2013 V41 4: pp. 709–746
DOI: 10.1111/reec.12011
REAL ESTATE
ECONOMICS

The Foreclosure–House Price Nexus: A Panel VAR Model for U.S. States, 1981–2009

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Despite housing's economic importance, little has been written on how foreclosures and home prices interact in a framework that includes macroeconomic and housing variables such as employment, permits or sales. Panel VAR results for quarterly state-level data indicate that price–foreclosure linkages run both ways. Foreclosures negatively impact home prices. The negative impact of prices on foreclosures, however, is much larger. These results suggest the low-frequency association observed between foreclosures and prices is mostly driven by the endogenous adjustment of foreclosures to prices via the strategic choices of homeowners and lenders, rather than through the effects of foreclosures on home prices.

The decline of housing-related activity before and through the 2008–2009 recession was unprecedented in both its depth and breadth. The drop in residential investment was the deepest in the post-WWII era. The collapse in the values of subprime mortgage-backed securities was accompanied by a substantial increase in foreclosures and unusually large declines in house prices in some states—especially Arizona, California, Florida and Nevada. Widespread loose mortgage credit—as exemplified by the doubling of subprime originations between 2003 and 2005 and the tripling of Alt-A originations over the same period (Mayer, Pence and Sherlund 2009)—was reflected in unprecedented default and foreclosure rates for those cohorts of mortgage originations. In response to rising foreclosure rates, numerous policy initiatives were targeted at reducing foreclosure activity, many with the explicit rationale that housing prices would not stabilize until foreclosure rates declined.

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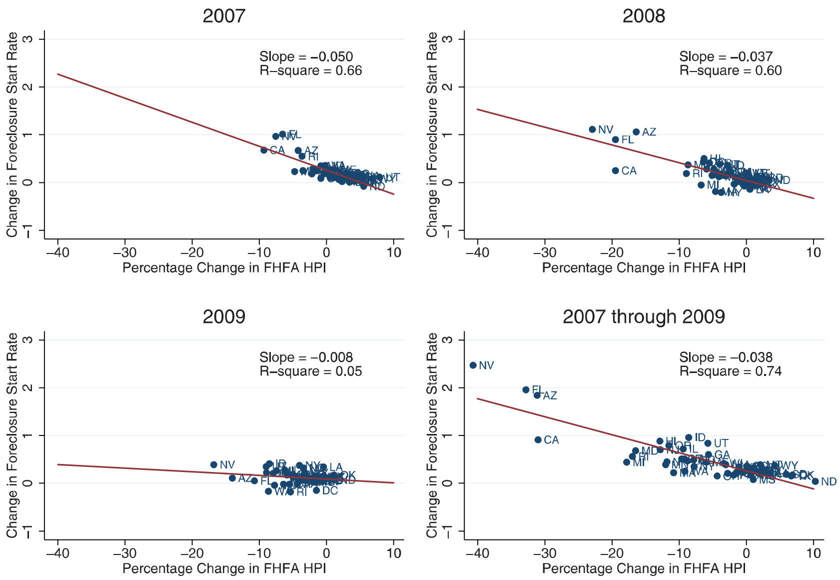
Figure 1 ■ Change in foreclosure start rate vs. FHFA HPI.



Note: Annual graphs are derived using year-over-year changes based on fourth-quarter values. The three-year graph shows the cumulative changes between 2006Q4 and 2009Q4. The Foreclosure Start Rate is the percentage of loans serviced that began the foreclosure process during the quarter. The FHFA HPI is the state-level Federal Housing Finance Agency all-transactions house price index.

Figure 1 illustrates the possible cause for concern about house price declines in the wake of widespread foreclosures. Using data from 2007 through the end of 2009 and regressing price change on the change in foreclosure starts at the state level (where we use the Federal Housing Finance Agency (FHFA) all-transactions index to measure price and the Mortgage Bankers Association (MBA) quarterly delinquency surveys to measure foreclosure starts relative to mortgages), we generally find a close fit between the two series, both on an annual basis and for the period as a whole, with an R^2 during the entire crisis period of 0.74. Concern over the effect of foreclosures on prices was cited as justification for mortgage modification policies such as the HAMP (Home Affordable Modification Program) and foreclosure moratoria enacted by some states in late 2008. The hope was that by preventing foreclosures such programs would stop (or slow) the decline in house prices and restore stability to the housing market.

Of course, Figure 1's description of the low-frequency association between price change and foreclosures growth says nothing about the *causal* relationships between prices and foreclosures and should not be interpreted as providing an estimate of the response of prices to foreclosure shocks. This regression line reflects a combination of three influences: (1) the responses of prices to foreclosure shocks, (2) the responses of foreclosures to price shocks and (3) the responses of both foreclosures and prices to shocks originating in other variables.

We focus our attention in this paper on measuring the relative importance of these three influences. To our knowledge, ours is the first paper to estimate the interaction of foreclosures and house prices for the United States as a whole and the first to investigate that question within a dynamic model of housing market conditions and the local (state-level) economy. Our model is capable of disentangling the various contributing influences that could explain the low-frequency association between foreclosures and price changes, and thus it allows us to gauge the potential housing-price and macroeconomic consequences of continuing mortgage distress. In particular, we find that the long-term impact of prices on foreclosures is 79% larger than the impact of foreclosures on prices.

Modeling the housing market at the state level is helpful for improving empirical identification. Quarterly data on the main housing variables of interest exist for each state going back to 1981. Although there have been only three nationwide housing cycles since the 1980s, there have been numerous state- or regional-level cycles, which often have entailed significant price declines and increases in foreclosures. Furthermore, even within a given national economic cycle, there is wide variation across states in employment growth, net migration and other factors that can affect local housing markets. As a result, there is substantial variation in housing market experiences across states, which can be useful for identifying empirical linkages among variables.

Leamer (2007) notes that no macroeconomics textbook contains any lengthy treatment of real estate, despite its central role as a leading indicator of business cycle conditions. Instead, academic studies tend to focus on aspects of the housing market and the broader economy in isolation from each other, such as examining the interaction of house prices and home sales, but nothing else. Despite the importance of housing to the economy, little has been written about the interaction between prices and foreclosures at the aggregate level, and to our knowledge nothing has been written that links prices and foreclosures dynamically within the broader context of the macroeconomic environment and other conditions in the housing market. This is an important omission when one considers that the impact of financial liquidation on measures of prices and output in the economy is highly controversial; some fear that allowing liquidations will cause further distress for home prices, while others have pointed to episodes in which dragging out the liquidation process leads to prolonged large, negative effects on asset prices (Anari, Kolari and Mason 2005).

This paper proceeds as follows. The next section reviews existing literature on the connections between home prices and foreclosures. The third section describes our estimation methodology and the results of our primary panel VAR. The fourth section presents results from a series of robustness checks, while the fifth section concludes.

Previous Literature

At the macro level, little has been written about the empirical relationships between home prices and foreclosures or other measures of financial distress, although some have examined how price volatility may affect the probability of default (Foster and Van Order 1984). In contrast, a number of recent studies have used micro data to assess the interaction of foreclosures and prices. Gerardi, Shapiro and Willen (2008), using data from Massachusetts, find that price declines were a major catalyst in pushing subprime borrowers into foreclosure during the recent downturn. Bajari, Chu and Park (2008) use a nationwide dataset from LoanPerformance on subprime and Alt-A mortgages and similarly find that home prices are a significant determinant of the probability of default.

Examining the opposite direction of causality, from distress to prices, Lin, Rosenblatt and Yao (2009) use a random sample of about 20% of all U.S. mortgages, including only those that are conforming, and find that there is a clear negative impact of foreclosures on prices of local homes. They find that this effect of foreclosures is much larger during a housing downturn than during a boom, indicating the importance of controlling for the state of the housing cycle when measuring the effects of foreclosures. Leonard and Murdoch (2009) investigate foreclosures in the greater Dallas area and similarly uncover a negative effect of housing distress on prices, which diminishes as distance from the foreclosed property grows. Neither of these studies, however, controls for the number of nondistressed homes available for sale at the time of foreclosure, so their results do not distinguish between the "distress" effect of foreclosure and the "supply" impact of simply adding more homes for sale in the market.

Rogers and Winter (2009) examine foreclosures in St. Louis county and find the expected negative impact. Interestingly, they also find that the marginal impact on prices of additional foreclosures *declines* as foreclosures increase, which contradicts the proposition that rising foreclosure rates may have an increasing incremental effect on house prices. The authors, while examining the impact of foreclosures on prices, also acknowledge the endogeneity issue and the possibility that there is an impact of prices on foreclosures. The authors concede that simultaneity bias is an issue but state that they cannot find an instrument for foreclosures. They note therefore that "claims of causation must be made cautiously" (p. 459). Similarly, another study of home price change (OFHEO 2007) found no evidence that, on average, neighborhoods with high foreclosure rates suffered greater price declines, *ceteris paribus*.

Campbell, Giglio and Pathak (2011) employ data from Massachusetts to distinguish the different price behavior of "forced" sales (foreclosure sales or those motivated by bankruptcy or the death of the owner) from unforced sales. The authors find that the price impacts of forced and unforced sales are quite different. Unforced sales pricing appears efficient, in that prices are close to a random walk. Forced sales, by comparison, display pricing that is clearly mean-reverting. The authors then attempt to discern the impact of forced sales on unforced sales and find "the prices of forced sales had relatively little predictive power for the prices of other transactions in the housing market" (pp. 2110–2111). Thus it appears that foreclosure sales are a special type of sales, distinct from less distressed transactions, and may thus have little effect on the prices of other houses. To the extent that this finding generalizes, it could have important implications for foreclosure prevention policies.

In some contrast to the Campbell, Giglio and Pathak (2011) findings, Harding, Rosenblatt and Yao (2009) use evidence from 37 MSAs in 13 states and find that foreclosure sales reduce the prices of nearby homes. Hartley (2010) uses data from Chicago spanning 1998–2008 and notes that foreclosures may affect prices through two channels—first, via a straightforward increase in supply and second through a disamenity effect if the foreclosed property is not maintained or suffers from vandalism. Hartley (2010) finds that in census tracks with low vacancy rates, the supply effect is twice the disamenity effect, while in high vacancy census tracks the supply effect disappears while the disamenity effect remains. Along a similar vein, Anenberg (2012) develops a theoretical model and examines data from Los Angeles and San Francisco and finds that Real-Estate Owned (REO) properties have a negative impact on the prices of nearby homes for sale, but that this effect is not different from that of non-REO sales.

Mian, Sufi and Trebbi (2010) also examine the impact of foreclosures on house prices, as well as the effect of the latter on residential investment and durable consumption. Employing data covering 31,000 ZIP codes across the United States, the authors gauge the effect of foreclosures on prices with an important empirical innovation. First, they acknowledge that any study of the impact of foreclosures on prices is plagued by endogeneity—both variables are affected by other influences, and there is also reverse causality, as prices can impact housing distress. The authors address this simultaneity by finding an instrument for foreclosures in the different U.S. state laws on judicial versus nonjudicial foreclosure. Specifically, some U.S. states require a mortgage servicer to sue a delinquent homeowner in court before proceeding to (judicially) foreclose, while other states require only a notice of sale to the borrower (nonjudicial foreclosure). The authors find a large negative correlation between judicial foreclosure requirements and the actual level of foreclosures across states. Employing judicial foreclosure laws as an instrument for foreclosures and adding a number of control variables such as the unemployment rate in 2000, the results indicate that a one-standard-deviation increase in foreclosures results in an 8–12% decline in home prices over nine quarters. By way of comparison, we find the nine-quarter response of prices to this size of foreclosure shock to be a cumulative house price drop of 2.7%. Carrying our model forward, we find the long run, six-year response to this size shock results in a 6.8% drop in house prices.

To summarize, the recent housing crisis has spurred new research on the relationship between foreclosures and house prices. At the micro level, the general conclusion is that rising foreclosures do lower house prices, although different authors find varying magnitudes for that effect. None of these studies, however, compares the foreclosure-price effect with the price-foreclosure effect. Furthermore, these studies do not model the dynamic relationship between the local economic environment and the housing market.

Because housing markets are local and highly segmented, one would expect to find a stronger relationship between foreclosures and home prices using micro-level data than with the state-level aggregates we use. Nevertheless, we do find large effects of home price shocks on foreclosures at the state level, indicating that spatial aggregation at the state level does not eliminate observed linkages between prices and foreclosures. Indeed, we would emphasize that our main findings relate to the *relative* magnitudes of shocks, which should be robust to spatial aggregation. In particular, our finding that linkages between price changes and foreclosure shocks mainly reflect shocks that originate in prices should be robust to the level of spatial aggregation—both impulse responses may be larger in magnitude at a more micro-level, but we would not expect disaggregation to affect the relative magnitudes of the two responses. Furthermore, state-level data have unique value because they allow us to explore foreclosure-price linkages in a model that takes account of the broader economic environment. State-level data are the most "granular" level of data available that allows for investigating and disentangling the linkages among the macroeconomic environment, distress and home values.

Among our results, we find that other shocks to local market conditions (demand shocks to housing sales) are important drivers of both house prices and foreclosures. Furthermore, in analyzing the connections between foreclosures and prices, we find that price shocks have a 79% larger long-term (six-year) impact on foreclosures than foreclosure shocks have on prices.

A Quarterly Panel VAR Model of the State-Level Housing Market, 1981–2009

We model home prices and foreclosures at the state level, using quarterly data since 1981 and treat the growth of home prices and the foreclosure rate as part of a five-variable system of equations, which also includes the growth rates of employment, single-family permits and existing home sales. We employ a panel vector autoregressive model (PVAR) that captures the dynamic linkages among all five variables, which are all treated as mutually endogenous.

More specifically, we employ the following data in our analysis. *Employment* is measured as the log difference of the quarterly average of seasonally adjusted monthly total nonfarm employment for each state. *Sales* is the log difference of the seasonally adjusted annual rate of existing home sales in each state as reported by the National Association of Realtors (NAR). *Permits* is the log difference of the quarterly average of the monthly seasonally adjusted annual rate of single-family residential building permits for each state. *Prices* is the log difference of the FHFA all-transactions home price index (inclusive of same-home sales and refinancings).[1] Finally, *Foreclosures* is the log of the ratio of new foreclosures started during the quarter to total mortgages serviced for each state based on MBA surveys. In our robustness checks, we also include the mortgage interest rate in our system of equations, where the *Mortgage Rate* is defined as the quarterly average of the 30-year fixed mortgage rate for the region in which the state is located, as reported by Freddie Mac; we omit this variable from our baseline model, since the national integration of mortgage finance in the U.S. limits variation in financing cost across states and since including the variable reduced the degrees of freedom in our regressions. A detailed description of how each of the variables used in our analysis is constructed can be found in Appendix A. After some experimentation with different lag lengths, we found that 12 quarterly lags were necessary to capture fully the significant dynamic relationships among these five variables.

We also ran a version of the model using foreclosures outstanding from the MBA data (a stock variable as opposed to a flow variable) with very similar

[1]In what follows we also discuss results when we employ the FHFA purchase-only index. As we discuss in more detail below, we believe that including refinancings when measuring price change is desirable because it reduces any bias arising from variation in the types of homes that sell over different phases of the housing cycle.

results, which are not reported here.[2] We focus in the main body of the paper on results using foreclosure starts for two reasons. First, the measured effects of foreclosures on house prices in this version of the model are slightly larger; given that one of our central conclusions is the relatively small magnitude of this effect, it is conservative to focus on these results. Second, the flow of foreclosures has been used in other studies that have found larger price effects (notably, Mian, Sufi and Trebbi 2010), and thus using the flow of foreclosures facilitates comparisons of results.

All data run from 1981 through the fourth quarter of 2009. For many states, however, the early years of the FHFA indices exhibit a great deal of volatility, reflecting the small number of transactions available for estimating the index early in the sample. To account for this, we drop early observations of the state-level price indices that are "too volatile," using a procedure described in Appendix A; in our robustness checks we demonstrate that keeping these observations has no substantive impact on our key results.

Due to the forward (Helmert) de-meaning of observations used to control for state fixed effects, we lose the last observation, and thus our useable sample runs through the third quarter of 2009.[3] The PVAR regression results are shown in Table 1.[4]

In order to generate impulse responses and variance decompositions, one must identify the sources of covariance among the residuals in each of the five equations. We follow the existing PVAR literature by employing the Choleski decomposition, which models the residuals matrix as a recursive, triangular system. The main advantage of that approach is its simplicity: one selects an ordering of variables that posits the degree of within-quarter endogeneity among each of the five endogenous variables.

We experimented with various possible orderings among the five variables and found that our key results regarding the relationship between home prices and foreclosure starts were robust to the orderings chosen, which reflects the

[2]Tables and figures from regressions using the foreclosure inventory data are reported in a supplemental appendix available at http://realestate.wichita.edu/data-research/academic-research/.

[3]We follow Love and Ziccino (2006) in our methodology for Helmert de-meaning. This process was first proposed by Arellano and Bover (1995).

[4]Granger-causality tests (not reported) are highly significant for all equations and all variables in the system with the lone exception that permits do not appear to Granger-cause prices.

Table 1 ■ Panel VAR regression results (dependent variables in columns).

	Employment	Sales	Permits	Prices	Foreclosures
Employment					
L1	0.444852***	−0.325925	0.394684	−0.019063	−1.399245
	(0.052215)	(0.410751)	(0.717624)	(0.042294)	(0.955229)
L2	0.198130***	−0.275171	1.179180	0.035300	−0.660079
	(0.032629)	(0.453796)	(0.832567)	(0.041618)	(0.946323)
L3	0.086224***	−2.426219***	−3.583954**	0.014563	0.342988
	(0.025966)	(0.422188)	(1.125925)	(0.042165)	(1.107133)
L4	−0.149104***	−0.242306	−3.830172***	0.116864**	0.182134
	(0.024997)	(0.417057)	(1.084326)	(0.043880)	(1.360551)
L5	0.124205***	0.589767	1.102271	−0.038663	1.334925
	(0.023205)	(0.422152)	(0.839420)	(0.044953)	(0.893076)
L6	0.052821**	−0.098667	1.110666	−0.079764	0.939791
	(0.017953)	(0.387743)	(0.938408)	(0.040866)	(0.867759)
L7	0.012559	−0.088491	0.307503	0.128241**	−0.829059
	(0.017255)	(0.372896)	(0.815076)	(0.041726)	(0.838302)
L8	−0.157157***	−0.603313	−1.168211	−0.065751	−0.852597
	(0.018247)	(0.387024)	(0.648028)	(0.045120)	(0.817457)
L9	0.094625***	0.489735	0.354994	−0.026362	−2.295495**
	(0.019334)	(0.377311)	(0.680005)	(0.040983)	(0.839917)
L10	0.039689*	−1.023045**	0.238489	−0.113182*	1.234198
	(0.018649)	(0.392104)	(0.712031)	(0.045327)	(0.835696)
L11	0.017484	−0.023373	−0.009710	0.062112	−0.325889
	(0.015450)	(0.361195)	(0.642748)	(0.047007)	(0.826097)
L12	−0.080386***	0.290264	0.436668	0.060465	−0.140804
	(0.014665)	(0.362101)	(0.549283)	(0.042569)	(0.773257)
Sales					
L1	0.001783*	−0.220502***	0.208668***	0.004568*	−0.109339**
	(0.000749)	(0.029292)	(0.037021)	(0.002207)	(0.037403)
L2	0.001710*	−0.058191*	0.147598***	0.008731***	−0.081800*
	(0.000793)	(0.024165)	(0.037661)	(0.002636)	(0.037824)
L3	0.000507	−0.090254***	0.105978*	0.005253*	−0.007954
	(0.000828)	(0.023493)	(0.041991)	(0.002468)	(0.038857)
L4	0.002166**	0.067022**	0.086505*	0.003253	−0.017151
	(0.000820)	(0.023131)	(0.036080)	(0.002283)	(0.037353)
L5	0.003033***	0.001164	0.025276	0.006295**	−0.042080
	(0.000796)	(0.021317)	(0.035130)	(0.002201)	(0.038308)
L6	0.003453***	0.079344***	0.055292	0.005961**	−0.067327
	(0.000749)	(0.021641)	(0.035870)	(0.002232)	(0.042909)
L7	0.003794***	−0.016528	0.052357	0.007970***	0.049119
	(0.000778)	(0.023417)	(0.042015)	(0.002121)	(0.038381)
L8	0.001961*	−0.020345	−0.008380	−0.000250	0.061113
	(0.000829)	(0.024907)	(0.037350)	(0.002231)	(0.040072)
L9	−0.000285	−0.037033	−0.113707**	0.001836	0.086301*
	(0.000790)	(0.021708)	(0.038839)	(0.002084)	(0.036302)
L10	−0.001138	0.050767**	−0.087598*	0.002043	0.046175
	(0.000736)	(0.019658)	(0.039715)	(0.002019)	(0.035327)
L11	−0.000424	0.013761	−0.111378**	0.000692	0.052222
	(0.000695)	(0.018322)	(0.037451)	(0.002102)	(0.037784)
L12	−0.000541	0.012412	−0.102706***	0.002095	0.088078*
	(0.000707)	(0.018016)	(0.030210)	(0.001868)	(0.036413)

Table 1 ■ Continued

	Employment	Sales	Permits	Prices	Foreclosures
Permits					
L1	0.003044***	0.064964***	−0.366309***	0.002241	−0.029887
	(0.000533)	(0.012075)	(0.051488)	(0.001697)	(0.018469)
L2	0.002070**	0.029084*	−0.176038***	0.002686	−0.064992**
	(0.000689)	(0.012360)	(0.048831)	(0.001600)	(0.019971)
L3	0.001691**	0.003063	0.002960	−0.000433	−0.106147***
	(0.000533)	(0.011794)	(0.083174)	(0.001299)	(0.019705)
L4	0.001152*	−0.049881***	−0.078611	−0.000490	−0.104461***
	(0.000517)	(0.012475)	(0.073523)	(0.001819)	(0.020647)
L5	0.002120**	−0.010077	0.126972*	0.000564	−0.093783***
	(0.000667)	(0.012741)	(0.053862)	(0.001721)	(0.022937)
L6	0.001496*	0.000287	0.169391*	0.000324	−0.057157*
	(0.000602)	(0.012033)	(0.066664)	(0.001459)	(0.022290)
L7	−0.000729	−0.029415*	0.011233	−0.000372	−0.058768*
	(0.000526)	(0.012899)	(0.057333)	(0.001658)	(0.024841)
L8	−0.000651	−0.029497*	−0.021848	0.001582	−0.046224
	(0.000552)	(0.012189)	(0.062838)	(0.001689)	(0.024943)
L9	0.000943	0.011600	0.051986	−0.000973	−0.042555
	(0.000635)	(0.013349)	(0.067235)	(0.001648)	(0.023095)
L10	0.000775	−0.002445	0.184738**	−0.000439	0.015280
	(0.000596)	(0.012000)	(0.060245)	(0.001651)	(0.024009)
L11	0.000255	−0.001738	0.206986***	−0.002407	0.002703
	(0.000612)	(0.012264)	(0.050300)	(0.001584)	(0.021955)
L12	−0.000572	−0.011913	0.128389*	0.000630	0.001193
	(0.000562)	(0.012087)	(0.059981)	(0.001459)	(0.021169)
Prices					
L1	0.009588	1.164632***	1.581391***	0.351544***	−0.750330*
	(0.006229)	(0.165845)	(0.409964)	(0.023598)	(0.304428)
L2	0.009295	0.141823	1.331579*	0.090661***	−0.986313**
	(0.006561)	(0.173464)	(0.554083)	(0.024158)	(0.322936)
L3	0.019648**	0.104127	−0.189663	0.261744***	−1.874992***
	(0.006425)	(0.164533)	(0.337558)	(0.022588)	(0.323721)
L4	−0.017620**	−0.217835	−0.592920	0.143281***	−0.011993
	(0.006547)	(0.171757)	(0.559806)	(0.021519)	(0.355206)
L5	−0.028624***	−0.727439***	−1.001034*	0.003924	0.324945
	(0.006794)	(0.189712)	(0.480820)	(0.023173)	(0.376992)
L6	−0.002992	−0.074577	−0.173485	−0.058978**	−0.227232
	(0.006734)	(0.186328)	(0.348820)	(0.020398)	(0.389797)
L7	0.015573*	0.634722***	0.241556	−0.032287	−0.459568
	(0.006789)	(0.188426)	(0.425469)	(0.020312)	(0.361211)
L8	−0.002408	−0.745866***	−0.552348	0.063594**	0.287624
	(0.006366)	(0.178173)	(0.304669)	(0.019799)	(0.354376)
L9	0.002026	−0.345677*	−0.416646	0.059893**	0.816745*
	(0.006713)	(0.166037)	(0.300057)	(0.019000)	(0.375157)
L10	0.007720	0.106085	−0.246473	−0.041028*	0.734581*
	(0.006028)	(0.168234)	(0.302617)	(0.017814)	(0.366973)
L11	−0.014304*	−0.334903	−0.870388***	−0.049303**	0.761443*
	(0.006030)	(0.171762)	(0.260108)	(0.018026)	(0.361369)
L12	−0.008868	−0.122981	−0.324879	0.001210	0.757001*
	(0.005464)	(0.163495)	(0.236695)	(0.016798)	(0.333142)

Table 1 ■ Continued

	Employment	Sales	Permits	Prices	Foreclosures
Foreclosures					
L1	−0.000109	−0.014184	−0.013155	−0.003170***	0.528446***
	(0.000481)	(0.009626)	(0.012230)	(0.000924)	(0.022902)
L2	−0.000054	0.010947	0.020799	−0.000809	0.167689***
	(0.000396)	(0.009853)	(0.013298)	(0.001013)	(0.025380)
L3	−0.000396	−0.003745	−0.039021**	−0.000469	0.169174***
	(0.000370)	(0.009825)	(0.012957)	(0.000980)	(0.027394)
L4	−0.001543***	−0.022861*	−0.030869*	0.000970	0.094619***
	(0.000395)	(0.010983)	(0.013632)	(0.000949)	(0.026733)
L5	0.000104	−0.003153	−0.000170	−0.000200	−0.016862
	(0.000377)	(0.010525)	(0.013335)	(0.000969)	(0.026523)
L6	−0.000651	−0.000605	−0.003241	0.001905*	0.015519
	(0.000367)	(0.010122)	(0.013670)	(0.000958)	(0.025224)
L7	0.000281	0.004768	0.006671	−0.001661	−0.014606
	(0.000361)	(0.010319)	(0.013651)	(0.000950)	(0.023964)
L8	0.000753*	0.023041*	0.045422***	0.003328***	−0.010898
	(0.000378)	(0.010445)	(0.013285)	(0.000898)	(0.025364)
L9	0.000086	−0.005599	−0.012936	0.001519	0.013891
	(0.000382)	(0.009304)	(0.013697)	(0.000991)	(0.022609)
L10	0.000595	−0.004019	−0.006065	−0.000588	−0.032723
	(0.000400)	(0.010198)	(0.012812)	(0.000915)	(0.025990)
L11	0.000269	−0.008426	−0.008265	−0.001096	−0.011195
	(0.000364)	(0.009242)	(0.011884)	(0.000971)	(0.022057)
L12	−0.000565	−0.016953*	0.002246	−0.000246	0.028614
	(0.000312)	(0.007809)	(0.011191)	(0.000815)	(0.019917)

Note: Standard errors are presented in parentheses below the regression coefficients. ***, ** and * indicate coefficient significant at the 0.1%, 1% and 5% levels, respectively. The variables used in the analysis are as follows:

- *Employment* – Growth rate (log difference) of the quarterly average of seasonally adjusted monthly total nonfarm employment for the state.
- *Sales* – Growth rate (log difference) of the seasonally adjusted annual rate of existing home sales for the state in the quarter.
- *Permits* – Growth rate (log difference) of the quarterly average of the monthly seasonally adjusted annual rate of single-family residential building permits for the state.
- *Prices* – Growth rate (log difference) of the quarterly FHFA house price index (all transactions) for the state.
- *Foreclosures* – Log level of the MBA quarterly foreclosures started as a percent of loans serviced for the state.

All regression variables were de-meaned using a Helmert transformation, while the actual values of the variables were used as instruments to obtain consistent estimates.

generally low contemporaneous correlations among shocks in our system of equations; most of the observed connections among variables occur only with a lag (the exceptions, shown in Table 2, are the high contemporaneous correlations between permits shocks and shocks to employment and sales).

As our baseline specification we use the following ordering: employment, sales, permits, prices and foreclosure starts. Employment appears first in

Table 2 ■ Residuals correlation matrix.

	Employment	Sales	Permits	Prices	Foreclosures
Employment	1				
Sales	0.0767	1			
	(0.0000)				
Permits	0.1490	0.1701	1		
	(0.0000)	(0.0000)			
Prices	−0.0658	0.0610	0.0062	1	
	(0.0000)	(0.0000)	(0.6721)		
Foreclosures	−0.0125	−0.0918	−0.0369	−0.0495	1
	(0.4008)	(0.0000)	(0.0128)	(0.0008)	

Note: All variables are Helmert de-meaned log differences of levels except for foreclosures, which is the (de-meaned) log foreclosure start rate (see the notes on Table 1 and Appendix A for a complete description of the variables); p-values are reported in parentheses.

our ordering, since we assume that any correlations between within-quarter innovations in employment and the within-quarter innovations in our four housing-sector variables reflect the role of employment as a source of disturbance (both with respect to the labor market and as a general macroeconomic barometer).

Foreclosure starts are placed at the end of our ordering for two reasons. First, foreclosure reflects the strategic decisions of borrowers and lenders; thus we think it is appropriate to allow foreclosure decisions to respond to other variables within the quarter. Second, conceptually, placing foreclosure shocks at the end of the ordering ensures that foreclosure shocks reflect influences other than shocks to the supply and demand for housing (which are captured by housing sales, permits and prices, which precede foreclosure starts in the ordering). We interpret foreclosure shocks as reflecting average changes in housing finance distress, after accounting for changes in employment as well as the supply and demand for housing. For example, the prevalence of subprime mortgages in recent years meant that the amount of increased foreclosures conditional on a given fall in housing demand should be higher than average. That higher amount of foreclosures (in the current data) would appear in our analysis as a larger foreclosure shock. Similarly, variation in foreclosure laws across states, or changes in foreclosure policy over time (*e.g.*, recent mortgage modification policies) will result in differences in foreclosure shocks, conditional on the same shocks to employment and housing supply and demand. We discuss this latter point below, with reference to the different observed foreclosure shocks for "judicial foreclosure" states and "nonjudicial foreclosure" states.

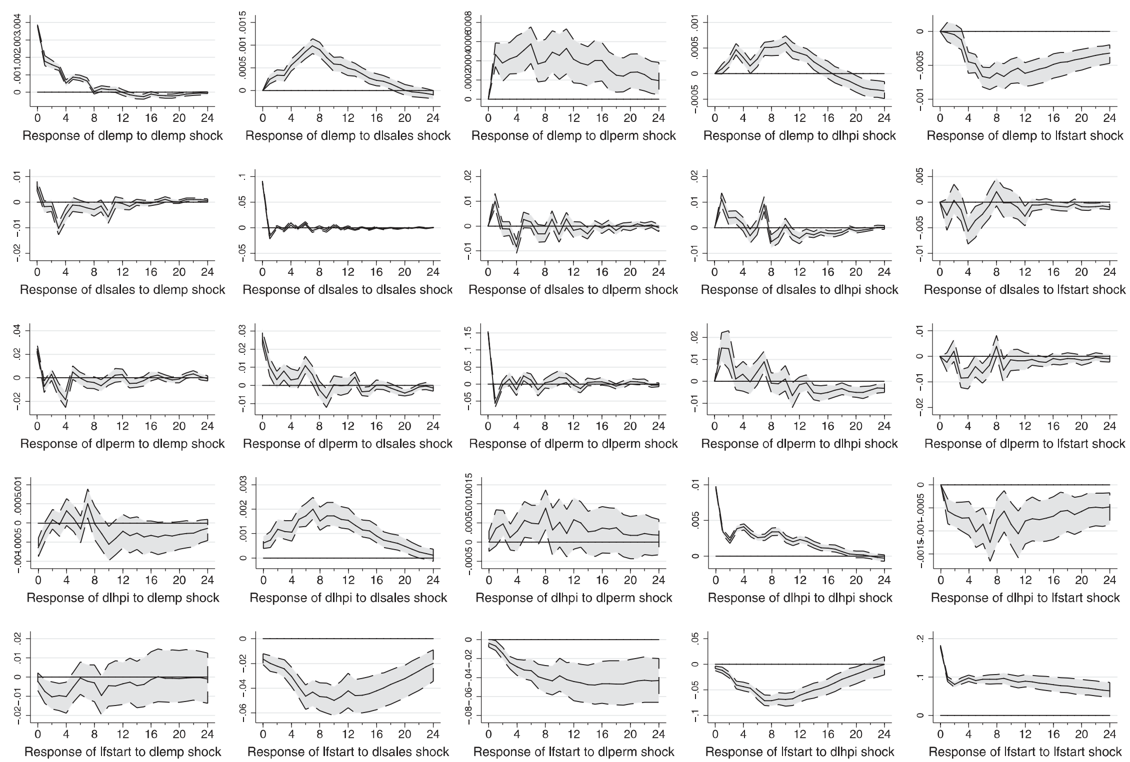
We place house price changes second to last in our system. Within-quarter price shocks are not strongly correlated with foreclosure shocks (the correlation is –0.0495, as shown in Table 2); allowing prices to follow the other three variables and precede foreclosures maximizes the extent to which contemporaneous price changes can reflect other influences within the quarter, while still allowing within-quarter foreclosures to respond to price changes within the quarter. As mentioned above, our reported results are highly robust to the choice of ordering of variables in the Choleski decomposition; we report robustness checks for different orderings below. That robustness reflects the generally low contemporaneous correlations among the quarterly shocks identified in the system of equations.

The impulse responses (Figure 2) of the five endogenous variables to orthogonalized shocks that are identified by the recursive orthogonalization do not reflect clear structural identifying restrictions. In particular, housing sales, permits and prices each reflects a mix of shocks to the demand and supply of housing. Still, it can be possible to infer the relative extent to which identified shocks are associated with demand- or supply-side disturbances based on the combination of observed patterns of response. For example, if a housing sales shock is associated with rising initial impulse responses for prices and permits, as in our reported results in Figure 2, then that sales shock could be interpreted as reflecting mainly housing market demand-side influences. In the same way, if a housing price shock is associated with positive sales and permits impulse responses, as in Figure 2, then that too could be viewed as indicative that housing price shocks reflect mainly housing market demand-side influences.

Our impulse responses display a number of reassuring and robust tendencies. In particular, sales, permits and price shocks all have a positive impact on employment. Employment responds negatively to foreclosure shocks. One interpretation of this latter effect is that borrowers' and lenders' forecasts of future macroeconomic conditions (which are not fully captured by contemporaneous innovations in the four other variables) affect their decisions, which result in foreclosures. More generally, it is important to bear in mind that impulse responses indicate correlative, not necessarily causal, relationships.

Foreclosures respond negatively to shocks in each of the other four variables in our system. At the same time, the relationship between foreclosure starts and the other variables in our system is bidirectional, as foreclosure shocks (increases in the quarterly log foreclosure start rate that are unforecastable on the basis of lagged values of the five variables and contemporaneous values of the other four variables) are associated with declines in employment, prices and sales. The negative response of foreclosures to a sales shock may reflect the fact that a home sale is the primary alternative to foreclosure when a borrower

Figure 2 ■ Impulse response function.



Note: Impulse responses are based on growth rates (difference of logs) of all variables in the system except the foreclosure start rate, which is modeled as a log level. The impulse responses are derived using a Cholesky decomposition with the following ordering: employment, sales, permits, prices (HPI) and foreclosure start rate. Shaded areas represent 95% confidence intervals for the estimated impulse responses.

is delinquent; if the market for sales is robust, a delinquent borrower is more likely to sell the house and avoid foreclosure. Similarly, the impulse response of employment to permits shocks indicates that permits shocks are associated with future economic growth; thus, the negative response of foreclosures to a permits shock likely reflects expected improvements in economic growth.[5]

Two of the impulse responses merit particular attention, given the focus of our study. The impulse response of prices to foreclosure shocks is negative and statistically significant. The impact of prices on foreclosures is also negative and statistically significant.

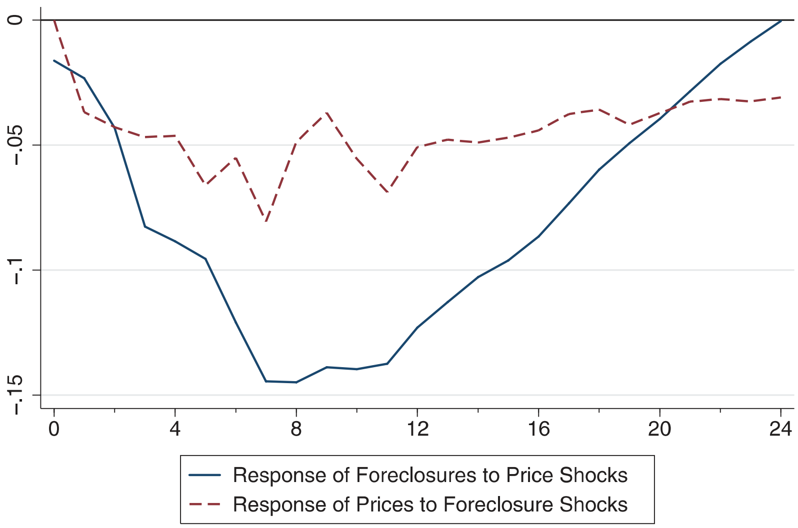
To quantify the magnitudes of these effects, using the impulse response functions shown in Figure 2 we calculate the cumulative (25-quarter) response of prices to a one-standard-deviation foreclosure shock, and the cumulative response of foreclosures to a one-standard-deviation price shock. The log foreclosure start rate shock is 0.1794, corresponding to a shock in the actual foreclosure start rate of 0.2 percentage points.[6] The cumulative impact of this shock over the following six years is a 1.7% decline in house prices. In contrast, a one-standard-deviation shock in the HPI growth rate (dlhpi) is 0.96%. This shock results in a cumulative (25 quarter) response in the foreclosure start rate of –0.95 percentage points.

The comparative magnitude of these two effects (that of price shocks on foreclosures and that of foreclosure shocks on prices) can be described in various ways. Figure 3 provides one perspective on that relative magnitude. In Figure 3, the impulse responses are standardized by the in-sample standard deviation of the responding variables. By this measure (analogous to a coefficient of variation adjustment to the impulse response), the effects of price shocks on foreclosures are substantially larger than the effects of foreclosures on prices; on a cumulative basis over six years, the impact of price shocks on foreclosures is 79% larger than the magnitude of foreclosure shocks on prices.

[5]The impulse responses of the foreclosure starts variable to its own shock are highly persistent. The persistence of the estimated impulse response is substantially less using a sample that ends at 2006 (not reported). Thus, we believe that the persistence of the foreclosure response to foreclosure shocks shown in Figure 2 largely reflects the current crisis and the fact that the crisis period is truncated in time. We expect that, with the passage of time and the use of additional post-crisis data, estimated persistence will decline.

[6]This is calculated as $\exp(0.1794) - 1 = 0.2$ (our underlying foreclosure rate data are expressed in whole percentage points, not decimals). Note that we subtract 1 from the exponentiated shock so that the log baseline from which shocks are measured is zero ($\ln(1) = 0$).

Figure 3 ■ Standardized impulse reponses.



Note: The standardized responses are calculated by dividing the model impulse responses shown in Figure 2 by the sample standard deviations of the response variable. Cumulating over all 25 quarters, the standardized foreclosure response to prices is 79% larger than the standardized price response to foreclosures (–0.1445 vs. –0.0806).

Another measure of the magnitude of effects is the percentage contribution to the variance decomposition. Table 3 uses this measure to gauge the importance of shocks originating in the five endogenous variables for each of the five variables (entries in this table show the percent of the row variable's error variance that is explained by shocks to the column variable at the specified lag). In many cases, the variables do not contribute importantly to each other's forecast variance. For example, using a 5% threshold to gauge importance, employment shocks contribute importantly only to the forecast variance of employment, no variables other than sales shocks contribute importantly to the forecast variance of sales, and no variables other than permits shocks contribute importantly to the forecast variance of permits. On the other hand, all the variables in our system are important for the forecast variance of employment growth (the least important variable, prices, explains over 6% of employment error variance at 24 lags) and sales, permits and price shocks are all important for the forecast variance of foreclosures.

Price shocks explain 16% of the 24-lag forecast variance of foreclosures. On the other hand, foreclosures explain only about 5% of the forecast variance of

Table 3 ■ Variance decompositions.

	Lag	Employment	Sales	Permits	Prices	Foreclosures
Employment	4	0.9526	0.0119	0.0228	0.0120	0.0007
	8	0.7949	0.0896	0.0474	0.0243	0.0438
	24	0.5925	0.1316	0.0852	0.0608	0.1299
Sales	4	0.0173	0.9518	0.0118	0.0181	0.0010
	8	0.0199	0.9252	0.0210	0.0274	0.0065
	24	0.0246	0.9040	0.0262	0.0370	0.0082
Permits	4	0.0266	0.0293	0.9257	0.0156	0.0028
	8	0.0369	0.0330	0.9049	0.0180	0.0072
	24	0.0394	0.0353	0.8914	0.0248	0.0090
Prices	4	0.0036	0.0271	0.0029	0.9564	0.0100
	8	0.0047	0.0759	0.0068	0.8850	0.0276
	24	0.0093	0.1281	0.0144	0.8004	0.0478
Foreclosures	4	0.0042	0.0285	0.0139	0.0375	0.9158
	8	0.0033	0.0681	0.0439	0.1243	0.7604
	24	0.0019	0.1065	0.1155	0.1579	0.6183

Note: Percent of row variable explained by the column variable at the specified lag.

prices after 24 lags. Thus, as with the impulse response functions, the evidence strongly points to a large effect of prices on foreclosure starts but a much smaller impact of foreclosure starts on prices.

Our estimate of the magnitude of the effect of foreclosure start shocks on house prices is smaller than that of Mian, Sufi and Trebbi (2010). Using their approach to identification, they find that a one-standard-deviation increase in foreclosures during the period 2008–2009 (a 4.3-percentage-point increase in the foreclosure start rate) results in an 8% to 12% decline in house prices over the nine quarters from 2007q4 through 2010q1. A comparable shock to foreclosure starts in our model (that is, a foreclosure shock that results in a two-year increase in the foreclosure start rate of 4.3 percentage points) results in a nine-quarter cumulative decline of house prices of 2.7%. Carrying our model forward, we find that the long run, six-year house price response to that magnitude foreclosure start shock is a 6.8% price decline.[7]

Whenever VAR or PVAR models include asset prices, a potential interpretation problem arises. Asset prices should be forward-looking measures of value,

[7] Part of the difference in these measured impacts may result from their use of Zillow.com ZIP-code level house price indices, which may exhibit greater variation than the FHFA indices used in our analysis.

and therefore they could foresee influences originating in other variables. For example, it is conceivable that adverse housing price shocks may occur in anticipation of foreclosure shocks that are predictable to market participants. If that were true, foreclosures would properly be viewed as causing declines in house prices even though the declines in house prices predate (and Granger-cause) foreclosure shocks.

Our empirical results, however, do not support that reverse-timing causation story. There is little contemporaneous correlation between housing price shocks and foreclosure shocks (the correlation is –0.05), suggesting that house prices are not highly responsive to news about foreclosure starts. The impulse response of house price shocks on foreclosure starts reaches its peak after two years. It is implausible therefore to argue that house price shocks reflect home buyers' ability to forecast foreclosure shocks (foreclosure start increases unrelated to current or lagged foreclosure experience or other lagged housing variables) many months in advance. Moreover, our results indicate that housing prices generally are not important predictors of other housing variables (*i.e.*, housing sales or housing permits); the contribution of housing prices to the forecast variance of those two variables is negligible. These results confirm the widespread view that, unlike stock or bond prices, housing prices do not respond quickly to long-term shifts in housing market supply and demand. We conclude that the predictive role of housing prices for foreclosure starts primarily reflects the endogenous reactions of homeowners and lenders to declining house prices (*e.g.*, to foreclose instead of renegotiating the terms of a mortgage), rather than the adjustments of housing prices to foreclosure shocks in the distant future that are anticipated by market participants.

Robustness

In this section we consider several robustness checks on our results. First, we consider whether nonlinearities in the effects of foreclosures on house prices could be important and might alter the conclusions of our analysis. Second, we rerun our model adding back the initial periods in each state that we had removed when estimating our model due to concerns about noise in the house price data. Third, we consider whether our results are robust to redefining house prices in real rather than nominal terms. Fourth, we consider potential problems associated with the particular choice of house price index used in our study. Fifth, we report results for various different orderings of contemporaneous shocks in the system. Finally, we add mortgage interest rates to the system of equations to investigate whether the identification of shocks to prices and foreclosure starts, or their dynamic relationship, is affected by the inclusion of the mortgage rate.

Nonlinear Foreclosure Effects

One possible concern about the estimation results reported in Tables 1–3 and Figures 2 and 3 is that they are based on a *linear* PVAR model of the relationship between foreclosure starts and housing price changes. The impact of foreclosure starts on prices may reflect nonlinear (or threshold) effects; that is, a rise in foreclosure starts when foreclosure rates are high may have a bigger effect on prices than a rise in foreclosures when foreclosure rates are low.[8] The housing slump in the late 2000s was the largest downturn in the housing sector since the Great Depression in terms of the decline in residential investment. The rise in foreclosures was similarly dramatic. If there are threshold effects in foreclosures, our results may understate, perhaps dramatically, the impact of foreclosure starts on home values.

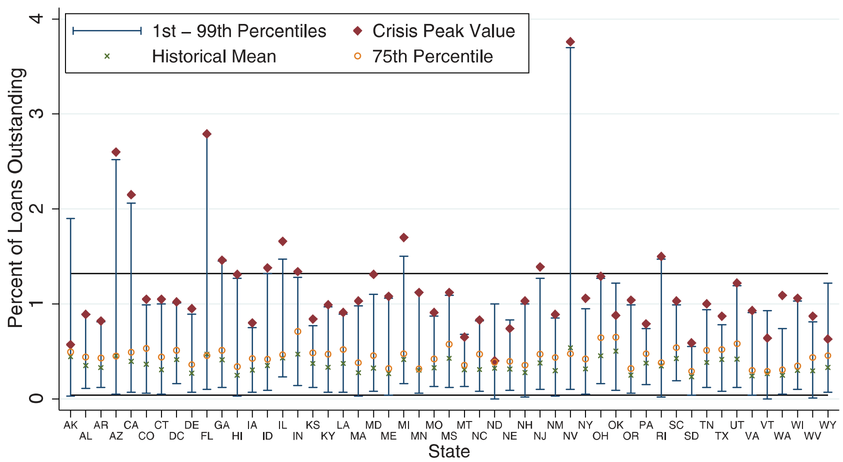
There is reason to be concerned about the potential importance of nonlinearity, given some of the extreme values observed for foreclosures and prices in our sample. Figure 4 shows that, for all but a few states, the peak foreclosure start rate during the recent crisis (since 2005) was the highest in that state's history, and in some cases, these foreclosure start rates were higher than rates previously experienced by any state. As Figure 5 shows, those same high foreclosure rate states also tend to be states that could be considered outliers with respect to their price experience; only eight states saw price declines of greater than 15% from 2007 to 2010, but their average declines were twice those of the next most severely affected states. Given these extreme values in foreclosures and prices, to the extent that nonlinear effects exist, they could have important implications for the states that are the most severely affected by the housing crisis.

While any VAR model is inherently linear, we were able to construct tests to explore whether the linear structure of the model biases the measures of foreclosure-price effects during the recent crisis. If our model suffered from a poor fit due to threshold effects, we should observe large, negative residuals for the price series over the final crisis quarters in our sample. As displayed in the third row of Table 4, however, over the crisis period, the average value for the price shocks is only 0.03% and not significantly different from zero, supporting the results of the model.

A further test of the potential bias from linearity is suggested by the work of Mian, Sufi and Trebbi (2010). These authors employ judicial versus nonjudicial foreclosure requirements at the state level as an instrument for exogenous

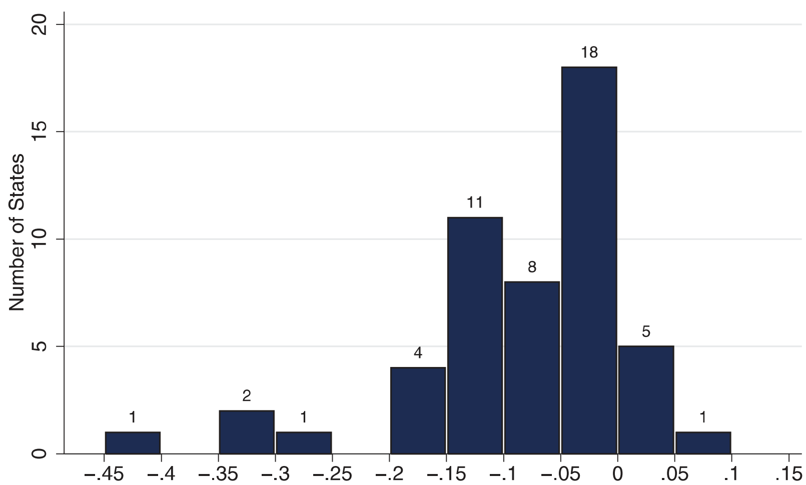
[8]It is worth noting here that using microlevel data, Rogers and Winter (2009) found that the price impact of additional foreclosures diminished as the number of foreclosures in the neighborhood rose. This is the opposite non-linearity effect from that typically discussed.

Figure 4 ■ Crisis foreclosure start rates vs. historical values.



Note: The bars show the range of historical foreclosure start rate values (1st through 99th percentiles) for each state between 1979 and 2009; the historical mean and 75th percentile figures are calculated using this same time frame. The diamonds show the peak value of the foreclosure start rate since 2005. The horizontal lines reflect the 1st and 99th percentiles of the foreclosure start rate over the entire panel.

Figure 5 ■ Distribution of total house price changes between 2007Q2 and 2010Q1.



Note: The District of Columbia is included as a state. The four states with the largest price declines over this period are Nevada (–40.9%), Florida (–33.0%), Arizona (–32.1%) and California (–29.8%).

Table 4 ■ Orthogonalized foreclosure and price "shocks" since 2007.

Group	Obs.	Foreclosure Shocks	Price Shocks
Nonjudicial-Foreclosure States	341	0.0173**	0.0002
		(0.0059)	(0.0006)
Judicial-Foreclosure States	220	–0.0095	0.0006
		(0.0090)	(0.0007)
Combined	561	0.0068	0.0003
		(0.0051)	(0.0005)
Difference		0.0268*	–0.0004
		(0.0108)	(0.0010)

Note: Cell entries show mean orthogonalized shocks of the variable in question, with standard errors presented in parentheses below. ***, ** and * indicate coefficient significant at the 0.1%, 1% and 5% levels, respectively. Orthogonalized shocks are calculated as the one-step-ahead forecast errors minus the contemporaneous responses to the shocks of earlier variables in the system according to our Cholesky ordering. Thus, employment shocks are simply the forecast errors, sales shocks are the forecast errors less the contemporaneous response of sales to the observed employment shock, and so forth. Judicial foreclosure states are identified by Mian, Sufi and Trebbi (2010) as Connecticut, Delaware, Florida, Illinois, Indiana, Kansas, Kentucky, Louisiana, Maryland, Massachusetts, Maine, Nebraska, New Jersey, New Mexico, New York, North Dakota, Ohio, Pennsylvania, South Carolina and Vermont.

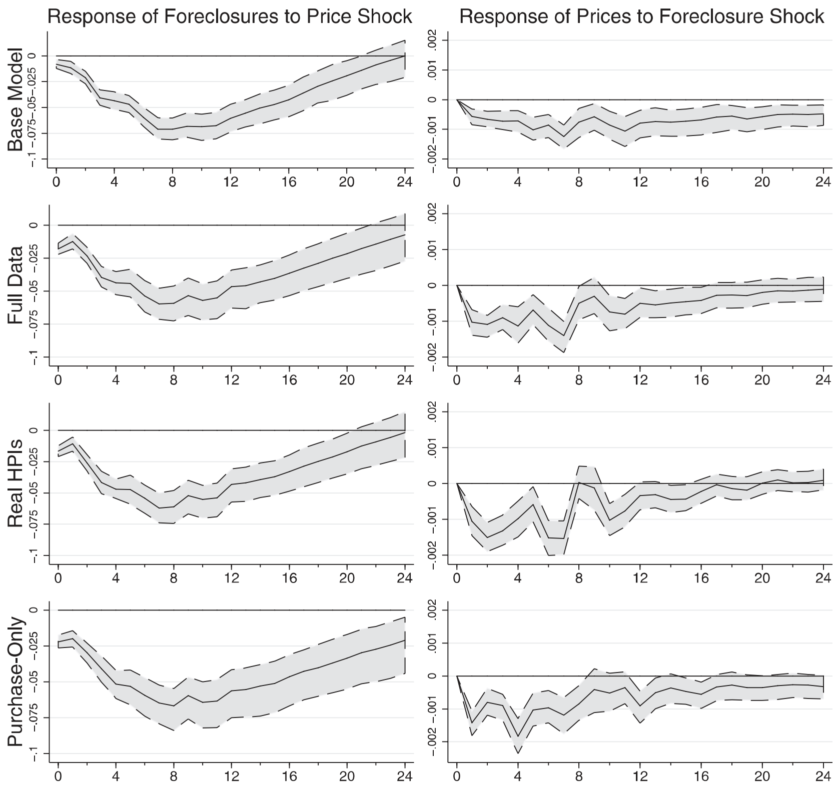
differences in foreclosure rates. As shown in Table 4, realized foreclosure shocks in our model are indeed much higher for nonjudicial foreclosure states during the crisis, as suggested by Mian, Sufi and Trebbi (2010). But these high exogenous shocks to foreclosure rates are not associated with higher identified price shocks in those states during the crisis. Price shocks are small, and there is no significant difference between the identified price shocks in judicial versus nonjudicial states. These results indicate that our linear model is able to capture linkages between foreclosure starts and prices without falsely identifying the results of foreclosure shocks as price shocks, even when foreclosure shocks are very high.[9]

Restoring Omitted Early Observations

The FHFA house price indices are constructed using a weighted repeat sales methodology. This method of measuring house prices is prone to noisy-price problems in the early years of the sample (when the number of same-house sales is small). In the estimates reported in the third section, we eliminated early observations for each state based on a volatility criterion, as discussed in

[9] We also ran our PVAR model separately for judicial and nonjudicial foreclosure states, the results of which are discussed in Appendix B.

Figure 6 ■ IRFs for various data samples.



Note: This figure shows the impulse responses of the foreclosure start rate to a shock in prices (left column) and of prices to a shock in the foreclosure start rate (right column) for our base model and four alternatives; shaded regions represent 95% confidence intervals. The Full Data graphs incorporate early observations that were deleted in the base model due to concerns about volatility in the HPI. Real HPIs deflate each state's house price index by the quarterly average of the consumer price index. Finally, the Purchase-Only graphs use the FHFA purchase-only indices (spliced with the all-transactions indices in the early years as discussed in the text). The basic relationships between the two variables remain qualitatively unchanged regardless of the sample employed, with the response of prices to foreclosure shocks being the strongest under our base model.

Appendix A. Here we restore those omitted observations and examine whether including those observations affects our results. We find that our results are qualitatively similar. As the second row of Figure 6 shows, when we retain the early "noisy" observations, the impulse response function of prices with respect to foreclosure shocks are similar but persist for fewer quarters than was the case with our base model. In contrast, foreclosure start responses to price shocks

Table 5 ■ Variance decompositions for various data samples.

		Base Model		Full Data		Real HPIs		Purchase-Only	
	Lag	Prices	For.	Prices	For.	Prices	For.	Prices	For.
Prices	4	0.9564	0.0100	0.9373	0.0157	0.9351	0.0212	0.8956	0.0129
	8	0.8850	0.0276	0.8786	0.0331	0.8913	0.0392	0.8364	0.0302
	24	0.8004	0.0478	0.7787	0.0349	0.8252	0.0395	0.7701	0.0328
Foreclosures	4	0.0375	0.9158	0.0359	0.9014	0.0393	0.9118	0.0470	0.8805
	8	0.1243	0.7604	0.0943	0.7575	0.1059	0.7764	0.1165	0.7227
	24	0.1579	0.6183	0.1047	0.5385	0.1067	0.5597	0.1463	0.5281

Note: Percent of row variable explained by the column variable at the specified lag. The Full Data cells incorporate early observations that were deleted in the base model due to concerns about volatility in the HPI. Real HPIs deflates each state's house price index by the quarterly average of the consumer price index. Finally, the Purchase-Only cells use the FHFA purchase-only indices (spliced with the all-transactions indices in the early years as discussed in the text). In each case, prices explain a larger percentage of the variation of foreclosures at 24 lags than do foreclosures for prices.

remain large and more important, as before. Similarly, Table 5 shows that the variance decompositions are qualitatively similar across the two samples.

Real vs. Nominal House Prices

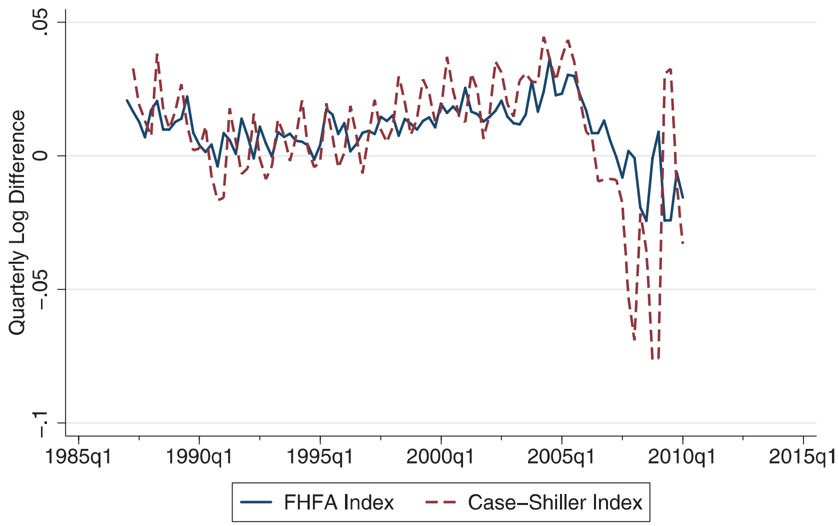
Next, we consider whether deflating house prices using the consumer price index affects our results. Given the low and relatively stable rates of inflation in the U.S. economy during most of our sample period, we chose not to deflate house prices in our estimation in the third section, since deflating can be a source of measurement error. When we use deflated rather than nominal house prices in our model, the impulse responses are quite similar to those in our baseline model (Figure 6), as are the variance decompositions (Table 5).

Different Measures of House Prices

Our model uses the comprehensive FHFA all-transactions index (including both sales and refinancings) as our measure of house prices in each state in each quarter. The FHFA also produces a purchase-only index, which excludes refinancing when determining repeat transactions. We believe on *a priori* grounds that the all-transactions index is the least-biased concept of price to employ for the purposes of this study, since it does not suffer as much from selectivity bias relating to cyclical variation in the composition and frequency of home sales.

As a robustness check, however, we ran a version of our model using the FHFA purchase-only index as the measure of house prices, with qualitatively similar results. Because the purchase-only index is not available for the earliest years of

Figure 7 ■ Quarterly house price appreciation.



Note: The Case-Shiller U.S. national house price index exhibits more quarterly volatility than the FHFA all-transactions index.

our sample period (prior to 1991), we used the all-transactions index for those early years and spliced the two series (as discussed in the appendix). Once again, Figure 6 illustrates that the effects of price and foreclosure start shocks on prices and foreclosure impulse responses are quite similar. The variance decompositions are also quite similar, as shown in Table 5.

One further measure of house price appreciation—the Case-Shiller index—is often reported in the press, and this index has suggested that housing price declines over the final years of our study was much greater than that measured by the FHFA index. While we would like to run a version of our model using the Case-Shiller index as well, it is not available at the state level nor for a sufficiently long time period to be used in this study. There are reasons to believe, however, that our conclusions would be similar if state-level Case-Shiller indices were available for our Panel VAR model.

First, both indices measure the same underlying phenomenon—home price appreciation—with error. As can be seen in Figure 7, the U.S. Case-Shiller index exhibits more quarterly volatility than the U.S. FHFA index, but changes in the two indices are strongly correlated (0.51), and this correlation is even higher at lower frequencies (0.89 at the annual level). Second, Table 6 uses aggregate U.S. versions of the two indices to show that the correlations between

Table 6 ■ Correlations between house price growth and other U.S. aggregate system variables.

	Employment	Sales	Permits	Foreclosures
FHFA Index	0.3746	0.1006	0.1845	–0.4938
	(0.000)	(0.340)	(0.078)	(0.000)
Case-Shiller Index	0.3784	0.2830	0.5517	–0.4672
	(0.000)	(0.006)	(0.000)	(0.000)

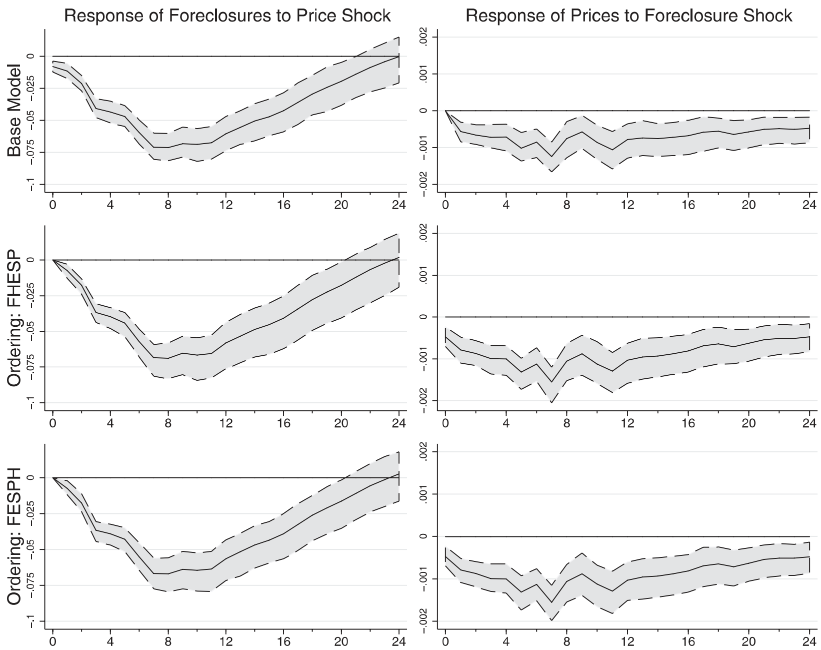
Note: Cells show the pairwise correlations of prices and the other variables in the system for U.S. aggregate values; p-values are shown in parentheses below the correlations. In the top row, prices are measured using the FHFA all-transactions house price index. In the bottom row, prices are measure using the Case-Shiller U.S. national house price index (not seasonally adjusted). The Case-Shiller HPI exhibits larger correlation with existing home sales and building permits, but the correlations with employment and the foreclosure start rate are similar across the two measures of home prices.

prices and the other variables in the system are qualitatively similar regardless of the price index used. Although the growth rates of sales and permits are more strongly correlated with home price appreciation using the Case-Shiller index, the correlations with employment and the foreclosure start rate are similar across the two measures of home prices. As a result, if a state-level version of the Case-Shiller index were available for our analysis, the low-frequency relationships among the variables in the system should be qualitatively similar to what we find using the FHFA index.

Different Orderings of Contemporaneous Shocks

We report two robustness checks with respect to the ordering of contemporaneous shocks. In Figure 8 we show the impulse responses of foreclosure starts and prices to shocks originating in prices and foreclosures from our baseline model and these two alternative orderings; the variance decompositions for those orderings are reported in Table 7. Both of these alternative orderings place foreclosures (F) first. Giving priority to foreclosure shocks in the ordering maximizes the potential for foreclosure shocks to explain other variables in the system. While foreclosures reflect the strategic decisions of borrowers and lenders and likely reflect factors such as employment and housing market conditions, to the extent that shocks to foreclosures reflect macroeconomic conditions and normal responses to housing demand and supply shocks, placing foreclosure starts first in the system should increase the explanatory power of foreclosures for other variables. In the FHESP ordering, house price (H) appears second, followed by employment (E), sales (S) and permits (P). In the FESPH ordering, house price appears last in the ordering. By reporting both of these orderings, we investigate the extent to which an ordering that maximizes

Figure 8 ■ IRFs for various orderings.



Note: This figure shows the impulse responses of the foreclosure start rate to a shock in prices (left column) and of prices to a shock in the foreclosure start rate (right column) for our base model and two alternatives orderings. Ordering FHESP is Foreclosures, House Prices, Employment, Sales and Permits. Ordering FESPH is Foreclosures, Employment, Sales, Permits and House Prices. Shaded regions represent 95% confidence intervals. The basic relationships between the two variables are virtually identical under any of the alternative orderings.

the explanatory power of foreclosure shocks affects the explanatory power of foreclosure shocks for house prices, and we consider how that result depends on the position of house prices in the ordering.

As Figure 8 shows, the impulse responses of prices and foreclosures to shocks originating in foreclosures and prices are virtually identical across the three specifications (baseline, FHESP and FESPH). Not surprisingly, as shown in Table 7, the FHESP and FESPH orderings assign a bit more explanatory power to foreclosure starts in the variance decompositions than under the baseline model, but qualitatively the results are similar to those reported before. In particular, price shocks continue to explain a much greater percent of the forecast variance of foreclosures than foreclosure shocks explain of the forecast variance of prices.

Table 7 ■ Variance decompositions for various orderings.

		Base Model		FHESP		FESPH	
	Lag	Prices	For.	Prices	For.	Prices	For.
Prices	4	0.9564	0.0100	0.9627	0.0201	0.9503	0.0201
	8	0.8850	0.0276	0.8912	0.0486	0.8747	0.0486
	24	0.8004	0.0478	0.8137	0.0777	0.7876	0.0777
Foreclosures	4	0.0375	0.9158	0.0282	0.9484	0.0278	0.9484
	8	0.1243	0.7604	0.1096	0.8178	0.1043	0.8178
	24	0.1579	0.6183	0.1437	0.6914	0.1350	0.6914

Note: Percent of row variable explained by the column variable at the specified lag. Ordering FHESP is Foreclosures, House Prices, Employment, Sales and Permits. Ordering FESPH is Foreclosures, Employment, Sales, Permits and House Prices. In each case, prices explain a larger percentage of the variation of foreclosures at 24 lags than do foreclosures for prices.

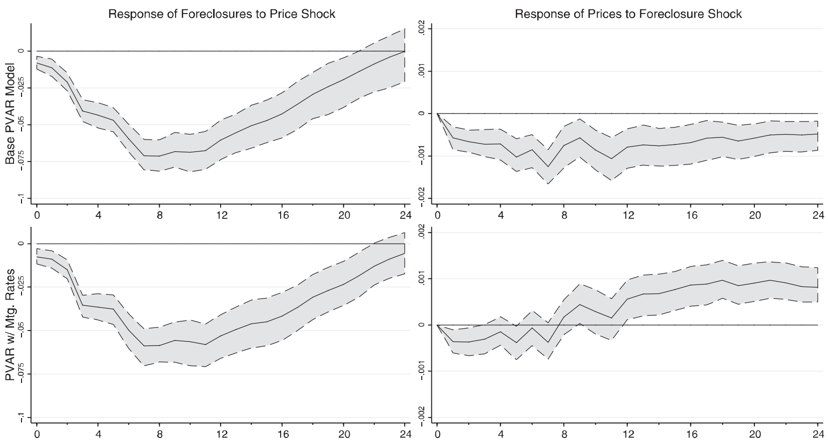
Including the Mortgage Interest Rate

Finally, we consider whether adding the mortgage interest rate to our model affects our conclusions about the dynamic interrelationship between house prices and foreclosures. Figure 9 reports impulse responses of foreclosures to price shocks and also prices to foreclosure shocks for the state-level PVAR system.

The inclusion of mortgage interest rates in the new six-variable PVAR model (the mortgage rate appears first in our ordering, which otherwise retains the same ordering as our baseline model reported above) has virtually no effect on the response of foreclosures to price shocks (which remains large). The presence of mortgage interest rates in the system of equations, however, substantially diminishes the response of house prices to foreclosure shocks. In other words, part of the causal relationship from foreclosure shocks to prices identified in our baseline five-variable model seems to reflect the common influence of mortgage interest rate shocks on both variables: when mortgage interest rates rise in the six-variable system (mortgage interest rates, employment, sales, permits, house prices and foreclosures), house prices decline and foreclosures increase. In that same six-variable system, the identified effect of foreclosure shocks on house prices is smaller than in the previous five-variable system, in which some of the endogenous reductions in house prices, which reflect mortgage interest rate rises, are attributed to foreclosure shocks.

We conclude that our central results are quite robust to possible variations in samples and specifications. Foreclosure starts and prices respond to shocks that

Figure 9 ■ IRFs with and without mortgage rates.



Note: This figure shows the impulse responses of the foreclosure start rate to a shock in prices (left column) and of prices to a shock in the foreclosure start rate (right column) for our base PVAR model and our base PVAR model with the regional 30-year fixed mortgage rate included at the beginning of the ordering. The response of prices to foreclosures is less negative when mortgage rates are included in the system.

originate in both variables, but the response of prices to foreclosure shocks is the smaller of the two effects. Furthermore, foreclosure starts are highly responsive to other influences, too, including shocks to employment, house sales and permits. Our estimates indicate that most of the low-frequency correlation between foreclosure starts and house prices reflect the effects of common shocks and the effects of price shocks on foreclosure starts; foreclosure shocks do reduce prices, but this is not the main source of the low-frequency connection between the two variables. These findings are not the result of a failure to capture nonlinearities, and they are robust to various modeling choices, including the ordering of orthogonalization, the way house prices are measured and the inclusion of mortgage interest rates in the model.

Conclusion

Our study is the first to model the dynamic macroeconomic relationships among house prices, foreclosure starts, employment, house permits and house sales. We do so using a PVAR model at the state level for the United States for the period 1981–2009.

We offer the following summary of our findings:

1. It is important and helpful for identification to take account of the enormous variation across states, which facilitates identification of links among key macroeconomic and housing variables. Our PVAR model is able to identify the dynamic relations among the key housing market variables and the macro economy, taking advantage of the high degree of variation in the experiences of different states over the past two decades. The identified relationships make sense, and the variables explain a large amount of each other's forecast variance.
2. Foreclosure starts and house prices are closely associated at low frequency, but that reflects a combination of linkages, not just the effects of foreclosure shocks on prices. For the most part, the association between foreclosures and prices results from the endogenous response of foreclosure starts to price shocks, and foreclosure starts and prices to other influences and, to a lesser extent, the effect of foreclosure shocks on prices.
3. Our estimated impulse responses indicate that a 0.2-percentage-point increase in the quarterly foreclosure start rate (a one-standard-deviation shock) results in a cumulative price decline of only 1.7% over six years. In contrast, a one-standard-deviation shock to prices (0.96%) results in a 0.95-percentage-point cumulative decline in the foreclosure start rate over six years.
4. Standardizing our impulse responses by the standard deviations of the responding variables, our estimates suggest that the impact that prices have on foreclosures is 79% larger than the impact of foreclosures on prices.
5. The variance decompositions show that prices explain 16% of the variation in foreclosures after 25 quarters, while foreclosures explain only 5% of the variation in prices over this same interval.

It bears repeating that one of our key results—the relatively small impact of foreclosure starts on price—stands in contrast to some of the popular wisdom about the connections between foreclosures and prices, and this is important to consider when formulating housing policy. The decline in house prices between 2007 and 2009 was driven mainly by shocks originating elsewhere and reflected in shocks to housing sales, which in turn likely reflect the steep recession's effect on housing demand. Furthermore, the strong connection between housing prices and foreclosure starts that is illustrated in Figure 1 mainly reflects the effect of house price shocks on foreclosures rather than the effect of foreclosure shocks on house prices.

The authors thank Inessa Love for sharing her panel VAR programs using Helmert de-meaning and Mark Zandi for sharing Economy.com data. The authors are also grateful to Jay Brinkmann, Michael Carliner, Robert Martin, Chris Mayer, Joseph Nichols, Mark Zandi, an anonymous referee, and seminar participants at the Federal Reserve Board, DePaul University, the Midwest Finance Association, the American Real Estate and Urban Economics Association Midyear Meeting and the Riksbank for helpful comments and suggestions. An earlier version of this paper circulated under the title "The Foreclosure Crisis: How Far Will House Prices Fall?" Calomiris is Henry Kaufman Professor of Financial Institutions at Columbia Business School and Research Associate, National Bureau of Economic Research. Longhofer is Stephen L. Clark Chair of Real Estate and Finance, and Director, Center for Real Estate, at the Barton School of Business, Wichita State University. Miles is Professor of Economics and Barton Fellow at Wichita State University.

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Appendix A: Data and Methodology

Data Sources

Prices: FHFA All-Transactions House Price Indices

Our home price appreciation measure comes from the state-level, all-transactions house price indices produced by the Federal Housing Finance Agency (FHFA). We use the 2010Q1 release of these data, which includes observations from 1975Q1 through 2010Q1. We renormalize these indices to set 2007Q4 as the base quarter.

Some of the state HPIs exhibit a large amount of volatility in the early years of the sample, presumably because of a paucity of repeat transactions for deriving the price index. In our preferred specification we drop early observations of the HPIs based on the following procedure. For each state we calculate the mean and standard deviation of the quarterly change in the quarterly log-difference of the HPI after 1994. Using the full sample, we determine the last quarter for which this change exceeds five standard deviations of the calculated post-1994 mean, and we drop all observations up through this quarter.

In our robustness checks, we also use the full-sample (unrestricted) all-transactions price indices, as well as the FHFA purchase-only price indices. Because the purchase-only indices start at 1991Q1, we join the purchase-only index with the corresponding all-transactions index (both renormalized to 1991Q1) to provide full coverage through the entire sample period. The resulting spliced indices are then normalized to set 2007Q4 as the base quarter.

All of our regressions measure home price appreciation as the log difference of these indices, not seasonally adjusted.

Foreclosures: Foreclosure Start Rate

Historical values of the foreclosure start rate come from the Mortgage Bankers Association (MBA) Quarterly Delinquency Survey, which provides the number of mortgage loans beginning the foreclosure process as a percent of all loans serviced. These data run from 1979Q1 through 2009Q4 and are not seasonally adjusted. We use the log level of the foreclosure start rate in our regression specifications.

Permits: Single-Family Residential Building Permits

The Bureau of the Census prepares a monthly release of building permits by state (not seasonally adjusted); these are available back to January 1988. We used the Census X12 program using default settings to calculate the seasonally adjusted annualized rate of single-family building permits for each state beginning in 1988. To extend the dataset back to January 1980, we merged it with data provided by Economy.com.[10] We use the quarterly average of these monthly SAAR figures as our measure of permits. All of our regressions measure the growth rate of permits as the log difference of these quarterly averages. Because permits are zero in some states for some quarters (most notably the District of Columbia), we added one to each of the quarterly permit values before taking logs.

Employment: Total Nonfarm Employment

Total nonfarm employment by state (not seasonally adjusted) is available from the Bureau of Labor Statistics dating back to 1960. We seasonally adjusted each monthly state series using the Census X12 program using default settings.[11] We then calculated the quarterly average of these figures. All of our regressions measure the growth rate of employment as the log difference of these quarterly averages.

Sales: Single-Family Existing Home Sales

The quarterly, seasonally adjusted annual rate of existing, single-family home sales for each state is available from the National Association of Realtors. These data are available dating back to the beginning of 1981.

One quarter's observation was missing for South Dakota (2009Q1), four for Idaho (2006) and 16 for New Hampshire (2004–2007). In order to keep these observations in our sample, we interpolated values based on the growth rates

[10] According to Economy.com, the original raw data that underlie these series come from the Bureau of the Census. For observations between 1980 and 1988, Economy.com derived the monthly values based on the annual data reported by the Bureau of the Census.

[11] The BLS also provides seasonally adjusted employment data; these data are only available back to 1990, however.

of existing home sales in neighboring states. Specifically, we assumed that the growth rate (percentage change from the prior quarter) in South Dakota in the missing quarter was equal to the average of the same-quarter sales growth rates in Nebraska, North Dakota, Minnesota, Wyoming and Iowa. The missing value is then calculated as this average growth rate applied to the prior period sales in South Dakota. Similarly, missing values in Idaho are interpolated based on the average of the same-quarter sales growth rates in Montana, Wyoming and Utah,[12] while missing values in New Hampshire are interpolated based on the average of the same-quarter sales growth rates in Maine, Massachusetts and Vermont.

Mortgage Rates: National 30-Year Mortgage Rate

Freddie Mac releases a weekly average commitment rate on 30-year fixed-rate mortgages by region as a part of its Primary Mortgage Market Survey. In our robustness checks we use the quarterly average of these figures as the regional mortgage rate, assigning each state's value based on its region. These data are available starting with the second quarter of 1971.

PVAR Methodology

Because of the lagged dependent variables inherent in a PVAR model, we follow Arellano and Bover (1995) and de-mean our variables using Helmert's transformation:

$$y_{it}^{*} = w_i \left[y_{it} - \frac{1}{T-t}(y_{i(t+1)} + \cdots + y_{iT}) \right], \quad t = 1, \ldots, T-1,$$

where $w_t^2 = (T-t)/(T-t+1)$. In other words, each of the first $T-1$ observations are de-meaned using all future observations (with the next-to-last observation de-meaned by the final observation, which is lost from the sample). The weighting w_t^2 is included to equalize the variances.

Consistent parameter estimates then can be obtained by using two-stage least squares on these transformed variables, using the nontransformed values of the variables as instruments. We performed our estimation in Stata, using a PVAR program provided by Inessa Love.

[12] Washington and Oregon were excluded here because they were deemed to be "Pacific" states rather than "Mountain" states and thus less comparable for Idaho.

Appendix B: Judicial vs. Nonjudicial Foreclosure States

As we discuss in the body of the text, it is interesting to compare the results of impulse response functions for samples that separately model judicial- and nonjudicial-foreclosure states. Most of the impulse responses are nearly identical for the two sets of states and the few impulse responses that are different do not exhibit large and statistically significant differences, as can be seen by comparing Figures B1 and B2.[13] Nonetheless, with those caveats, there are some suggestive patterns visible in three of the impulse responses that are consistent with potentially important differences between judicial-foreclosure and nonjudicial-foreclosure states.

One difference is that in nonjudicial-foreclosure states, the effect of employment shocks on house prices (the first column and fourth row in Figures B1 and B2) is positive rather than zero or slightly negative. It is conceivable that judicial foreclosure may insulate house prices from the effects of employment shocks, which may mute the positive association between employment shocks and house prices (*e.g.*, if judicial foreclosures delay the completion of foreclosures, one would expect to observe less of a decline in house prices in the wake of an adverse employment shock).

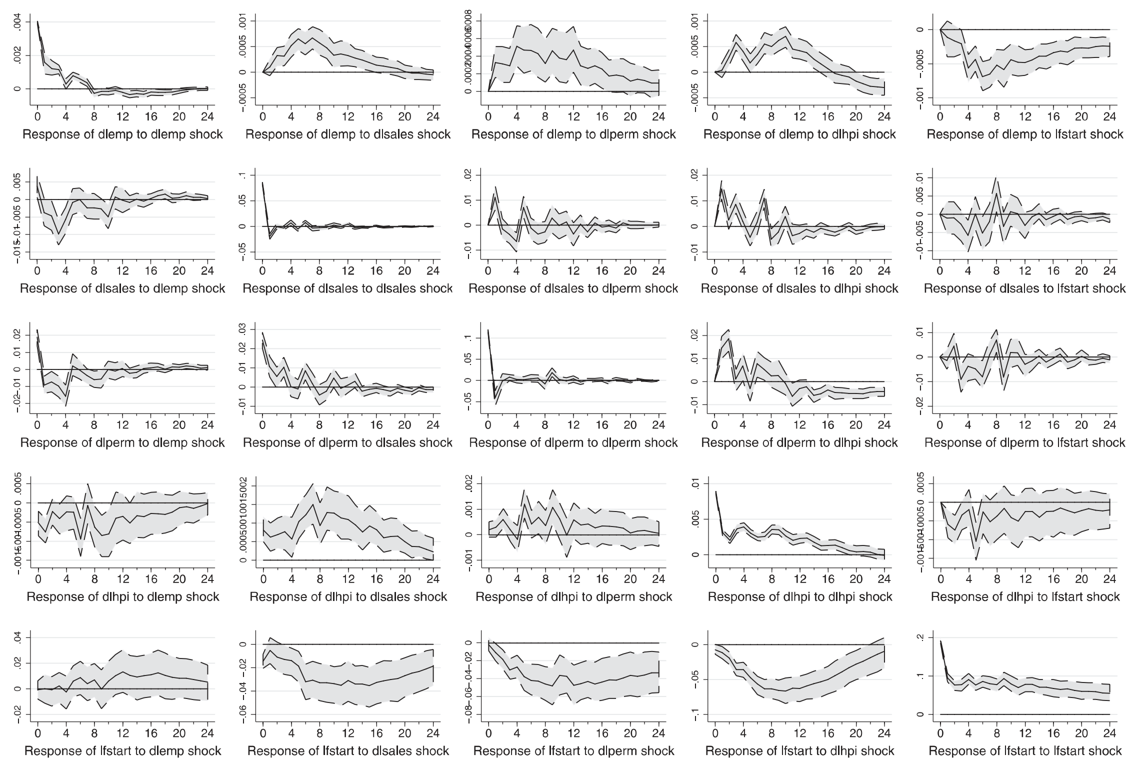
The impulse responses of house price shocks to foreclosure start shocks also differ somewhat between judicial-foreclosure and nonjudicial-foreclosure states, and in a manner that is also consistent with the view that judicial-foreclosure states mitigate the effect of foreclosure starts on house prices. To examine these relationships more closely, Figure B3 shows the impulse response functions that relate (1) house price shocks to foreclosure start responses and (2) foreclosure start shocks to house price responses for both subsamples.

The effect of foreclosure start shocks on house prices in nonjudicial-foreclosure states is more negative (roughly twice as negative at the peak) and longer-lived. The observed negative effect of foreclosure start shocks in nonjudicial-foreclosure states remains statistically significant for six years, while the response in judicial-foreclosure states is only significant in a few of the first quarters. Because the effect on house prices is smaller in judicial-foreclosure states, that finding is consistent with the view that judicial foreclosure mitigates the effect of foreclosure starts on foreclosure completions and thereby mitigates the effect of foreclosure starts on house prices.

The response of foreclosure starts to house price shocks is somewhat different between the two types of states as well. In nonjudicial-foreclosure states the

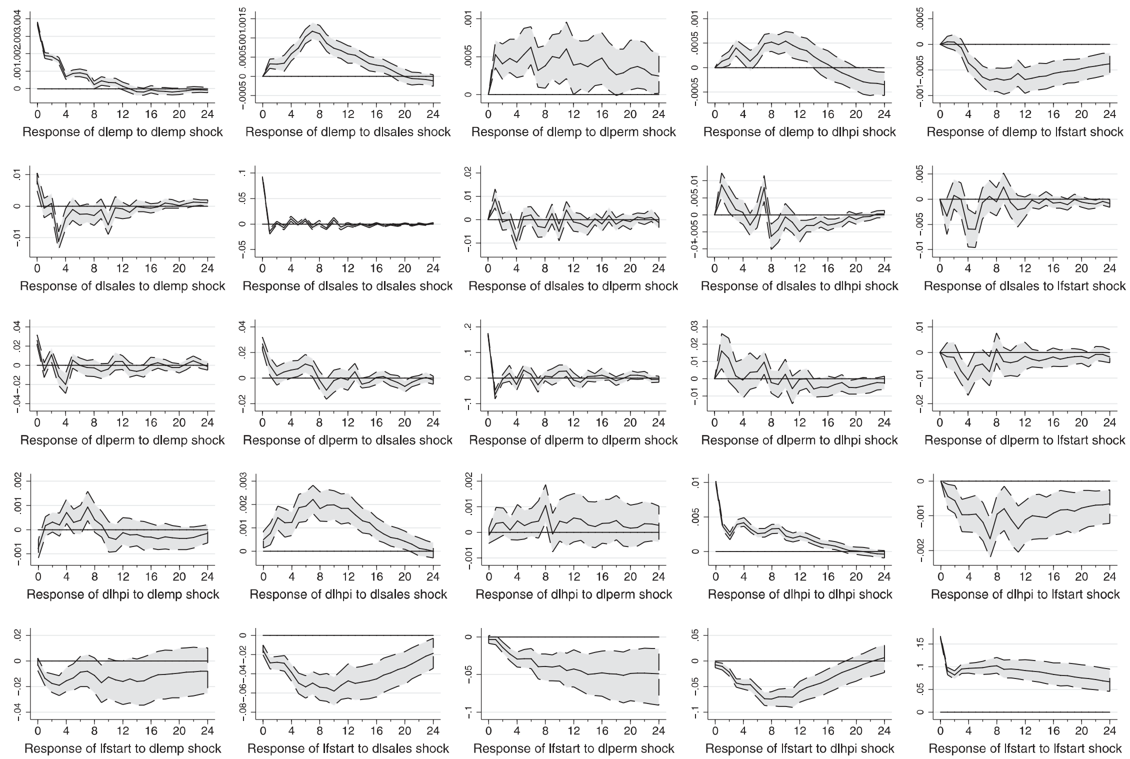
[13] More complete results from these regressions can be found in supplemental appendices available at http://realestate.wichita.edu/data-research/academic-research/.

Figure B1 ■ Impulse response function—Judicial states.



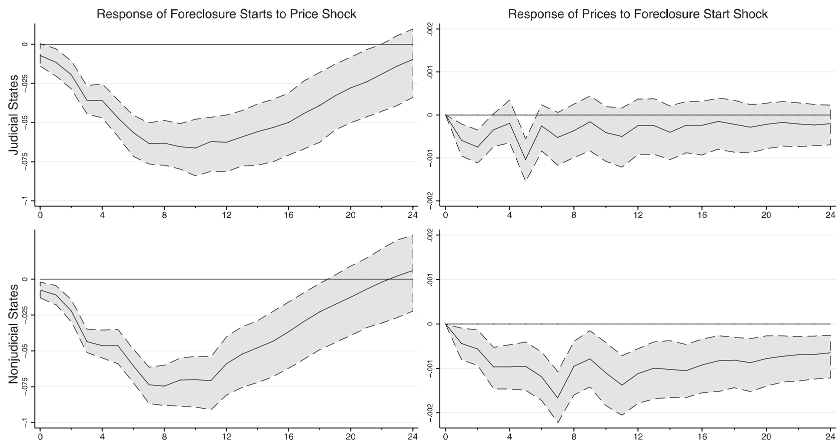
Note: Impulse responses are based on growth rates (difference of logs) of all variables in the system except the foreclosure start rate, which is modeled as a log level. The impulse responses are derived using a Cholesky decomposition with the following ordering: employment, sales, permits, prices (HPI) and foreclosure start rate. Shaded areas represent 95% confidence intervals for the estimated impulse responses. Only judicial states are included.

Figure B2 ■ Impulse response function—Nonjudicial states.



Note: Impulse responses are based on growth rates (difference of logs) of all variables in the system except the foreclosure start rate, which is modeled as a log level. The impulse responses are derived using a Cholesky decomposition with the following ordering: employment, sales, permits, prices (HPI) and foreclosure start rate. Shaded areas represent 95% confidence intervals for the estimated impulse responses. Only nonjudicial states are included.

Figure B3 ■ IRFs for judicial- and nonjudicial-forclosure states.



Note: This figure shows the impulse responses of the foreclosure start rate to a shock in prices (left column) and of prices to a shock in the foreclosure start rate (right column) for subsamples that separate judicial and nonjudicial states. The response of prices to a foreclosure start shock is larger and more persistent in nonjudicial states. The response of foreclosure starts to a price shock is greater in nonjudicial states but does not last as long.
Judicial-foreclosure states are identified by Mian, Sufi and Trebbi (2010) as Connecticut, Delaware, Florida, Illinois, Indiana, Kansas, Kentucky, Louisiana, Maryland, Massachusetts, Maine, Nebraska, New Jersey, New Mexico, New York, North Dakota, Ohio, Pennsylvania, South Carolina and Vermont.

responsiveness is a little greater and somewhat less persistent. The peak for nonjudicial-foreclosure states occurs at –0.075 (rather than at –0.06) and that somewhat larger effect becomes insignificant by quarter 18, while the smaller response in judicial-foreclosure states remains significant until quarter 23.

This pattern is consistent with the following interpretation. In judicial-foreclosure states, foreclosures starts increase less when house prices fall because foreclosures are expected to prove less advantageous for creditors. Because there is greater delayed resolution of delinquencies in judicial-foreclosure states, however, the effects of prices on foreclosure starts is more protracted.

As we noted at the outset, we recognize that the results between the two subsamples are not very different, and there are probably other interpretations of those results that do differ. Nevertheless, we believe that our findings at least are internally consistent and consistent with the notion that judicial-foreclosure states and nonjudicial-foreclosure states exhibit slightly different relationships between foreclosure starts and price shocks in ways that make sense.

Supporting Information

Additional Supporting Information may be found in the online version of this article at the publisher's website:

Disclaimer: Supplementary materials have been peer-reviewed but not copy-edited.

Foreclosure Inventory Regressions

Table A1 ■ Panel VAR regression results.

Table A2 ■ Residuals correlation matrix.

Table A3 ■ Variance decompositions.

Table A4 ■ Orthogonalized foreclosure and price "shocks" since 2007.

Table A5 ■ Variance decompositions for various data samples.

Table A6 ■ Correlations among U.S. aggregate system variables.

Table A7 ■ Variance decompositions for various orderings.

Figure A1 ■ Change in foreclosure rate vs. FHFA HPI.

Figure A2 ■ Impulse response function.

Figure A3 ■ Standardized impulse reponses.

Figure A4 ■ Crisis foreclosure rates vs. historical values.

Figure A6 ■ IRFs for various data samples.

Figure A8 ■ Case-Shiller vs FHFA IRFs – U.S. data.

Figure A9 ■ IRFs for various orderings.

Figure A10 ■ IRFs with and without mortgage rates.