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Economic policy uncertainty, monetary policy, and housing price in China

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ABSTRACT

This paper analyzes the impact of macroeconomic variables on house price volatility under different regimes of policy uncertainty, incorporating the Economic Policy Uncertainty Index and several Chinese macroeconomic data sets for the period from 1999 to 2014. We adopt a logistic smooth transition vector autoregressive model and a generalized impulse response function. The results show that macroeconomic progress leads to house price growth, which is augmented by policy uncertainty. In addition, the effect of macroeconomic shocks on house price volatility varies under different regimes of policy uncertainty. We find that shocks are asymmetric under regimes of high and low policy uncertainty. Under a high policy uncertainty regime, expansionary quantitative monetary policy can facilitate house price growth, whereas a contractionary monetary policy gives rise to an enduring "Home Price Puzzle," which makes it difficult to regulate house prices.

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Economic policy uncertainty; house price volatility: LSTVAR model; Chinese market

1. Introduction

As real estate is a major component of household wealth in China, real estate price volatility attracts considerable attention from researchers and practitioners. House price volatility is mainly determined by housing demand and supply in the long run, while also being driven by macroeconomic variables in the short run. Jarociński and Smets (2008) apply a Bayesian vector autoregressive (VAR) model to house price volatility in the United States and find that both housing demand and monetary policy shocks result in house price volatility. Moreover, several other studies reveal that macroeconomic shocks in interest rates, industry output, and the consumer confidence index contribute to house price volatility (Rapach & Strauss, 2007; Vargas-Silva, 2008; Das, Gupta, & Kabundi, 2009). Economic policy also plays a prominent role in the Chinese housing market. The Chinese housing market is often characterized as "policy-driven," as short-term house price volatility is closely related to the implementation of government policies. As the timing of the introduction of new economic policies is unpredictable and sometimes random, the Chinese housing market exhibits great uncertainty, which affects buyers'

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and suppliers' response to external shocks, giving rise to unnecessary market volatility or even temporary market breakdown. The impact of policy uncertainty on the housing market and indeed the entire capital market can be enormous; Pastor and Veronesi (2013) show that it can augment market uncertainty and increase market volatility.

Drawing on Higgs (1997), Baker, Bloom, and Davis (2015) defines policy uncertainty as "economic risk due to the government's future policy uncertainty." Policy uncertainty broadly derives from external shocks and economic recession. Negative external shocks like war, terrorist attacks, and financial crises increase policy uncertainty. Bloom (2009) investigates 17 external shocks in the U.S. from 1962 to 2008, including the Gulf War, the Cuban Missile Crisis, the Asian Financial Crisis, and the 9/11 terrorist attacks. Most of these shocks were negative, and there is empirical evidence that negative information shocks and policy uncertainty shocks occur in quick succession. During economic recession, policymakers make active attempts to promote recovery, whereas less effort is required to maintain the current level of economic growth (see Pastor and Veronesi 2011 for further discussion). This viewpoint is also presented by Baker, Bloom, and Davis (2012).

As real estate is both consumable and investable, income shocks from economic policies result in volatile house prices (Zettelmeyer, 2004; Rigobon & Sacks, 2004; Bernanke & Kuttner, 2005). Policy uncertainty can affect demand and supply in the housing market. Under policy uncertainty, consumers tend to reduce their consumption and investors tend to delay their investment (Brennan & Schwartz, 1985; Bloom, 2009), depressing housing market demand. Enterprises facing uncertainty also delay their investment to obtain higher rates of return in the future (McDonald & Siegel, 1986), which in turn depresses housing market supply. Therefore, policy uncertainty inhibits consumption and investment and thus curbs housing market demand and supply. In addition, policy uncertainty can change the behavior of market participants, reducing house price supply elasticity and resulting in inelastic consumer demand for houses and other commodities (Rodrik, 1991). Changes in the price elasticity of demand and supply cause the market-clearing price to vary dramatically and bring about unnecessary price fluctuations.

Although policy uncertainty is closely related to house price volatility, few published studies examine the mechanism through which policy uncertainty affects the housing market. The main reason is that policy uncertainty is difficult to quantify. To measure policy uncertainty, most existing studies use various measures of market uncertainty as proxies, such as the VIX index (Bekaert, Hoerova, & Lo Duca, 2013) or the gap between the real and expected value of economic variables (Scotti, 2013; Nakamura, Sergeyev, & Steinsson, 2012).

This gap is addressed by Baker et al. (2015), who develop indices to measure policy uncertainty. They construct a policy-related uncertainty index for China, among a basket of countries, using data from 1995. This index forms a major data component of our current research.

Some studies report a stable long-term relationship between house prices and economic fundamentals. However, some find a lack of cointegration between house prices and economic fundamentals, attributable to the neglect of nonlinearity in some cointegration approaches. Kim and Bhattacharya (2009) use a smooth transition autoregressive (STAR) model to test for nonlinearity in the regional housing market in the United States. Zhou (2010) uses data from 10 U.S. cities and finds that cointegration among house prices and fundamentals holds only in one city with the standard linear cointegration technique.

However, when nonlinear cointegration is used, he finds support for cointegration in six other cities. Due to asymmetric effects, nonlinear models are also used in other studies. Balcilar, Gupta, and Miller (2015) use a STAR-type model to forecast house price distributions. Bahmani-Oskooee and Ghodsi (2016) show that the nonlinear model reveals that income and interest rate changes have asymmetric effects on house prices in the short and long run. Canepa and Chini (2016) adopt a generalized STAR (GSTAR) model to capture asymmetries in real estate cycles. They find that prices rise rapidly above their expected levels under improving economic conditions, which boosts housing demand above the potential stock; however, house prices fall slowly when economic conditions worsen and house prices fall below expected values. Alqaralleh (2019) also adopts the STAR model to highlight significant differences in the asymmetric patterns of house prices between regions and finds that the LSTAR model outperforms other models.

As the impact of macroeconomic variables may be asymmetric, we adopt a logistic smooth transition vector autoregressive (LSTVAR) model. The data are the Chinese Economic Policy Uncertainty Index (the CEPU Index) provided by Baker et al. (2015), the level of house price volatility, and other macroeconomic variables. We also incorporate a generalized impulse response function (IRF) to examine the effect of macroeconomic variables on house price volatility under different levels of policy uncertainty.

This paper makes two major innovative contributions. First, we include policy uncertainty in the construction of a short-term house price volatility model to predict the impact of macroeconomic variables in different environments. Second, we introduce the CEPU Index into empirical research and verify the asymmetric effect of macroeconomic variables on policy uncertainty by applying an LSTVAR model and generalized impulse response function.

The rest of the paper proceeds as follows. Section 2 discusses policy uncertainty indices in China and in other major economies. Section 3 presents an empirical analysis using Chinese data. Section 4 provides an analysis of the asymmetric effect of policy uncertainty using the LSTVAR model and impulse response function. Section 5 presents a further analysis based on U.S. data and a robustness check. We conclude the paper in Section 6.

2. Policy uncertainty indices

The Chinese Economic Policy Uncertainty Index (CEPU Index) in Baker et al. (2015) is constructed by identifying articles relating to policy-related economic uncertainty posted in the *South China Morning Post*. The indices of other economies are the number of federal tax code provisions set to expire in future years and disagreement among economic forecasters. For more details, see http://www.policyuncertainty.com/china_monthly.html.

2.1. Analysis of the Chinese Economic Policy Uncertainty Index (the CEPU Index)

Figure 1 shows that the CEPU Index identifies three periods of high volatility since 1999. The first occurred after the 9/11 terrorist attacks. The global recession following the 9/11 terrorist attacks hindered the growth of Chinese exports, hampered industrial production, reduced employment rates, and weakened consumer confidence. As consumer confidence and international oil prices declined after the 9/11 terrorist attacks, China was at risk of deflation. To resolve these problems, the Chinese government implemented

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Figure 1. CEPU Index from 1999 to 2013 in China.

a range of fiscal and monetary policies, resulting in a dramatic increase in Chinese economic policy uncertainty during this period.

The second period of high volatility occurred from late 2008 to early 2009. During this period, the subprime mortgage crisis occurred due to the collapse of the investment banks Bear Stearns and Lehman Brothers. As the crisis spread, the Chinese economy faltered. In the fourth quarter of 2008, China's economic growth rate dropped to 6.1%, its lowest point since 1999. Its GDP growth rate in 2008 was below the 30-year average. To fend off recession, the Chinese government frequently made adjustments in economic policies, which caused uncertainty to increase dramatically. In late 2008, the Chinese central bank, the People's Bank of China, reduced interest rates five times in succession, reduced the savings deposit rate four times, and removed controls on credit. As a result, the volume of financial credit increased from 77 billion RMB to 1.62 trillion RMB in January 2009. At the same time, the Chinese government announced a 4 trillion RMB investment plan to boost consumer consumption and raise the incomes of urban and rural residents, which included extensive tax cuts. Accordingly, policy uncertainty increased sharply due to successive changes in economic policies and the resultant economic unpredictability.

The third period of high volatility was triggered by the European debt crisis in 2012. China was affected by the economic recession in Europe, which forced it to make changes to its long-term Europe-oriented economic policies. Factors such as decreasing exports, more frequent international capital flows, and pressure due to imported inflation increased the level of economic policy-related uncertainty.

It is clear that major fluctuations of the CEPU Index between 1999 and 2013 were closely related to changes in external political and economic environments, except for two small-scale increases due to changes in party and national leadership in 2002 and 2012. To validate the effect of economic policy uncertainty, we further examine changes in external economies' Economic Policy Uncertainty Indices.

2.2. Analysis of the economic policy uncertainty index of other economies

Figure 2 shows the Economic Policy Uncertainty Indices of the United States, China, Canada, India, and Europe from January 1999 onwards. Although the values of different economies vary due to differences in sampling, the overall trends are significantly synchronous. In particular, all of the indices soared simultaneously after events such as the 9/11 attacks, the subprime mortgage crisis, and the European debt crisis. These negative events produced global economic recessions and greatly increased policy uncertainty in the various economies. Evidently, global financial integration means that major political and economic events have a global economic impact and cause policy uncertainty to fluctuate on a global scale.

Nevertheless, some events affected only a single economy's policy uncertainty. For example, Manmohan Singh, known as the "father of Indian reform," was elected as Prime Minister of India in May 2004. He promised a series of economic reforms in his inauguration speech, which triggered dramatic policy uncertainty in India. When Greece requested economic aid from the European Union and IMF in 2010, its debt crisis only occurred on a small scale. European policy uncertainty increased, while the policy uncertainty of China, India, and Canada remained stationary. However, when the European debt crisis worsened, rating agencies such as S&P and Moody repeatedly downgraded the debts of European countries; this affected the United States and Canada, and their corresponding Europe-oriented policy uncertainty began to rise. As the European debt crisis gained momentum, China and India were affected through international trade and capital flow, and their Economic Policy Uncertainty Indices consequently rose.

It is vital to take uncertainty into consideration when researching expectation. The formulation of economic policies is affected by global economic changes, and uncertainty is significantly increased by external impacts. Meanwhile, the secrecy and bureaucracy involved in policy formation and implementation lead to more uncertainty, and affect the factors that determine expectation. Baker and Bloom (2013) hold that the macro-economic effect of policy uncertainty is mainly reflected in expectation.



Figure 2. EPU Indices of the United States, China, Canada, India, and Europe.

3. Empirical analysis

3.1. Model selection

Numerous studies use the VAR model to analyze the impact of macroeconomic variables on house prices (Lastrapes, 2002; Ahearne, Ammer, Doyle, Kole, & Martin, 2005; Uhlig, 2005). Unlike the previous literature, we adopt the LSTVAR model proposed by Weise (1999) to analyze Chinese house price volatility. The LSTVAR model has advantages over the VAR model in describing the nonlinear, asymmetric relationship among variables, and depicting the diverse impact of house prices under different policy uncertainty regimes. Moreover, the LSTVAR model assumes that the process of transformation is continuous and gradual. Other nonlinear models, such as the TAR and MSVAR models, assume that the process is sudden and sharp, which is less realistic. In addition, the LSTVAR model can select converted variables using the LM test, and calculate the speed of the switching mechanism and threshold value through a grid search method. The LSTVAR model also helps avoid the subjective selection of constraints, as seen in traditional impulse response models.

3.2. Model specification

Following Weise (1999), we construct the LSTVAR model as follows:

$$X_{t} = A_{0} + A(L)X_{t-1} + [B_{0} + B(L)X_{t-1}]F(s_{t-d}; \gamma, c) + \varepsilon_{t}$$
(1)

$$F(s_{t-d}; \gamma, c) = (1 + \exp\{-\gamma(s_{t-d} - c)/\delta_s\})^{-1}$$
(2)

where X_t is a k × 1 vector, A(L) and B(L) are complicated polynomials in the lag operator, ε_t is a 1 × k vector, and $\varepsilon_t \sim i.i.d(0, \Sigma)$. $F(\cdot)$ is an indicator function bounded between zero and one; its coefficients are kept constant across realizations of s_{t-d} . s_{t-d} is a switching variable, d is the lag length of the switching variable, c is the threshold, y is the "smoothness" parameter, and δ_s is the standard deviation of s_{t-d} . If $\gamma \rightarrow 0$, the LSTVAR model changes to a VAR model; if $\gamma \rightarrow \infty$, it changes to a TAR model.

3.3. Data

We use monthly data from January 1999 to March 2014 as our sample. House price growth rate ($\Delta \ln p$) is measured by the logarithmic differential of "sales of houses/area of house sales in current month." Housing market situation (MC) is measured by the China housing sentiment index in the current month. Consumer confidence (CC) is the Consumer Confidence Index in the current month. Real estate companies' behavior (EB) cannot be directly measured using any index. We therefore use "area of land purchased in the current month" to measure real estate companies' behavior, as real estate companies will make more land purchases when they have an optimistic view of the future housing market. In most studies, macroeconomic growth (EG) is measured by GDP. However, because Chinese monthly GDP data are unavailable, we use the year-onyear monthly growth of industrial value added as a proxy.¹ As monetary policy (MP) is

¹The GDP is the only published quarterly in China. Because the data do not contain residual seasonality and there are no data quality issues, we use the year-on-year monthly growth of industrial value added as a proxy.

a leading driver of house price volatility, we also include the monthly year-on-year growth rate of M2 (M) and the market benchmark interest rate (R). All of the data are obtained from the database of the National Bureau of Statistics of the People's Republic of China. To measure policy uncertainty (EPU), we adopt the CEPU Index constructed by Baker et al. (2015), which is available at www.policyuncertainty.com.

3.4. Data validation

3.4.1. Unit root test

We conduct a unit root test to avoid a spurious regression result. The Narayan–Popp unit root test takes two endogenous (unknown) structural breaks into account. Many papers apply the Lee–Strazicich unit root test with two structural breaks. However, Narayan and Popp (2013) illustrate that their unit root test is more powerful than the Lee–Strazicich unit root test with two structural breaks, particularly in small sample cases. Furthermore, the Narayan–Popp unit root test can more accurately locate structural breaks than the Lee–Strazicich unit root test (Narayan and Popp 2013). For these reasons, we use the Narayan–Popp unit root test. Another task of the unit root test methodology involves modeling structural breaks in the constant and the time trend terms (Smyth & Narayan 2015).

Table 1 presents the unit root test results. The null hypothesis of the existence of a unit root is rejected.

3.4.2. Model specification testing

First, we test for nonlinearity in the VAR model. In equation (1), the null hypothesis is y = 0, which is a VAR model:

$$X_t = A_0 + A(L)X_{t-1} + \varepsilon_t \tag{3}$$

where $X_t = (\Delta \ln p, EPU, EG, R, M, CC, MC, EB)'$.

The alternative hypothesis is $\gamma > 0$, which means that the model is an LSTVAR model. From the Schwarz value, the optimal lag length in the linear VAR model is identified as 2. Accordingly, we test lag lengths of 1 and 2 for all variables to obtain the optimal lag length and switching variable.

We use Lagrange multiplier (LM) statistics to test for nonlinearity in the VAR model. However, the model is not rejected under the null hypothesis. When the null hypothesis cannot be rejected, the coefficients in the nonlinear components can have arbitrary values. Based on Granger and Tersvirta, we use the first-order Taylor expansion to approximate the LSTVAR model.

Table 2 presents the results of the LM test. The *p*-values of the LR [Please check whether this should be "LM".] statistics show that the null hypothesis is rejected. As a result, we use the LSTVAR model. As suggested by Tersvirta and Anderson (1992), in this case EPU_{t-2} is a switching variable, because it has the smallest *p*-value of all of the endogenous variables.

					Narayan-Popp Unit Root Test		
variable	ADF-stat (C,T,K)	Critical value (1%)	Critical value (5%)	Critical value (10%)	ADF- level (K)	ADF- level and trend (K)	
EPU	-3.1090 (C,0,2)	-3.4668	-2.8774	-2.5753	-4.6532(2)	-6.3453(2)	
EG	-6.6589 (C,T,0)	-4.0150	-3.4375	-3.1429	-8.3254(0)	-7.2347(0)	
R	-3.8566 (C,T,0)	-4.0093	-3.4347	-3.1413	-5.0123(0)	-5.8635(0)	
М	-2.8664 (C,0,3)	-3.4670	-2.8775	-2.5753	-4.7983(2)	-5.2342(3)	
СС	-3.8750 (C,T,0)	-4.0093	-3.4347	-3.1413	-4.9976(1)	-5.2456(0)	
МС	-3.5168 (C,T,3)	-4.0101	-3.4351	-3.1416	-5.0467(3)	-5.9835(3)	
EB	-3.7681 (C,0,13)	-3.4692	-2.8785	-2.5759	-6.4253(11)	-7.7245(12)	
∆ In p	-5.0932 (C,T,12)	-4.0129	-3.4364	-3.1423	-12.3565(10)	-9.4576(8)	

Table 1. The unit root test.

Note: C, T, and K are the constant, trend and the optimal lag length in the ADF test, and the optimal lag length are obtained from the Akaike information criterion (AIC) Value. The Narayan–Popp Unit Root Test results both include (i) the breaks on the level (left column) and (ii) the breaks in the level and the trend terms (right column). Null hypothesis: the series have a unit root. The optimal number of lags is based on the Akaike information criterion (AIC) Value. The critical values for the breaks on the level: 1%, -5.259; 5%, -4.514; and 10%, -4.143. The critical values for the breaks in the level and the trend terms: 1%, -5.949; 5%, -5.181; and 10%, -4.789. ***, **, and * indicate the rejection of the null hypothesis at the 1%, 5%, and 10% significance levels, respectively.

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switching variable	EPU	EG	М	СС	∆ ln <i>p</i>	R	МС	EB	P value of LR-stat
EPU _{t-1}	0.0039	0.1063	0.0659	0.0028	0.2244	0.0969	0.4428	0.0195	2.39E-07
EPU_{t-2}	0.7274	0.0392	0.0018	0.0035	0.5847	0	0.7629	0.0031	1.84E-09
EG_{t-1}	0.7092	0.0005	0.1684	0.0344	0.7843	0.2414	0.0922	0.187	6.47E-05
EG_{t-2}	0.822	0.1181	0.2783	0.1008	0.8985	0.2932	0.0811	0.0905	0.031553
M_{t-1}	0.0937	0.008	0.0136	0.8882	0.4094	0.8063	0.4694	0.056	0.004587
M_{t-2}	0.0593	0.0807	0.0267	0.9335	0.2656	0.8991	0.1894	0.0828	0.00692
CC_{t-1}	0.9535	0.0029	0.0016	0.0042	0.2688	0.7012	0.0404	0.1328	1.42E-06
CC_{t-2}	0.6305	0.0018	0.0009	0.0007	0.4878	0.3335	0.0309	0.4242	2.53E-08
$\Delta \ln p_{t-1}$	0.392	0	0.5991	0.9851	0.0054	0.2961	0.6043	0.0018	8.78E-06
$\Delta \ln p_{t-2}$	0.6849	0.1816	0.0187	0.0042	0.4187	0.0497	0.9848	0.0996	0.000394
R_{t-1}	0.8244	0.0019	0.0291	0.1675	0.2541	0	0.141	0.0239	2.66E-09
R_{t-2}	0.76	0.0034	0.033	0.1743	0.2259	0	0.1278	0.0398	4.15E-09
MC_{t-1}	0.5685	0.1303	0.0079	0.0333	0.3421	0.6258	0.5135	0.0196	0.000106
MC_{t-2}	0.7043	0.0587	0.0045	0.0111	0.3714	0.6872	0.5204	0.018	3.09E-05
EB_{t-1}	0.42	0.0125	0.2697	0.5193	0.0336	0.0001	0.0897	0.0001	1.01E-08
EB_{t-2}	0.247	0.0006	0.064	0.0271	0.2952	0.0138	0.4709	0.0029	2.97E-07

Table 2. P-value of LM test.

3.5. Threshold setting

Using the switching variable identified in the previous discussion, we estimate Equation (1). Weise (1999) suggests that in this case no constraints should be imposed. The value of *c* is chosen isometrically, ranging from the 5% quantile to the 95% quantile of the switching variable, with 0.5% as the step length. The value of γ is chosen isometrically from 0.1 to 50, with 0.1 as the step length. Based on the two-dimensional grid search method, we substitute *c* and γ into Equation (1), and perform the estimations using equation-by-equation ordinary least squares (OLS) regression. As the initial values for the LSTVAR model, we then choose the levels of *c* and γ that minimize the determinants of the variance-covariance matrix of residuals from these regressions. We accordingly obtain c = 204.4237, $\gamma = 27$, which indicates a rapid switching mechanism (see Figure 3).



Figure 3. Transition function.

3.6. The switching mechanism

The threshold *c* obtained from the grid search method divides policy uncertainty into a high uncertainty regime (c > 204.4237) and a low uncertainty regime (c < 204.4237). With this threshold, when the level of policy uncertainty reaches 204.4, a regime is considered to be a high policy uncertainty regime; otherwise, it is a low policy uncertainty regime. Figure 4 demonstrates the value of the transition function from 1999M1 to 2014 M3. Across this timeframe, Chinese economic policy was generally stable (low levels of policy uncertainty) with a few occurrences of high policy uncertainty: these occurred in the wake of the global economic crisis following the 9/11 terrorist attacks in 2001, the sub-prime mortgage crisis that emerged in the U.S. in 2008, and the European debt crisis in late 2011.



Figure 4. Value of transition function.

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4. Analysis of the asymmetric effect of policy uncertainty

As a result of the impulse response function of the VAR model depends on the order in which variables enter the model,² it is highly subjective. Koop, Pesaran, and Potter (1996) show that due to its sensitivity to both initial conditions and the scale of shock, the traditional impulse response function is very complicated under asymmetric conditions and thus lacks robustness. Koop et al. (1996) consequently propose an improved generalized impulse response function method for analysis. The decomposition results are completely independent of the sequential variables' relationships in the VAR system. Therefore, we adopt the generalized impulse response function proposed by Koop et al. (1996), as follows:

 $GI_Y(n, v_t, \omega_{t-1}) = E[Y_{t+n}|v_t, \omega_{t-1}] - E[Y_{t+n}|\omega_{t-1}], n = 0, 1, \dots, (4)$

where GI_Y is the generalized impulse response function of variable *Y*; *n* is the forecast period; and $E[\cdot]$ is the expectation operator.

Using the threshold value of 204.4 calculated above, we can determine the positive impacts of macroeconomic variables on house price volatility under high and low policy uncertainty, respectively. Figure 5–9 present a comparative analysis of the results.

Figures 5 and 6 present house price volatility after a positive one-standard-error shock in money supply and interest rates, respectively. Figure 5 demonstrates that short-term growth in money supply causes house prices to grow, fluctuate, and eventually stabilize. Growth in money supply boosts market demand and increases inflation, which stimulates demand for inflation-resistant commodities such as houses and thus causes house prices to rise. When policy uncertainty is low, house prices become volatile in the short term, and stabilize over time; however, when policy uncertainty is high, house prices show greater volatility, especially in periods 4 and 7, in which troughs are apparent. The reason is that when economic policy uncertainty is high, house prices rebound and fluctuate more vigorously than under low policy uncertainty, because policy effects are hard to anticipate. In Figure 6, we see that high interest rates raise house purchasers' costs and initially significantly depress house



Figure 5. Response of $\Delta \ln p$ to M under the effect of positive one-standard-error shock.

²The variance-covariance matrix of the innovations in the VAR model is not a diagonal matrix, so the diagonalization matrix must be obtained by orthogonal processing. This process is generally treated by the Cholesky decomposition method proposed by Sims (1980). However, the disadvantage of this method is that its estimation results are sensitive to the ordering of variables in the VAR system.



Figure 6. Response of $\Delta \ln p$ to R under the effect of positive one-standard-error shock.

prices. However, house prices reverse in the next quarter. This is known as the "Home Price Puzzle." As more economic policies may be announced in times of high policy uncertainty, the phenomenon of the Home Price Puzzle becomes more evident. Figures 5 and 6 demonstrate that increasing the money supply stimulates house prices to grow more rapidly under high than low policy uncertainty. Moreover, escalating interest rates lead to a more enduring Home Price Puzzle phenomenon.³

Figure 7 depicts the impact of consumer confidence on house price volatility. Increasing consumer confidence causes house prices to fluctuate positively; this impact diminishes over time and eventually stabilizes. The impact is asymmetric at different levels of policy uncertainty. The initial impact under high policy uncertainty is more dramatic because high policy uncertainty encourages consumers to invest and push up house prices, as they are more optimistic about making a profit in the housing market.

In Figure 8, we can see that an increase in MC, which is a proxy for housing market environment, leads first to positive house price volatility, then to alternating negative and



Figure 7. Response of $\Delta \ln p$ to CC under the effect of positive one-standard-error shock.

³The IRFs appear to contain cycles at a quarterly frequency. However, there is no seasonal feature in the data used in this paper. Meanwhile, the monthly data we use do not involve the interpolation of quarterly into monthly series. Thus, the fact that part of the graph appears seasonal is a coincidence. We thank the paper's reviewer for this valuable observation.

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Figure 8. Response of $\Delta \ln p$ to MC under the effect of positive one-standard-error shock.

positive volatility, which eventually stabilizes. The reason for initially positively fluctuating house prices is that optimism in the housing market brings about a growth of demand. However, optimistic property developers increase the house supply, and excess supply depresses house prices. House prices fluctuate alternatively in positive and negative directions and eventually reach an equilibrium. In terms of the scale of volatility, house prices fluctuate more dramatically under a high than a low policy uncertainty regime, because delay in individuals' consumption and property developers' investments causes market failure, and further causes house prices to vary radically. Generally, the market can more effectively stabilize house prices under low than high policy uncertainty, as it is less influenced by external economic policies and expectations.

In Figure 9, an increase in the area of land purchased causes house prices first to fluctuate positively, and then to alternate between positive and negative trends. For consumers, an increase in the area of land purchased reflects property developers' optimism, which can boost market demand and house prices. However, for suppliers, it reflects an expected increase in supply, and may accordingly depress house prices. Affected by these two regimes, house prices fluctuate, as shown in Figure 9. However, in terms of impact, the response of house prices to the degree of uncertainty is minor, and thus the impact of asymmetry is not obvious.



Figure 9. Response of $\Delta \ln p$ to EB under the effect of positive one-standard-error shock.

In summary, the impact of macroeconomic variables on house price volatility differs under different levels of policy uncertainty. Under high policy uncertainty, the Home Price Puzzle phenomenon is prominent, and other macro variables have an enormous effect on house price volatility. It is possible that the EPU measure must rise for a prolonged period of time before it reaches the threshold. For instance, during the Great Recession and European debt crisis, there was at least a full year of increase in the EPU index before hitting the threshold, which means that the IRFs for the high uncertainty regime tended to be identified with recession troughs. This situation makes it difficult to distinguish high uncertainty from a recession trough. However, in our view, China's real estate market is not directly affected by the international market, due to limits on foreign investment; it is more impacted by domestic policy in China. Therefore, although it is difficult to distinguish high uncertainty from a recession trough, we believe that the impact of CEPU on housing prices is more important. High policy uncertainty can mean that individuals delay their consumption and investment, further depressing real estate companies' supply of houses. Moreover, it may cause market failure and lead to unnecessary volatility. The expectations of demanders and suppliers are also affected when policy uncertainty is high, which can lead to excess adjustments and aggravate house price volatility.

5. Further analysis

5.1. EPU in the United States

In China, a completely market-based housing system was established in 1998. The rapid increase in house prices can be attributed to factors on both the supply and demand sides. There are many regulations restricting the housing supply. To ensure the food supply, the government imposed strong restrictions on converting land from agricultural to urban use. In addition, in China, land is owned by the government. Sales revenue from land is local governments' most important off-budget income source. Local governments thus have a strong motivation to restrict land supply and push up land prices, resulting in higher house prices. Therefore, China's unique economic and property rights systems mean that the impact of policies on housing prices is more obvious here than in other countries and regions.

To further analyze the characteristics of China's real estate market, we also test samples from the housing market in the United States and Canada from the same period. We again use LM statistics to test for nonlinearity in the VAR model. The results show that the null hypothesis cannot be rejected if we use the EPU as the switched variable in Canada. This means that under different EPU regimes, the impact of shocks by other macro variables on housing prices has no significant difference in Canada, at least in the chosen sample period.

However, in the United States, the LM statistics show that the null hypothesis can be rejected at the 1% significance level. The EPU is thus also a switching variable.

Based on the two-dimensional grid search method, we substitute c and y into Equation (1), and perform equation-by-equation OLS estimation. As the initial values for the LSTVAR model, we choose levels of c and y that minimize the determinants of the variance-covariance matrix of residuals from these regressions. We accordingly obtain c = 161.3.

Figures 10 and 11 show house price volatility in the U.S. after a positive one-standarderror shock of money supply and interest rates, respectively. Figure 11 demonstrates that short-term growth in money supply causes house prices to grow and eventually stabilize. A growth in the money supply can boost market demand and expected inflation, which stimulates demand for inflation-resistant commodities such as houses, and accelerates house price growth. When policy uncertainty is low, house prices become volatile in the short term and stabilize over time. However, when policy uncertainty is high, house prices show greater volatility in the long term. This situation resembles that of China.

Figure 11 shows that high interest rates increase house purchasers' costs, and significantly depress house prices. Moreover, this influence is persistent, and not subject to reversal as in China (the Home Price Puzzle). Meanwhile, the effects of the impact under different EPU regimes reveal that the impact of interest rates on housing prices is also different. Under a high (vs. low) uncertainty regime, the negative impact on housing prices is significantly greater and lasts longer. Under the impacts of high and low uncertainty regimes, housing prices respond differently.

In general, even in the United States, the impact of external shocks on house prices differs under different policy uncertainty regimes. However, when housing prices are affected by interest rate shock in the United States, under a high or low policy uncertainty regime, there is no Housing Price Puzzle.

5.2. Robustness check

It is possible that the IRFs for high policy uncertainty are associated with the narrow periods surrounding three foreign crises. For a robustness check, we test different thresholds and take c = 161.3 as the threshold of US Economics Policy Uncertainty (USEPU). The new transition function is reflected in Figure 12.

In contrast with Figure 4, if we set c = 161.3, the value of the transition function is more frequently 1. Using the threshold value of 161.3, we can find the positive impacts of macroeconomic variables on house price volatility under high and low policy uncertainty.

Following the threshold obtained from the U.S. data, we use the USEPU threshold c = 161.3. The IRFs using the USEPU threshold c = 161.3 are given in Figures 13 and 14.



Figure 10. Response of $\Delta \ln p$ to R under the effect of positive one-standard-error shock in the U.S.



Figure 11. Response of $\Delta \ln p$ to R under the effect of positive one-standard-error shock in the U.S.



Figure 12. Transition Function (c = 161.3).



Figure 13. Response of $\Delta \ln p$ to R under the effect of positive one-standard-error shock (c = 161.3).

Lastly, in Figure 15 we further analyze the impact of USEPU on China's house price volatility. A positive shock in the USEPU index leads to a negative trend in China's house prices. A sudden increase in the USEPU index leads to uncertainty about China's



Figure 14. Response of $\Delta \ln p$ to M under the effect of positive one-standard-error shock (c = 161.3).



Figure 15. Response of $\Delta \ln p$ to USEPU under the effect of positive one-standard-error shock.

economic development, which reduces people's willingness to buy houses and causes negative fluctuations in house prices. At the same time, under different EPU regimes, the impact of shocks presents an obvious asymmetric trend. Under the high uncertainty regime, the impact of USEPU makes house price volatility significantly greater than under the low uncertainty regime. The reason may be that when the EPU is high, buyers are worried about future changes in the market. When an external shock occurs, market participants tend to panic, and excessive buying and selling behavior lead to greater "overshooting" of housing prices and correspondingly greater volatility.

6. Conclusion

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We combine the CEPU Index proposed by Baker et al. (2015) and macroeconomic data dating back to 1999 to construct an empirical study of the effect of monetary policy variables on house price volatility under different levels of policy uncertainty, using an LSTVAR model. House price volatility in China derives from the impact of monetary policy. Optimism in the macro environment leads to positive volatility in house prices, and this volatility tends to increase with policy uncertainty. That is, the impact of the macro environment on house price volatility differs under different levels of policy uncertainty. When policy uncertainty is high, the macro-environmental impact on house prices will also be relatively high.

The empirical results show that the threshold of policy uncertainty is c = 204.4237. We divide policy uncertainty into two regimes, high and low. At different levels, the impact of macroeconomic variables on house price volatility exhibits asymmetry. Under the high-level regime, macroeconomic variables such as macroeconomic development, real estate market environment, money supply, and consumer confidence cause house prices to exhibit dramatic volatility. Moreover, empirical results show that under high policy uncertainty, increased money supply accelerates house price growth and higher interest rates lead to an enduring Home Price Puzzle phenomenon, which makes it more difficult to regulate house prices.

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References

- Ahearne, A., Ammer, J., Doyle, B., Kole, L., & Martin, R. 2005. *Monetary policy and house prices: A cross-country study* (International Finance Discussion Papers, No. 841. Board of Governors of the Federal Reserve System. doi:10.17016/IFDP.2005.841
- Alqaralleh, H. (2019). Asymmetric sensitivities of house prices to housing fundamentals: Evidence from UK regions. *International Journal of Housing Markets and Analysis*, 12(3), 442–455.
- Bahmani-Oskooee, M., & Ghodsi, S. H. (2016). Do changes in the fundamentals have symmetric or asymmetric effects on house prices? Evidence from 52 states of the United States of America. *Applied Economics*, 48(31), 2912–2936.
- Baker, S. R., & Bloom, N. 2013. *Does uncertainty drive business cycles? Using disasters as a natural experiment* (NBER Working Paper, No. 19475).
- Baker, S. R., Bloom, N., & Davis, S. J. 2012. *Policy uncertainty: A new indicator* (No. 362, Centre for Economic Performance). LSE.
- Baker, S. R., Bloom, N., & Davis, S. J. 2015. *Measuring economic policy uncertainty*. Chicago Booth Research Paper No. 13-02.
- Balcilar, M., Gupta, R., & Miller, S. M. (2015). The out-of-sample forecasting performance of non-linear models of regional housing prices in the U.S. *Applied Economics*, 47(22), 2259~2277.

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- Bekaert, G., Hoerova, M., & Lo Duca, M. (2013). Risk, uncertainty and monetary policy. *Journal of Monetary Economics*, 60(7), 771–788.
- Bernanke, S. B., & Kuttner, K. N. (2005). What explains the stock market's reaction to federal reserve policy. *Journal of Finance*, 60(3), 1221–1257.
- Bloom, N. (2009). The impact of uncertainty shocks. Econometrica, 77(3), 623-685.
- Brennan, M. J., & Schwartz, E. S. (1985). Evaluating natural resource investments. *Journal of Business*, 1, 135–157.
- Canepa, A., & Chini, E. Z. (2016). Dynamic asymmetries in house price cycles: A generalized smooth transition model. *Journal of Empirical Finance*, *37*, 91–103.
- Das, S., Gupta, R., & Kabundi, A. 2009. Forecasting real house price growth in the nine census divisions of the US (Working Paper No. 200902) Department of Economics, University of Pretoria.
- Higgs, R. (1997). Regime uncertainty why the great depression lasted so long and why prosperity resumed after the war. *The Independent Review*, 1(4), 561–590.
- Jarociński, M., & Smets, F. 2008. *House prices and the stance of monetary policy* (European Central Bank Working Paper Series, No. 0891).
- Kim, S., & Bhattacharya, R. (2009). Regional housing prices in the USA: An empirical investigation of nonlinearity. *The Journal of Real Estate Finance and Economics*, *38*(4), 443~460.
- Koop, G., Pesaran, M. H., & Potter, S. M. (1996). Impulse response analysis in nonlinear multivariate models. *Journal of Econometrics*, 74(1), 119–147.
- Lastrapes, W. D. (2002). The real price of housing and money supply shocks: Time series evidence and theoretical simulations. *Journal of Housing Economics*, *11*(1), 40~74.
- McDonald, R., & Siegel, D. (1986). The value of waiting to invest. *Quarterly Journal of Economics*, 101(4), 707–727.
- Nakamura, E., Sergeyev, D., & Steinsson, J. 2012. Growth-rate and uncertainty shocks in consumption: cross-country evidence (NBER Working Paper, No. 18128).
- Narayan, P. K., & Popp, S. (2013). Size and power properties of structural break unit root tests. *Applied Economics*, 45(6), 721–728.
- Pastor, L., & Veronesi, P. (2013). Political uncertainty and risk premia. *Journal of Financial Economics*, 110(3), 520-545.
- Rapach, D. E., & Strauss, J. K. (2007). Forecasting real housing price growth in the Eighth District States. *Regional Economic Development*, *3*, 33–42.
- Rigobon, R., & Sacks, B. (2004). The impact of monetary policy on asset price. *Journal of Monetary Economics*, *51*, 1553–1575.
- Rodrik, D. (1991). Policy uncertainty and private investment in developing countries. *Journal of Development Economics*, 36(2), 229–242.
- Scotti, C. (2013). Surprise and uncertainty indexes: real-time aggregation of real-activity macro surprises. *International Finance Discussion Paper*, 2013(1093), 1–35.
- Sims, C. A. (1980). Macroeconomics and reality. *Econometrica: Journal of the Econometric Society*. 48(1), 1–48.
- Smyth, R., & Narayan, P. K. (2015). Applied econometrics and implications for energy economics research. *Energy Economics*, 50, 351–358.
- Tersvirta, T., & Anderson, H. M. (1992). Characterizing nonlinearities in business cycles using smooth transition autoregressive models. *Journal of Applied Econometrics*, 7, 119–136.
- Uhlig, H. (2005). What are the effects of monetary policy on output? Results from an agnostic identification procedure. *Journal of Monetary Economics*, 52(2), 381–419.
- Vargas-Silva, C. (2008). Monetary policy and the US housing market: A VAR analysis imposing sign restrictions. *Journal of Macroeconomics*, *30*(3), 977–990.
- Weise, C. L. (1999). The asymmetric effects of monetary policy: A nonlinear vector autoregression approach. *Journal of Money, Credit and Banking*, *31*(1), 85–108.
- Zettelmeyer, J. (2004). The impact of monetary policy on the exchange rate: Evidence from three small open economies. *Journal of Monetary Economics*, *51*(3), 635–652.
- Zhou, J. (2010). Testing for cointegration between house prices and economic fundamentals. *Real Estate Economics*, *38*, 599–632.