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Uncertainty in the housing market: Evidence from the US states

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Uncertainty in the Housing Market: Evidence from U.S. States

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Abstract

Housing is distinct from other financial assets, since it is a durable consumer good for households. Due to the irreversible nature of housing investment, uncertainty should be an important determinant of housing investment. From a theoretical point of view, though, this impact is ambiguous. This paper extends previous empirical work by employing the techniques of bivariate Generalized Autoregressive Conditional Heteroskedasticity (GARCH) models in a group of forty-eight US states. In particular, we use data on housing permits as a proxy for housing investment and the house price index for the forty-eight contiguous US states and estimate bivariate GARCH models (BEKK) for each state, in order to obtain proxies of housing investment and house price uncertainty. Moreover, we use the Economic Policy Uncertainty index as an alternative measure of uncertainty. This setup allows us to test for the impact of uncertainty on housing investment growth and house price inflation and examine whether the effects differ across the different states. In general, we find that in most states uncertainty tends to increase housing investment growth and to decrease house price inflation. The cross-state differences in results may be due to variation in the degree of speculation in housing markets.

Keywords housing; house prices; investment; uncertainty; GARCH

JEL Classification C22, C32, E22, R31

1 Introduction

Housing has played a major role in the recent financial crisis. Due to this role, housing investment is considered as a significant determinant of economic fluctuations. According to the Bureau of Economic Analysis, residential investment represents about twenty-five percent of total private fixed investment and is one of the more volatile components of GDP in the United States. Moreover, residential investment leads the business cycle in the United States, according to Green (1997). Consumption is also a factor that is highly affected by housing, since the linkage between house price movements and consumer price inflation is strong (Goodhart and Hofmann, 2000). In addition, consumption in the United States is more closely connected to housing than in other countries (Economist, 2005).

Housing is distinct from other financial assets, since it is also a durable consumer good and it is fully insurable. Housing is considered as the psychological equivalent of gold (Trimbath and Montoya, 2002) and, as more tangible, it is much safer. Apart from these characteristics, housing is also an irreversible form of investment, since it is reversible only at a high cost. Due to the irreversible nature of housing investment, uncertainty should be an important determinant of decreasing housing investment, since when investment is irreversible agents delay their decisions (Bernanke, 1983). Cukierman (1980) also argues that when uncertainty increases, investment decisions under risk neutrality delay, in order that investors gather more information.

The theoretical literature on the effects of uncertainty on investment is quite rich. Under risk aversion and incomplete markets the relation between uncertainty and investment is probably negative (Craine, 1989). When risk aversion and incomplete markets do not apply, though, ambiguity arises. Under either risk neutrality or complete markets, the effect of uncertainty may be positive (Hartman, 1972). Moreover, Caballero (1991) presents a model where the effect of uncertainty on investment is ambiguous a priori. He shows that the effect of uncertainty on investment under asymmetric adjustment costs is not always negative, as it depends also on the degree of competition. Along the same lines Abel and Eberly (1999) focus on the impact of uncertainty on the long-run capital stock. They show that depending on the relative size of parameters, uncertainty may increase or decrease the long-run capital stock under irreversibility relative to the case of reversible investment.

Macroeconomic uncertainty and its effects on macroeconomic variables, such as output growth and inflation, as well as aggregates like investment, has been the subject of a growing volume of research in recent years. Inflation uncertainty is considered an important determinant of output, following the seminal contribution of Friedman (1977), and of inflation (Cukierman and Meltzer, 1986). Their theoretical predictions are supported by empirical findings reported in Fountas et al. (2002) and Bredin and Fountas (2009), respectively. Output uncertainty has also been examined in the literature; uncertainty on real output may increase (Black, 1987; Blackburn, 1999) or decrease (Blackburn and Pelloni, 2005) output growth and increase inflation (Devereux, 1989).

What are the effects of uncertainty on housing investment and on house prices? Are the effects similar across different US states? These questions have not yet been widely addressed in the literature; therefore, in this paper we try to fill this gap by characterizing empirically the impact of uncertainty on housing investment and house prices. Drawing on prior work by Fountas et al. (2002) we adopt a simple methodology that allows us to assess the effects of uncertainty on the US housing market and in addition answer whether these effects differ across the different states. In particular, we employ two approaches in measuring uncertainty - the conditional variance approach, based on the estimation of bivariate GARCH models for the forty-eight contiguous US states, and the Economic Policy Uncertainty (EPU) index - which enable us to assess these effects in a quantitative manner. The bivariate model allows us to see whether uncertainty affects housing demand or supply. Moreover, we examine both the short run and the long run impact of uncertainty on the two housing variables by employing Granger causality methodology, which allows us to capture the lagged effects between uncertainty and the variables of interest.

Our contribution in the existing literature comes along three fronts. First, we use a bivariate GARCH setup to model simultaneously housing investment and house prices, as well as the associated uncertainties; second, we employ the EPU index for the first time as a measure of aggregate economic uncertainty, in order to capture its effects on housing investment and house prices; third, we use state-level data for forty-eight US states, in order to determine possible interstate differences in the effects of uncertainty on housing investment and prices. We obtain some interesting results: The effects of housing investment uncertainty and total uncertainty on housing investment growth are mostly positive, while such effects on house price inflation are mostly negative, in cases where statistical significance applies. Furthermore, house price uncertainty has a statistically significant but mixed effect on investment growth in a few states. In contrast, its effect on house price inflation is mostly negative.

The remainder of the paper is as follows; in the next section we briefly discuss the findings of previous empirical work, while in the third section we present the data; in the fourth section we present the structure of our methodology, while our main results are discussed in the fifth section; finally, the last section concludes.

2 Related approaches

The empirical literature concerning the impact of uncertainty on housing investment or house prices is still scant, therefore the results are inconclusive. The most relevant empirical studies are discussed below.

Holland et al. (2000) study the impact of uncertainty on commercial investment for the United States for the period from 1972 through 1992. As a measure of uncertainty they use the volatility of returns from commercial mortgage interest rates. According to their study, irreversibility is an important determinant of slowing down investment, since they find a negative impact of uncertainty on commercial construction. However, their results indicate a short term relation, since they are based on a first difference equation.

The theory of irreversible investments is also studied by Sivitanidou and Sivitanides (2000), using data on office commercial construction for the fifteen largest US metropolitan markets for the period from 1982 to 1998. As a measure of uncertainty they use five-year standard deviations of office growth rates and according to their results, greater volatility decreases commercial construction.

Somerville (2001) examines data on permits, starts and completions for a panel of fifteen Canadian metropolitan areas to find an insignificant impact of house price returns uncertainty on housing investment, using GARCH models. This lack of significance between uncertainty and investment Somerville imputes to the ability of delay, since he finds that when a permit is obtained then the investment proceeds to completion, but with a delay. Similar methodology is also used by Bulan et al. (2009) for Canada for the period from 1979 to 1998. According to their results, higher uncertainty in real estate investment reduces the probability of investment and investors delay development during periods of uncertainty.

Recently, Miles (2008, 2009) uses a GARCH methodology to study the impact of uncertainty in the US housing market on important housing market variables, such as house price inflation and housing investment. In particular, Miles (2008) studies the impact of house price uncertainty on house price inflation for the fifty US states. In order to study the direct impact of uncertainty on house price inflation he uses GARCH-in-mean (GARCH-M) models. His analysis includes ARMA models on the Federal Housing Finance Agency house price index growth rate and shows a negative effect in three and a positive in five states. Moreover, Miles (2009) uses the same methodology in order to study the relation between housing investment uncertainty and housing investment for the United States. His study comprises aggregate US data for the period from 1975 to 2006 and shows a negative impact of uncertainty on housing investment.

House price uncertainty is also examined by Cunningham (2006), who uses micro-level data for the Seattle area for the period from 1984 to 2002. His measure of uncertainty is the volatility of real estate prices and, according to his findings, greater price uncertainty delays investment and increases land prices.

Our paper is in the spirit of Miles (2008, 2009) with some important differences. First, it applies a bivariate GARCH model examining both housing investment and house prices in a joint setting. This allows us to test not only how uncertainty in one variable affects the growth rate of the other variable, but also whether uncertainty affects housing demand or supply. Second, it uses both aggregate and disaggregated (state) US data. Third, it includes a more recent dataset that covers the period until the end of 2012. Fourth, it makes use of the EPU index as an alternative general measure of economic uncertainty.

3 Data

Our dataset comprises housing investment and house prices for the forty-eight contiguous US states and the aggregate economy for the period from the first quarter of 1988 to the last quarter of 2012. As a measure of housing investment we use the number of privately owned housing units authorized by building permits (1-unit structures), obtained from the Federal Reserve Bank of St. Louis. The data are monthly and converted to quarterly, using the average value of each quarter, in order to be consistent with the house price data. As a measure of house prices we use the all-transactions house price index, obtained from the Federal Housing Finance Agency. The all-transactions index is estimated using sales prices and appraisal data and is measured in a quarterly basis. All data are seasonally adjusted and in logarithmic form. Table 1 reports some summary statistics for house prices across the states. The house price index varies considerably across the states. In addition the volatility of house prices differs across states. According to the mean figures, high-price states are Massachusetts, New York, Rhode Island, New Jersey, California, Connecticut, Delaware and Maine.

As a measure of uncertainty we use the EPU index, developed by Baker et al. (2012, 2016).[1] The index is constructed from three types of components. The first component is an index of the volume of news articles from ten large newspapers referring to economic policy uncertainty; the second component is an index which measures the level of uncertainty regarding the federal tax code provisions, relying on reports by the Congressional Budget Office; and the third component is an index that measures the dispersion on predictions about future levels of the Consumer Price Index, Federal Expenditures and State and Local Expenditures, relying on the Federal Reserve Bank of Philadelphia's survey of professional forecasters.

4 Methodology

In order to test the impact of uncertainty on housing investment and house prices, we adopt a simple methodology employed in Fountas et al. (2002), in a different context. Our methodology allows us to test causality relationships between uncertainty, housing investment growth and house price inflation.

We model uncertainty using two alternative measures. First, we use GARCH models, which are very popular in modeling uncertainty and, second, we use the EPU index as an aggregate measure of uncertainty. Under the GARCH approach, uncertainty is defined as the conditional variance obtained from the GARCH model estimated for each state and the aggregate economy, as well. In order to estimate the conditional means, variances and covariances we use vector autoregressive (VAR) models and a bivariate GARCH model, namely the Baba-Engle-Kraft-Kroner

[1] http://www.policyuncertainty.com

(BEKK) model, defined in Engle and Kroner (1995). The BEKK model has the attractive property that its structure ensures positive definiteness of the conditional covariance matrices (Silvennoinen and Terasvirta, 2008).

The models we employ are of the general form:

$$x_t = \Phi_0 + \sum_{i=1}^{p} \Phi_i x_{t-i} + \varepsilon_t, \ \ \varepsilon_t \backsim N(0, H_t) \tag{1}$$

$$H_t = CC' + A'\varepsilon_{t-1}\varepsilon'_{t-1}A + B'H_{t-1}B \tag{2}$$

The first equation specifies a VAR model in x_t, where x_t is a $n \times 1$ vector of endogenous variables observed over time $t = 1, ..., T$, Φ_0 is a $n \times 1$ vector of constants, Φ_i is a $n \times n$ matrix of autoregressive parameters and ε_t is a $n \times 1$ vector of disturbances. Equation (2) gives the first-order BEKK model, where H_t is the conditional covariance matrix, A, B and C are $n \times n$ parameter matrices and C is lower triangular, in order to ensure positive definiteness of H_t. The BEKK model has an advantage against alternative multivariate GARCH models as the positive definiteness of the variance-covariance matrix does not require the model's parameters to satisfy sign restrictions.

In our analysis we specify a two-dimensional VAR with $x_t = [y_{it} \ \pi_{it}]'$, where y_{it} is housing investment growth and π_{it} is house price inflation in state i in quarter t. Both housing investment and the house price index are I(1), as indicated by the Ng-Perron (2001) unit root test, given in Table 2. Therefore, both variables are expressed in terms of their growth rates, namely the housing investment growth rate and the house price inflation.[2]

The selection of the VAR order is based on information criteria, the log likelihood and the lack of autocorrelation and remaining ARCH effects. In particular, we have estimated eight models for each state and the aggregate economy, with one to eight lags; the best model is then the one that combines all the characteristics mentioned above. With the exception of four states (Arizona, Georgia, Mississippi and Oklahoma) a model could be successfully estimated in all cases, in order to obtain the conditional variances as our measure of uncertainty; since the model is bivariate the two conditional variances represent uncertainty in housing investment and uncertainty in house

[2]In the case of Pennsylvania the unit root null could not be rejected for the house price index when taking first differences; however, we use its growth rate, in order to be consistent with the other states.

prices, respectively.

The impact of uncertainty on housing investment growth and house price inflation is estimated using a two-step approach. In the first step, we obtain the uncertainty measures from the estimation of the bivariate BEKK model and in the second step we perform Granger causality (Granger, 1969) tests between housing investment uncertainty, house price uncertainty, housing investment growth and house price inflation. In order to examine both the short run and the long run impact of the two uncertainty measures on the two variables, we estimate Granger causality test equations with one, four, eight and twelve lags and compute the sum of the lagged coefficients.

Next we use the EPU index, where uncertainty is measured across the whole country and, thus, we have a measure of total uncertainty. Granger causality test equations are then estimated between the EPU index, housing investment growth and house price inflation. We use the EPU index in levels, since the unit root null is rejected, according to the Ng-Perron (2001) unit root test.[3] Since the EPU index is an aggregate measure of uncertainty, it conveys a different type of information in comparison with the uncertainties proxied by the conditional variance. However, in the empirical analysis that follows, we compare the alternative measures of uncertainty regarding their impact on housing investment growth and house price inflation.

The Granger causality test equations we estimate are of the form:

$$x_t = \beta_0 + \sum_{i=1}^{k} \beta_i x_{t-i} + \sum_{i=1}^{k} \alpha_i unc_{t-i} + \varepsilon_t \tag{3}$$

where x_t is either housing investment growth or house price inflation, unc_t is housing investment uncertainty or house price uncertainty or total uncertainty, ε_t is the error term and k = 1, 4, 8 and 12. In order to measure the short run and long run impact of uncertainty on the two variables, we compute the sum of the lagged coefficients $\sum_{i=1}^{k} \alpha_i$.

The above methodology is known as a two-step procedure. In the first step, a multivariate GARCH model is estimated in order to obtain estimates of the conditional variances of housing investment growth and house price inflation, which represent proxies of uncertainty. In the second step, each of the conditional variances is used in Granger causality tests to estimate the predictive ability of uncertainty for housing investment growth and house price inflation. It is well

[3]The Ng-Perron test statistic is -10.02, while the 10% and 5% critical values are -5.7 and -8.1, respectively.

known that such an approach is inefficient. Hence, some authors choose a multivariate GARCH-in-mean model. For example, Elder (2004) uses a VAR framework, where the structural shocks are contemporaneously uncorrelated, enriched with a multivariate GARCH-in-mean model to analyze the effects of inflation uncertainty on growth. We have chosen the first approach for two reasons: First, using Granger causality tests we can test for both the short run and long run effects of uncertainty on housing investment growth and house price inflation by changing the size of the lags. Such an option is not available in GARCH-in-mean models of the type estimated by Miles (2009), where only contemporaneous effects of uncertainty are captured, even though it would be available in the model chosen by Elder (2004). Second, as one of our uncertainty proxies, i.e., the EPU index, is available a priori and is not estimated, our results across the three uncertainty proxies are more comparable.

5 Results

We start from the estimation of the bivariate BEKK model using data for the US and for each state separately. Given the large number of estimations, the estimated GARCH models are not reported. Figures 1 and 2 show the estimated conditional variances for housing investment growth and house price inflation, respectively, at the national (US) level. It is obvious that the conditional variance is time varying implying that uncertainty is quite volatile over the sample period. Uncertainty seems to be quite high, for both housing investment growth and house price inflation, during the recent financial crisis from 2007 to about 2011. The results of the Granger causality tests are reported in Tables 3 to 8. In particular, Tables 3 to 8 show the responses of housing investment growth and house price inflation to an increase in uncertainty, where uncertainty is measured either as the conditional variance derived from a BEKK model (Tables 3 to 6), or by the EPU index (Tables 7 and 8). More specifically, these tables report the sum of the lagged coefficients in the Granger causality test equations with one, four, eight and twelve lags and only in the cases where the Granger causality test gives significant results.[4]

As we have mentioned above, housing investment is irreversible and as such housing is considered to be more supply than demand inelastic; thus quantity takes time to respond to a change

[4] In cases where the residuals are serially correlated, standard errors have been corrected using the Newey-West approach. Serial correlation was more of a problem in regressions with a few lags.

in an exogenous factor, such as uncertainty. Due to the above, we consider a change in housing investment growth alone as supply driven, a change in house price inflation alone as demand driven and a change in both as follows; a rise (fall) in both investment growth and inflation denotes an increase (decrease) in housing demand, while a rise (fall) in investment growth accompanied by a fall (rise) in inflation denotes an increase (decrease) in housing supply.

5.1 Housing investment uncertainty

Tables 3 and 4 show the impact of housing investment uncertainty on housing investment growth and house price inflation, respectively. As we can see, most responses of housing investment growth are positive, while almost all responses of house price inflation are negative. Moreover, uncertainty affects house price inflation in more cases than investment growth in the short run, namely in the first two periods. However, in the long run the impact of uncertainty on investment growth becomes significant in more states than in the short run. The results denote an overall decrease in demand in the short run, while in the long run there is also an increase in supply.

In particular, after a rise in investment uncertainty we observe a fall in house price inflation in nineteen states in the first quarter, denoting a decrease in demand, while only in three there is a change in investment growth; in one state there is an increase and in the other two a decrease.

The decrease in inflation is also observed during the first year in eighteen states and is accompanied by a fall in investment growth in four states, underlying a fall in demand, and by an increase in investment growth in two states, denoting an increase in supply. A rise in investment growth is also the case for two states and the aggregate economy, showing an increase in supply. Finally, in two states there is a decrease in investment growth, denoting a fall in supply.

During the second and third year the increase in investment growth seems to be the case for thirteen and twelve states, respectively, along with the aggregate economy, being accompanied by a fall in inflation in eight states during the second year and in five states during the third, denoting an increase in supply. Moreover, there is a decrease in inflation alone during the last two periods in five and seven states, respectively, denoting a decrease in demand. Finally, a decrease in inflation, accompanied by a fall in investment, is the case for three states during the third year.

5.2 House price uncertainty

Tables 5 and 6 show the impact of house price uncertainty on housing investment growth and house price inflation, respectively. As before, uncertainty seems to affect inflation in more cases than investment growth both in the short run and in the long run. Moreover, the responses of housing investment growth are both positive and negative, while the responses of house price inflation are mostly negative. The results show an increase in demand, observed only in the first two periods, while a decrease in demand is the case in all periods and mostly in the long run.

In particular, after an increase in house price uncertainty investment growth rises in only two states during the first quarter, in one of which it is accompanied by a fall in inflation, denoting a rise in supply. On the other hand, there is a fall in investment growth in only two states, denoting a fall in supply. In eleven states we see a change in inflation; in six states there is a rise, while in five there is a fall, showing an increase and decrease in demand, respectively.

Similar results hold during the first year, as well, while in the second year the increase in investment is observed for three states without a change in inflation, underlying an increase in supply, and in one state it is accompanied by a rise in inflation, denoting an increase in demand. On the other hand, in ten states there is a fall in inflation, denoting a decrease in demand, while in two states, along with the aggregate economy, there is a fall in investment growth, denoting a fall in supply.

Finally, during the third year, in two states there is a rise in investment growth, in one of which it is accompanied by an increase in inflation. Moreover, in nine states there is a fall in inflation, while in two a fall in investment growth, showing a fall in demand and supply, respectively. On the other hand, in the aggregate economy there is a decrease both in investment growth and in inflation, showing a decrease in housing demand.

5.3 Economic policy uncertainty

Tables 7 and 8 show the impact of total uncertainty, measured by the EPU index, on housing investment growth and house price inflation, respectively. Once again, uncertainty affects inflation in more cases than investment growth, though the impact on the latter is observed in more states than in the case of the two previous uncertainty measures. As we can see, all significant effects on investment growth are positive, though most significant cases are observed in the short run. On the other hand, the negative sign is mostly the case in the impact of total uncertainty on house price inflation. In other words, a fall in housing demand as well as an increase in housing supply are observed mostly in the first period and weaken afterwards.

In particular, in fifteen states, along with the aggregate economy, an increase in the EPU index leads to an increase in housing investment growth in the first quarter, underlying an increase in housing supply. In nine of these states this increase is accompanied by a decrease in house price inflation, confirming the previous finding. Moreover, in eighteen states there is a decrease in house price inflation, without being accompanied by a change in investment growth, denoting a decrease in housing demand.

The rise in housing investment growth is also the case during the first year for eighteen states, in four of which it is accompanied by a fall in house price inflation, denoting a rise in supply, while in six it is accompanied by a rise in inflation, denoting a rise in demand. However, in thirteen states the increase in uncertainty affects only house price inflation, leading to a decrease in inflation in nine states and to an increase in inflation in four states, along with the aggregate economy, denoting a change in demand.

The rise in investment growth is also observed in seven states during the third period, in two of which it is accompanied by a fall in inflation, underlying a rise in supply. On the other hand, in four states there is a rise in inflation, while in seven states a fall in inflation, showing a change in housing demand.

Finally, during the fourth period, in six states there is a rise in investment growth, in five states a rise in inflation, and in five states a decrease in inflation, denoting respectively a rise in supply and a rise and fall in demand.

5.4 Discussion of the results

The overall results show that investment uncertainty and total uncertainty tend to increase housing investment growth in most states, while the impact of house price uncertainty on housing investment growth is inconclusive. These results show a rather robust influence of uncertainty on investment growth. On the other hand, the impact of all three measures of uncertainty on house price inflation is negative in most cases, indicating strong robustness of this result. Our results show that the negative effect of uncertainty on house price inflation does not usually apply in states where house prices are relatively high as expressed by the mean house price (see Table 1). This is the case for example in states like California, Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island and Vermont. In these states we usually (with some exceptions) find that there is no causal effect from any of the three measures of uncertainty on house price inflation (see Tables 4, 6 and 8). This result seems to imply that house prices in these high-price states are insensitive to changes in uncertainty. In other words, uncertainty seems to have a larger negative price effect on states where house prices are lower. Perhaps the explanation for this finding lies in the literature on speculative bubbles in the US housing markets. Empirical evidence by Case and Shiller (2003) shows that in the states of California, Connecticut, Massachusetts, New Hampshire, New Jersey, New York and Rhode Island, large swings in home prices are not explained well by changes in fundamentals, including income. This evidence agrees to a large extent with the conclusion of Higgins and Osler (1998) that the regions of New England, Mid-Atlantic and Pacific are more likely to have experienced speculative bubbles in the 1982-1993 period.

The positive effect of uncertainty on housing investment that we find in several cases differs from the related empirical literature, since the empirical studies on housing investment mentioned above find a negative relation between uncertainty and investment. However, as noted before, the empirical literature in this field is still scant and therefore our results may be a significant contribution to the particular literature. There are two important differences with previous studies. First, previous studies use other measures of uncertainty, such as the conditional variance obtained from univariate GARCH models (Somerville, 2001; Bulan et al., 2009; Miles, 2008, 2009), or the unconditional volatility of investment or prices (Holland et al., 2000; Sivitanidou and Sivitanides, 2000; Cunningham, 2006), while our results are based on bivariate GARCH models. In our view, our modeling choice captures better the relationship between housing investment and house prices. Second, our dataset differs from most studies, since we use disaggregated (state) data, in addition to the aggregate data.

It would be interesting to attempt explaining the different effects of uncertainty on house investment across the US states. It is possible that in the presence of higher uncertainty in the housing market or in the overall economy housing investment may increase, if housing markets behave in a speculative manner. In some states where we find a positive effect of uncertainty on housing investment growth, such as Connecticut (Tables 3 and 7), Massachusetts (Table 3), Oregon (Tables 3 and 7), and Rhode Island (Table 3), the evidence by Higgins and Osler (1998) and Case and Shiller (2003) indicates speculative housing markets. In addition, Gao et al. (2017) argue that in states with zero capital gains tax, speculation in the housing markets may be more common. We do find a positive effect of uncertainty on housing investment growth in some cases (depending on how uncertainty is measured) for Florida, Nevada, Tennessee, Texas and Wyoming, which are all states that do not levy a capital gains tax.

Our empirical results, which show that in some states uncertainty may positively affect investment growth, have some theoretical backing. There is a rich theoretical literature on the uncertainty-investment nexus that supports our findings, regarding the effect of uncertainty on investment. Under either risk neutrality or complete markets the effect of uncertainty on investment may be positive (Hartman, 1972) or negative (Bernanke, 1983). On the other hand, according to Caballero (1991) and Abel and Eberly (1999), the effect of uncertainty on investment is ambiguous. In a recent empirical paper Patnaik (2016) examines the impact of uncertainty on capital investment at the firm level and finds that the effect may be positive when firms operate in highly competitive industries. Using data on US industrial firms, the author finds that this is more likely to be the case if firms have operational flexibility (i.e., firms operate in a less unionized sector) or in firms where labour is a larger share of the production technology than capital.

At the aggregate economy level there is a large empirical literature that examines the relationship between uncertainty about the GDP growth rate and economic growth. This literature includes a number of empirical methodologies that are based on panel or time series data and various ways of measuring uncertainty about the growth rate of the economy. Some authors have found the effect of uncertainty on economic growth to be negative supporting the Keynesian belief that more uncertainty makes entrepreneurs less willing to undertake investment projects, thus reducing overall growth. Others have found that uncertainty may actually increase growth (Fountas et al., 2006).

6 Conclusions

In the present study we examine the impact of uncertainty on housing investment growth and house price inflation for the forty-eight US states. All in all, the results show heterogeneity in the effects of uncertainty across the different states. We obtain two major results. First, regarding the effects of uncertainty on housing investment, we find that in most cases the impact is positive. Second, in contrast to the above result, we find that house price inflation seems to respond negatively to all measures of uncertainty in the majority of cases. Different degrees of speculation in the housing markets across US states may explain some of the differences in results. In particular, we find that in states where speculation is more common, uncertainty does not impact negatively on house price inflation. Also, it seems that in several states with speculative housing markets, the effect of uncertainty on housing investment is positive.

According to our results, uncertainty affects house price inflation in more cases than housing investment growth, independently of the measure of uncertainty being used. In particular, housing investment growth is affected by total uncertainty mostly in the short run and by housing investment uncertainty mostly in the long run. However, house price uncertainty does not have significant impact on housing investment growth in the majority of states, either in the short run or in the long run. Likewise, house price inflation is affected in more cases by total uncertainty and housing investment uncertainty and in fewer cases by house price uncertainty. This leads us to the conclusion that housing investment uncertainty contributes more to the overall uncertainty in the housing market than house price uncertainty does.

A number of extensions is possible. It would be interesting to include some other variables that may affect the uncertainty-housing investment and the uncertainty-housing price nexi. Also, an important addition to this paper would be the attempt to discuss more factors that may explain the different results across states.

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Table 1. Summary statistics – House price index

	Mean	Median	Max	Min	SD
US	5.482	5.457	5.935	5.001	0.302
AL	5.369	5.362	5.734	4.960	0.258
AR	5.217	5.203	5.550	4.838	0.250
AZ	5.348	5.318	6.052	4.888	0.362
CA	5.723	5.607	6.464	5.096	0.396
CO	5.474	5.601	5.896	4.821	0.386
CT	5.727	5.609	6.157	5.381	0.274
DE	5.720	5.597	6.219	5.256	0.309
FL	5.442	5.335	6.173	4.956	0.373
GA	5.422	5.462	5.791	5.038	0.257
IA	5.197	5.243	5.525	4.647	0.284
ID	5.307	5.283	5.833	4.704	0.332
IL	5.510	5.514	5.922	4.970	0.283
IN	5.288	5.341	5.550	4.847	0.225
KS	5.162	5.197	5.482	4.760	0.265
KY	5.366	5.402	5.689	4.882	0.267
LA	5.090	5.083	5.513	4.604	0.319
MA	6.076	6.050	6.583	5.640	0.362
MD	5.660	5.491	6.276	5.121	0.362
ME	5.775	5.670	6.233	5.401	0.320
MI	5.401	5.466	5.774	4.855	0.276
MN	5.427	5.458	5.915	4.882	0.359
MO	5.349	5.359	5.701	4.953	0.266
MS	5.197	5.209	5.554	4.778	0.259
MT	5.388	5.356	5.941	4.698	0.405
NC	5.451	5.467	5.826	5.018	0.264
ND	5.137	5.085	5.674	4.669	0.307
NE	5.260	5.322	5.553	4.776	0.266
NH	5.685	5.620	6.175	5.251	0.339
NJ	5.806	5.668	6.354	5.429	0.348
NM	5.346	5.299	5.805	4.869	0.302
NV	5.321	5.227	6.016	4.825	0.324
NY	5.974	5.858	6.466	5.615	0.334
OH	5.324	5.392	5.589	4.855	0.229
OK	4.984	4.984	5.333	4.575	0.263
OR	5.502	5.526	6.128	4.615	0.434
PA	5.578	5.475	5.986	5.145	0.276
RI	5.839	5.676	6.401	5.451	0.345
SC	5.448	5.456	5.839	4.989	0.276
SD	5.295	5.308	5.704	4.741	0.314
TN	5.364	5.378	5.722	4.966	0.262
TX	5.097	5.096	5.439	4.737	0.248
UT	5.404	5.475	5.947	4.722	0.379
VA	5.594	5.463	6.145	5.103	0.352
VT	5.666	5.539	6.126	5.216	0.320
WA	5.622	5.612	6.217	4.801	0.388
WI	5.396	5.439	5.791	4.788	0.322
WV	5.066	5.045	5.417	4.607	0.264
WY	5.094	5.047	5.662	4.360	0.414

Table 2. Unit root tests

	Housing investment	House price index
US	-1.974	-0.383
AL	-1.075	-0.323
AR	-1.299	-0.136
AZ	-1.263	-0.619
CA	0.115	-0.573
CO	-0.705	-0.401
CT	-0.579	-1.163
DE	-1.409	-0.555
FL	-1.705	-0.647
GA	-1.027	-1.196
IA	-0.621	-0.105
ID	-0.773	0.119
IL	-0.046	-0.485
IN	-0.711	-0.538
KS	-1.166	-0.589
KY	-0.772	-0.579
LA	-0.320	-0.045
MA	0.093	-0.959
MD	-0.342	-0.809
ME	-0.100	-0.803
MI	-0.452	-0.316
MN	-0.888	-0.955
MO	-1.136	-1.087
MS	-1.180	0.293
MT	-0.514	0.115
NC	-1.076	-0.381
ND	-0.211	1.080
NE	-1.182	-0.153
NH	0.006	-1.126
NJ	0.351	-1.164
NM	-1.059	-0.611
NV	-1.308	-1.034
NY	1.319	-0.629
OH	-0.591	-1.051
OK	-0.369	0.188
OR	-1.128	-0.399
PA	-0.448	0.020
RI	0.436	-1.366
SC	-1.283	-0.840
SD	-0.354	0.646
TN	-1.122	-0.139
TX	-0.449	0.356
UT	-0.743	-0.397
VA	-0.565	-0.620
VT	-0.058	0.015
WA	-1.741	-0.365
WI	-0.836	-0.199
WV	-1.023	0.382
WY	-0.408	0.140

Notes: DF GLS test statistics. 5% and 1% critical values are -1.944 and -2.589, respectively.

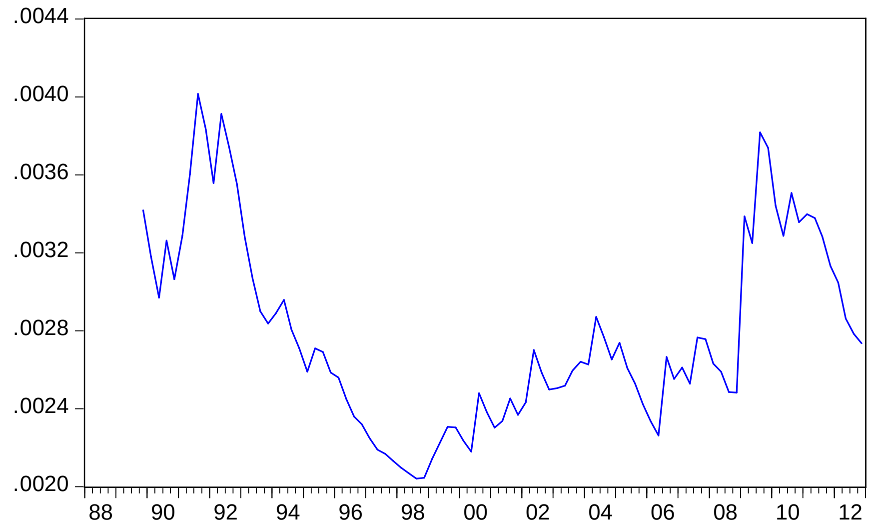

Figure 1. Conditional variance: Housing investment growth – US

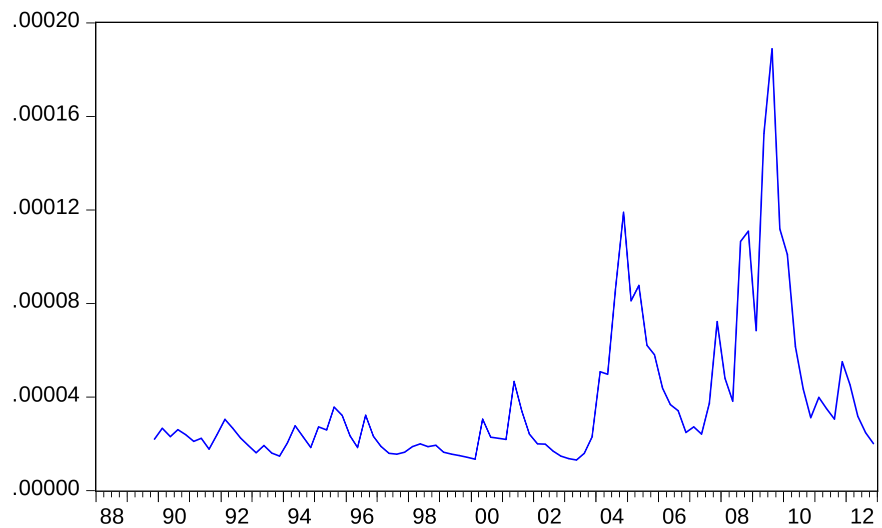

Figure 2. Conditional variance: House price inflation – US

Table 3. Impact of housing investment uncertainty on housing investment growth

	1 lag	4 lags	8 lags	12 lags
US		13.52*	24.04***	15.10**
AL				
AR				
AZ				
CA				
CO			3.84***	10.67***
CT		2.00**	3.04***	
DE				
FL				
GA				
IA				
ID		-1.09**	2.12*	3.80*
IL				
IN				
KS				
KY				
LA				
MA				2.69**
MD				
ME				
MI				
MN		-2.21*		5.11**
MO		7.43*		6.06*
MS				
MT	-20.25*			
NC			9.38**	10.37**
ND				1.92*
NE				-0.61**
NH				
NJ				
NM				
NV		-0.32**	0.04**	
NY				
OH				
OK				
OR		2.13***	3.03***	3.54***
PA				
RI		-0.27**	1.12**	2.12**
SC			8.42**	
SD				27.86**
TN				
TX		-1.18*	1.92***	-1.19***
UT			0.09**	-1.03**
VA	92.1*			
VT	-0.46**			
WA				
WI		0.06***	1.71***	4.81***
WV		-2.16*	2.36**	6.87***
WY			6.76**	

*Notes: Sum of lagged coefficients from a Granger causality test equation. *, ** and *** denote significance at 10%, 5% and 1% significance level, respectively.*

Table 4. Impact of housing investment uncertainty on house price inflation

	1 lag	4 lags	8 lags	12 lags
US				
AL	-1.02***	-0.87**		
AR		0.17*		
AZ				
CA		-0.17**		
CO	-0.48***	-0.20***	-0.35**	-0.43*
CT				
DE				
FL	-0.70***	-1.12*	-2.36**	-1.38***
GA				
IA				
ID	-0.41***	-0.41***		
IL				-0.58***
IN				
KS	-0.35***	-0.35*		-0.56*
KY	-0.43**			0.11*
LA		-0.24*	-0.41**	-0.39***
MA	-0.38**			
MD				
ME				
MI				
MN		-0.66**		-1.21*
MO	-0.32*			
MS				
MT				
NC	-1.04***	-0.71**	-1.83**	-1.93*
ND				
NE	-0.06***	-0.05***	-0.01**	-0.02**
NH				
NJ				
NM				
NV	-0.20***	-0.15***	-0.18***	-0.14***
NY				
OH				
OK				
OR	-0.42***	-0.15***	-0.24***	-0.29***
PA				
RI				
SC	-0.64***	-0.78***	-1.14***	-2.13**
SD				-0.84***
TN	-0.53***	-0.34**	-0.54*	
TX	-0.21***	-0.47***	-0.60***	-0.46*
UT	-0.16**	-0.11***	-0.05***	-0.17***
VA				
VT				
WA	-0.63**	-0.43***	-0.34***	-0.72**
WI	-0.29***	-0.15*		
WV	-0.96***			
WY			-0.57**	

*Notes: Sum of lagged coefficients from a Granger causality test equation. *, ** and *** denote significance at 10%, 5% and 1% significance level, respectively.*

Table 5. Impact of house price uncertainty on housing investment growth

	1 lag	4 lags	8 lags	12 lags
US			-49.50***	-131.15**
AL				
AR	429.92**			
AZ				
CA				
CO				
CT				
DE				
FL		-5.60**	41.85*	
GA				
IA	-2364.82*			
ID				
IL				
IN				737.04**
KS				
KY		175.30*	298.84**	
LA				
MA				
MD				
ME				
MI			289.10**	589.39**
MN				
MO		371.55***	863.35**	
MS				
MT				
NC				
ND				-6818.06**
NE	-24000.98***	-2249.17***	-38032.36***	-13019.43**
NH				
NJ				
NM		2583.86*		
NV			-45.65*	
NY				
OH				
OK				
OR				
PA				
RI				
SC				
SD				
TN				
TX				
UT	367.73*			
VA				
VT				
WA				
WI				
WV				
WY				

*Notes: Sum of lagged coefficients from a Granger causality test equation. *, ** and *** denote significance at 10%, 5% and 1% significance level, respectively.*

Table 6. Impact of house price uncertainty on house price inflation

	1 lag	4 lags	8 lags	12 lags
US				-64.96*
AL				
AR	-28.62**			
AZ				
CA	3.32**	1.10**	-1.74**	-6.71*
CO				
CT				
DE		-53.46***	-78.45***	-127.36***
FL				
GA				
IA				
ID				
IL				
IN	-34.34*			
KS				
KY				
LA	-63.43**			-197.33*
MA		5754.22*	-63985.84**	
MD	10.65*	6.82***	-12.90**	-26.45***
ME				
MI		25.40***	8.98***	11.59***
MN		1.94***	-24.91**	-31.99*
MO		-0.43***		
MS				
MT				
NC	-177.56***			
ND	-101.01**	-157.37***	-201.02**	
NE				
NH				
NJ	16.06***			-36.42*
NM	97.59***			
NV				
NY				
OH				
OK				
OR		46.91***	-73.37***	-78.28**
PA		-1111.84*		
RI				
SC			-1010.51*	-3069.83*
SD				
TN		-5.59*		
TX	-141.14**			
UT				
VA		-15.52***	-34.65***	-39.18***
VT	52.53**	-22.03**	-23.21**	
WA	9.64***			
WI				
WV				
WY				

*Notes: Sum of lagged coefficients from a Granger causality test equation. *, ** and *** denote significance at 10%, 5% and 1% significance level, respectively.*

Table 7. Impact of total uncertainty on housing investment growth

	1 lag	4 lags	8 lags	12 lags
US	0.06**			
AL				
AR	0.07*	0.12**		
AZ	0.09**	0.12*		
CA		0.10*		0.11*
CO	0.07*	0.13**		
CT				
DE		0.11**		
FL	0.08**			
GA	0.06**	0.09**	0.10**	
IA	0.11**	0.14*		
ID				
IL	0.07*			
IN				
KS		0.09**		
KY		0.08*		
LA	0.07**			
MA				
MD			0.08*	
ME				
MI	0.12***	0.14**		0.10**
MN	0.08*			
MO	0.10**	0.14**		
MS				
MT				
NC				
ND				0.56**
NE			0.07**	0.10**
NH				
NJ				
NM		0.09***	0.07**	0.07**
NV		0.19**		
NY				
OH	0.06*			
OK	0.06*			
OR		0.09*		
PA				
RI				
SC				
SD				
TN	0.08**			
TX			0.08**	
UT	0.09**	0.11**		
VA				
VT		0.07*		
WA				
WI				
WV		0.08**	0.15*	0.18*
WY		0.08***	0.10*	

*Notes: Sum of lagged coefficients from a Granger causality test equation. *, ** and *** denote significance at 10%, 5% and 1% significance level, respectively.*

Table 8. Impact of total uncertainty on house price inflation

	1 lag	4 lags	8 lags	12 lags
US		0.003*		
AL	-0.012***	-0.01***	-0.004***	-0.003**
AR	-0.009***	-0.002**		
AZ		0.009**		
CA		0.008*		
CO				
CT				
DE				
FL		0.01*		
GA	-0.013***	-0.009*		
IA	-0.004**	0.001**	0.003*	
ID	-0.01**	-0.001**		
IL		0.003*	0.004**	0.001**
IN	-0.006**			
KS	-0.009***		0.002*	0.002*
KY	-0.008***			
LA	-0.009***	-0.005***		-0.005*
MA				
MD		0.005*		-0.001**
ME				
MI				
MN	-0.008*			
MO	-0.005**			
MS	-0.02***	-0.015*	-0.014*	
MT	-0.01**			
NC	-0.011***	-0.01***	-0.003**	-0.001**
ND		0.003*		
NE	-0.005**			
NH				
NJ				
NM	-0.008**	0.001**		
NV		0.01**		
NY				
OH				
OK	-0.009***			
OR	-0.006*	0.004***	0.002***	0.003***
PA				
RI				
SC	-0.012***	-0.011***	-0.001***	0.002**
SD	-0.01***			
TN	-0.01***	-0.008***	-0.001**	-0.007***
TX	-0.009***	-0.008**	-0.004*	
UT	-0.01**	-0.001**	-0.001*	
VA				
VT				
WA	-0.007*	-0.001***	-0.001**	0.002**
WI	-0.006*			
WV	-0.012***	-0.004***	-0.001**	
WY	-0.027***			

*Notes: Sum of lagged coefficients from a Granger causality test equation. *, ** and *** denote significance at 10%, 5% and 1% significance level, respectively.*