Interest Rate Policy and House Prices: Evidence from Taiwan

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Abstract

In this paper, we examine the relationship between monetary policy and house prices in Taiwan. Using quarterly data from 1991 to 2021, we find that a loose monetary policy does significantly contribute to an increase in house prices. Moreover, in the short run, monetary policy shocks account for a small fraction of the forecast error fluctuations of house prices (at most 6.58% within 1 year), whereas in the long run, they explain nearly 47.18% (40 quarters) of the forecast error fluctuations. Finally, the soaring house prices since the fourth quarter of 2001 can be attributed to both credit shocks, sentiment shocks, and monetary policy shocks. Overall, the evidence suggests that the loose monetary policy is an important factor in the house price hike in Taiwan. A further investigation via a counterfactual analysis shows that the real output, real mortgage rate, and sentiment channels amplify the effects of monetary policy shocks on real house prices, while the construction cost channel helps dampen the impact of monetary policy shocks.

Keywords: House Price; Housing Market Boom; Monetary Policy; Interest Rate

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1 Introduction

It is generally considered that monetary policy influences movements in house prices. The relevant literature suggests that there are several channels through which interest rates may affect house prices. For example, through the user cost channel, a decrease in interest rates lowers housing costs, which results in an increase in housing demand and leads to a house price boom (see, e.g., Himmelberg et al., 2005; Kuttner, 2013). Moreover, most buyers need to obtain mortgage loans to purchase a house, and households typically face borrowing constraints. A loose monetary policy reduces borrowing constraints and eases credit market conditions, which are crucial factors in housing market booms (Agnello et al., 2018). In addition to the user cost channel, because the low interest rate causes search-for-yield behavior (Gambacorta, 2009), a risk-taking channel encourages investors to invest in riskier investments, such as real estate. Moreover, in a low interest rate environment, market participants may begin to expect that "house prices will never fall." This expectation exacerbates the overheating of the housing market, as it has been shown that market sentiment plays an important role in asset price dynamics. For example, Bekiros et al. (2020) provide a theoretical framework to demonstrate how a rise in optimistic expectations about future house prices trigger housing market booms. Kaplan et al. (2017) show that beliefs about future house prices are the key source of variation in home values. While house prices reflect the present value of the future cash flow or house rents, the expectations of the future housing market influence how those upcoming house rents may vary. Using questionnaire surveys of homebuyers, Case and Shiller (2003) and Case et al. (2012) find that expectations of a boost in future house prices play an important role in recent US house price booms. In addition, Lambertini et al. (2013) and Ben-David et al. (2021) show that expectations of rising house prices explain a sizable fraction of the fluctuations in house prices. Thus, consideration of housing sentiment may help us to identify the linkage between house prices and market expectations, and further clarify how monetary policy affects house prices. However, it is worth noting that these boost demand may not feed into house price changes because not all potential home buyers can find or afford the item they want. Hence, whether monetary policy has a significant impact on house prices is an empirical question.

In this paper, we use a structural vector autoregressive (VAR) model of the housing market and data from Taiwan to examine the relationship between monetary policy and house prices in Taiwan. There are a number of reasons why we focus on the housing market in Taiwan. First, as Taiwan has experienced rapid increases in house prices since 2001, the accumulated growth rate has reached 285% (2001:Q3–2021:Q3). High house prices, particularly in metropolitan areas such as Taipei, have become a serious public concern. The housing affordability index, which is measured by the ratio of the median house price to the median household income, has exceeded 15 for the city of Taipei since 2012, and reached 15.86 in the second quarter of 2021. A comparison with the three least affordable major markets (metropolitan areas) around the world—Hong Kong (20.7), Vancouver (13.0), and Sydney (11.8),[1] —indicates that Taiwan does face a serious housing affordability problem. As housing affordability issue is a critical issue, it is important to understand the causes of house price booms.

Second, monetary policy has been extremely loose since 2000 in Taiwan. Figure 1 shows short-run interest rates for Taiwan, South Korea, and the US. It is clear that during 2008–2016, both Taiwan and the US have kept interest rates near zero. However, Taiwan barely followed the rising interest rate cycle in the US during 2004M06–2007M07 and 2015M11–2019M07. Comparing Taiwan with South Korea, a similar economy in Asia, indicates that, on average, Taiwan's interest rate was 1.8% lower than Korea's from

[1]See the 2021 edition of Demographia International Housing Affordability, the Urban Reform Institute and the Frontier Centre for Public Policy.

2000. Therefore, the low interest rate environment in Taiwan provides a good opportunity to examine whether loose monetary policy has brought about the booms in the housing market.

Finally, Taiwan's central bank is reluctant to admit the role of monetary policy in encouraging housing booms in Taiwan. In a recent speech, Governor Chin-Long Yang (Yang, 2022) claimed that the dominant factors that cause house price surges in Taiwan are aggregate income growth, rising construction costs, and speculative demand due to expectations of housing market booms. To dispute the central bank's claim, we seek a framework that examines the impact of monetary policy on house prices after accounting for the above-mentioned factors.

Thus, we consider the following structural shocks in the structural VAR model: monetary policy, real output, user costs, credit, construction cost, and sentiment shocks. We construct a measure of housing market sentiment using text mining and incorporate the sentiment index into the structural VAR model to capture speculative demand due to expectations.

The novelty of the paper is as follows. First, although the strong link between monetary policy and house prices have already been established using data from a large set of countries globally, the empirical evidence from Taiwan is slim, which is the reason why Taiwan's central bank can continue to use empty rhetoric repeatedly to say that low interest rates should not be blamed for rising house prices.

Second, we include the determinants of soaring house price proposed by Taiwan's central bank in the structural VAR model, so that we can examine whether the housing market cycle in Taiwan is driven by monetary policy, and to what extent interest rate changes influence house prices after controlling other factors based on the suggestions of Taiwan's central bank. Disentangling these various shocks helps us to better measure the impact of monetary policy shocks on house prices.

Third, we focus on quantifying different channels of monetary policy on house prices using counterfactual analysis, which has not yet been investigated in previous studies using Taiwan's data. Finally, we use a text-mining technique to construct our own measure of housing market sentiment, which can be used to quantify the impact of expectations on housing market developments in Taiwan. It is found that housing market sentiment in Taiwan has significant impacts on real house prices, in terms of impulse responses analysis and shock accounting such as variance decomposition and historical decomposition. Moreover, evidence shows that sentiment channel helps amplify the effect of monetary policy shocks.

2 Related Literature

A weak link between monetary policy and house prices has been reported in the early literature. For example, using quarterly data from 14 OECD countries from 1970 to 2002, Dokko et al. (2011) show that traditional channels of monetary policy accounted for little of the housing market booms. They thus conclude that the main factor causing the housing boom of the 2000s was not monetary policy. After a thorough literature review on the relationship between monetary policy and house prices, Kuttner (2013) concludes that there is still no "smoking gun" evidence that the real estate booms in the US or elsewhere over the past decade can be attributed to monetary policy. Finally, Luciani (2015) uses US quarterly data from 1982 to 2010 to estimate a structural dynamic factor model, and shows that the Fed's expansionary monetary policy during 2002–2004 was not the main cause of the recent housing cycle.

Conversely, recent studies find compelling evidence of a link between monetary policy and house prices. For example, Agnello et al. (2020) emphasize how monetary policy can assist in mitigating the undesirable boom–bust house price fluctuations. Baur and Heaney (2017) examine the role of monetary policy for the housing market, using property and equity market data from Australia, and provide evidence that monetary policy has influences on both markets. In particular, they find that a lower interest rate leads to appreciation of house prices. More supportive evidence that loose monetary policy causes house price appreciation can be found in Sá et al. (2011), Bordo and Landon-Lane (2014), Head and Lloyd-Ellis (2016), Nocera and Roma (2018), Kishor and Marfatia (2018), and Robstad (2018). In a recent study by Chen and Lin (2022), they examine a compiled long series of quarterly house price data constructed by the Bank for International Settlements for 20 countries. They find that a lower interest rate unambiguously causes a significant rise in real house prices for 19 of the 20 countries (the exceptions being Japan). It is worth noting that in contrast with the early literature, most recent studies that find a strong link between monetary policy and house prices are based on a structural VAR framework, which has the advantage to disentangle a set of orthogonal shocks, in particular, to identify monetary policy shocks.

Concerning the effect of market sentiment on house prices, Towbin and Weber (2016) quantify the contribution of house price expectation shocks from 1973Q3 to 2014Q2, and find that house price expectation shocks are the most important driver of the US house price boom, followed by mortgage rate shocks, housing demand, and housing supply shocks. About 30% of the increase in house prices is explained by price expectation shocks and 25% by mortgage rate shocks in the historical decomposition. However, from the forecast error variance decomposition, price expectation shocks account for about 20% and mortgage rate shocks for 28% of the house price variation at the 10-year horizon. Cox and Ludvigson (2019) attempt to determine whether credit conditions or beliefs are the driving forces of US house price fluctuations. They use a structural VAR model to analyze the dynamic causal effects on house price changes and use four measures of beliefs about house value. These measures are mainly constructed by the answers to the survey of the Census Bureau's Survey of Construction, except for the housing media sentiment index, which is constructed through textual analysis of newspapers. They conclude that beliefs do bear some relation to contemporaneous house price growth after controlling for credit conditions. Finally, Soo (2018) uses news media to construct a sentiment index for house price expectation, and compares it with different survey-based indices. She finds that housing media sentiment has significant predictive power for the future house price, and suggests that sentiment should be taken seriously as a potential determinant of house prices, especially in research on policy concerns.

3 A Structural VAR Model

We consider the following structural VAR model:

$$A_0 y_t = \nu + A_1 y_{t-1} + \cdots + A_p y_{t-p} + e_t. \tag{1}$$

Vector y_t is:

$$y_t = [R_t \;\; rgdp_t \;\; rmr_t, \;\; loan_t \;\; ccost_t \;\; sent_t \;\; hp_t]',$$

where R_t is the short-run interest (interbank overnight rate), $rgdp_t$ is real GDP, rmr_t is the real mortgage rate, $loan_t$ is the housing loan ratio of the home purchase loans to GDP, $ccost$ is the construction cost, $sent_t$ is the housing market sentiment, and hp_t represents the real house price. The real house price is deflated by consumer price index (CPI), while the real mortgage rate is defined as the difference between the nominal mortgage rate and CPI inflation. In general, the real mortgage rate is deemed to represent a measure of housing user costs, but it is also the *price* of housing credits. By contrast, the housing loan is the *quantity* of housing credits. Broadly speaking, both real mortgage rates and housing loans represent the credit conditions.

All data except interest rates, sentiment, and the loan ratio are expressed as logarithms. Term e_t is a vector of structural shocks including e_t^R, e_t^{rgdp}, e_t^{rmr}, e_t^{credit}, e_t^{ccost}, e_t^{sent}, and e_t^{hp}, which represent respectively monetary policy socks, real output shocks, user cost shocks, credit shocks, construction cost shocks, sentiment shocks, and house price shocks which represent other shocks that are not accounted for in the model.

Let ε_t denote the vector of the residuals from the reduced-form VAR model, we implement the identification strategy by applying a Cholesky factorization to $\Sigma_\varepsilon = E(\varepsilon_t \varepsilon_t')$ with the Wold causal chain. In the first equation, the key assumption is that monetary policy does not respond instantaneously to all other variables in the structural VAR system. In particular, we assume that Taiwan's central bank does not respond to house price movements in setting monetary policy within the quarter. As argued in Chen et al. (2021), the *de facto* goal of interest rate policy in Taiwan is to accommodate external shocks and minimize the central bank's interest payments. Thus, monetary policy can be treated as exogenous in the current housing market VAR model.[2] Moreover, we assume that monetary policy shocks drive real output, and both monetary policy and real income affect the user cost proxied by the real mortgage rate. We also assume that the housing loans will increase because of loose monetary policy, higher income, and lower user costs.

Construction costs, which consist of the costs in the capital, material, and labor invested in construction projects, will move the housing supply.[3] We assume that a reduction in interest rates and user costs, a higher income and an increase in credit lower the construction cost.

As emotions are influenced by changing economic conditions, housing market senti-

[2]Nevertheless, we will consider a systematic monetary policy that considers house price movements. It will be shown in Section 9 that the empirical evidence confirms our assumption.

[3]Materials including cement, ores, bricks, metals, timber, paint, and electronics.

ment is assumed to be affected by shocks to monetary policy and other fundamental variables in the SVAR model. Finally, all types of shocks in the structural VAR system affect house prices. After accounting for shocks to monetary policy, aggregate income, user costs, housing credit conditions, and market sentiment, we treat the shock in the house price equation as a residual shock that is not accounted for in the model, and simply denote it a house price shock.

4 A Measure of Housing Market Sentiment

We construct a dictionary-based sentiment index from news content through textual analysis. Three major news media in Taiwan are included in our news sources: Liberty Times, United Daily News, and China Times. All news from the above three media sources that contain "house price" or "housing market" in Chinese are included.[4]

Following Soo (2018), we define the sentiment of each article by:

$$v_i = \frac{pos_i - neg_i}{w_i}, \tag{2}$$

where pos_i, neg_i, and w_i represents the total number of positive words, the total number of negative words, and the total number of words in article i, respectively. The sentiment index $sent_t$ for a given period of time t is constructed by averaging the sentiment value of all articles at time t.

To match and sort positive or negative words, we use the National Taiwan University Sentiment Dictionary (NTUSD),[5] a widely used traditional Chinese sentiment dictionary, which contains 2,812 positive words and 8,276 negative words in Chinese. We first utilize a Python package called Chinese Knowledge and Information Processing tagger (CKIP

[4]Only articles containing "house price" or "housing market" in Chinese are scraped.

[5]http://nlg.csie.ntu.edu.tw

tagger) to divide the Chinese sentences into words to adopt the dictionary matching process.[6] Then, we calculate the sentiment index based on the above rules.

5 Data

The sample period is chosen as 1991:Q1 to 2021:Q3, based on the data availability of house price data. The house price data are obtained from Sinyi Real Estate Planning and Research Center. Data for the interbank overnight interest rate, mortgage rate, home purchase loans are obtained from Taiwan's central bank. The construction cost index is from AREMOS Databank, constructed by the Taiwan Economic Data Center. Media news contents are scraped from three major newspapers in Taiwan: Liberty Times Net, United Daily News (UDN), and China Times Media Group.[7] GDP (nominal and real) and consumer price index data are obtained from the Directorate-General of Budget, Accounting, and Statistics. Table 1 provides details about the data, and Figure 2 shows the time series plots for the data used in the structural VAR model.

5.1 External Validity

To examine the validity of the sentiment index constructed by the textual analysis, we compare our sentiment index to the component of the Consumer Confidence Index (CCI) constructed by the Research Center for Taiwan Economic Development of National Central University. The CCI is an index composed of several questionnaires measuring consumers' expectations and sentiment about the general economic situation. The survey

[6] The CKIP tagger is provided by Academia Sinica, and their official website can be accessed at https://ckip.iis.sinica.edu.tw

[7] Some media companies own several subsidiary media companies. For example, UDN owns Economic Daily News, Min Sheng Daily, United Evening News, Star News, and Upaper. China Times Media Group owns China Times, Commercial Times, and China Times Express. The total number of news articles is 125,641.

covers six subindices: domestic business condition, employment opportunities, family economic conditions, investment in stocks, inflation expectations, and willingness to buy durable goods. We use the subindex of the CCI (subCCI) that quantifies the future price expectations, through questions such as "[d]o you agree that it is a good time to buy durable goods in the next six months?"[8]

Figure 3 shows the housing market sentiment index and the subCCI concerning the question about durable goods. The correlation coefficient of the two indices is 0.5411. Further, we conduct the Granger causality test to examine the relationship between the proposed housing market sentiment index and the subindex of the CCI. It is worth noting that both indices are stationary processes, as the null hypothesis of a unit root can be rejected at the 5% significance level for each series.[9] Hence, the conventional F statistic for the Granger causality test is valid.

Table 2 shows that the sentiment index Granger-causes the subindex of the CCI, whereas the subindex of the CCI fails to Granger-cause the sentiment index. The test results suggest that the proposed sentiment index constructed by text mining can predict future movements of the questionnaire-based index of consumer confidence on purchases of durable goods (such as homes). The evidence reveals the usefulness of the proposed sentiment index for providing timely information about housing market expectations.

6 Empirical Results

In this section, we report our main empirical results. We select the lag length $p = 1$ of the VAR model, which is based on both the Akaike and the Bayesian information criteria.

[8]After 2020Q3, one more survey question was added: "Do you agree that it is a good time to buy real estate in the next six months?" However, because of the short sample period available for empirical analysis, we only use the respondents' answers to the question about durable goods in the CCI to evaluate our sentiment index.

[9]The DF-GLS statistics for the subCCI and sentiment index are –2.70 and –2.77, respectively.

We first examine the impulse response functions to evaluate whether the structural VAR model can characterize the cyclical properties of the housing market in Taiwan. Our purpose is to check whether the house price responses are plausible reactions to the different types of shocks and, most importantly, whether monetary policy shocks have a significant impact on house prices. We also use the structural forecast error variance decomposition to see if the monetary policy shock accounts for a considerable portion of the variation in house prices. Finally, a historical decomposition is used to examine whether loosening monetary policy has caused house price booms after 2001.

6.1 Impulse Response Functions

First, we examine the effects of an expansionary monetary policy. The responses of each variable to a 1% drop in the short-run interest are presented in Figure 4, along with 95 and 90 percent bootstrap confidence intervals. A loose monetary policy would result in a statistically significant increase in real output, housing loans, and the real house price in the housing market, while it would reduce real mortgage rates (user costs) and construction costs significantly as expected. It is worth noting that the construction cost gradually rises due to booms in the housing market. The decline in the short-run interest rate causes a fall in housing market sentiment on impact because people may perceive the unexpected expansionary monetary policy as signaling weak economic conditions. Confidence is restored over time, and the responses are statistically significant. As to the magnitude of the impact on real house prices, a 1% interest rate cut will cause a 2.8% increase in the real house price after four quarters, peaking at 5.5% after 20 quarters.

Next, we investigate how different shocks affect the real house price. In Figure 5, all structural shocks are positive except for the monetary policy shock and the real mortgage rate (user cost) shock. That is, we consider an expansionary monetary policy, a real output boom, a reduction in user costs, a loose credit condition, a rising construction cost, and optimistic sentiment.

Clearly, most shocks have significant impacts on the real house price. As mentioned above, a decline in the short-run interest rate unambiguously causes house prices to rise. An increase in real output raises house prices, which provides evidence of the wealth effect. Moreover, improving credit conditions have a positive and statistically significant effect on house prices, while a lower real mortgage rate (a reduction in user costs) eventually causes a rise in the house price, although the responses are insignificant. Finally, the optimistic housing market expectations help encourage speculative activities and thus lead to house price hikes, and a greater construction cost causes house prices to go up.

Overall, the results of the impulse response functions for the various shocks are in line with economic intuition, which suggests that our structural VAR model specification and identification assumption are quite plausible. Most importantly, we provide compelling evidence that a lower interest rate helps fuel house price booms in Taiwan.

6.2 Variance Decomposition

According to the impulse response analysis, we find evidence that monetary policy has a significant impact on house prices. Here, we further examine the extent to which monetary policy shocks account for any variability in house prices. Table 3 reports the contribution (in percent) of different shocks to the forecast error variance of house prices over various horizons.

First, the sentiment shocks explain a fairly large proportion (about 15.84%) of the variations in the short run, and the proportion declines to 4.20% in the long run, which may suggests that sentiment has a large effect within one year but the impact is short-lived. The construction cost shock account for a steadily large proportion of the variation of house prices around 11–23% in all time horizons. For various horizons, real output shocks can explain only a small proportion of the variation of house prices (smaller than 8.33%). It is worth noting that at first glance credit shocks seem to play a minor role, which may be due to our linear framework that fails to detect credit's role as a nonlinear propagator of shocks (see e.g., Balke, 2000). However, adding up the explanation shares of credit shocks (from housing loans, the quantity of credits) and user cost shocks (from real mortgage rates, the price of credits) gives us explanatory power around 3.30–12.62%.

Finally, when turning to our main focus on monetary policy shocks, we can see that in the short run (e.g., over the two-quarter or six-month horizon), monetary policy shocks account for only 1.93% of the real house price fluctuations. However, over the long run the explanatory power rises to 35.64 (a 5-year horizon) and 47.18% (a 10-year horizon). The growing importance of monetary policy shocks reveals the fact that a loose monetary policy affects house prices more in the long run. The increasing explanatory power of monetary policy shocks over the long run may be related to their persistence and propagation overtime.

7 Monetary Policy and the House Price Hike in Taiwan Since 2001

From Figure 2, we can observe that during the recent housing market boom, which started in 2001:Q3, real house prices more than doubled (nearly tripled) over two decades. It is important to determine the role of monetary policy in promoting real house appreciation since 2001.

To quantify how much a particular structural shock is able to explain historically the observed fluctuations in real house prices, we conduct a historical decomposition exercise by following Burbidge and Harrison (1985). Using the projection from the VAR model without any stochastic shocks, we first construct a base projection of the real house price. Then, a dynamic simulation of the VAR model is carried out with only one realized historical shock turned on, and the others set to zero. Hence, by examining the extent to which the introduction of the shock to real house prices is able to close the gap between the base projection and the actual series, we can assess the importance of the particular shock.[10]

Figure 6 shows the actual real house price series, the base projection, and the time series made of the cumulative contribution of one particular structural shock to real house prices. We find that shocks to real output play some roles in explaining the Taiwan's housing market booms during 2013–2016. Credit shocks can explain parts of the real house price increases during 2011–2013, while construction cost shocks dominate the movements of real house prices during 2010–2016. House price shocks dominate the rise of real house prices during 2011 to 2016, whereas sentiment shocks also play some roles for the historical movements of real house prices between 2004 and 2008. In particular, the real house price would have been higher after 2018 in the absence of shocks other than sentiment shocks. Monetary policy shocks are the most important driver of the real house price during 2001–2012, and it is worth noting that the level of the real house price would have been higher between 2001 and 2010 when monetary policy shocks are the only source of fluctuations in real house prices.

[10]Kilian and Lütkepohl (2017) emphasize that historical decompositions are designed for stationary VAR. The roots of characteristic polynomial show that our VAR satisfies the stability condition.

8 How Important are the Different Channels for the Monetary Policy Transmission Mechanism?

We have shown that monetary policy has a nonnegligible influence on real house prices. The next question is how important are the different channels through which low interest rates cause the housing market to boom? To respond to this question, we conduct a policy counterfactual analysis, following the approach proposed by Kilian and Lewis (2011), who investigate how the monetary policy channel amplifies the effects of oil price shocks on real output.

We rewrite the structural VAR model in equation (1) as:

$$y_t = \nu + (I - A_o)y_t + A_1 y_{t-1} + \cdots + A_p y_{t-p} + e_t, \tag{3}$$

and define a $k \times k(p+1)$ matrix

$$B \equiv [C, A_1, \ldots, A_p],$$

where $C = I - A_0$.

Using the real output channel as an example, to quantify this channel, we consider a counterfactual in which real GDP reacts to fluctuations in all variables in the structural VAR model except monetary policy shocks. To shut down the direct response of real GDP to monetary policy shocks, we construct a sequence of hypothetical shocks to real GDP that offset the contemporaneous and lagged effects of the overnight rate on real GDP:

$$e_h^{rgdp} = -B_{2,1}x_{1,h} - \sum_{m=1}^{\min(p,h)} B_{2,mk+1}z_{1,h-m}, \quad h = 0, 1, 2, \ldots \tag{4}$$

At $h = 0$, $e_0^{rgdp} = -B_{2,1}x_{1,0}$, where $x_{i,0}$ for $i = 1, 2, \ldots, k$ denotes the contemporaneous response of variable i to the monetary policy shock in the absence of hypothetical real output shocks, and $B_{i,j}$ refers to the (i, j) element of the matrix B.

The counterfactual impulse response of variable i to the monetary policy shock at the impact date ($h = 0$) is:

$$z_{i,0} = x_{i,0} + \frac{\theta_{i,2,0} e_0^{rgdp}}{\sigma_2}, \tag{5}$$

where σ_2 is the standard deviation of the exogenous real output shocks, and $\theta_{i,j,h}$ refers to the (i, j) element of the $k \times k$ impulse response coefficient matrix at horizon h, denoted by Θ_h, as defined by Lütkepohl (2005, p.46).

For $h > 0$, the corresponding values of $x_{i,h}$ and $z_{i,h}$ can be generated recursively as:

$$x_{i,h} = \sum_{m=1}^{\min(p,h)} \sum_{j=1}^{k} B_{i,mk+j} z_{j,h-m} + \sum_{j<i} B_{i,j} x_{j,h}, \tag{6}$$

and

$$z_{i,h} = x_{i,h} + \frac{\theta_{i,2,0} e_h^{rgdp}}{\sigma_2}, \tag{7}$$

where $j = 1, 2, \ldots, k$.

Following the approach in Kilian and Lewis (2011), we only shut down the response of real GDP to monetary policy shocks, and allow real GDP to respond to the other endogenous variables in the structural VAR model, i.e., the response of real GDP need not be zero. Hence, we can use the difference between the unrestricted (actual) and counterfactual impulse responses to quantify the effects of monetary policy shocks on house prices through real output (i.e., the wealth effect). A large gap between these two responses suggests that the real output channel plays an important role in the transmission of monetary policy. By contrast, if the actual and counterfactual responses are close to each other, we would conclude that real output does not act as a channel for monetary policy. We can quantify alternative channels, including the real mortgage rates, credit conditions, construction costs, market sentiment, and house price channels, using an analogous procedure.

Using the case of an expansionary monetary policy shock, Figure 7 illustrates the counterfactual results for the different channels. The solid line represents the unrestricted response of real house prices to a loose monetary policy shock, whereas the dashed line represents the counterfactual responses. The difference between the two lines indicates the effects of the channels. According to Figure 7, other than the house price channel *per se*, real output, real mortgage rates, construction costs, and housing market sentiment are important channel variables. An increase in real output caused by the drop in interest rates can enhance the impacts of monetary policy shocks on house prices, which suggests the importance of the wealth effect. Moreover, a loose monetary policy shock lowers the construction cost and thus increases housing supply, which assists in offsetting the effect of monetary policy, and keeps the real house price down. The sentiment channel also plays some role in the transmission of monetary policy shocks to house prices.

Finally, in the absence of the credit channel, the responses of house prices are close to what they were. This seems to imply that the credit conditions in the housing market are not that important in the transmission of monetary policy shocks. One possible explanation is that the low-interest rate policy of Taiwan's central bank may encourage the home buyers to take out a housing loan, which may have contributed to the increase in housing demand. However, such a growing demand may not reflect in the equilibrium prices because not all potential home buyers can find or afford the item they want, and hence there is no substantial increase in mortgages to amplify the effects of monetary policy shocks. Moreover, as mentioned above, this could also be evidence of the possible non-linearity in the credit channel. However, it is worth noting that the credit channel in our model is the quantity channel of credits, while the real mortgage rate (user cost) channel is the price channel of credits. Although we find a minor role of the quantity channel of credits, the price channel of credits that amplifies monetary policy shocks has been shown to be of importance.

9 Does Monetary Policy React to House Prices?

According to Chen and Lin (2022), they show evidence that in 15 of the 20 countries,[11] central banks are keen to raise their interest rate in response to house price appreciation shocks. Here we further ask if Taiwan's central bank has taken house prices into account in its monetary policy response function. We follow Chen and Lin (2022) to consider a Taylor-rule-type SVAR model:

$$y_t = \nu + D_o y_t + D_1 y_{t-1} + \cdots + D_p y_{t-p} + e_t$$

where

$$y_t = [gap_t, \pi_t, hp_t, R_t]'$$

is a vector containing output gap, consumer price inflation ($\pi_t = 100 \times \log(CPI_t/CPI_{t-4})$), real house prices, and short-run interest rates. Identification of the SVAR model is based on a recursive ordering such that (see e.g., Chen and Lin, 2022; Kilian and Lütkepohl, 2017):

$$D_0 = \begin{bmatrix} 0 & 0 & 0 & 0 \\ d_{21} & 0 & 0 & 0 \\ d_{31} & d_{32} & 0 & 0 \\ d_{41} & d_{42} & d_{43} & 0 \end{bmatrix}$$

That is, let $\theta = (0 \ \ 0 \ \ 0 \ \ 1)'$ be a selecting vector, the equation

$$R_t = \nu_4 + d_{41} gap_t + d_{42} \pi_t + d_{43} hp_t + \theta' D_1 y_{t-1} + \cdots + \theta' D_p y_{t-p} + e_{4t}$$

represents the central bank's policy reaction function. The central bank is assumed to respond endogenously to output gap, inflation and house prices, i.e., a Taylor rule augmented with house prices. The output gap is calculated as the difference between real GDP and its HP filter trend by following Chen and Wu (2010).[12]

[11]The exceptions are Belgium, Denmark, Ireland, Korea, and the Netherlands.

[12]The results are quantitatively similar when the potential GDP is estimated by a quadratic trend.

Figure 8 presents the responses of short-run interest rates to various shocks. It is clear that an increase in output gap and consumer prices would contemporaneously prompt the central bank to raise interest rates, which is consistent with the sign expected by the Taylor rule. However, the response to real output shocks is statistically significant, but the response to inflation shocks is insignificant, which may suggest that Taiwan's central bank seems to focus more on economic fluctuations than inflation.

As for the response of real house price, it is evident that Taiwan's central bank does not significantly respond to house prices, which is consistent with its longstanding stance that rising house prices are not necessary associated with low interest rates, and that monetary policy is considered a blunt tool for containing house price booms.

10 Robustness

In this section, we provide a battery of robustness checks to validate our results from the baseline model. First, we consider alternative structural VAR specifications. The lag lengths in our benchmark VAR is set to $p = 1$ according to the Bayesian and Akaike information criteria. Because we are dealing with quarterly data, $p = 4$ is another natural lag length to use. Empirical results using different lag lengths are shown in Figure 9 and Table 4.

Further, we examine two alternative measures of the housing market cycle. In the baseline model, the real house price is constructed by the ratio of the nominal house price to the the consumer price index, which aims to measure the house price in terms of the whole final consumption basket. However, to further focus on housing affordability, we replace the real house price by the logarithm of the ratio of the nominal house price to the nominal disposable GDP per capita. The results are reported in Figure 10 and Table 5. In addition, we check whether the empirical results remain valid if we focus on the nominal house price instead of the real house price. Finally, we also consider the house price in Taipei city, as Taipei is one of the world's most expensive cities. The results are reported in Figure 12 and Table 7.

According to Figures 9 to 12, the evidence that an expansionary monetary policy causes a housing market boom continues to hold. Moreover, Tables 5 to 7 show that monetary policy is able to explain 26.52% to 44.88% of the variation of the house prices (in terms of the price to income ratio, the nominal house prices, and Taipei real house prices, respectively). In sum, our baseline results are robust to different data measurements and model specifications.

11 Conclusion

In this paper, we examine the relationship between monetary policy and real house price movements in Taiwan. In particular, we consider a structural VAR model of the housing market that incorporates monetary policy, real output, real mortgage rates, housing loans, construction costs, and housing market sentiment, with the sentiment index constructed through a textual analysis.

Using quarterly data from 1991 to 2021, the impulse response analysis shows that an expansionary monetary policy causes the real house price to increase. Lowering the interest rate by 1% leads to a 2.8% increase of the real house price after four quarters, and a 5.5% increase in the long run. Moreover, the results from the variance decomposition suggest that although the explanatory power is slightly smaller in the short run, monetary policy shocks are able to explain 43.30% of the house price fluctuations in the long run.

We further investigate the causes of the house price hikes in Taiwan since 2001 using historical decomposition. The evidence indicates that both monetary policy shocks, credit shocks and sentiment shocks are the main drivers of the house price movements. In particular, the level of the real house price would have been higher between 2001 and 2010 under only monetary policy shocks and in the absence of other shocks.

We have also examined different channels for the monetary policy transmission mechanism, and found that the real output channel (wealth effect), real mortgage rate channel, and sentiment channels are essential in the transmission of monetary policy shocks. Finally, it is found that Taiwan's central bank may not use interest rate policy to lean against house price appreciation, which is consistent with its longstanding stance that rising house prices are not necessary associated with low interest rates, and that monetary policy is considered a blunt tool for containing house price booms.

Overall, although Taiwan's central bank is reluctant to admit the role of monetary policy in encouraging housing booms in Taiwan, the evidence shows that loose monetary policy has unambiguously contributed to the house price hikes, and the role of monetary policy cannot be disregarded.

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Table 1: Data Description

Data	Resource
Overnight Rate (%)	Taiwan's Central Bank
Mortgage Rate (%)	Taiwan's Central Bank
Home purchase loan	Taiwan's Central Bank
Sentiment Index	Constructed by the authors using the following medias
	UDN (1991m01-2021m09)
	China Times (1994m01-2021m09)
	LTN (2005m01-2021m09)
Construction Cost Index	AREMOS
House Price Index	Sinyi Real Estate Planning and Research Center
GDP (Nominal and Real)	Directorate-General of Budget, Accounting and Statistics
Consumer Price Index	Directorate-General of Budget, Accounting and Statistics

Table 2: Granger Causality Test

	F-Statistic	p-value
CCI does not Granger Cause SENT	0.6189	0.6503
SENT does not Granger Cause CCI	5.5777	0.0005

Note: SENT is the proposed housing market sentiment index constructed by text-mining, and CCI is the sub-index of consumer confidence on purchasing durable goods such as homes. The lag length is chosen to be 4 according to the Akaike information criterion.

Table 3: Variance Decomposition of Real House Prices

horizon	Monetary Policy Shock	Real Output Shock	User Cost Shock	Credit Shock	Construction Cost Shock	Sentiment Shock	House Price Shock
$h = 1$	0.50	2.54	1.84	1.46	22.99	15.84	54.84
2	1.93	1.22	1.34	4.01	19.31	18.66	53.52
4	6.58	1.98	0.67	9.01	13.98	18.12	49.65
8	17.11	4.41	0.99	11.63	11.53	12.49	41.84
12	25.28	3.76	1.93	9.41	15.01	9.42	35.18
20	35.64	2.78	2.73	5.85	21.54	6.64	24.83
32	44.49	5.70	2.42	4.10	21.25	4.65	17.39
40	47.18	8.33	2.14	3.60	19.37	4.20	15.18

Table 4: Robustness Check 1: Four Lags in VAR

horizon	Monetary Policy Shock	Real Output Shock	User Cost Shock	Credit Shock	Construction Cost Shock	Sentiment Shock	House Price Shock
$h = 1$	0.00	3.23	3.65	0.94	19.47	17.11	55.61
2	0.21	2.62	6.00	5.74	19.05	19.07	47.30
4	9.81	2.15	8.03	16.81	11.71	14.64	36.85
8	22.69	3.89	5.04	20.29	6.58	10.65	30.86
12	31.12	2.72	4.23	15.91	11.65	8.21	26.15
20	43.65	2.26	2.98	9.17	21.53	4.79	15.61
32	47.38	5.58	2.65	6.41	23.75	3.31	10.93
40	47.15	8.16	2.46	6.16	22.41	3.06	10.61

Table 5: Robustness Check 2: House Prices to Income Ratio

horizon	Monetary Policy Shock	Real Output Shock	User Cost Shock	Credit Shock	Construction Cost Shock	Sentiment Shock	House Price Shock
$h = 1$	0.28	11.22	0.00	25.03	14.07	5.70	43.71
2	0.14	11.52	0.24	24.17	15.69	6.65	41.59
4	0.48	11.59	1.15	21.84	19.31	7.82	37.82
8	3.11	9.97	3.24	16.39	27.39	8.50	31.40
12	7.06	7.68	4.67	12.05	34.26	8.25	26.02
20	15.39	5.37	5.42	8.17	39.77	6.89	18.97
32	24.20	6.52	4.82	6.96	37.38	5.42	14.69
40	27.18	7.99	4.46	6.61	35.01	5.14	13.61

Table 6: Robustness Check 3: Nominal House Prices

horizon	Monetary Policy Shock	Real Output Shock	User Cost Shock	Credit Shock	Construction Cost Shock	Sentiment Shock	House Price Shock
$h = 1$	0.00	2.64	0.27	1.33	25.00	14.04	56.71
2	0.59	1.22	0.21	3.03	23.15	20.42	51.38
4	3.96	1.69	0.42	6.79	19.05	23.73	44.35
8	13.43	4.35	1.81	9.28	17.06	18.56	35.51
12	21.08	3.74	3.18	7.47	21.11	14.45	28.96
20	31.03	2.69	3.96	4.43	27.86	10.35	19.68
32	41.16	5.96	3.33	2.94	26.17	7.12	13.32
40	44.88	8.86	2.88	2.51	23.31	6.19	11.37

Table 7: Robustness Check 4: Real House Prices: Taipei City

horizon	Monetary Policy Shock	Real Output Shock	User Cost Shock	Credit Shock	Construction Cost Shock	Sentiment Shock	House Price Shock
$h = 1$	0.50	8.23	1.22	1.06	14.90	6.75	67.33
2	1.23	5.34	0.80	3.07	13.01	9.65	66.91
4	3.70	2.74	0.45	7.54	10.28	11.43	63.86
8	9.86	2.93	1.82	11.13	10.39	9.59	54.27
12	14.58	2.70	4.22	9.52	16.32	8.33	44.34
20	20.13	2.40	6.30	6.44	27.03	7.33	30.37
32	25.23	6.57	5.55	5.51	27.07	5.88	24.18
40	26.52	9.64	5.14	5.15	24.94	5.62	22.99

Figure 1: Short-run Interest Rates

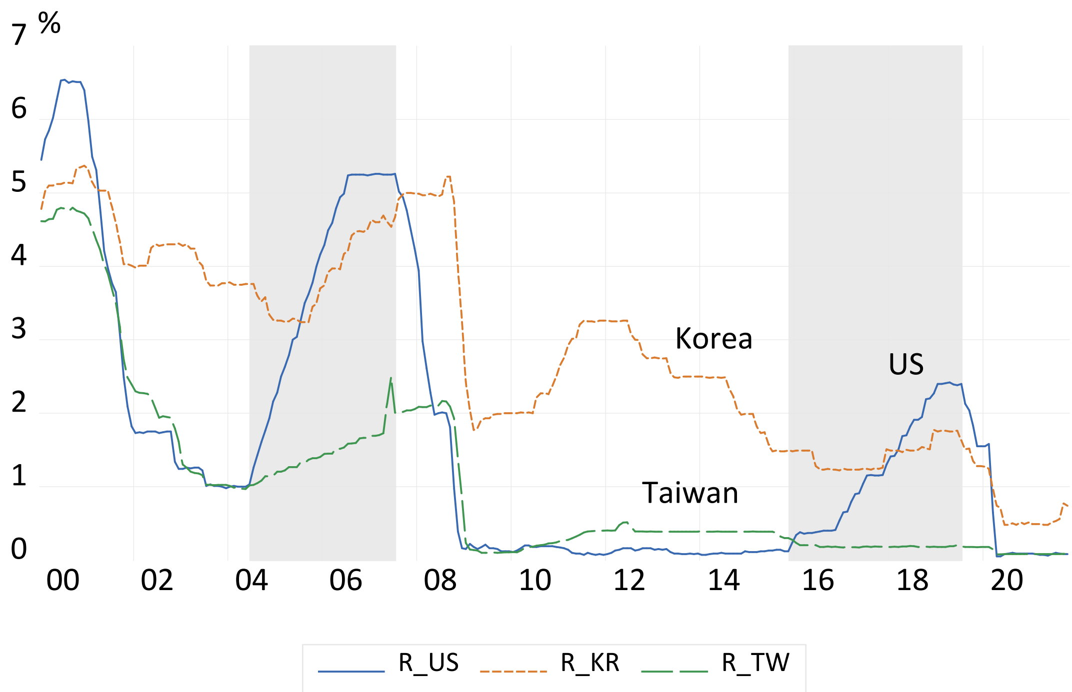


Figure 2: Data Plots

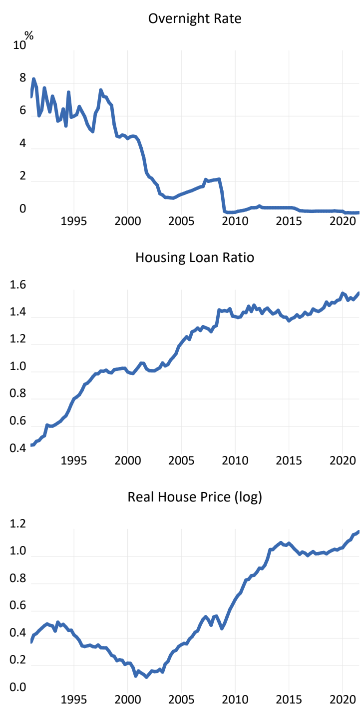


Figure 3: Sentiment Index and Sub-Index of Consumer Confidence

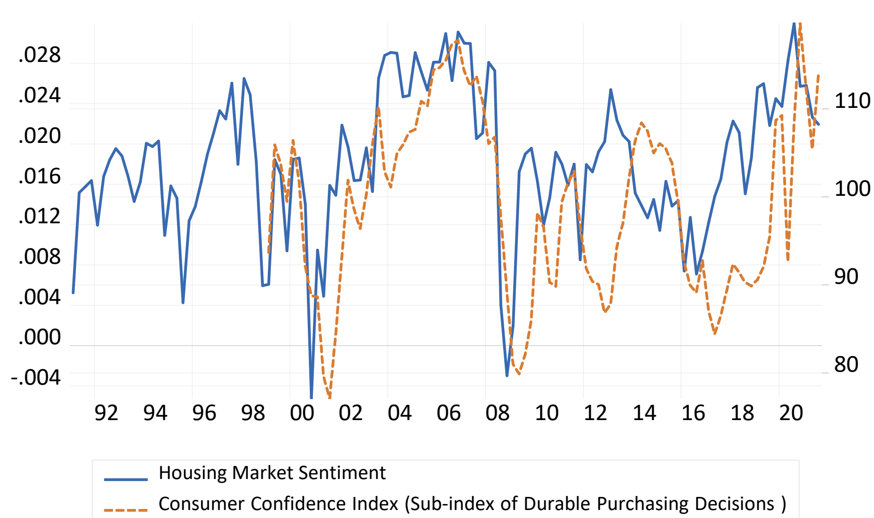


Figure 4: The Responses of Endogenous Variables to Monetary Policy Shocks with 95 and 90 Percent CIs

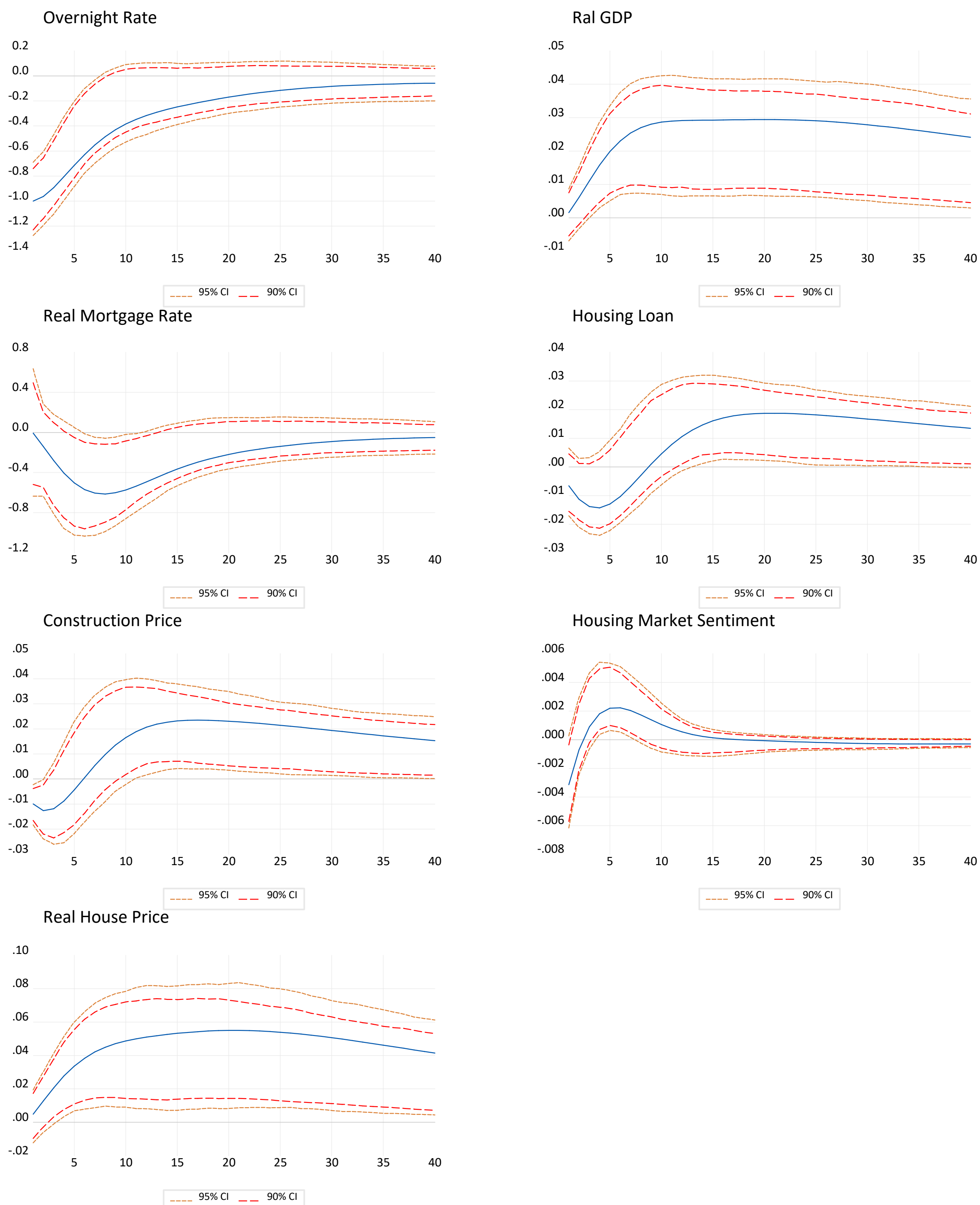


Figure 5: The Responses of Real House Prices to Various Shocks with 95 and 90 Percent CIs

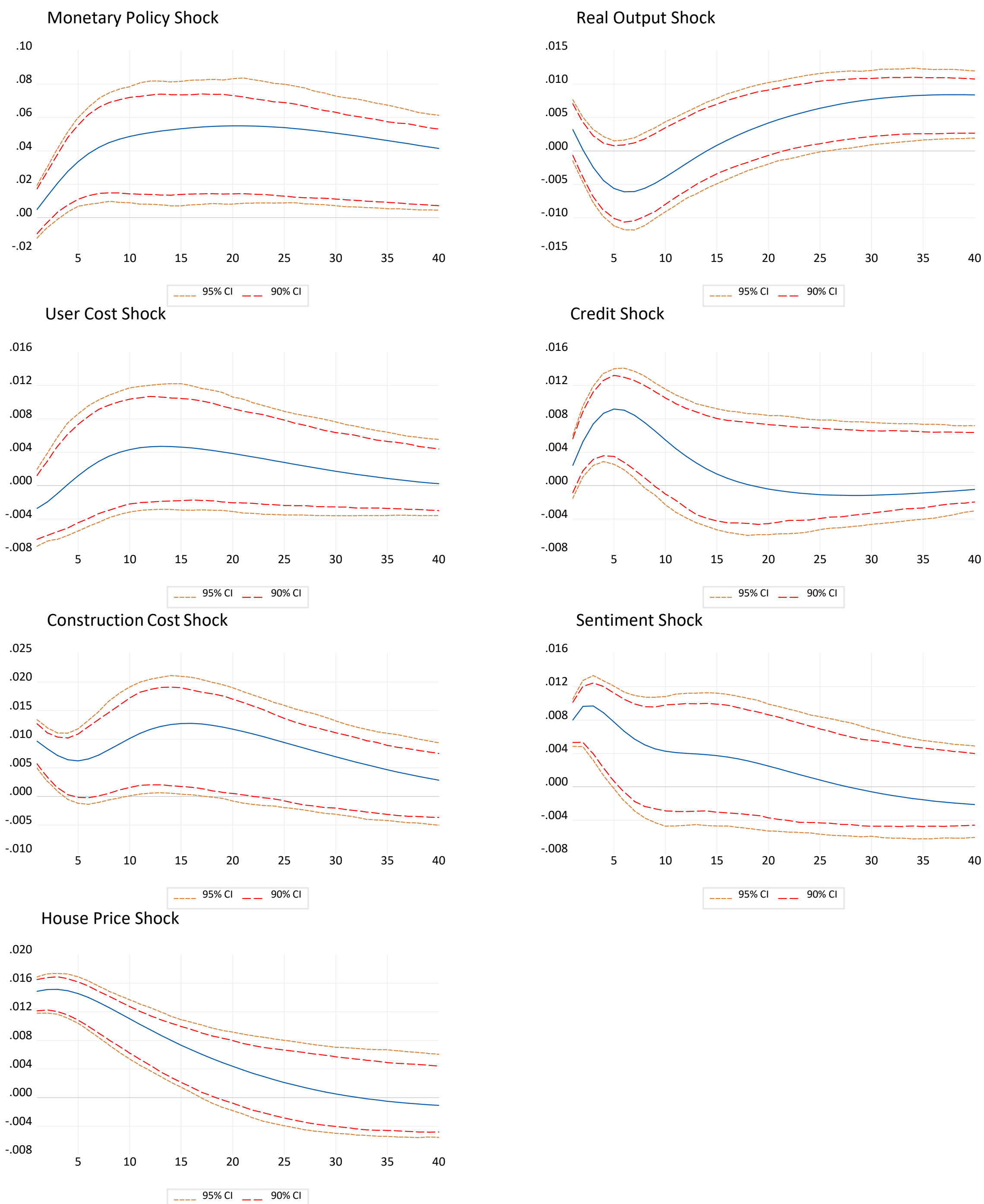


Figure 6: Historical Decompositions

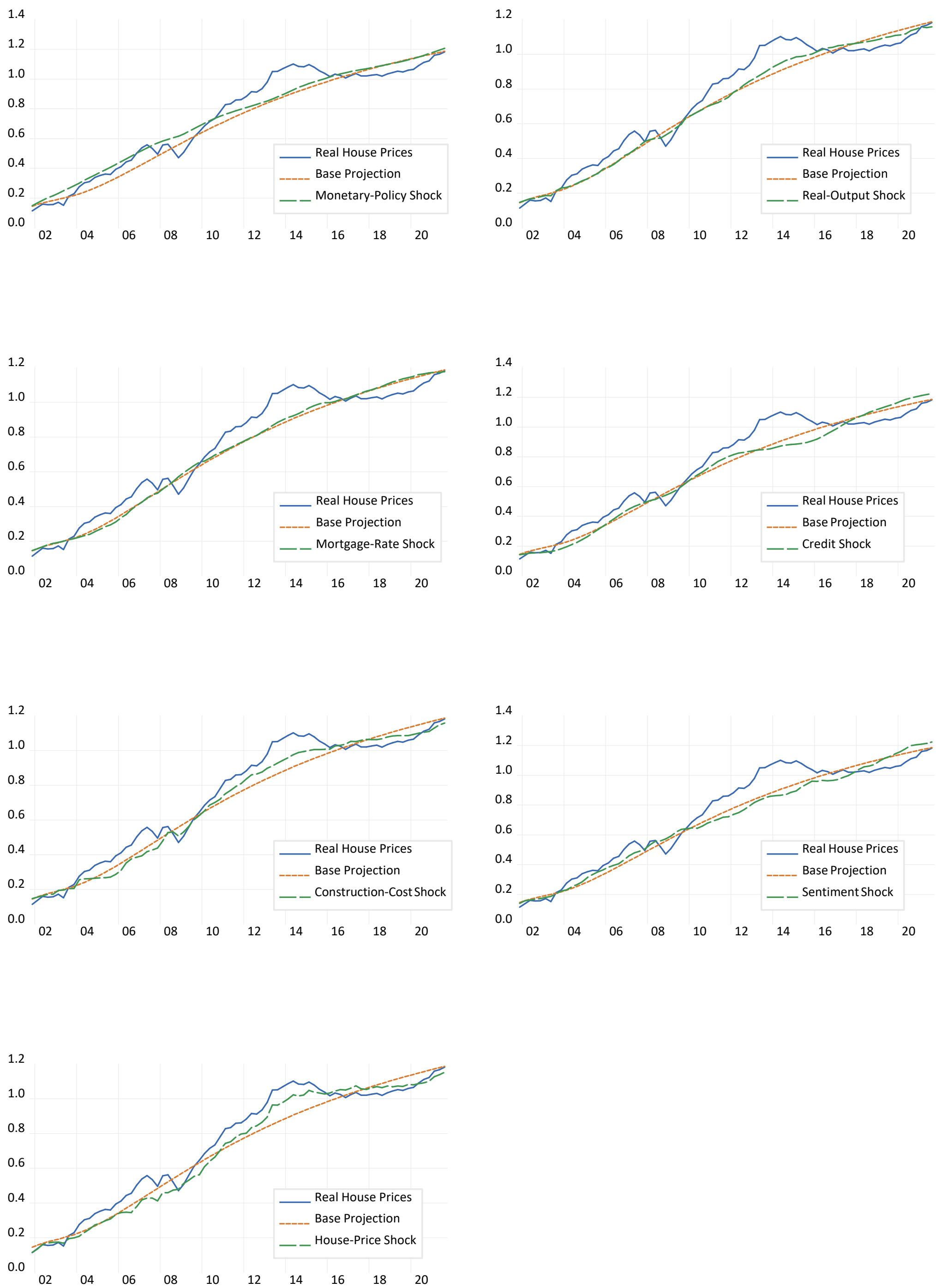
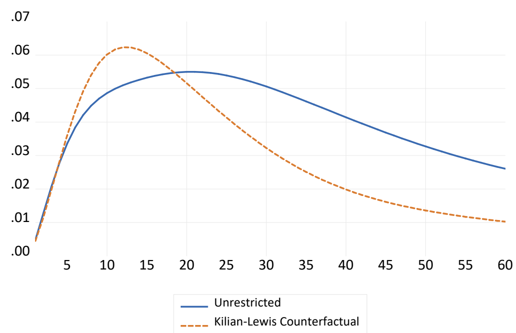
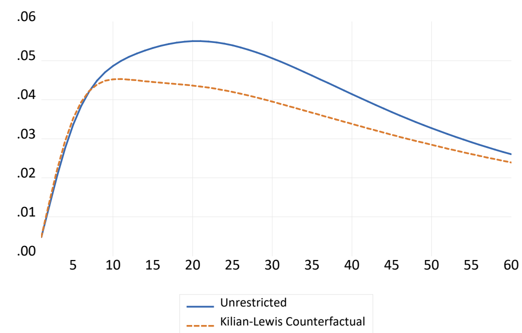


Figure 7: Unrestricted and Counterfactual Responses (Kilian and Lewis (2011)'s Counterfactual)

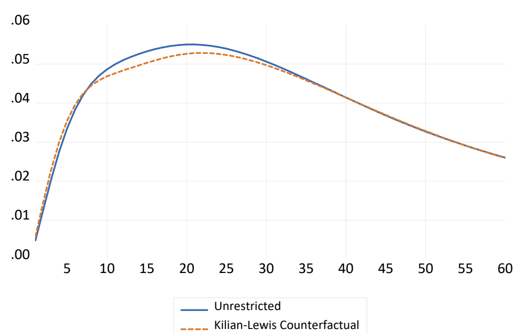
(a) Real Output Channel



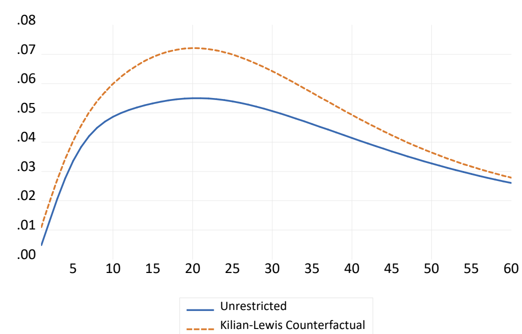
(b) Real Mortgage Rate Channel



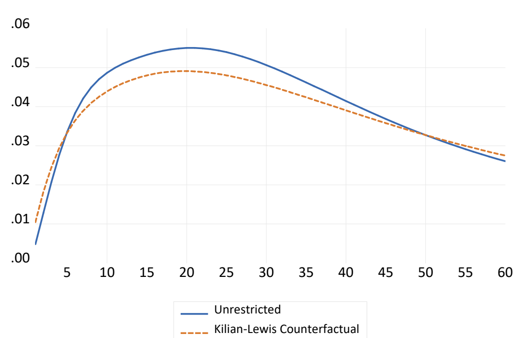
(c) Credit Channel



(d) Construction Cost Channel



(e) Sentiment Channel



(f) House Price Channel

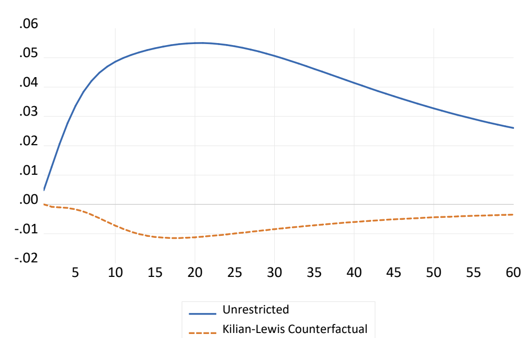


Figure 8: The Responses of Short-run Interest Rates to Various Shocks with 95 and 90 Percent CIs

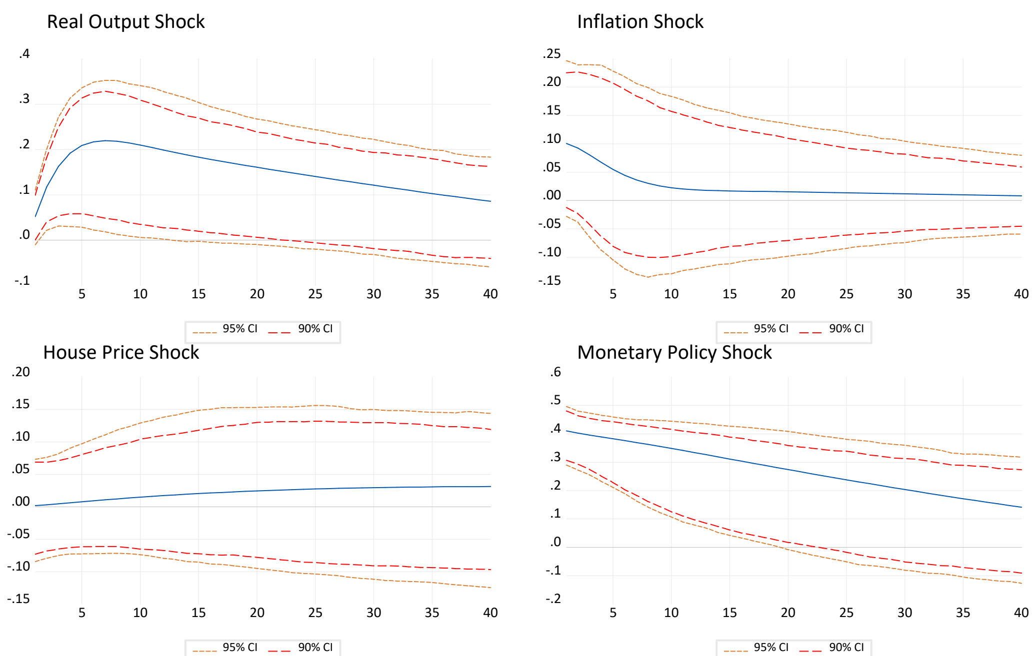


Figure 9: Robustness Check 1: The Responses of Real House Prices with 95 and 90 Percent CIs (Four lags in VAR)

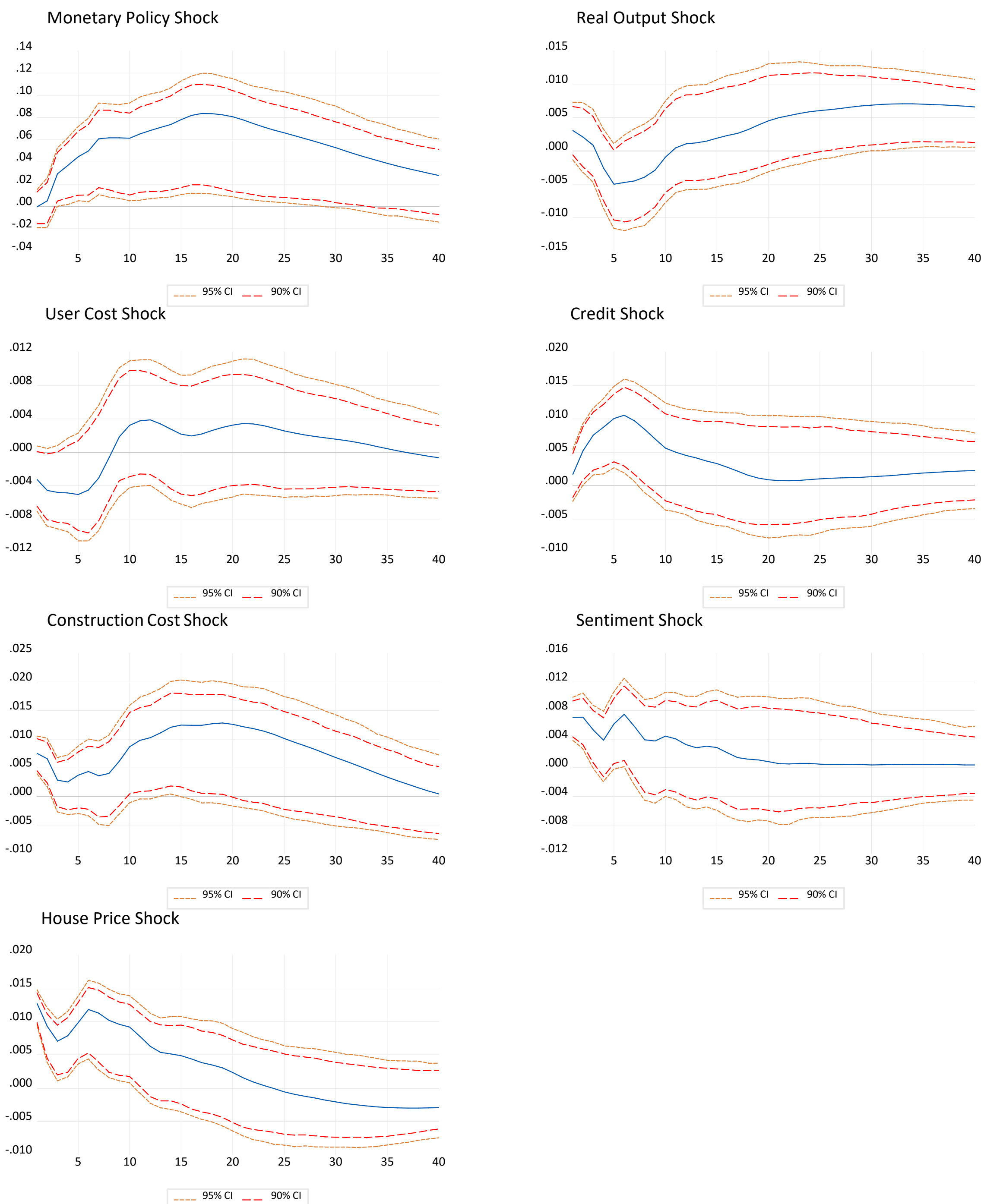


Figure 10: Robustness Check 2: The Responses of House Prices to Income Ratio with 95 and 90 Percent CIs

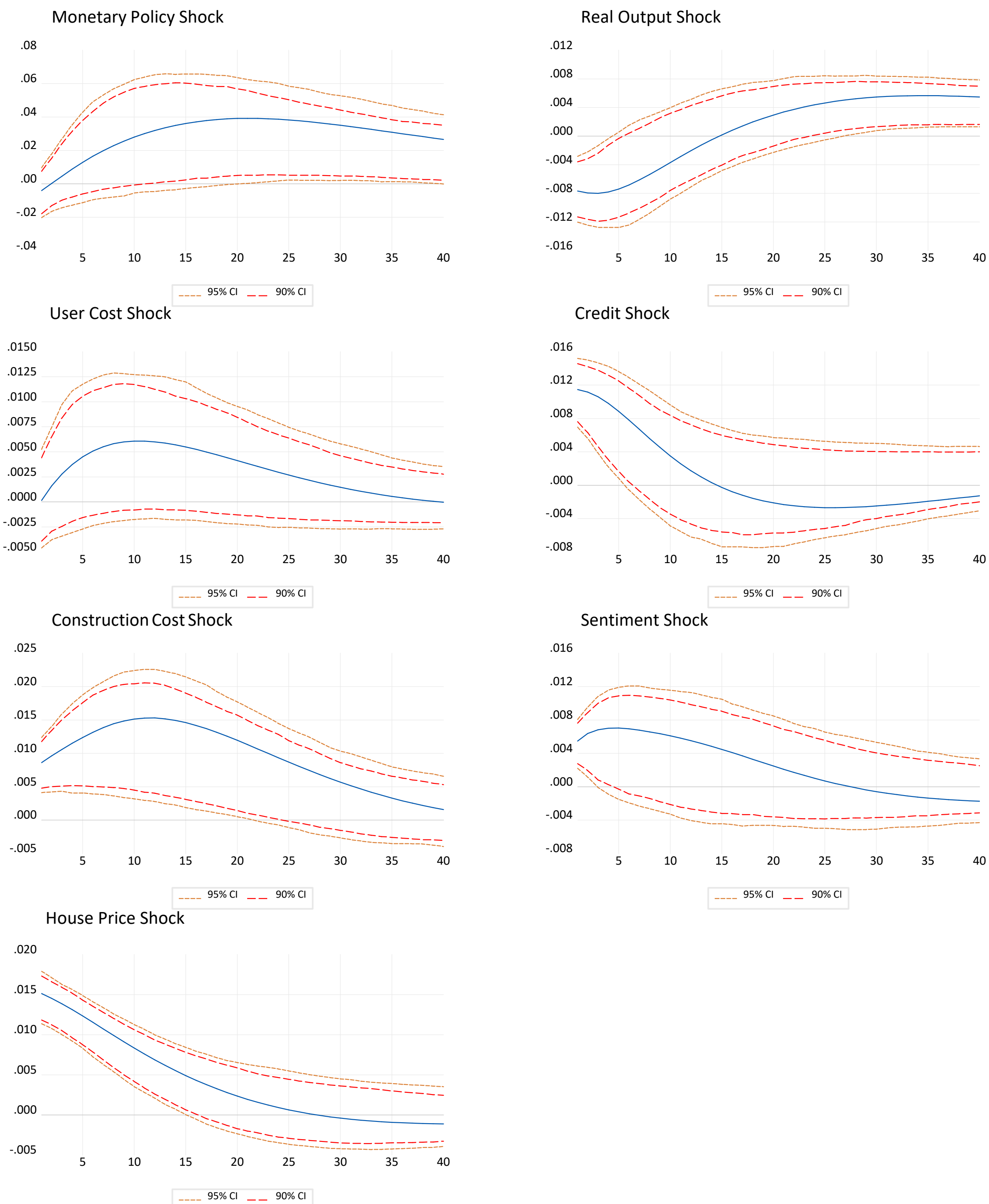


Figure 11: Robustness Check 3: The Responses of Nominal House Prices with 95 and 90 Percent CIs

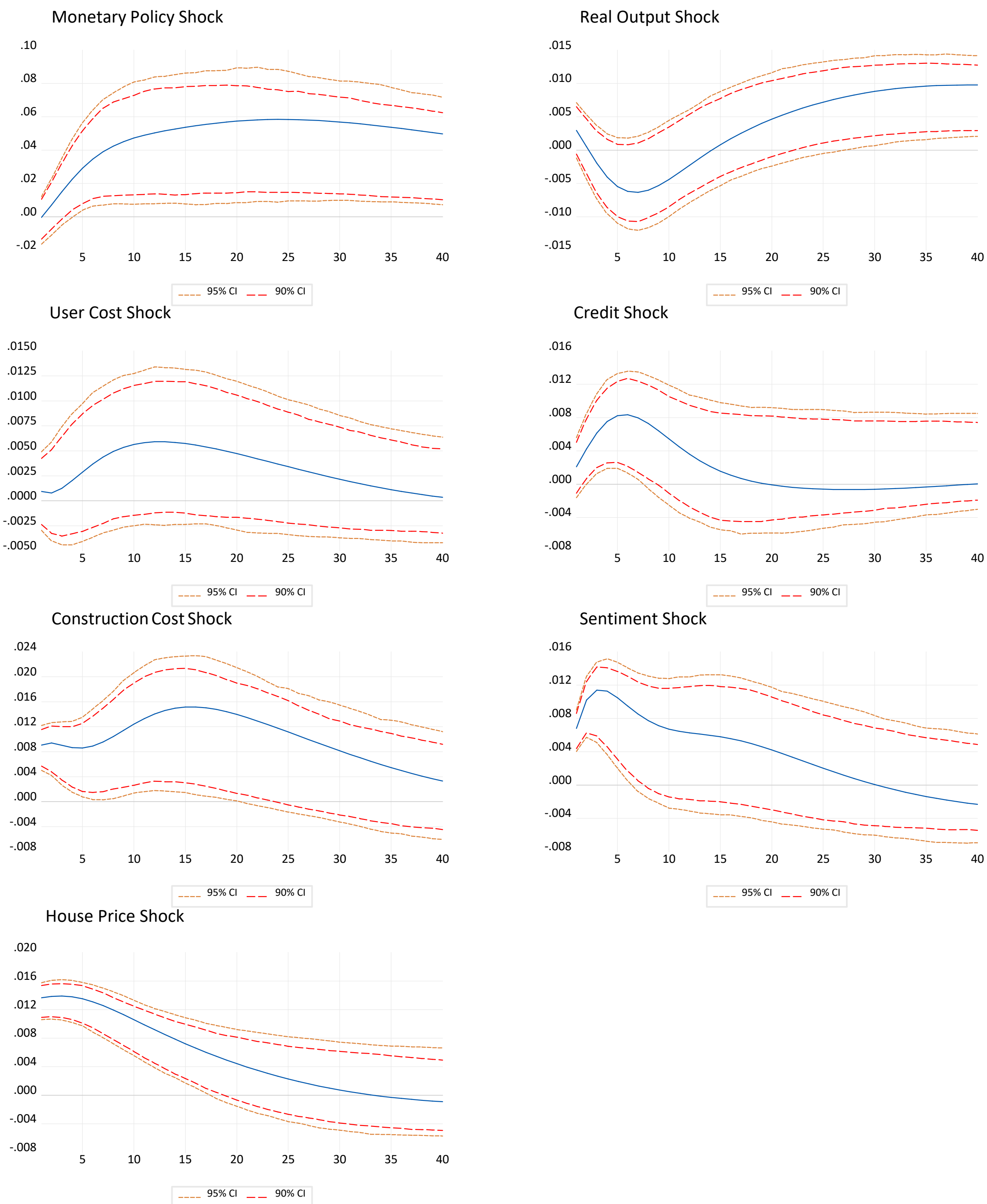


Figure 12: Robustness Check 4: The Responses of Real House Prices with 95 and 90 Percent CIs (Taipei City)