U_{t-2}$           | -0.03 (-2.39)    | -0.01 (-1.67) |                |               |                |                |                |                |
| $\Delta \ln U_{t-3}$           | -0.02 (-2.61)    |               |                |               |                |                |                |                |
| $\Delta \ln U_{t-4}$           |                  |               |                |               |                |                |                |                |
| $\Delta \ln U_{t-5}$           |                  |               |                |               |                |                |                |                |
| $\Delta \ln U_{t-6}$           |                  |               |                |               |                |                |                |                |
| $\Delta \ln U_{t-7}$           |                  |               |                |               |                |                |                |                |
| $\Delta \ln U_{t-8}$           |                  |               |                |               |                |                |                |                |
| Panel B: Long-Run Estimates    |                  |               |                |               |                |                |                |                |
| Constant                       | -9.40 (-1.35)    | -2.16 (-0.12) | -1.74 (-0.12)  | -5.16 (-2.30) | -5.05 (-0.58)  | 3.72 (0.30)    | -17.65 (-1.46) | 3.54 (0.57)    |
| $\ln I_t$                      | 0.64 (2.26)      | 0.48 (0.63)   | 0.38 (0.60)    | 0.59 (5.23)   | 0.71 (1.77)    | 0.13 (0.24)    | 1.38 (2.15)    | 0.15 (0.53)    |
| $\ln M_t$                      | 0.53 (1.25)      | -0.34 (-0.79) | -0.07 (-0.25)  | 0.13 (1.56)   | -0.32 (-1.09)  | -0.28 (-0.94)  | 0.11 (0.34)    | -0.22 (-0.89)  |
| $\ln U_t$                      | 0.46 (1.48)      | -0.20 (-0.91) | -0.05 (-0.43)  | -0.18 (-3.80) | -0.40 (-2.28)  | -0.04 (-0.38)  | -0.16 (-0.94)  | -0.09 (-0.81)  |
| Panel C: Diagnostic Statistics |                  |               |                |               |                |                |                |                |
| $F$                            | 5.47             | 3.86          | 1.82           | 8.29          | 4.08           | 2.94           | 2.45           | 4.14           |
| $ECM_{t-1}$                    | -0.04 (-4.75)    | -0.02 (-3.99) | -0.02 (-2.74)  | -0.09 (-5.84) | -0.04 (-4.09)  | -0.02 (-3.43)  | -0.02 (-3.03)  | -0.04 (-4.13)  |
| $LM$                           | 3.69             | 4.26          | 6.07           | 5.87          | 2.94           | 0.96           | 6.71           | 1.38           |
| QS (QS <sup>2</sup> )          | S (U)            | S (S)         | S (U)          | S (S)         | S (S)          | S (S)          | S (S)          | S (S)          |
| Adj. R <sup>2</sup>            | 0.74             | 0.62          | 0.51           | 0.62          | 0.67           | 0.63           | 0.75           | 0.49           |

**Exhibit 2** (continued) | Estimates of Model (2) for Each State

|                                | South Dakota  | Tennessee     | Texas          | Utah           | Virginia      | Vermont         | Washington    | Wisconsin      |
|--------------------------------|---------------|---------------|----------------|----------------|---------------|-----------------|---------------|----------------|
| Panel A: Short-Run Estimates   |               |               |                |                |               |                 |               |                |
| $\Delta \ln I_t$               | 0.08 (1.23)   | 0.28 (3.36)   | 0.08 (1.22)    | 0.29 (2.25)    | 0.21 (1.89)   | 0.31 (3.13)     | 0.02 (1.29)   | 0.34 (3.61)    |
| $\Delta \ln I_{t-1}$           | -0.17 (-2.41) | -0.19 (-2.23) | -0.23 (-3.39)  |                |               |                 |               |                |
| $\Delta \ln I_{t-2}$           |               | -0.06 (-0.69) |                |                |               |                 |               |                |
| $\Delta \ln I_{t-3}$           |               | -0.09 (-1.09) |                |                |               |                 |               |                |
| $\Delta \ln I_{t-4}$           |               | -0.10 (-1.12) |                |                |               |                 |               |                |
| $\Delta \ln I_{t-5}$           |               | 0.13 (1.44)   |                |                |               |                 |               |                |
| $\Delta \ln I_{t-6}$           |               | 0.07 (0.85)   |                |                |               |                 |               |                |
| $\Delta \ln I_{t-7}$           |               | -0.24 (-2.87) |                |                |               |                 |               |                |
| $\Delta \ln I_{t-8}$           |               |               |                |                |               |                 |               |                |
| $\Delta \ln M_t$               | -0.04 (-1.90) | -0.06 (-4.36) | -0.06 (-3.91)  | -0.08 (-3.82)  | -0.07 (-4.05) | -0.07 (-3.26)   | -0.05 (-2.36) | -0.03 (-1.73)  |
| $\Delta \ln M_{t-1}$           | -0.06 (-2.72) |               |                | 0.04 (1.82)    | 0.04 (2.12)   |                 |               |                |
| $\Delta \ln M_{t-2}$           | 0.002 (0.12)  |               |                | 0.07 (3.39)    |               |                 |               |                |
| $\Delta \ln M_{t-3}$           | -0.04 (-2.12) |               |                |                |               |                 |               |                |
| $\Delta \ln M_{t-4}$           | -0.03 (-1.51) |               |                |                |               |                 |               |                |
| $\Delta \ln M_{t-5}$           |               |               |                |                |               |                 |               |                |
| $\Delta \ln M_{t-6}$           |               |               |                |                |               |                 |               |                |
| $\Delta \ln M_{t-7}$           |               |               |                |                |               |                 |               |                |
| $\Delta \ln M_{t-8}$           |               |               |                |                |               |                 |               |                |
| $\Delta \ln U_t$               | -0.01 (-1.23) | 0.002 (0.56)  | -0.002 (-0.56) | -0.004 (-0.59) | 0.001 (.44)   | -0.0001 (-0.02) | -0.01 (-2.32) | -0.001 (-0.30) |
| $\Delta \ln U_{t-1}$           |               |               |                | 0.03 (2.92)    |               |                 |               |                |
| $\Delta \ln U_{t-2}$           |               |               |                | 0.03 (2.70)    |               |                 |               |                |
| $\Delta \ln U_{t-3}$           |               |               |                | 0.03 (2.77)    |               |                 |               |                |
| $\Delta \ln U_{t-4}$           |               |               |                | 0.02 (3.04)    |               |                 |               |                |
| $\Delta \ln U_{t-5}$           |               |               |                | 0.02 (2.63)    |               |                 |               |                |
| $\Delta \ln U_{t-6}$           |               |               |                | 0.01 (1.89)    |               |                 |               |                |
| $\Delta \ln U_{t-7}$           |               |               |                | 0.02 (3.14)    |               |                 |               |                |
| $\Delta \ln U_{t-8}$           |               |               |                |                |               |                 |               |                |
| Panel B: Long-Run Estimates    |               |               |                |                |               |                 |               |                |
| Constant                       | -4.54 (-1.93) | 2.95 (0.65)   | -2.00 (-0.90)  | 13.00 (1.87)   | 4.84 (0.37)   | -0.37 (-0.04)   | -4.37 (-0.57) | -6.07 (-0.53)  |
| $\ln I_t$                      | 0.62 (5.10)   | 0.18 (0.88)   | 0.38 (3.97)    | -0.11 (-0.38)  | 0.07 (0.12)   | 0.39 (0.83)     | 0.62 (1.81)   | 0.62 (1.13)    |
| $\ln M_t$                      | 0.04 (0.45)   | -0.10 (-0.65) | 0.06 (0.61)    | -0.86 (-2.40)  | -0.47 (-0.98) | -0.26 (-0.82)   | -0.12 (-0.40) | -0.06 (-0.19)  |
| $\ln U_t$                      | -0.14 (-3.00) | -0.12 (-1.22) | -0.13 (-2.27)  | -0.76 (-4.28)  | 0.07 (0.44)   | -0.004 (-0.02)  | -0.31 (-1.88) | -0.04 (-0.29)  |
| Panel C: Diagnostic Statistics |               |               |                |                |               |                 |               |                |
| $F$                            | 6.53          | 5.32          | 9.85           | 5.91           | 2.96          | 2.72            | 4.37          | 1.15           |
| $ECM_{t-1}$                    | -0.14 (-5.19) | -0.05 (-4.69) | -0.06 (-6.37)  | -0.07 (-4.94)  | -0.02 (-3.44) | -0.03 (-3.24)   | -0.04 (-4.22) | -0.02 (-2.15)  |
| $LM$                           | 16.19         | 4.32          | 0.41           | 1.74           | 5.73          | 1.30            | 1.04          | 4.63           |
| $QS (QS^2)$                    | S (S)         | S (S)         | S (S)          | S (S)          | S (S)         | S (S)           | S (S)         | S (S)          |
| Adj. $R^2$                     | 0.35          | 0.56          | 0.66           | 0.67           | 0.69          | 0.53            | 0.62          | 0.42           |

**Exhibit 2** (continued) | Estimates of Model (2) for Each State

|                                | West Virginia | Wyoming       | Washington DC  |
|--------------------------------|---------------|---------------|----------------|
| Panel A: Short-Run Estimates   |               |               |                |
| $\Delta \ln I_t$               | 0.35 (2.63)   | 0.01 (0.09)   | 0.03 (1.37)    |
| $\Delta \ln I_{t-1}$           | 0.12 (0.87)   | 0.14 (1.29)   |                |
| $\Delta \ln I_{t-2}$           | -0.11 (-0.82) | -0.08 (-0.73) |                |
| $\Delta \ln I_{t-3}$           | -0.01 (-0.09) | -0.01 (-0.12) |                |
| $\Delta \ln I_{t-4}$           | 0.17 (1.61)   | 0.22 (2.09)   |                |
| $\Delta \ln I_{t-5}$           | -0.14 (-1.34) | -0.05 (-0.47) |                |
| $\Delta \ln I_{t-6}$           | 0.16 (1.52)   | 0.01 (0.16)   |                |
| $\Delta \ln I_{t-7}$           | -0.18 (-1.70) | -0.27 (-2.32) |                |
| $\Delta \ln I_{t-8}$           |               |               |                |
| $\Delta \ln M_t$               | -0.09 (-3.65) | -0.06 (-2.13) | -0.08 (-2.90)  |
| $\Delta \ln M_{t-1}$           |               | -0.04 (-1.60) |                |
| $\Delta \ln M_{t-2}$           |               |               |                |
| $\Delta \ln M_{t-3}$           |               |               |                |
| $\Delta \ln M_{t-4}$           |               |               |                |
| $\Delta \ln M_{t-5}$           |               |               |                |
| $\Delta \ln M_{t-6}$           |               |               |                |
| $\Delta \ln M_{t-7}$           |               |               |                |
| $\Delta \ln M_{t-8}$           |               |               |                |
| $\Delta \ln U_t$               | 0.01 (-0.69)  | -0.01 (-0.91) | -0.01 (-1.73)  |
| $\Delta \ln U_{t-1}$           | 0.01 (2.36)   |               | -0.01 (-1.16)  |
| $\Delta \ln U_{t-2}$           |               |               | -0.02 (-2.59)  |
| $\Delta \ln U_{t-3}$           |               |               | -0.01 (-1.66)  |
| $\Delta \ln U_{t-4}$           |               |               |                |
| $\Delta \ln U_{t-5}$           |               |               |                |
| $\Delta \ln U_{t-6}$           |               |               |                |
| $\Delta \ln U_{t-7}$           |               |               |                |
| $\Delta \ln U_{t-8}$           |               |               |                |
| Panel B: Long-Run Estimates    |               |               |                |
| Constant                       | 57.38 (0.95)  | -6.33 (-2.15) | -14.16 (-1.25) |
| $\ln I_t$                      | -2.55 (-0.82) | 0.76 (5.07)   | 1.15 (1.89)    |
| $\ln M_t$                      | -1.57 (-1.03) | -0.07 (-0.50) | -0.28 (-0.62)  |
| $\ln U_t$                      | -0.82 (-1.31) | -0.22 (-2.67) | 0.13 (0.72)    |
| Panel C: Diagnostic Statistics |               |               |                |
| $F$                            | 7.25          | 3.75          | 3.18           |
| $ECM_{t-1}$                    | -0.03 (-5.47) | -0.10 (-3.83) | -0.03 (-3.61)  |
| $LM$                           | 8.87          | 4.89          | 1.64           |
| QS (QS <sup>2</sup> )          | S (S)         | S (S)         | S (S)          |
| Adj. R <sup>2</sup>            | 0.34          | 0.43          | 0.61           |

Note: Numbers in parentheses are  $t$ -ratios.

stable coefficients by “S” and unstable ones by “U.” As can be seen, clearly all coefficient estimates seem to be stable in almost all cases. Finally, we report the size of adjusted R<sup>2</sup> to measure the goodness-of-fit. Clearly, most models exhibit a good fit.

## CONCLUSION

The long-run relation between house prices and economic fundamentals has been the subject of many

studies. While some use time series data, others rely on panel data. No matter which model and data are used, the findings are mixed at best and mostly lean toward finding the lack of a long-run relation between house prices and economic fundamentals. While the definition of economic fundamentals may differ from one study to another, all studies include a measure of income and interest rate as two main determinants of house prices.

The prolonged recession of 2008 in the U.S. enticed us to look into another determinant of housing prices—a measure of economic and policy uncertainty that could make the public become cautious about the future course of the economy and save rather than spend. As they save more and postpone their spending on housing, house prices could be affected adversely. Now that a measure of policy uncertainty has been constructed by the Economic Uncertainty Policy Group and is readily available to researchers, it is our main purpose to assess the impact of this policy uncertainty measure on house prices here in the U.S. To that end, we include this uncertainty measure in addition to income and mortgage rates as long-run determinants of house prices. We then use Pesaran, Shin, and Smith’s (2001) bounds testing approach and quarterly data from each of the 50 U.S. states and Washington, DC to show that while policy uncertainty has significant short-run effects in 24 states, the short-run effects last into the long run only in 17 states.

Different public expectations in different states could be a contributing factor to our findings. For example, in Wisconsin the housing market and house prices are not too volatile no matter what. Therefore, we do not expect any significant effects of any uncertainty measure. However, in Californian where the market is relatively more volatile, we expect policy uncertainty to have significant effects. These findings also have implications for portfolio managers who invest part of their portfolio in mutual funds that include securities related to housing markets and real estate. With the development of mortgage-backed securities (MBSs) and real estate investment trusts (REITs), portfolio managers try to diversify their portfolio among assets that are safe and subject to lower risk. REITs are an asset

class that is attracting increased attention by individual investors and portfolio managers and knowledge about their performance and the determinants of their prices and returns are important. We have identified a measure of economic uncertainty to be one of the determinants and clearly, our findings provide some insight to investors as to in which state's REITs they should invest. Individual investors and portfolio managers clearly will invest in REITs associated with states that are not adversely affected by the economic uncertainty measure.

## APPENDIX

### DATA DEFINITION AND SOURCES

All data are quarterly over the period 1985:Q1–2014:Q3. The main reason to start with 1985:Q1 is due to the fact that the uncertainty measure was introduced in that year.

### Variables

$P$  = House Price. This is the House Price Index (HPI) that is based on repeat mortgage transactions on single-family properties whose mortgages have been securitized or purchased by Fannie Mae or Freddie Mac since 1975. Federal Housing Finance Agency publishes monthly and quarterly HPI data. We use seasonally adjusted HPI data that are adjusted for inflation by using the Consumer Price Index (CPI). All data are also available from Federal Reserve Economic Data (FRED) at the St. Louis Federal Reserve Bank.

$I$  = Measure of household income. We use the Total Personal Income of each state published by the U.S. Bureau of Economic Analysis. This measure of income accounts for population growth in each state that is said to be a determinant of the housing demand.<sup>9</sup> Again the data are seasonally adjusted and deflated by the CPI. All data are available at Federal Reserve Economic Data (FRED) at the St. Louis Federal Reserve Bank.

$M$  = Mortgage rate. This is the 30-year conventional mortgage rate in each state. The main source is Primary Mortgage Market Survey data by Freddie Mac,

which provides it to the Board of Governors of the Federal Reserve. Again, the data are available at Federal Reserve Economic Data (FRED) at the St. Louis Federal Reserve Bank.

$U$  = Measure of policy uncertainty. This measure is constructed as an index by the Economic Uncertainty Policy Group. The data are available for several countries from: [http://www.policyuncertainty.com/europe\\_monthly.html](http://www.policyuncertainty.com/europe_monthly.html). The group basically search for such words as “policy,” “uncertainty,” “budget,” “tax,” “deficit,” “regulation,” “spending,” etc. in major newspapers and then constructs a normalized index of the volume of news articles as a measure of economic policy uncertainty.

## ENDNOTES

1. This new measure is constructed as an index by the Economic Uncertainty Policy Group. Obviously, under this method number of words varies across newspapers and time. The group scales the raw counts by the total number of articles in the same newspaper and month. They then standardize each monthly newspaper-level series to unit standard deviation and then average across the newspapers by month. Finally, the series is normalized to conform it to an index with a base of 100. For more details and source of the data visit: [www.policyuncertainty.com](http://www.policyuncertainty.com). The procedure follows that of Baker, Bloom, and Davis (2015).
2. It is possible that the volatility in house prices could affect the uncertainty measure, introducing endogeneity into the model. However, in the autoregressive distributed lags approach we employ, we assume all the lagged values serve as instruments (Bahmani-Oskooee and Hajilee, 2010, p. 650). Pesaran, Shin, and Smith. (2001, p. 299) also alert us to this issue by stating that “our approach is quite general in the sense that we can use a flexible choice for the dynamic lag structure in ... as well as allowing for short-run feedbacks.”
3. Note that no data were available for Puerto Rico.
4. The numbers in parentheses in Exhibit 2 are  $t$ -ratios.
5. This critical value is at the 10% level of significance and for upper bound when there are three exogenous variables in our model. It comes from Pesaran, Shin, and Smith (2001, Table CI(iii) Case III, p. 300).
6. This exercise follows Pesaran, Shin, and Smith (2001) and Bahmani-Oskooee and Tanku (2008).
7. The critical value for this  $t$ -ratio comes from Banerjee, Dolado, and Mestre (1998, Table 1), who tabulate these values that depend on number of observations and number of regressors.
8. For a graphical presentation, see Pesaran, Shin, and Smith (2001) and Bahmani-Oskooee, Economidou, and Goswami (2005).
9. Some studies include per capita income and population as two separate determinants. Our measure of income combines these two into one measure.

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