Uncertainty, Consumption, and Housing Market in the United States− A Structural VAR Approach

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Abstract

This paper investigates the relationship between uncertainty, consumption, and housing sector. Using quarterly data from 1987Q1 to 2019Q4, I estimate coefficients by a 5-equation Structural Vector Autoregressive (SVAR) model. I found that the Economic Policy Uncertainty Policy Index has more ability than interest rate spread to explain the boom and bust of housing market. The impulse response suggests that the housing output has been significantly affected by the shock of housing price and durable goods consumption. Future research avenues are also provided.

Keywords: Economic Policy Uncertainty Index; housing market; structural VAR

1 Introduction

Housing market has been a crucial part of the macroeconomic research as its impact on the aggregate economy. According to U.S. Bureau of Economic Analysis, housing sector account for 14.6% of gross domestic product in the United States.[1] During the financial crisis, housing price experienced nearly 25% of plunge from 2006 to 2012. The crashed bubble of the housing market made substantial losses to investors and even triggered recessions in the world for years.

[1] U.S. Bureau of Economic Analysis (2020) "Residential Fixed Investment" and "Housing Services," Gross Domestic Product, accessed on April 10, 2020. Available at https://www.bea.gov/data/gdp/gross-domestic-product.

Consumption was constrained during the recession and the shocks in the economy, where people choose to postpone their consumptions that are not urgent and essential, mostly durable goods. The relationship between the housing consumption and other durable goods will offer us the insight of how the public makes decisions during economic uncertainty.

Black swan comes from our misunderstanding of the likelihood of surprises, said Taleb (2007). From the Street to the academia, many practitioners, researchers, and policymakers try their best to understand the uncertainty and the volatility of the market, with different proxies that are incorporated into the decision making process. The objective of this paper is to quantify the effects of the economic uncertainty on the housing market, and to better understand the "known unknown." The rest of the paper is structured as follows. Section 2 offers the literature review. Section 3 describes the source of data and summary statistics. Section 4 illustrates the methodology. Section 5 shows the empirical results of contemporaneous relation and impulse response. Section 6 concludes and provides recommendations for future research.

2 Literature Review

2.1 Uncertainty

The relationship between uncertainty and housing market performance has been widely discussed in the literature. (Antonakakis and Floros, 2016; Antonakakis *et al.*, 2015; Benzoni *et al.*, 2018; Cepni *et al.*, 2020; Chow *et al.*, 2017; Christidou and Fountas, 2017; Sum and Brown, 2012; Wang *et al.*, 2020; Zhang, 2001) Among them, Economic Policy Uncertainty Index (EPU)[2] is widely used as a proxy of volatility of market. Chow *et al.* (2017) found that uncertainty level has relevance in the prediction and understanding of the housing price in China and India. Using Dynamic Conditional Correlation (DCC) model, Antonakakis *et al.* (2015) confirmed a strong feedback loop between EPU and real housing market returns, after controlling selected macroeconomic variables, including real industrial production growth, inflation, real federal funds rate, and CBOE Volatility Index (VIX) in the United States. They also found EPU carries predictive information for housing returns and the volatility. Christidou and Fountas (2017) also

[2] I will give detailed descriptions in Section 3.

showed that uncertainty tends to increase housing output and decrease house price inflation among forty-eight contiguous US states.

2.2 Interest Rate Spread

Interest rate spread, or term spread, is defined as the long-term interest rate minus the short-term one. It is also translated as the slope of the yield curve interchangeably, which has been used to predict the probability of recession, reflect the pessimistic sentiments, or represent the future negative economic conditions by Wall Street and researchers. (Benzoni *et al.*, 2018; Estrella and Hardouvelis, 1991; Estrella and Mishkin, 1998; Rudebusch and Williams, 2009; Zaloom, 2009) When the term spread is positive, the investors expect the long-term bond yields will generate higher return, which shows the confidence in the future economic expansion. Conversely, when the spread is below zero, or "inversion of the yield curve," is deemed as a sign of expectation for economic downturn.

2.3 Durable Goods Consumption

Traditionally, the housing[3] and durable goods are more sensitive to the credit constraints, than the non-durable goods. The dynamic of consumption and other macroeconomic variables is investigated by theoretical as well as empirical models. It is also widely investigated from the perspective of monetary policy transmission mechanism, for example, how contractionary monetary policy affects the consumption and housing market. (Carlstrom and Fuerst, 2006; Elbourne, 2008; Erceg and Levin, 2006; Hofmann and Peersman, 2017; Lastrapes and Potts, 2006; Musso *et al.*, 2011; Wadud *et al.*, 2012). Using Vector Autoregressive (VAR) model, Erceg and Levin (2006) found that the monetary policy shock decreases the durables spending including residential investments. Lastrapes and Potts (2006) and Barsky *et al.* (2007) also used VAR to investigated the different responses of the durable goods and housing spending to the monetary supply shocks in the United States.

[3] Housing is categorized as a type of consumption rather than the investment since the objects transacted are mostly in the form of final goods, though most researchers used two terms interchangeably. (Source: U.S. Bureau of Economic Analysis (2019), "NIPA Handbook: Concepts and Methods of the U.S. National Income and Product Accounts," Chapters 1-4: Concepts, Source Data, and Estimating Methods, pp. 20, November 2019, accessed on April 20, 2020. Available at https://www.bea.gov/system/files/2019-12/Chapter-1-4.pdf.)

Overall, macroeconomic variables were empirically used in previous research to delve into the relationship between uncertainty, consumption, and consumer choice in housing market. However, there are limited research investigating the shocks from term spread to the consumptions and the housing activities, which is the innovation of this paper.

3 Data

3.1 Data Source

Quarterly data during 1987Q1 to 2019Q4 is retrieved from the Federal Reserve Bank of St. Louis,[4] including following variables.

1. Economic Policy Uncertainty Index (EPU)[5]

It is widely used to investigate the impact of holistic economic condition on the housing market and how this index reflects the fluctuation of the shocks from housing markets. The index is constructed by Baker *et al.* (2016), measuring three main components. First, it includes the newspaper (such as USA Today, the New York Times, the Wall Street Journal) coverage of policy-related economic uncertainty. The second component reflects the number of federal tax code provisions set to expire in future years. The third component uses disagreement among economic forecasters as a proxy for uncertainty. Details of the index can be accessed on the website of Economic Policy Uncertainty Index.[6] EPU is transformed in its logarithm term, denoted as L_EPU.

2. Interest Rate Spread (IRS)[7]

As suggested by Benzoni *et al.* (2018), academic studies often used the difference between 10-Year Treasury Constant Maturity and 3-Month Treasury Constant Maturity, which represents the long-term view of investors and the short-term is a close substitute for the federal funds rate targeted by the Federal Reserve's policymaking body, the Federal Open Market Committee

[4] Federal Reserve Bank of St. Louis (2020), "Economic Data," accessed on March 20, 2020. Available at https://fred.stlouisfed.org/.
[5] Federal Reserve Bank of St. Louis (2020), "Economic Policy Uncertainty Index for United States," accessed on March 20, 2020. Available at https://fred.stlouisfed.org/series/USEPUINDXD.
[6] Economic Policy Uncertainty Index (2020), "Methodology," accessed on April 1, 2020. Available at http://www.policyuncertainty.com/methodology.html.
[7] Federal Reserve Bank of St. Louis (2020), "10-Year Minus 3-Month Treasury Constant Maturity," accessed on March 20, 2020. Available at https://fred.stlouisfed.org/series/T10Y3M.

(FOMC). Noted that I take the negative value of IRS, meaning the pessimistic economic sentiment, when running the SVAR model and rest of the analysis for convenience of interpretation. The negative value of IRS is denoted as M_IRS.

3. Personal Consumption Expenditures on Durable Goods (PCEDG)[8]

According to the NIPA Handbook,[9] consumer durable goods are defined as tangible commodities purchased by consumers that can be used repeatedly or continuously for a prolonged period. To investigate the relationship between housing consumption and other durable goods, I include this variable in the estimation. It is originally released from "Personal Income and Outlays" from U.S. Bureau of Economic Analysis. PCEGD is transformed in its logarithm term, denoted as L_PCEDG.

4. Housing Price (HP)[10]

S&P/Case-Shiller U.S. National Home Price Index was developed by economists Allan Weiss, Karl Case, and Robert Shiller in 1980s. It measures the residential, repeat-sales real estate prices in the United States and tracks changes in the value of residential real estate nationally.[11] It is commonly used to measure the housing price in the U.S. HP is transformed into the logarithm form, denoted as L_HP.

5. Housing Starts (HOUST)[12]

Housing starts, or new privately owned housing units started, is originally provided by U.S. Census Bureau. It measures the time when excavation occurs for the footings or foundation of a building. This can be viewed as the output, or quantity, in the U.S. housing market equilibrium. (Wadud *et al.*, 2012) HOUST is also transformed into the logarithm form, denoted as L_HOUST.

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[8] Federal Reserve Bank of St. Louis (2020), "Personal Consumption Expenditures: Durable Goods," accessed on March 20, 2020. Available at https://fred.stlouisfed.org/series/PCEDG.

[9] U.S. Bureau of Economic Analysis (2019), "NIPA Handbook: Concepts and Methods of the U.S. National Income and Product Accounts," Chapters 1-4: Concepts, Source Data, and Estimating Methods, pp. 20, November 2019, accessed on April 20, 2020. Available at https://www.bea.gov/system/files/2019-12/Chapter-1-4.pdf.

[10] Federal Reserve Bank of St. Louis (2020), "S&P/Case-Shiller U.S. National Home Price Index," accessed on March 20, 2020. Available at https://fred.stlouisfed.org/series/CSUSHPISA.

[11] S&P Dow Jones Indices LLC (2020), "S&P CoreLogic Case-Shiller Home Price Indices," accessed on March 21, 2020. Available at https://us.spindices.com/index-family/sp-corelogic-case-shiller/sp-corelogic-case-shiller-composite.

[12] Federal Reserve Bank of St. Louis (2020), "Housing Starts: Total: New Privately Owned Housing Units Started," accessed on March 20, 2020. Available at https://fred.stlouisfed.org/series/HOUST.

3.2 Data Summary

Plots of original level data are shown in Figure A1 to A5 in Appendix A. Table 1 shows the summary statistics and Table 2 shows the correlation between each series.

Table 1. Descriptive Statistics

Variable	Observations	Mean	Std. Dev.	Min	Max
EPU	132	99.39121	37.28452	43.71804	225.2321
IRS	132	1.710227	1.125339	-0.63	3.61
PCEDG	132	940.3111	320.893	418.5	1549.7
HP	132	127.5148	44.83046	64.398	212.797
HOUST	132	1319.497	387.8602	525.6667	2120.333
L_EPU	132	4.536904	0.346859	3.777761	5.417131
M_IRS	132	-1.710227	1.125339	-3.61	0.63
L_PCEDG	132	6.780388	0.377434	6.036677	7.345817
L_HP	132	4.783279	0.367114	4.165082	5.360339
L_HOUST	132	7.134117	0.337533	6.264668	7.659328

Table 2: Correlation Matrix

	L_EPU	M_IRS	L_PCEDG	L_HP	L_HOUST
L_EPU	1	-	-	-	-
M_IRS	-0.4313	1	-	-	-
L_PCEDG	-0.0412	0.1145	1	-	-
L_HP	-0.0315	0.0962	0.9645	1	-
L_HOUST	-0.5473	0.3620	-0.1784	-0.2099	1

4 Methodology

4.1 Unit Roots Test

Augmented Dickey-Fuller test is performed to check for the stationarity on each series and its differencing. The testing hypotheses are designed as follows:

H_0: Presence of unit root in the series

H_a: Unit root does not exist in the series

The Augmented Dickey-Fuller test shows that the all series are stationary at 5% significance level in the first difference, except for the housing price. However, it is stationary after taking second difference, with p-value of 0.0000.[13] The results are shown in Table 3. The plots of variables in their respective differencing are shown in the Figure A6 to A10 in Appendix A.

Table 3. Unit roots test result

	P-value (Level)		P-value (First Difference)		Order of Integration
Variables	With Constant	With Trend	With Constant	Without Constant	
L_EPU	0.0001	0.0007	0.0000	0.0000	I(0)
M_IRS	0.3072	0.6249	0.0000	0.0000	I(1)
L_PCEDG	0.4597	0.8642	0.0000	0.0000	I(1)
L_HP	0.8614	0.9754	0.1250	0.3582	I(2)
L_HOUST	0.5967	0.9372	0.0000	0.0000	I(1)

4.2 Structural Vector Autoregressive (SVAR) model

SVAR model is used to investigate the contemporaneous relations among endogenous variables. The impulse response after the estimation could also provide insights of how shocks in the one variable affect another variable. Sum and Brown (2012) suggested that the impact of EPU Shocks on the housing sector during 1985-2011 in the United States. Elbourne (2008) constructed a SVAR model to investigate the transmission mechanism of monetary policy, interest rate, and consumption in United Kingdom. Wadud *et al.* (2012) also proposed a 9-variable SVAR model to quantify the relationship between endogenous variables in Australia, including aggregate output, inflation, house price index, material costs, number of new houses, federal fund rate, number of private sector housing approval, government expenditures on housing and community, exchange rate, interest rate. Musso *et al.* (2011) also found that the contractionary monetary policy, or shocks in short term interest rate, does not have strong explanatory ability on mortgage market in the United States. Thus, I choose to use the SVAR model to quantify the contemporaneous relations among endogenous variables and also shows how the shock of each variable affect each other in

[13] Since series are not stationary in the same difference order, I did not use the cointegration test or consider the vector error correction model.

the impulse responses analysis. The structural model of the relationship between variables is shown as follows:

$$A_0 Z_t = A_1(L) Z_t + B\varepsilon_t$$

where A_0 and B are 5x5 matrices of all coefficients and Z_t is a vector including 5 variables. $A_1(L) = \sum_{i=1}^{q} A_{1i} L^i$ are matrices polynomial in the lag terms with A_{1i} being a 5x5 matrix of coefficients. ε_t is a vector of serially uncorrelated, zero mean structural shocks with identity covariance matrix, $\sum_{\varepsilon} = E[\varepsilon_t \varepsilon_t'] = I$.

For the number of the lags in the VAR system, I adopted the criteria including Final Prediction Error (FPE), Akaike's Information Criterion (AIC), Hannan and Quinn Information Criterion (HQC), and Schwarz's Bayesian Information Criterion (SBIC). The result suggests that the optimal numbers of lags is two, shown in Table B1 in Appendix B.

The restrictions on the matrix in the Structural VAR system can be used to specify the structural shocks. According to Cholesky decomposition, we need at least $\frac{n^2-n}{2}$ restrictions for n variables to avoid the problem of identification. The system has 10 restrictions and is exactly identified, which can be represented in the matrix form below:

$$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ a_{21} & 1 & 0 & 0 & 0 \\ a_{31} & a_{32} & 1 & 0 & 0 \\ a_{41} & a_{42} & a_{43} & 1 & 0 \\ a_{51} & a_{52} & a_{53} & a_{54} & 1 \end{bmatrix} \begin{bmatrix} L\_EPU \\ M\_IRS \\ L\_PCEDG \\ L\_HP \\ L\_HOUST \end{bmatrix} = \begin{bmatrix} x & 0 & 0 & 0 & 0 \\ 0 & x & 0 & 0 & 0 \\ 0 & 0 & x & 0 & 0 \\ 0 & 0 & 0 & x & 0 \\ 0 & 0 & 0 & 0 & x \end{bmatrix} \begin{bmatrix} \varepsilon^{L\_EPU} \\ \varepsilon^{M\_IRS} \\ \varepsilon^{L\_PCEDG} \\ \varepsilon^{L\_HP} \\ \varepsilon^{L\_HOUST} \end{bmatrix}$$

The matrix A_0 in the model specifies the contemporaneous relations of endogenous variables. Sum and Brown (2012) used VAR model and found that EPU affect the housing returns, but not vice versa. Wadud *et al.* (2012) also showed the order as housing price will affect the housing starts in the SVAR model. Based on literature previously mentioned as well, I assumed that all variables affecting latter variables without feedback effect, in the order of EPU, IRS, PCEDG, HP, and HOUST. In words, the uncertainty will affect the economic sentiment, which constrains the durables consumption, housing price and output. However, the housing market will not affect the uncertainty level, interest rate, or the durable goods consumption contemporaneously.

5 Empirical Results[14]

5.1 Contemporaneous relation

Table 4 shows the estimated coefficients of the SVAR model. As expected, the uncertainty index and term spread has positive relationship; however, it is not statistically significant at any conventional level. The EPU has positive relationship with consumption of durable goods, and also with the housing price. The Granger causality test shown in Table B2 (Appendix B) suggests that the null hypothesis that the coefficients on the two lags of all the other endogenous variables are jointly zero cannot be rejected at 5% confidence level. Noted that all variables except for housing starts do not granger cause the EPU.

Table 4: Estimated coefficients with standard error in parenthesis

	L_EPU	M_IRS	L_PCEDG	L_HP	L_HOUST
L_EPU	1	0	0	0	0
M_IRS	0.0552286 (0.124141)	1	0	0	0
L_PCEDG	0.0202734* (0.006939)	-0.0003781 (0.004898)	1	0	0
L_HP	0.0050291* (0.001852)	-0.0000181 (0.001266)	-0.0272708 (0.022678)	1	0
L_HOUST	-0.0193335 (0.020599)	0.0317347* (0.013704)	-1.282367* (0.246721)	-2.491581* (0.948896)	1

Note: * indicates significance at 97.5% confidence level.

Interest rate spread has negative relationship with durable goods consumption, while it has positive relationship with the housing starts, or the housing activities, with 97.5% confidence level. The durables consumption has a negative contemporaneous relation with the housing starts. My interpretation is that people tend to restrain their housing consumption but do not limit their consumption for durable goods in general, when there is the pessimistic sentiment towards the economy. Since the housing investment is account for a major component of total household

[14] I also conducted the stability test for SVAR model, shown in Table B3 and Figure B1 in Appendix B. The result shows that all the eigenvalues lie inside the unit circle. Though the eigenvalues are very close to the margin of the circle, we can still interpret properly the impulse response functions and forecast-error variance decompositions.

consumption, people would prioritize other more affordable goods. However, it is not suggested that the non-housing durable goods consumptions is the complement of the housing consumption. It is also suggested that the detailed decomposition of the durable goods should be analyzed in the further research.

The negative significant effect of housing price on housing starts at 5% of confidence level. This is shows that in the short run, the price increase in housing market will reduce the newly built housing activities. This shows that when the cost of housing increase, the demand decline. This is different from the result of Wadud *et al.* (2012), which found a positive relation between price and quantity in Australia. The difference may be derived from the different market and different timeline (they used quarterly data from 1974Q2 to 2008Q4). This also shows the possible structural change in the relationship between housing price and output after financial crisis in 2008.

5.2 Impulse response functions (IRF)[15]

1. Shocks of Economic Policy Uncertainty and Inverted Yield Curve

As shown in Figure 1 below, one positive standard deviation shock from EPU will decrease the interest rate spread significantly whereas the negative shock of term spread, or the shock of "inverted yield curve" does not affect the EPU significantly. Appendix D provides complete forecast error variance decomposition (FEVD) for the SVAR model. Table D1 and D2 (Appendix D) shows that the only 1.2% of the variance of EPU is contributed by IRS while nearly 25% of the variance of the IRS comes from EPU, which explains the impulse response of two variables. This confirms that when the uncertainty rises, the Federal Reserve Board tends to decrease the level of fed fund rate in order to increase the liquidity among the market, which is aligned with the result estimated by Antonakakis *et al.* (2015). This is also aligned with the previous literature that inverted yield curve should not be viewed as the signal for future recession since the economic uncertainty rises from different areas and causes. (Benzoni *et al.*, 2018)

[15] The complete result of impulse response is shown in Appendix C.

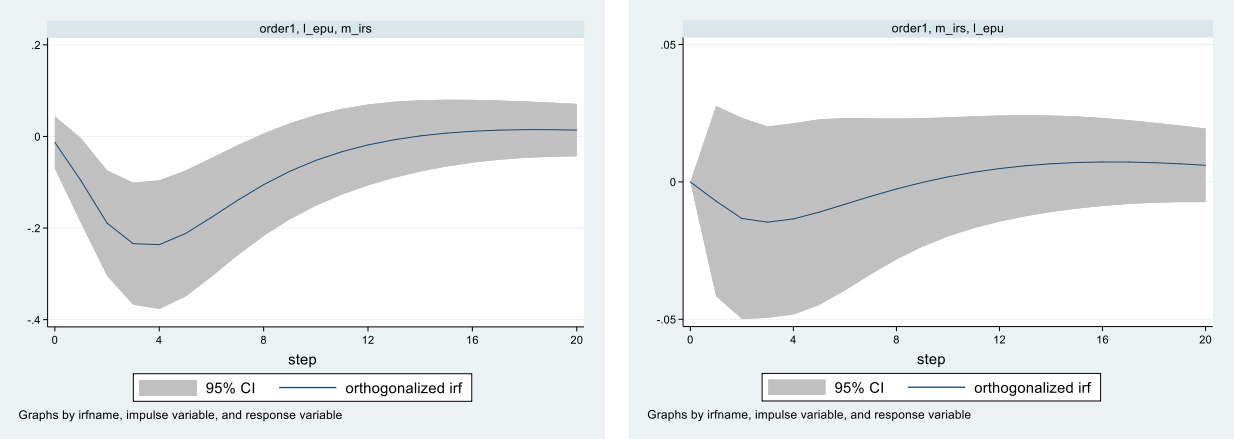


Figure 1: Impulse response of EPU and IRS

Figure 2 and 3 show that one standard deviation shock from EPU has significant negative impact on the housing price, similar to the findings of André *et al.* (2015). The shocks from EPU and inverted yield curve both have negative effects on housing starts but not significantly. The impact will soon fade away after approximately one year. Conversely, one standard deviation shock of negative term spread (or increased risk of inverted yield curve) has slightly positive impact on the housing starts at the first stage then become negative after one year. These results show the consumer's tendency to freeze the consumption on real estate. Noted that only the shock from EPU on housing price is significant among four selected impulse response functions. The possible reasons for insignificance could be explained by that the inversion of the yield curve may be derived from whether higher or lower recession probability, as suggested by Benzoni *et al.* (2018).

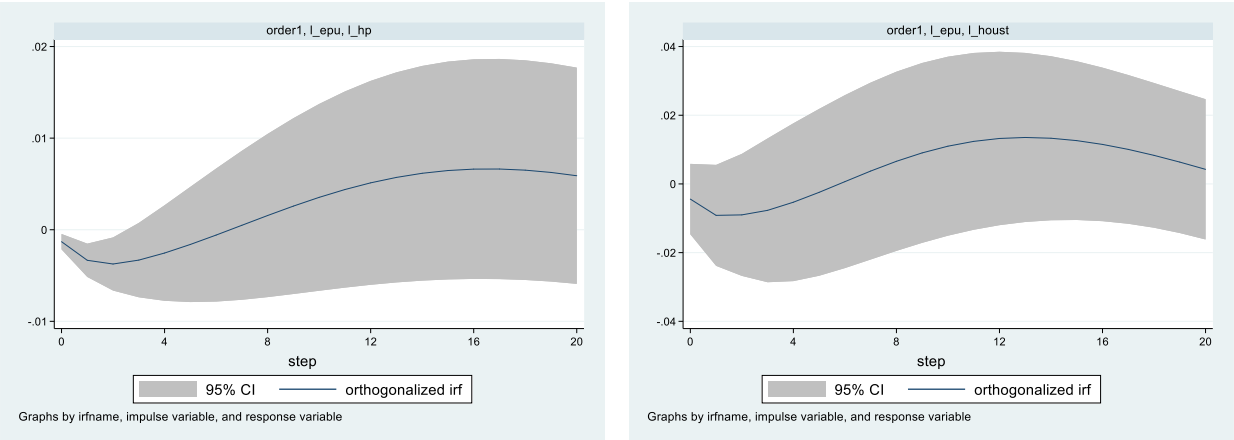


Figure 2: Housing market response to EPU shock

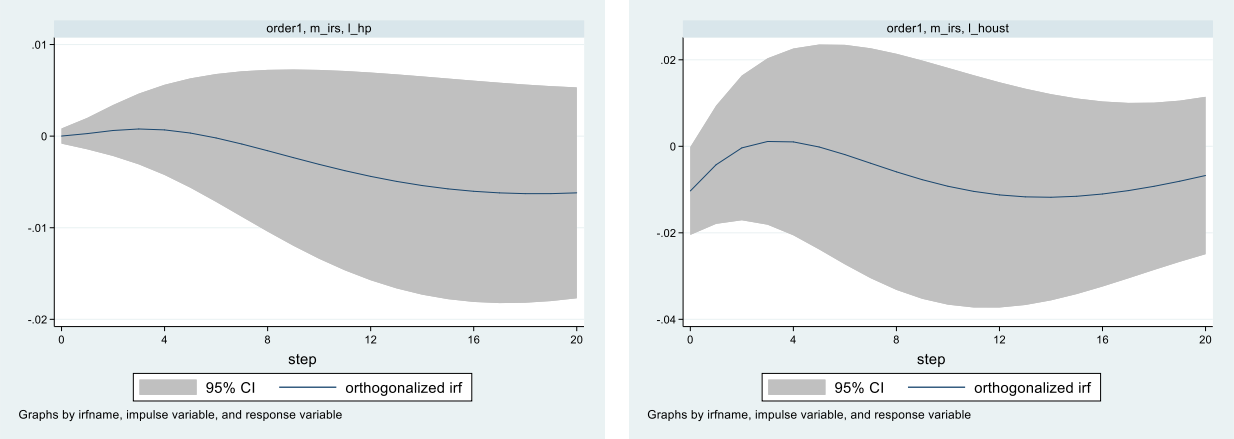


Figure 3: Housing market response to IRS shock

2. Shocks of Housing Market and Durables Consumption

Figure 4 shows that one standard deviation shock from EPU has negative impact on durable goods significantly. However, the increased risk of inverted yield curve slightly increases the durable goods consumption and then become negative after about one year, though not significantly. This shows people may restrain the durable consumption under economic uncertainty. After within one year, the shock of inverted yield curve will reduce the consumption on durable goods. Though this result does not confirm the shock of interest spread and durables consumption, Lastrapes and Potts (2006) showed the shock in money supply, or increased liquidity in the market, will decrease the durables expenditures, which would be the variable of interest in further analysis.

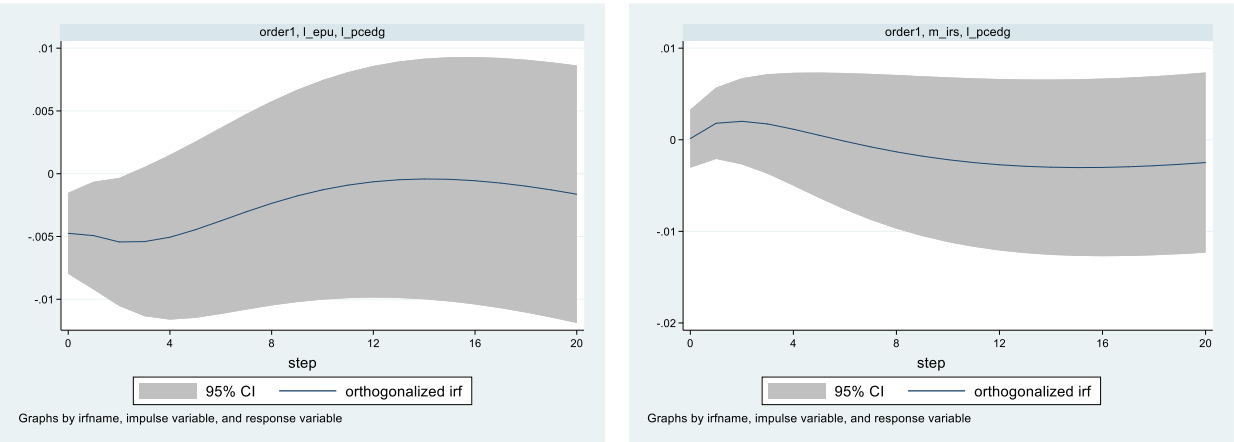


Figure 4: Durables consumption response to shocks

One standard deviation shock from housing starts and durables consumption both negatively affect EPU, whereas shocks of housing price do not have significant effect on EPU, shown in Figure 5. This could be explained by Table D1 that shows the durable good consumption makes up for 8.75% of the forecast error variance of EPU, which is however mainly contributed by EPU itself.

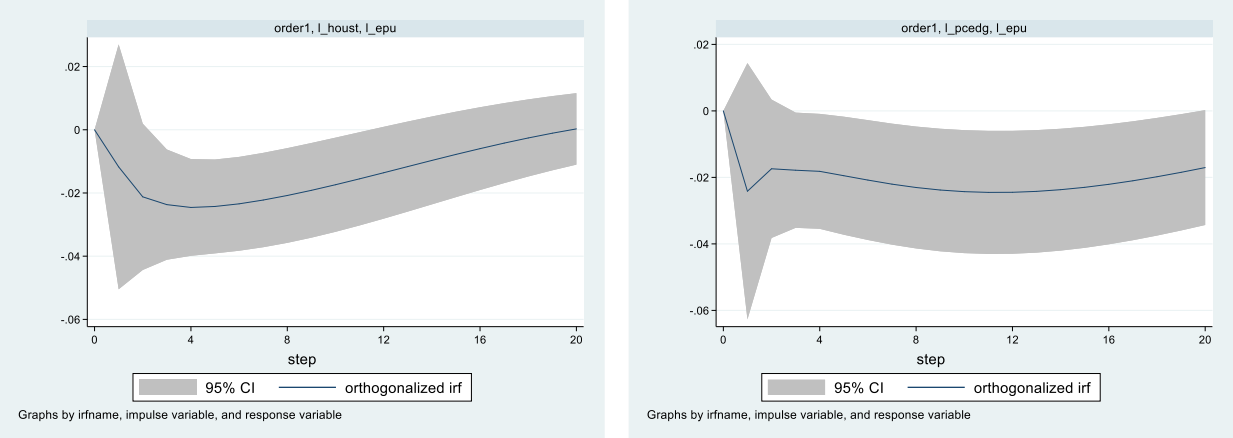
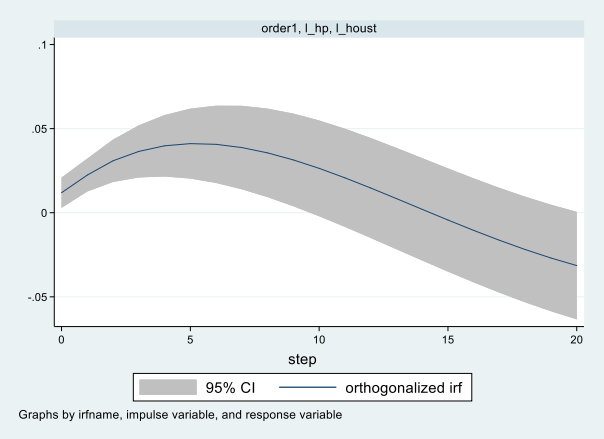


Figure 5: EPU response to shocks

As shown in Figure 6, one standard deviation shock of housing price will significantly increase housing starts. The shock of housing starts will also increase the price but not significantly. Figure 7 shows, the shock of consumption on durable goods has a positive significant effect on both housing price and output. Table D4 shows that durable consumptions accounts for nearly 34.7% of the forecast error variance of the housing price. Table D5 also specifies that of the forecast error variance of the housing starts comprises 39.1% of durable consumptions and 25.8% of housing price, which could explain the result of the impulse response of the housing sector. Conversely, Figure 8 shows that the shocks from housing price and output only has slightly positive and insignificant impact on consumptions. This is aligned with the result shown in Table D3 that the forecast error variance of durables consumption comes 0.59% of housing starts and 3.5% of housing price.



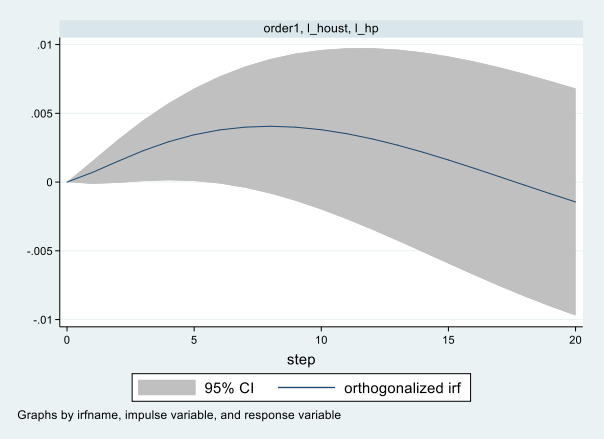
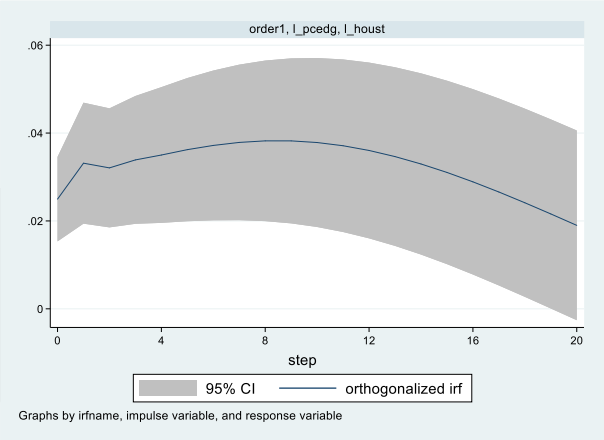


Figure 6: Impulse response of housing market



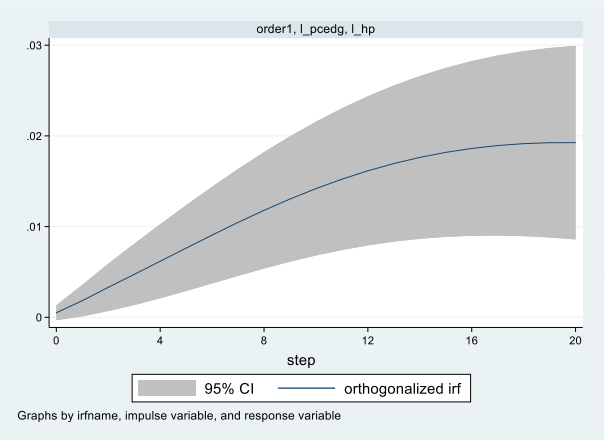
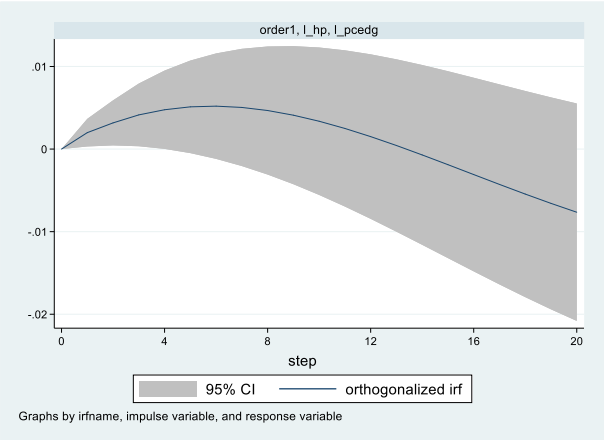


Figure 7: Impulse response of housing market to durables consumption shock



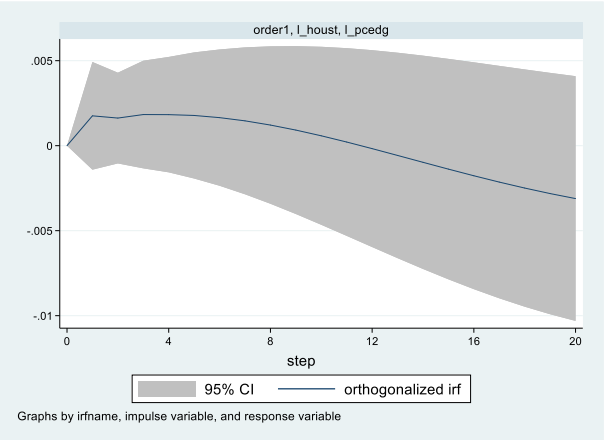


Figure 8: Impulse response of durables consumption to housing market shock

6 Conclusion

This paper used a SVAR model to investigate the contemporaneous relations between uncertainty, durables consumption, and housing market in the United States. The innovation of this paper lies in the inclusion of the variable "inverted yield curve risk" to study the fluctuations in consumer choice in durables and housing spending. For the contemporaneous relation, I found that the EPU has a positive relationship with durable goods consumption, as well as with the housing price. Compared to the inverted yield curve risk, EPU offers a better explanation of the movements of housing price, which is aligned with some previous research. (Antonakakis *et al.*, 2015; Benzoni *et al.*, 2018)

For the impulse response analysis, I found one standard shock of EPU leads to a decline in housing price and consumption on durable goods. It also causes inverted yield curve risks. Conversely, the shock of inverted yield curve does not have significant effects on other endogenous variables. It is suggested that the housing output has been positively affected by the shocks from housing price and durable goods consumption significantly. Furthermore, the shock of durables consumption also significantly increases the housing price. This can be explained by the fact that the durable goods consumption is the major part of forecast error variance of housing price and output.

For the extension of this work, constructing a theoretical model is necessary for the investigation of the supply and demand of housing market. As Wadud *et al.* (2012) showed in their work that impulse response to the shocks of either supply or demand could be analyzed separately. The theoretical model of intertemporal consumer choice, and the tradeoff between durable goods and housing spending could also be one of the further analysis, such as the study done by Lastrapes and Potts (2006).

In addition, Musso *et al.* (2011) suggested that the spillover effect of the monetary policy could not be ignored. Hence, the inclusion of impact from international capital flows would be relevant in domestic market fluctuation. Furthermore, the comparison of subgroups or across different regions could also show the potential structural change in the housing market, such as the framework proposed by Hofmann and Peersman (2017).

To sum up, this paper suggests that compared to the inverted yield curve, Economic Uncertainty Policy Index can better interpret the consumer choice of the durable goods and housing expenditure in the United States.

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Appendix is available upon request