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Interactions between Asset Prices and Monetary Policy in Taiwan: A Structural VAR Model

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Authors' contributions

Authors CCL and WHW designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors CML and WHW managed the analyses of the study. Author SMY managed the literature searches. All authors read and approved the final manuscript.

Research Article

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ABSTRACT

Aims: This paper analyzes the role of house prices in monetary policy transmission mechanisms in Taiwan using structural VAR (SVAR). The discussion of the role of asset prices in the monetary policy transmission mechanism can help us determine the effectiveness of monetary policy.
Results: The contemporaneous effect of contractionary monetary policy on house prices exhibits a significant and positive relationship, and the response gradually approaches zero. The contemporaneous effect of contractionary monetary policy on stock prices is negative and statistically insignificant. The empirical results of this study may not support the transmission role of house and stock prices due to the low interest rate and the possibility of non-banking system channels of investment and consumption capital sources. Shocks to house and stock prices have no simultaneous impact on monetary

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policy; the impact gradually appears in the third or fourth quarter after such shocks.
Conclusion: The result suggests that the asset market plays a prominent role in the Taiwan monetary policy setting, though the immediate response is small.

Keywords: Asset; monetary policy; house prices; stock prices; structural VAR.

1. INTRODUCTION

Responding to global financial liberalization trends, Taiwan's government released the financial system from some forms of government supervision in the 1980s. For example, the government relaxed the restrictions on setting up new branches for domestic banking units in 1984, and interest rate regulations were repealed in 1985. Furthermore, the Banking Act has been revised substantially. Other specific changes include opening up Taiwan to foreign banks, establishing financial holding cooperation to expand business servers and increase competition, and the privatization of public banks, among others. There are two kinds of classification in Taiwan's financial system. One type is categorized according to the Banking Act managed by the Financial Supervisory Commission. This type includes commercial banks, specialized banks, and trust investment companies. The other type is categorized according to their finance-related activities and includes post offices, credit cooperatives, off-shore banking units (OBUs), and insurance companies.

In Taiwan, real estate prices and housing loans do exert mutual influences, indicating that factors resulting from the banking system are closely related to housing prices. Since a period of instability in 2008 caused by the U.S. subprime mortgage financial crisis, Taiwan's financial system has been relatively stable, with no liquidity or capital shortages. Because mortgage rates can respond quickly to the easing of monetary policy by the central bank, once interest rates fall, the burden of capital costs for households and manufacturers becomes lower. Currently, money market and bank loan interest rates are low. According to statistical data from the central bank, the average mortgage rate for Taiwan's top five banks has decreased substantially from 9.20% in July 1994 to 1.99% in May 2013.

The impact of the U.S. subprime crisis and a series of financial crises in recent years suggest the importance of the role of the asset price in the monetary policy transmission mechanism, primarily due to the central collateral role of assets such as dwellings. It will not only affect the capital of the financial institutions but also change overall business investment and private consumption to make them sources of macroeconomic fluctuation. Bjørnland and Jacobsen [1] showed that central banks have managed to keep inflation in check through inflation targeting, but they have not managed to prevent asset prices from bursting and having negative real effects. The International Monetary Fund [2] reported that monetary policy makers should pay more attention to the overall financial risk caused by the bursting of real estate bubbles. Due to the asset's role in storing wealth, the impact of asset prices in times of disturbances should be carefully evaluated. However, asset prices can simultaneously respond to the monetary policy, making asset prices the major transmission mechanism of shocks (Zettelmeyer [3]; Rigobon and Sack [4]; Bernanke and Kuttner [5]). Hence, with their timely response to economic shocks, asset prices may be important indicators of the monetary policy stance. The discussion of the role of asset prices in the monetary policy transmission mechanism can help us determine the effectiveness of monetary policy.

Unlike other assets, housing has a dual role as an instrument to store wealth and important durable consumption goods. The house price shock may affect the property value of the household. According to the Tobin Q theory, when the collateral price increases, the rising house prices will stimulate housing construction activities.1 A shock to house prices may affect the actual output and commodity prices as an important forward-looking variable. Therefore, monetary policy makers will monitor the house price, which will not only affect the development of the housing market itself but also the capital flow and prices of other markets. Furthermore, Case et al. [6] pointed out the importance of the stock market and housing market to macroeconomic activities in a mature economy. Bjørnland and Leitemo [7] applied the SVAR model to analyze the relationship between the U.S. monetary policy and stock market. The research findings suggest that real stock prices and monetary policy have a contemporaneous interaction, meaning that stock prices are an important indicator of monetary policy. Hence, this paper will discuss the role of stock price shocks.

Vector auto regression or VAR is often used to estimate the relationship between macro variables. There are three forms of VAR: reduced form VAR, recursive VAR, and SVAR (structural VAR). The reduced form VAR does not require any economic theory for empirical study. Although reduced form VAR is convenient for the analysis of short-term dynamic relationships between variables, its over-parameterization often reduces the estimation efficiency of the model, and it cannot be used to illustrate the long-term relationships between economic variables. Bernanke and Blinder [8] pointed out that it is highly risky to use the unlimited VAR model for structural reasoning. Each variable of the reduced form VAR model is a linear function of the lag value of the variable, the lag values of other variables and errors, not considering the current impact of the variables. However, the reduced form VAR regression errors have current correlation. As a result, it is not easy to recognize the structural shock. In contrast, the structural errors of the recursive VAR and SVAR have no correlation, and the two are called orthogonalizing VARs. Due to the impulse response function (IRF), illustrating the dynamic impact of specific variables on endogenous variables requires no correlation between shocks, in which case the recursive VAR model is adopted.

For the recursive VAR model to effectively measure the structural effect arising from policy change, the monetary policy variable and other economic variables must be ordered, and the intra-variable contemporaneous effect must be recursive (for example, Goodhart and Hofmann [9]; Goux and Cordahi [10]). The model's variable ordering is determined by the contemporaneous relationship between monetary policy and other economic variables.

The second model, SVAR (for example, Chirinko, de Haan, and Sterken [11]; Elbourne [12]; Elbourne and de Haan [13]; Bjørnland and Leitemo [7]; Bjørnland and Jacobsen [14]; Bjørnland and Jacobsen [1]), is considerably more sensitive to model design and the assumptions that set the structural parameters. The biggest theoretical difference between the SVAR and the VAR model is that the variable ordering of the former is determined by the subjective judgment of the researcher in processing the contemporaneous problems of random shocks. Different ordering may lead to different results. Hence, the VAR model, which is not based on theory, cannot be used to obtain the only set of IRFs. On the contrary, when processing the contemporaneous problems of random shocks, the SVAR model must limit the time ordering relationship according to economic theory to obtain the only set of IRFs.

This paper uses the SVAR as the model-setting method. Monetary policy may affect asset prices (stocks and houses) through the interest-rate channel, which illustrates the interactions between asset prices and monetary policy. This study also considers the potential impact of asset prices on monetary policy when determining the empirical model for the short-term interactive relationship between monetary policy and asset prices. The proposed model is the traditional closed economic system model, including macroeconomic variables, monetary policy and asset prices, aimed at understanding the impact of the macroeconomic variables on house and stock prices and the effect of monetary policy shocks, house price shocks and stock price shocks. The response to shock elucidates the cross-period relationship between variables and the longer-term variable interactions. The estimated error variance decomposition is used to analyze the extent to which the estimated error change in a certain variable is caused by changes in other variables.

2. LITERATURE REVIEW

Monetary policy shocks will generally affect output and inflation. Elbourne and de Haan [13] used output and price indices as the proxy variables of the macro economy in an SVAR model analyzing the correlation between monetary transmission and structural financial indicators in E.U. countries. Their research found that inflation and output drive the difference in monetary transmission in E.U. countries. In addition, changes in reserves affect the willingness of banks to make loans and are reflected in the loan supply. Finally, except in Italy, the industrial production is negatively affected by the interest-rate shock in other countries. The macroeconomy is believed to have a critical effect on asset-price volatility (Gilchrist and Leahy [15]).

Elbourne [12] applied the SVAR model in the estimation of structural relationships involving commodity prices, the U.S. federal benchmark interest rate, retail sales, price levels, monetary demand, monetary supply, and foreign exchange rates and house prices to explain the dynamic effect of specific shocks on the endogenous variables. The model also analyzed the monetary policy shock and house price shock. The empirical results suggest that the rising interest rate directly affects the payment of loan interest. Hence, house prices play a very important role in the monetary policy transmission mechanism. Iacoviello and Minetti [16] discussed the impact of European monetary policy shocks on house prices with an analysis of four European countries—Finland, Germany, Norway and the United Kingdom—by using five variables, including interest rates, total loans of financial institutions, house prices, GDP and inflation. The empirical results suggest that the monetary policies of Finland and Germany have a significant and negative contemporaneous effect on house prices; the British monetary policy has a significant positive effect; and the Norwegian monetary policy has a positive but not significant effect. According to the research results, the difference in the response time and strength of various countries illustrates that monetary policy-making in different countries can lead to different effects on the housing market.

Through a combination of long- and short-term limitations, Bjørnland and Jacobsen [1] assumed that interest rates and house prices respond to information simultaneously and used the SVAR model to analyze the role of house prices on the monetary policy transmission mechanism in small open economies, with Norway, Sweden and Britain as examples. The research results show that the interest rates of Sweden and Britain will be affected by the house price shock: a 1% increase in house prices was associated with an interest rate hike of 15-20 base points. In the case of Norway, the initial impact of the house price shock on the interest rate is not significant; however, the latter increases by 10 base points after two quarters. Bjørnland and Jacobsen [14] analyzed the role of asset prices in the monetary policy transmission mechanism in the U.S., finding that the contractionary monetary policy shock had a contemporaneous and significantly positive impact on real stock prices. When the house price increases by 1%, the interest rate contemporaneously rises by 15 base points. The major conclusions of the article are robustly supported. Musso, Neri, and Stracca [17] showed that similarities outweigh differences as for as the housing market is concerned. The empirical evidence suggested a strong role for housing in the transmission of monetary policy shocks in the US.

Through a combination of long-term and short-term limitations, Bjørnland and Leitemo [7] applied the SVAR model to analyze the relationship between the U.S. monetary policy and stock market. The research findings suggest that real stock prices and monetary policy have a contemporaneous interaction, meaning that stock prices are an important indicator of monetary policy. Cheng and Jin [18] showed that monetary policy reacts directly to the term spread and indirectly to stock prices and house prices via output and inflation, that there is an asymmetry in the interactions between asset prices and aggregate activity, and that asset prices exhibit positive comovement.

In research on this issue in Taiwan, Lai [19] used the recursive VAR model to discuss the possible credit transmission channel of Taiwan's monetary policy. The empirical results suggest that except for housing investment costs, the contractionary monetary policy did not affect the consumption of durable consumption goods, corporate equipment or machinery. It is thus inferred that businesses may have other channels of capital sources. Huang [20] explored the 2000 to 2006 period of low interest rates, and found that monetary policy is a valid issue. Huang also verified that the interest rate channel, exchange rate channel, and stock channel were smooth. Huang applied a recursive VAR model was used to estimate the impulse response and to forecast error variance. Wu [21] added SVAR analysis, a monetary perspective view and the credit transfer channel of monetary policy into the model to explore these two transmission mechanisms of monetary policy on the real estate market impact, with empirical results showing the positive impact of sudden changes in housing prices on call rate loans and investments.

3. THE SVAR MODEL

First, y_t is assumed to represent the stationary variable vector in the macroeconomic respect (5×1) : $y_t = [\ln GDP, \ln CPI, \ln HP, \ln STOCK, RATE]'_t$. The endogenous variables in brackets represent the output, consumer price index, house prices, stock prices and the interest rate, respectively. If the VAR equation of y_t is $\Phi(L)y_t = \varepsilon_t$, $\Phi(L) = \sum_{j=0}^{p} \Phi_j L^j, \Phi_0 = I$ and $\Phi(L)$ is an invertible matrix, then it can be incorporated into the equation of the moving average as follows:

$$y_t = B(L)\varepsilon_t, \tag{1}$$

where ε_t is a (5×1) vector of reduced-form residuals assumed to be identically and independently distributed, $\varepsilon_t \sim iid(0, \Omega)$, with a positive definite covariance matrix Ω . $B(L)$ is the (5×5) convergent matrix polynomial in the lag operator L, $B(L) = \sum_{j=0}^{\infty} B_j L^j$.

Following the literature, the innovations (ε_t) are assumed to be linear combinations of the underlying orthogonal structure disturbances (e_t), i.e., $\varepsilon_t = Se_t$. The VAR can then be written in terms of the structural shocks as follows:

$$\begin{aligned} y_t &= B(L)SS^{-1}\varepsilon_t \\ &= C(L)e_t \end{aligned} \tag{2}$$

where $C(L) = B(L)S$. If S is identified, we can derive the MA representation in (2), as $B(L)$ is calculated from a reduced-form estimation. To identify S , the e_t 's are normalized to have unit variance. The normalization of $\mathrm{cov}(e_t)$ implies that $SS' = \Omega$. As the model contains five variables, the contemporaneous matrix S can identify 13 parameters at most. Therefore, the structural disturbance items can be identified after adding some restrictions to the S matrix. In this section, an SVAR model is established to set the contemporaneous parameter restriction equations of variables. The limitation of the 12 parameters of the model is zero, which assumes that a certain variable is not contemporaneously affected by another variable. Sims [22] pointed out that the identification of the SVAR model should be based on economic theory to set the relationship between variables for the short-term limitation of the S matrix.

With a five-variable VAR, we can identify five structural shocks, namely, the output shocks $\left(e_t^{\ln GDP}\right)$, the consumer price index shocks $\left(e_t^{\ln CPI}\right)$, house price shocks $\left(e_t^{\ln HP}\right)$, stock price shocks $\left(e_t^{\ln STOCK}\right)$ and monetary policy shocks $\left(e_t^{MP}\right)$. We then order the vector of structural shocks as follows: $e_t = \left[e_t^{\ln GDP}, e_t^{\ln CPI}, e_t^{\ln HP}, e_t^{\ln STOCK}, e_t^{MP}\right]$.

This paper bases the limits set on simultaneous variables used in past literature. Using the rules on implementing monetary policies set by the Central Bank, Rotemberg and Woodford [23] established a model with the interest rate as a function of the output and inflation. Bjørnland and Jacobsen [14] argued that macroeconomic variables do not simultaneously react to policy variables, while the simultaneous reaction from the macroeconomic environment to policy variables is allowed. Hence, the output in the first column and inflation in the second column are ranked higher than the interest rate (as shown in Eq. (3)). The output represents the aggregate demand relationship, and inflation stands for the aggregate supply relationship. The two columns represent commodity market equilibrium (Sims and Zha [24]; Elbourne and de Haan [13]).

The housing market cannot rapidly adjust to the current economic situation like other consumer goods. Elbourne [12] assumed that output and commodity prices have no contemporaneous effect on house prices, and house prices can generate contemporaneous effects on domestic monetary variables (such as the interest rate, M_0). The empirical results of the article also suggest that the contribution of output and commodity prices to contemporaneous house prices is extremely minimal; hence, this study assumes $S_{31} = 0$ and $S_{32} = 0$.

The third column is the equation of the house prices. As noted by Bjørnland and Jacobsen [1], house prices contribute greatly to the macroeconomic variables and the interest rate, indicating the importance of including house prices in the model. In other words, the unexpected rise of house prices will promote short-term consumption and output growth, which results in inflation, thereby affecting monetary policy. Unexpected house price shocks will worsen inflation, indicating the possibility of house price disturbance on monetary policy. Hence, house price shocks will affect the interest rate within one year, suggesting that the relationship between interest rates and house prices may have a time-lag effect (Bjørnland and Jacobsen [1]). According to the literature discussed above, house prices will not contemporaneously reflect the interest rate. Thus, in this model, the contemporaneous effect of house prices on the interest rate is limited to zero, namely, $S_{53} = 0$.

The fourth column is the equation of stock prices. As noted by Case, Quigley, and Shiller [6], the stock market, macroeconomic factors and the housing market are often correlated in a mature economic system. Regarding the stock and housing markets, assets of different types have apparent price spillovers (IMF [2]), suggesting that booming transactions will result in rising house prices, which trigger stock price fluctuations in times of a booming housing market. Bjørnland and Jacobsen [14] argued that the liberalization of the financial market promotes the development of asset prices. As a result, stocks and houses become the major sources of collateral for loans. Because both stocks and houses are the major assets of the macro economy, this study also sets the contemporaneous effect of stock prices on interest rates as zero, namely, $S_{54} = 0$.

Goodhart and Hofmann [9] and Giuliodori [25] assumed that a monetary policy shock had a contemporaneous effect on house prices. According to the theory, the estimated asset price is used as a forward-looking variable. Asset prices can contemporaneously respond to monetary policy shocks. Elbourne [12] analyzed the relationship between monetary policy and house prices, arguing that the house prices would contemporaneously respond to the temporary domestic interest rate shock in Britain. Bjørnland and Jacobsen [14] used the SVAR model to analyze the role of asset prices in the monetary policy transmission mechanism, pointing out that the monetary policy shock has a significant and contemporaneous negative effect on real stock prices. To confirm all shocks, Rigobon and Sack [4] and Bjørnland and Leitemo [7] assumed that the interest rate had a contemporaneous effect on asset prices (stock prices and house prices). Hence, in this model, the relationship between the interest rate and asset price is kept contemporaneous, namely, $S_{35} \neq 0$, $S_{45} \neq 0$.

In the monetary policy equation represented in the fifth column, the real GDP, CPI, house prices and stock prices are ranked ahead of monetary policy, indicating that the macroeconomic variables have a contemporaneous effect on the interest rate, given the constraints on simultaneous variables, under the assumption that “monetary policy has no simultaneous impact on economic variables.” Svensson [26] stressed that monetary shocks have no effect on output or inflation in the monetary policy transmission mechanism. However, macroeconomic changes occur simultaneously with monetary policy shifts. Therefore, Bjørnland and Jacobsen established a VAR model in 2010 that ranks output, inflation, and house prices ahead of interest rates. Therefore, we define the model as follows:

$$\varepsilon_t = \begin{bmatrix} S_{11} & 0 & 0 & 0 & 0 \\ S_{21} & S_{22} & 0 & 0 & 0 \\ 0 & 0 & S_{33} & 0 & S_{35} \\ S_{41} & S_{42} & S_{43} & S_{44} & S_{45} \\ S_{51} & S_{52} & 0 & 0 & S_{55} \end{bmatrix} \cdot \begin{bmatrix} e_t^{\ln GDP} \\ e_t^{\ln CPI} \\ e_t^{\ln HP} \\ e_t^{\ln STOCK} \\ e_t^{MP} \end{bmatrix} \quad (3)$$

4. DATA SOURCE AND DESCRIPTION

First, we describe the empirical data source and the data processing of the variables at their original levels. We then describe the decomposed sequence diagram by Hodrick-Prescott and the unit root test results.

4.1 Data Source

This paper sources 70 batches of quarterly empirical data over the period of the first quarter of 1993 to the second quarter of 2010. The five variables of the empirical model include the following: the natural logarithm of the real GDP after quarterly adjustment, the natural logarithm of CPI after quarterly adjustment, the natural logarithm of the Sinyi house price index, the natural logarithm of the weighted average stock prices and the weighted average lending interest rate. The real GDP and CPI data are taken from the Taiwan Economic Journal (TEJ) Database; the weighted average stock price index data are taken from the Taiwan Stock Exchange; and the weighted average lending interest data are based on the published data of the Central Bank of the Republic of China (Taiwan).

The data on house prices in this paper are represented by the Sinyi House Price Index. The index is compiled using hedonic pricing theory to remove problems of heterogeneity (excluding biased samples such as aged houses). The Sinyi house price index covers mainly the market of old and middle-aged houses (including apartment buildings, buildings with elevators and excluding pre-sale houses). The index is a relatively credible house price index based on publicly available information. The variables and the data source used in this study are shown in Table 1.

Table 1. Ariable and data description

Variables	Description	Data source
$\ln GDP$	Natural logarithm of real GDP	TEJ Database
$\ln CPI$	Natural logarithm of CPI	TEJ Database
$\ln HP$	Natural logarithm of Sinyi House Price Index	Sinyi Real Estate Agency
$\ln STOCK$	Natural logarithm of weighted average stock price index	Taiwan Stock Exchange Corporation
$RATE$	Weighted average lending interest rate	Central Bank of Taiwan

4.2 Data Pocessing

Before conducting the empirical study, we use the unit root test approach to test whether the variables included in the analysis are stationary, to avoid the problem of "spurious regression." This study uses the ADF and KPSS approaches to test whether the time series is stationary. If the time series is not stationary, the stationary test will be conducted after Hodrick-Prescott decomposition. The Hodrick-Prescott decomposition can decompose the non-stationary time series data into stationary and non-stationary portions. The empirical study of this paper uses the stationary portion of the data after the Hodrick-Prescott decomposition as the data for the empirical analysis.

According to the sequence of original levels for the variables shown in Fig. 1 and the unit root test results of the original levels shown in Table 2, the original sequences of $\ln GDP$, $\ln CPI$, and $\ln HP$ all have unit roots, indicating a non-stationary time series. Hence, we conduct the unit root test after the Hodrick-Prescott decomposition.

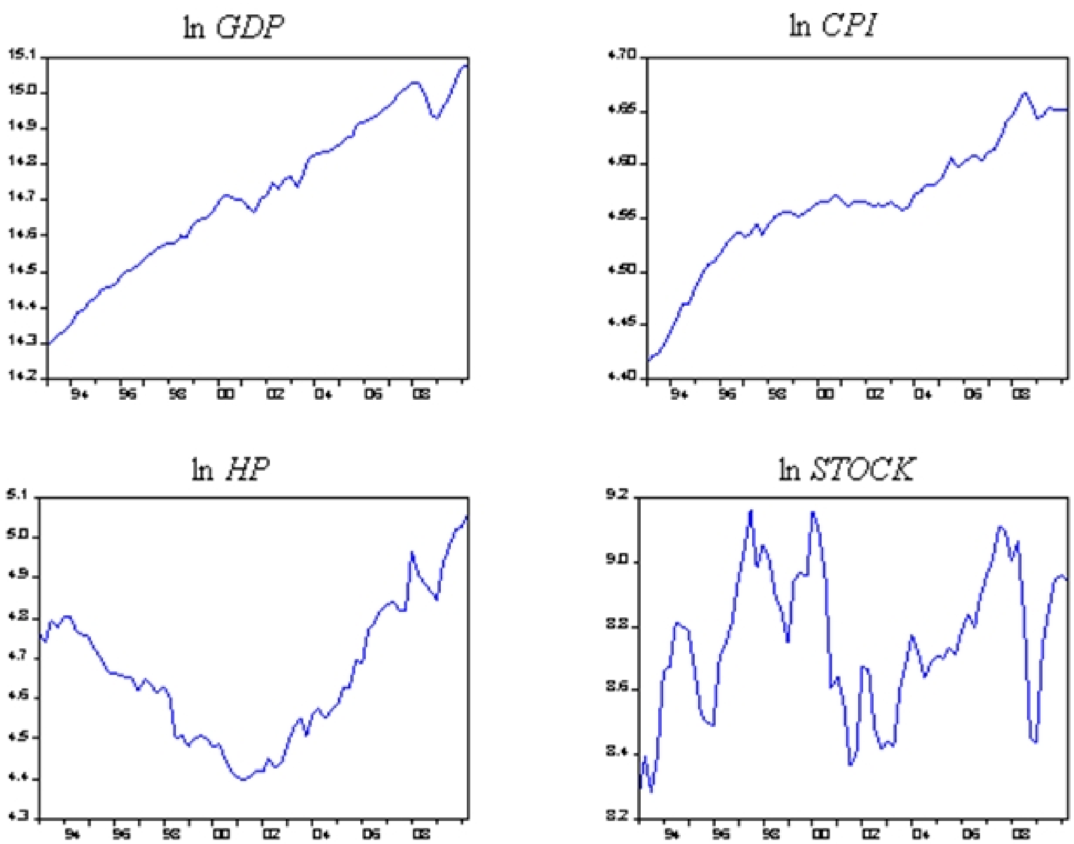


Fig. 1. Sequence of variable original levels

Table 2. Unit root test of the original levels of the variables

Variables	ADF	KPSS
$\ln GDP$	-1.12	1.10***
$\ln CPI$	-2.80*	1.01***
$\ln HP$	0.56	0.38*
$\ln STOCK$	-3.35**	0.17

*"***", "**" and "*"represent significance at the 1%, 5% and 10% levels, respectively; the ADF testing rejects the null assumption of unit root; and the KPSS testing rejects the null assumption of no unit root*

According to the results from the unit root test conducted after Hodrick-Prescott decomposition shown in Table 3, both the ADF test and the KPSS test confirm that real GDP, CPI and Sinyi house price index data become stationary time series data after the Hodrick-Prescott decomposition.

Table 3. Unit root test results after Hodrick-Prescott decomposition

Variables	ADF	KPSS
$\ln GDP$	-4.53***	0.04
$\ln CPI$	-2.97**	0.08
$\ln HP$	-4.44***	0.08

*"***", "**" and "*" represent significance at the 1%, 5% and 10% levels, respectively; the ADF testing rejects the null assumption of no unit root; and the KPSS testing rejects the null assumption of unit root*

5. EMPIRICAL RESULTS

In time series data, the choice of a lag period is closely related to stability. More lag periods in the model will result in more parameters to be estimated and fewer degrees of freedom. Hence, there should be a balance between lag periods and degrees of freedom. The lag order of the model is determined using LR (likelihood ratio), AIC (Akaike info criterion), SC (Schwarz criterion), Hannan-Quinn information criteria, and FPE (final prediction error criterion) for model reductions. The tests indicated that one lag was acceptable.[2]

5.1 SVAR Contemporaneous Structural Parameter Estimation

Table 4 illustrates the estimation results of the SVAR contemporaneous structural parameter. In the commodity price equation, the contemporaneous effect of GDP on commodity prices is negative. Although the relationship is not as expected, it is not significant. In the house price equation, the contemporaneous effect S_{35} of the interest rate on house prices is significant and positive. Previous research suggests that the contemporaneous effect of monetary policy on house prices is sometimes positive (Iacoviello and Minetti [16]) and sometimes negative (Elbourne [12]; Bjørnland and Jacobsen [1]). Bjørnland and Jacobsen [1] pointed out that the difference in the timing and strength of various countries' responses to monetary policy shocks may underlie the contrasting effects on house prices. The research findings of this paper may be due to housing construction companies partially transferring costs to consumers when the cost of loans rises, resulting in higher house prices.

Table 4. SVAR contemporaneous structural parameter estimation results

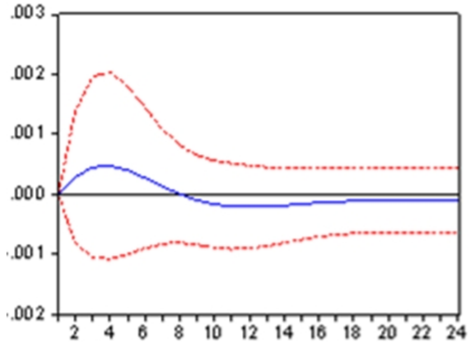
	$\ln GDP$	$\ln CPI$	$\ln HP$	$\ln STOCK$	$RATE$
$\ln GDP$	1	0	0	0	0
$\ln CPI$	-0.0112 (-0.2720)	1	0	0	0
$\ln HP$	0	0	1	0	0.0433 (1.6926)*
$\ln STOCK$	2.9033 (3.5456)***	3.6740 (1.5484)	0.9673 (2.3010)**	1	-0.0224 (-0.2407)
$RATE$	1.4341 (1.3430)	3.1744 (1.0203)	0	0	1

*Notes: the data of the table are of the contemporaneous parameters in the model; data in parentheses are the z-values; ***", "**" and "*" stand for a 1%, 5% and 10% significance level respectively*

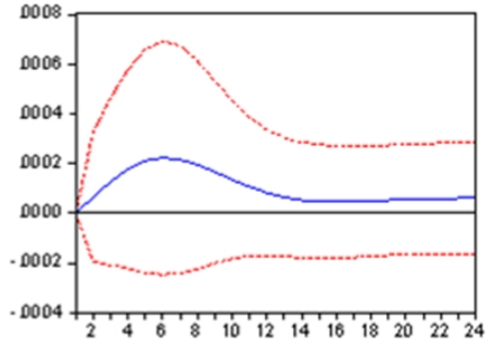
In the stock price equation, the contemporaneous effect of GDP on stock prices is positive, as expected, at a significance level of 1%, indicating that higher GDP can facilitate stock market investment. The contemporaneous effect of commodity prices on stock prices is also positive, though insignificant. A change in house prices positively affects the contemporaneous stock price, as expected, at a significance level of 5%, suggesting obvious price spillovers between different types of assets (IMF [2]); for example, plunging house prices may accelerate the decline of stock prices. The contemporaneous effect S_{45} of the interest rate on stock prices is negative in terms of parameter estimation, as the theory predicts, but the result is not significant. In the case of higher interest rates, investors may deposit the money from the stock market in the bank; conversely, when the interest rate is lower, investors may procure loans at lower cost from the bank to invest in the stock market, resulting in the negative effect of an interest rate change on stock prices. The research results of Bjørnland and Jacobsen [14] suggest that a monetary policy shock has a contemporaneous and significant negative effect on real stock prices. Finally, in the monetary policy equation, the contemporaneous effect of output and commodity prices on the interest rate is not significant.

5.2 Effects of a Monetary Policy Shock

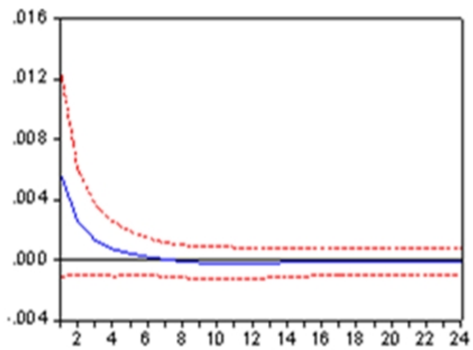
By the analysis of IRF as set by the theoretical model, we can explore whether a change of one standard deviation of a certain variable has a positive or negative, continuous or sporadic effect on other variables. The IRF of a stable model should be close to 0. Fig. 2 illustrates the IRFs of different structural shocks on the variables.



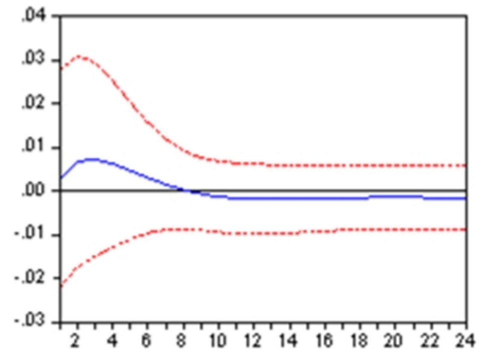
(A) $\ln GDP$ **response to monetary policy shock**



(B) $\ln CPI$ **response to monetary policy shock**



(C) $\ln HP$ **response to monetary policy shock**



(D) $\ln STOCK$ **response to monetary policy shock**

Fig. 2. Responses to a monetary policy shock

Many researchers point out that contractionary monetary policy shocks usually result in temporarily increasing the interest rate and lowering output and inflation gradually (Bjørnland and Jacobsen [1]). Fig. 2(A) illustrates that after the positive interest rate shock of 1 standard deviation (approximately 0.13%), the GDP response changed from positive to negative through the eighth quarter, at an insignificant level. The results suggest that the contractionary monetary policy shock will results in output reduction after the eighth quarter and is expected to have a negative effect on employment and wages. Among the E.U. countries studied by Elbourne and de Haan [13], the industrial production of all countries but Italy suffered after the interest rate shock, albeit at an insignificant level. The empirical results of this study are similar. As Fig. 2(B) illustrates, the CPI responds positively to the 1 standard deviation increase in the interest rate, but the effect is not significant. Goux and Cordahi [10] used the recursive VAR to analyze the transmission mechanism of international monetary shocks. The research findings suggest that the commodity prices and short-term interest rate exhibit a positive relationship at an insignificant level. Contractionary monetary policy has not resulted in the decline of commodity prices. Instead, it results in the rise of commodity prices, which is commonly known as the price puzzle. This puzzle may be explained by a cost channel of the interest rate, where the increase in firms' borrowing costs is offset by an increase in prices (Ravenna and Walsh [27]; Chowdhury, Hoffmann, and Schabert [28]).

As Fig. 2(C) illustrates, after the positive interest rate shock, the positive house price response falls to zero after sixth months but at an insignificant level. This result may be caused by the partial cost transfer to consumers by construction companies when loan costs rise, thereby increasing the house price. The research results relating to the effects of monetary shocks are quite controversial. For example, the Hong Kong Monetary Authority [29] discussed the role of the housing market in the monetary transmission mechanism of Hong Kong, finding that the interest rate will affect asset prices and the inflation rate through the housing market channel. The empirical results of Iacoviello and Minetti [16] suggest that the monetary policy of Finland and Germany had significant negative effects on house prices while the British monetary policy had a significant positive effect. The Norwegian monetary policy had a positive but not significant effect. The research findings suggest that the strength and timing of the response varies by country; housing may play a different role in various monetary policy settings.

Fig. 2(D) illustrates that the stock price responds negatively only after the eighth quarter, as expected, to the interest rate hike, though at an insignificant level. In the case of higher interest rates, investors may deposit money from the stock market in the bank, resulting in the negative relationship between interest rates and stock prices.

The empirical results of the monetary shock in this paper cannot fully explain the transmission of house prices and stock prices. The results may be due to the low interest rate policy. From the first quarter of 1993 to the second quarter of 2010, the average interest rate was 3.5%, and it has remained below 3% since the fourth quarter of 2010. Such low interest rates cannot affect the investment and consumption loan costs significantly, diminishing the monetary policy effect. Second, the capital sources of investment and consumption may be other non-banking channels. Lai [19] used the recursive VAR model to discuss the possible credit transmission channel of Taiwan’s monetary policy. The empirical results suggest that except for housing investment costs, the contractionary monetary policy did not affect the consumption of durable consumption goods, corporate equipment or machinery. It is thus inferred that businesses may have other channels of capital sources. Hence, we deduce that house prices and stock prices cannot become the transmission mechanism of monetary policy shocks because of low interest rates and capital channels.

The variance decomposition further clarifies the relative importance of monetary policy shocks. As the variance decomposition in Table 5 suggests, the explanatory variation of monetary policy shock on house prices and stock prices is very low: the explanatory variance of house prices is approximately 3% because Taiwan’s market interest rate has been relatively low for a long time and loan costs are extremely low and have no significant impact on housing and stock investment. Therefore, the role of the stock and housing markets as the transmission mechanism of monetary policy cannot be proven.

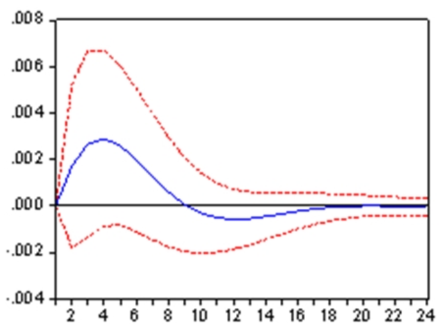
Table 5. Variance decomposition and contributions from monetary policy shocks

Period	$\ln GDP$	$\ln CPI$	$\ln HP$	$\ln STOCK$
1	0.000	0.000	3.833	0.051
2	0.025	0.010	3.671	0.226
3	0.068	0.041	3.488	0.336
4	0.105	0.093	3.344	0.386
5	0.125	0.160	3.247	0.400
12	0.144	0.403	3.114	0.395
24	0.175	0.450	3.118	0.460

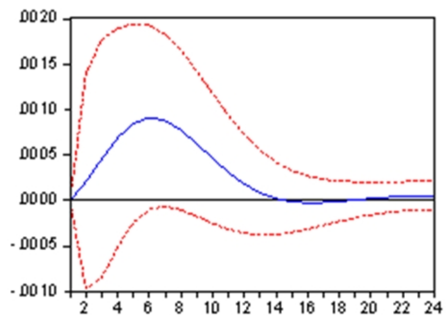
5.3 The Role of House Price Shocks

Given the above discussion of the effect of a monetary policy shock on relevant variables, we turn to the response of variables to house price shocks. As shown in Figs. 3(A) and 3(B), after a positive house price shock of 1 standard deviation (approximately 0.029 units), GDP and CPI respond positively, which is consistent with the findings of Chirinko, de Haan, and Sterken [11], Elbourne [12] and the study expectations, despite the nonsignificant level. Fig. 3(C) illustrates that the stock price responds significantly upon the house price hike, with the peak point at 0.05 units3 appearing in the third quarter after the shock and gradually disappearing after the fifth quarter. This finding confirms the obvious price spillovers between various types of assets (IMF [2]).

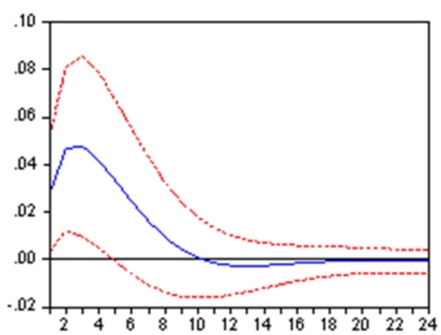
Fig. 3(D) illustrates that the interest rate responds positively and significantly after the house price shock after the fourth quarter, at which time it displays a significant positive relation. Relevant literature shows that house prices have a positive effect on interest rates (see Elbourne [12]; Bjørnland and Jacobsen [1]). The above results are identical with the findings of Bjørnland and Jacobsen [1], which suggest that monetary policy simultaneously responds to house prices in Sweden and Britain. In Norway, the initial response is insignificant, but after two quarters, the interest rate increases by 10 basis points. The strength and timing of the response thereafter varies from one country to another, indicating that housing may play different roles in the monetary policy setting. Bjørnland and Jacobsen [1] point out that an unpredicted shock to house prices influences the interest rate at least within one year. The empirical results of this paper are identical to the results of Bjørnland and Jacobsen.



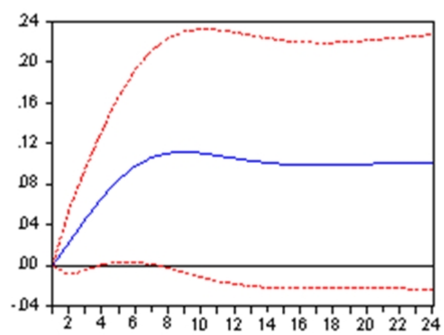
(A) $\ln GDP$ **response to** $\ln HP$



(B) $\ln CPI$ **response to** $\ln HP$



(C) $\ln STOCK$ **response to** $\ln HP$



(D) $RATE$ response to $\ln HP$

Fig. 3. Responses to a house price shock

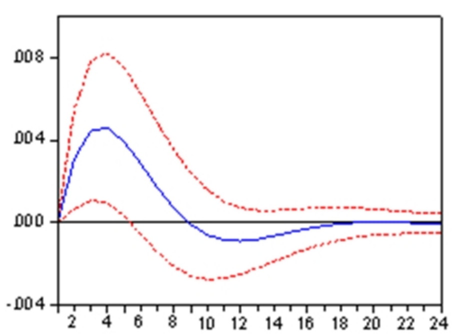
The variance decomposition further clarifies the relative importance of house price shocks. The variance decomposition in Table 6 suggests that the house price shock explains approximately 12%-19% of the variance of stock price after two quarters and approximately 6%-15% of the interest rate variation after four quarters. Over time, the explanatory variation of stock prices and interest rates gradually increases. The results suggest that the housing market plays a prominent role in the Taiwan monetary policy setting; however, the immediate response is small (and not significant, judging by Fig. 3) and explains approximately 5%-6% of GDP and consumer commodity price variation after 12 periods. This result suggests the significance of house price shocks on stock prices and interest rates.

Table 6. Variance decomposition and contributions from house price shocks

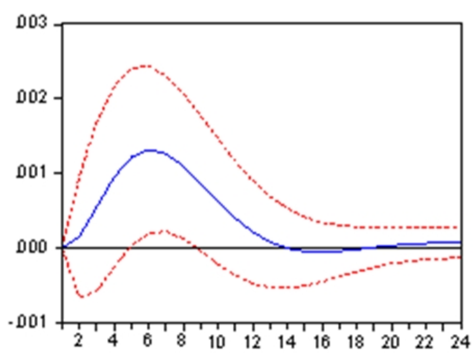
Period	$\ln GDP$	$\ln CPI$	$\ln STOCK$	$RATE$
1	0.000	0.000	5.906	0.000
2	0.844	0.109	12.737	1.187
3	2.320	0.515	16.775	3.277
4	3.711	1.320	18.780	5.549
5	4.626	2.428	19.603	7.603
12	5.110	6.006	19.353	13.521
24	5.181	5.998	19.315	14.705

5.4 The Role of Stock Price Shocks

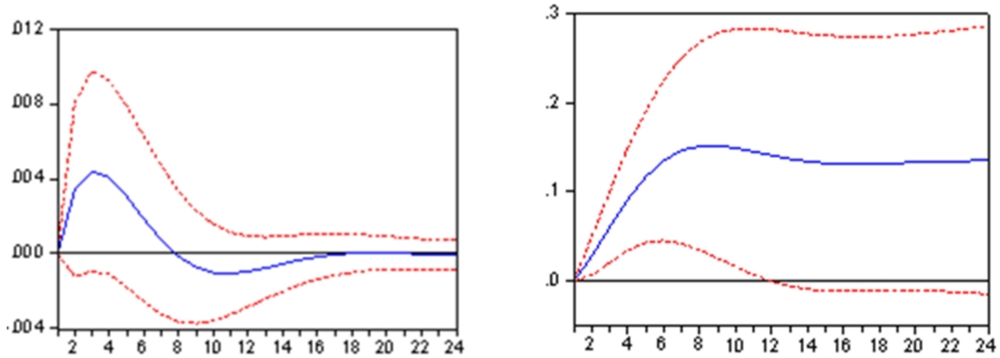
Fig. 4(A) illustrates that after a positive stock price shock of 1 standard deviation (approximately 0.1 unit), the GDP rises significantly and simultaneously with its peak at 0.004 units,[4] appearing four quarters after the stock price shock. The effect disappears after the fifth quarter. Fig. 4(B) shows that the CPI reaches a significant level in the fifth quarter after the stock price shock and become insignificant after the ninth quarter. Fig. 4(C) illustrates that the house price responds positively to a stock price increase, as expected, though at an insignificant level. Fig. 4(D) illustrates that the interest rate rises with the stock prices and is significantly positive between the third and tenth quarters, with a peak of approximately 1.52 unit appearing in the ninth quarter. The effect seems to be constant by point estimation; however, the effect becomes insignificant following the 12th quarter.



(A) $\ln GDP$ **response to** $\ln STOCK$



(B) $\ln CPI$ **response to** $\ln STOCK$



(C) $\ln HP$ **response to** $\ln STOCK$ **(D)** $RATE$ **response to** $\ln STOCK$

Fig. 4. Responses to a stock price shock

The variance decomposition in Table 7 suggests that the initial explanatory variance of stock price shocks to the GDP, consumer commodity prices, house prices, and interest rates is not high but becomes gradually stronger over time. The explanatory variance capability is ranked in order by interest rate, consumer commodity prices, GDP, and house prices, suggesting the stock price shock has a major effect on the interest rate, consumer commodity price index and GDP in the long run.

Table 7. Variance decomposition and contributions from stock prices shocks

Period	$\ln GDP$	$\ln CPI$	$\ln HP$	$RATE$
1	0.000	1.03E-30	1.78E-32	1.03E-30
2	2.717	1.806	1.102	1.806
3	6.761	5.639	2.677	5.639
4	10.141	10.110	3.871	10.110
5	12.114	14.227	4.469	14.227
12	12.809	25.100	4.822	25.100
24	12.937	26.644	4.885	26.644

6. CONCLUSIONS

This paper uses an SVAR model to discuss the effect of monetary policy shocks as well as the role of house price and stock price shocks. Regarding the effect of contractionary monetary policy shocks on asset prices, the contemporaneous effect on house prices is significant and positive, but the response gradually approaches zero after sixth months. This effect may be due to higher house prices caused by the partial cost transfer to consumers by the construction companies in the case of rising loan costs. The contemporaneous effect of contractionary monetary policy on stock prices is negative, as expected, though insignificant. In the case of monetary contractions, investors may consider depositing money in the bank instead of investing in the stock market. Conversely, when the monetary policy is relaxed, investors may procure bank loans at lower cost to invest in the stock market, resulting in a negative relationship between monetary policy and stock prices.

The empirical analysis of monetary policy shock cannot fully support the transmission role of house prices and stock prices. First, the interest rate may be too low: during the study period of the first quarter of 1993 to the second quarter of 2010, the average interest rate was 3.5%, and it has been lower than 3% since the fourth quarter of 2010. Such low interest rates have no significant impact on investment and consumption loan costs, making the monetary policy effects inconspicuous. Second, the capital sources of investment and consumption may be channels other than the banking system, making the interest rate unable to fully affect investment and consumption decision-making. Third, the average weighted lending rate of the Central Bank is used as a proxy variable for the monetary policy, but this rate is not fully manipulated by the monetary policy makers.

Upon the positive house price shock, the response of the interest rate was not significantly positive until the fourth quarter. In other words, house prices will not affect the monetary policy contemporaneously. Upon the positive stock price shocks, the interest rate immediately rises and reaches a significant level from the third to the tenth quarter after the shock, suggesting that house and stock price shocks do not affect the monetary policy until the third or fourth quarter. This result illustrates that real assets (houses) or financial assets (stocks) will not have significant effects on monetary policy in the short term.

A house price shock can result in a simultaneous and significant positive response of stock prices, and the response will not disappear until the fifth quarter. Upon positive stock price shocks, house prices will respond positively at an insignificant level. The GDP will significantly rise immediately after the positive stock price shock, and the effect will not disappear until the fifth quarter. The CPI response will be significant between the fifth and ninth quarters after the stock price shock.

We conclude that if asset price shocks were practically absent or had no effect on the economy, then inclusion of asset prices in the SVAR model would be unnecessary. The significance of asset price shocks on macro variables and the sizeable contribution to interest rate variance demonstrate that housing market developments have systematic implications for monetary policy.

This paper mainly discusses the interactive effect of monetary policy and assets. However, in a small open economy such as Taiwan, the interaction between foreign exchange rates and monetary policy may be significant, as suggested in the literature (e.g., Faust and Rogers [30]; Bjørnland [31]; Bjørnland and Halvorsen [32]). Foreign exchange rates or international crude oil prices may be added as foreign economic variables in subsequent studies. As mainland China, the United States and Taiwan are closely related in terms of economy, the data of mainland China and the United States may be added to the model in subsequent studies to discuss the interactions of monetary policy, the macro economy and asset prices in these countries. In this paper, the average weighted lending rate is used as a proxy variable for the monetary policy; however, the average weighted lending rate published by the central bank is not fully determined by the monetary policy. Hence, monetary supply or unborrowed reserves may be taken into consideration as proxy variables for the monetary policy. The impact of changes in fiscal policy or taxes on asset prices, but also to be considered for future research directions.

NOTES

1. The Tobin Q theory mainly illustrates that fluctuation in asset prices will affect the proportion of the corporate market value of all investment capital and thereby affect

business investment. Girouard and Blondal [33] pointed out that if the Tobin Q value is larger than 1, it is profitable to build new houses because the new house price exceeds the house construction cost; on the contrary, if the Tobin Q ratio is smaller than 1, then building new houses is not profitable, and construction investment will decline.
2. According to the VAR model lag periods selection rules, as shown in the table, the selection of two rules leaves two lag periods. Hence, we use a VAR model with two lag periods. The research findings suggest that the difference between VAR models with two lag periods versus one lag period is not great.
3. Elasticity = $0.05/0.029 = 1.724$.
4. Elasticity $= 0.004/0.1 = 0.04$.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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