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Asset price fluctuations in Taiwan: Evidence from stock and real estate prices 1973 to 1992

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Abstract

This paper studies the observed price fluctuations from 1973 to 1992 of two major assets in Taiwan: real estate and stocks. Equity prices are found to Granger-cause real estate prices. I then ask under which transmission channel do Taiwan's asset prices play a more important role. Bank loans are found to be much more significant than interest rates in predicting the movements of both asset prices. This suggests that Taiwan's asset price fluctuations support the theory that emphasizes the importance of balance sheet position and collateral value to credit-constrained firms. Finally, an experimental simulation suggests that even the rational bubble theory cannot fully explain the acceleration of asset prices during mid-1988 and 1990:Q1.

JEL classification: E30; E44; G10

Keywords*:* Asset prices; Collateral value; Bubbles

1. Introduction

Between the second half of the 1980s and early 1990s, Taiwan's asset markets (primarily stock and real estate markets) experienced a bigger boom-bust cycle than any other sector of the economy. The stock price index shot up more than 10-fold from late 1986 to early 1990 and then plummeted by more than 75% from the peak in just 6 months. Average housing prices in the Taipei area more than quadrupled during the same period and dropped

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afterwards, though less drastically. Such large fluctuations of Taiwanese asset prices have often been considered as the boom and burst of a bubble.

During the same period, however, the big swing in Taiwan's asset prices was far from a unique experience. Japan and Scandinavia went through an even more dramatic inflation and deflation in asset prices. In fact, nearly all other OECD countries experienced a similar pattern of asset price fluctuations around 1984 to 1993. In emerging economies, financial crises of this type have been particularly prevalent since the early 1980s, including Argentina, Chile, Mexico, and several East Asian countries. These tremendous fluctuations in asset prices not only have a huge impact on the net worth of corporations and individuals, but also have significant and persistent effects on real economic activities (Higgins and Osler, 1997; Kaminsky and Reinhart, 1996a,b).[1]

A common background for most of these crises was financial deregulation and substantial credit expansion. Credit expansion is then accompanied by a rapid rise in asset prices such as real estate and stocks.[2] At a certain point, the asset markets collapse and their prices plunge, due to a change in the regulatory or economic environment.[3] The collapse of asset prices and the exposure of banks to equity and real estate markets therefore initiate defaults of debtors, banking crises, and persistent economic downturns. Sometimes this may be accompanied by an exchange rate crisis.[4]

The Japanese asset price inflation that occurred in the 1980s provides a good example of this type of phenomenon. Financial liberalization throughout the 1980s led to an expansion in credit. The Nikkei 225 index rose from around 10,000 in 1985 to a peak of 38,916 in December 1989. The Bank of Japan then tightened money and this led to a sharp increase in interest rates in early 1990. The Nikkei 225 fell sharply down to 20,222 by October 1990. Commercial real estate prices dropped by as much as 70% from their peak (Peek and Rosengren, 1997). A severe banking crisis and recession followed. Furthermore, in the New England area of the U.S., the collapse of real estate markets following the boom in the mid-1980s eroded the net worth of banks due to huge losses on real estate loans. Together with a stricter regulatory bank capital requirement imposed about the same time, it caused a "capital crunch" (Peek and Rosengren, 1992).[5]

The boom in Taiwan's real estate and stock prices that occurred in the second half of the 1980s seemed to be consistent with the above story. Financial liberalization throughout the 1980s deregulated interest rates and the exchange rate. Deregulation in the banking industry and securities markets also promoted competition among financial institutions. Finally, the lifting of the capital mobility restraint and the desire to suppress the pace of the NT dollars appreciation led to a hike in credit expansion. The monetary policy stance was also unprecedented eased during this period, with the monetary aggregates growing at unusually high rates (e.g., M1B growth reached 51% between 1986:Q4 to 1987:Q1). The stock price index climbed rapidly from around 1100 at the end of 1986 and reached its peak of 12,000 in early 1990. In August 1989, the central bank raised the rediscount rate twice from 4.5% to 7.75%, and increased the required reserve ratio by 4%, aiming to abate the high growth rate of money supply. More importantly, the central bank executed an array of radical selective credit control procedures to tighten credit expansion in land development and construction and securities investment. However, in early 1990, the asset markets went bust, the stock price index sank from around 12,000 to under 3000 in half a year, and the real estate

market became sluggish if not outright collapsed. Economic activity was hit hard in the aftermath of the asset market slump.

There are several channels through which an exogenous shock can affect asset prices. I borrow from the theoretical frameworks in which asset prices amplify exogenous shocks by way of various transmission channels. The theoretical hypotheses are then put to test to understand what role do Taiwan's asset prices play in the interest rate channel and credit channel of transmission mechanism. Finally, although it is not this paper's purpose to identify whether asset prices contain bubbles, I simulate bubble paths based on the rational bubble theory to test whether they can fully capture the acceleration of asset prices during mid-1988 and early 1990.

The remainder of this paper is organized as follows. Section 2 discusses theoretical frameworks that are useful for understanding price movements of stocks and real estate in a dynamic setting and examines in detail the interaction of these two asset prices. Section 3 explores the factors behind the observed movements of these two asset prices, using a multivariate VAR. Given the assumption that asset prices are subject to bubbles during the late 1980s, I calculate hypothetical bubble paths to compare with the observed asset prices. Section 4 concludes.

2. The relationship between stock and real estate prices

Because stocks and real estate are the two major assets held by the private sector, I will examine in detail the relationship between the prices of these two assets. In light of the theoretical frameworks by Kiyotaki and Moore (1997) and Chen (2001), I consider an extension along the story of their models to shed light on the interaction between the prices of stocks and real estate in a dynamic setting.[6] In their models the commodities include a consumption good and a durable asset (such as land or buildings). The durable asset serves as production input as well as collateral for loans. A common feature of both models is that the expected value of the borrowers' holding of a collateralizable asset imposes a credit constraint on external financing; thus, the asset's price that determines the borrowers' borrowing capacity plays a key role in the "credit cycles." However, there is only one type of asset in both models, and so we add equities, representing the claims on a firm's net worth, to the story.

The mechanism that generates a boom-bust cycle in these asset prices may go something like this. If the price of real estate goes up, say due to an increase in bank credit supply, a firm that holds a certain amount of real estate or land has huge unrealized capital gains and thus has a stronger balance sheet position. Because real estate serves as collateral for loans, the firm will be able to borrow more for investment. This is particularly true for a firm that is credit-constrained in an environment where a borrower must demonstrate his or her ability to repay debts by putting forth collateral. Therefore, either the expected profits from realizing capital gains or the future revenue from expanded investment will lead stockholders to bid up the equity value of that firm. This further strengthens the balance sheet position and thus the firm's borrowing capacity. When all firms demand more land or buildings to carry out new investments, this in turn feeds back to stimulate the land or real estate market. In

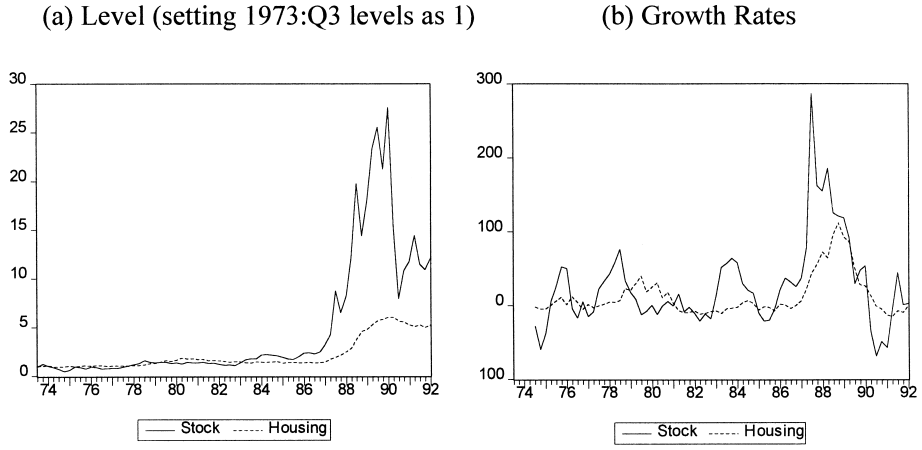

Fig. 1. Stock and real housing prices. Level (setting 1973: Q3 levels as 1). Growth rates.

subsequent periods, the initial effect propagates into the future through the interaction of these two asset markets, which also explains why an exogenous shock generates persistent effects on aggregate variables. Thus, a link between the prices of these two assets arises: whatever the reason that bids up either stock or real estate prices, there is a tendency that these two asset prices reinforce each other, leading to a spiraling upturn in both prices. Therefore, this transmission mechanism describes the co-movements of stock and real estate prices.

2.1. Data description and statistical properties

Real estate is the primary asset held by households almost everywhere in the world. Surprisingly, a consistently constructed real estate price of high frequency and enough length suitable for a real estate cycle analysis is sketchy. The quarterly data used in this study is taken from Young (1992), running from 1973:Q3 to 1992:Q1.[7] Real estate prices during this period primarily represent the to-be-constructed residential housing prices in the metropolitan Taipei area.[8] The stock price index is the value-weighted index of the Taiwan Stock Exchange, and the rest of the data are from AREMOS data bank.

To begin with, we examine the basic statistics of these two series: real housing prices (RHP) and stock prices (SP). Fig. 1 shows the levels and growth rates of stock and real estate prices, respectively. By using various measures of variance tests, we find that the volatility of stock prices is much higher than that of housing prices. According to Lin et al. (1997) that, within the sample period from 1973 to 1992, there contains two complete real estate cycles: 1975 to 1984 and 1984 to 1990.[9] The latter one was most remarkable in terms of scale as well as duration.

Table 1 compares the phenomenal booms of stock and housing prices during 1986-early 1990 with those in the previous years. It is obvious that housing prices are always lagging stock prices. Table 2a indicates that the autocorrelation of both series is very high. This is

Table 1
Growth rates of stock and real housing prices (%)

Year	Real housing prices	Stock prices
1975–1985	3.6	11.6
1986	0.4	25.2
1987	56.2	161.7
1988	112.0	121.2
1989	27.7	47.7
1990	−4.9	−49.2
1991	−9.5	0.9
1992:Q1	−0.7	2.7

true particularly for housing prices, suggesting that the effect of a shock to housing prices has a much greater persistence. The cross correlation between these two prices is of great interest. Table 2b shows that the largest correlation between the two prices comes at (RHP(t), SP(t-1)), that is, stock prices lead housing prices. Moreover, stock and housing prices are highly correlated.

2.2. Estimation of the bivariate VAR model

Before proceeding to estimate the vector autoregressions, I perform diagnostic testing on the data series to determine the data generating process, the cointegrating relationships

Table 2
Autocorrelation and cross correlation between stock prices (SP) and real housing prices (RHP)

a. Autocorrelation			
	SP		RHP
SP(−1)	0.9234	RHP(−1)	0.9922
SP(−2)	0.8631	RHP(−2)	0.9749
SP(−3)	0.8174	RHP(−3)	0.9483
SP(−4)	0.7588	RHP(−4)	0.9120
SP(−5)	0.6866	RHP(−5)	0.8699
SP(−6)	0.6443	RHP(−6)	0.8229
SP(−7)	0.5821	RHP(−7)	0.7721
SP(−8)	0.5144	RHP(−8)	0.7238

b. Cross correlation		
i	RHP, SP(−i)	RHP, SP(+i)
0	0.9003	0.9003
1	0.9168	0.8336
2	0.9152	0.7684
3	0.9026	0.6921
4	0.8626	0.6108
5	0.8239	0.5316
6	0.7832	0.4472
7	0.7470	0.3678
8	0.6849	0.3017

Table 3
Bivariate VAR of stock and housing prices

a. Full sample: 1973:Q3–1992:Q1						
	DLOGRHP (−1)	DLOGRHP (−2)	DLOGSP (−1)	DLOGSP (−2)	Constant	B-G LM test
DLOGRHP	0.8457*	−0.0342	0.1159*	−0.0230	0.0047	2.0850
	(6.4239)	(−0.2898)	(3.3310)	(−0.6244)	(0.4725)	(pval = 0.3526)
DLOGSP	0.6109	−0.4860	0.8713*	−0.2316	0.0542	0.2365
	(1.3437)	(−1.1901)	(7.2529)	(−1.8182)	(1.5862)	(pval = 0.8885
b. Sub-sample: 1973:Q3–1985:Q4						
	DLOGRHP (−1)	DLOGRHP (−2)	DLOGSP (−1)	DLOGSP (−2)	Constant	B-G LM test
DLOGRHP	0.6842*	0.1679	0.1110	−0.0505	−0.0005	0.0849
	(4.3771)	(1.1081)	(2.2107)	(−0.9784)	(−0.0054)	(pval =0.9585)
DLOGSP	0.3300	−0.4778	0.8702*	−0.3402*	0.0519	0.1263
	(0.8788)	(−1.3127)	(7.2146)	(−2.7425)	(2.1025)	(pval =0.9388)
c. Chow breakpoint test: 1986:Q1 (probability in the parentheses)						
Dependent Variable			DLOGRHP			DLOGSP
Log likelihood ratio			6.5926 (pval = 0.2527)			2.9578 (pval = 0.7065)

Note: *t*-statistics are in parentheses. Coefficients marked with asterisks (*) are significant at the 5% level.

between the variables, and the lag length and ordering in estimating VARs. Due to big swings in the data series, in the following I work on the logarithm of real housing and stock prices, denoted (LOGRHP, LOGSP). Firstly, both Augmented Dickey–Fuller (ADF) and Phillips–Perron (PP) unit roots tests indicate that a unit root is not rejected either for stock or housing prices.[10] After taking first differences, both series appear to be stationary. Next, Johansen's maximum likelihood procedure is conducted with various specifications.[11] The result shows that LOGRHP and LOGSP are not cointegrated at the 5% significance level for various lag lengths chosen for the cointegration test.

Table 3 presents the bivariate VAR results of the first difference of LOGRHP and LOGSP (DLOGRHP, DLOGSP) with *t*-statistics in parentheses. Panel (a) shows the estimation results with a full sample from 1973:Q3 to 1992:Q1. Housing prices are explained significantly by their own lagged variables and past stock prices, whereas stock prices are explained only by their own lagged variables.[12]

To check for the robustness of this relationship, samples are divided at 1986:Q1 which represents the beginning of the latest asset prices boom. Panel b of Table 3 presents the estimation results for the subsample before 1986:Q1. They are found to be qualitatively similar to the results under the full sample. Impulse responses and variance decompositions are also similar to the results under the full sample. In panel (c), Chow's breakpoint tests indicate that there is no significant structural change between the two subperiods. Our findings are therefore consistent with the causal observations that in Taiwan stock and housing prices highly co-moved throughout the sample period.

Fig. 2a plots the percentage of the square forecast errors of one variable attributable to

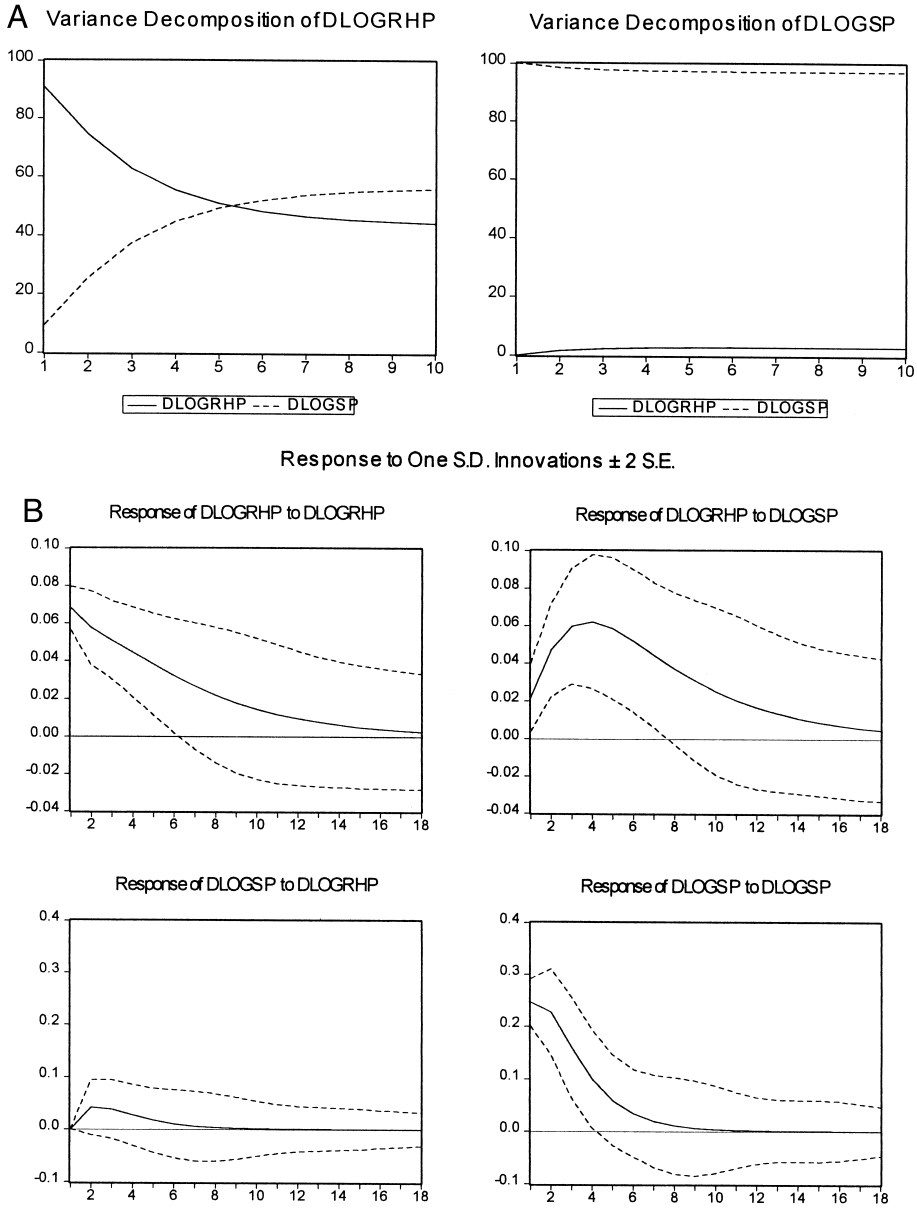

Fig. 2. (a) Variance decompositions. (b) Impulse responses.

innovations in another one.[13] The forecast error variance of housing prices can be accounted for by innovations in stock prices up to 56.5%. Conversely, innovations in housing prices can only explain less than 3% of the forecast error variance in stock prices. This means that fluctuations in the stock market contribute substantially to the variations in housing prices, while the reverse is not significant. This is further confirmed by the Granger Causality test, as is shown in Table 4, which shows that stock prices Granger-cause housing prices, but

Table 4
Granger causality tests (lags: 2)

From	To	F-Statistic	Probability
LOGSP	LOGRHP	4.7876	0.0114
LOGRHP	LOGSP	2.3206	0.1061

housing prices fail to cause stock prices in the Granger sense. Finally, Fig. 2b presents impulse responses of one variable to one standard deviation shock to another variable. The impulse response of housing prices either to an innovation in stock prices or their own is far more significant and persistent compared with that of stock prices.

3. Asset prices and the transmission channels

In Section 2, I sketched a story describing the interaction between stock and housing prices, however, the channels that transmit the effects of exogenous shocks, especially monetary policies, toward asset markets are not well understood. Furthermore, as mentioned above, in spite of the similarity of asset price inflation in the second half of the 1980s among many countries, the cause of an asset market boom and thus transmission mechanisms may be different from one case to another. The purpose of this section is to identify the relative importance of transmission channels that affect Taiwan's asset prices.[14]

To lay out a foundation for the following empirical investigation, I now return to the framework by Chen (2001). In this model the special role of banks is explicitly considered. Given asymmetric information between depositors and banks, and also between banks and borrowing firms, the amount of bank loans is found to be a function of aggregate bank capital and firms' net worth. The reason is that not only are the amounts of borrowing constrained by borrowers' net worth, but also the amounts of bank loan supply depend on bank capital positions. A distinct feature of this framework is that fluctuations in asset prices amplify the bank lending channel and/or the balance sheet channel in the transmission of exogenous shocks.[15] A tightening monetary policy, say, in the form of raising the bank capital adequacy requirement, leads to a shrinkage in the bank loan supply and therefore lowers the level of investment. Less investment demand results in lower demand for productive input (durable asset) and its price. Lower investments generate lower future earnings and thus depress the price of equities. Impaired capital positions (or collateral value) thus feedback to an even lower level of investment. This generates persistent fluctuations in economic activity.

Our question here is under which transmission channel do asset prices in Taiwan play a more important role. In the next subsection, I extend the bivariate VAR system by adding the amount of bank loans and an indicator of monetary policy through interest rates.

3.1. Multivariate VAR estimation

Bank loans (LOANS) consist of the amount of loans made by all financial institutions in Taiwan.[16] Because quarterly data for this series started in 1978:Q1, the data points between

Table 5
Multivariate VAR of stock and housing prices

a. Four-variable VAR (RDISRATE, LOGRLOANS, LOGSP, LOGRHP)				
Sample	1973:3 1992:1		1973:3 1985:4	
Observations after Adj.	72		47	
Dependent Variables	D(LOGSP)	D(LOGRHP)	D(LOGSP)	D(LOGRHP)
D(RDISRATE(−1))	0.0079	−0.0028	0.0131*	−0.0021
	(1.2417)	(−1.4933)	(4.2537)	(−1.0871)
D(RDISRATE(−2))	−0.0050	0.0001	−0.0048	0.0005
	(−0.8665)	(0.0750)	(−1.5578)	(0.2643)
D(LOGRLOANS(−1))	2.0577*	0.3593	0.4228	0.0092
	(2.0703)	(1.2296)	(0.6761)	(0.0234)
D(LOGRLOANS(−2))	0.2927	0.7534*	−0.1258	0.7372*
	(0.3083)	(2.6996)	(−0.2339)	(2.1806)
D(LOGSP(−1))	0.1644	0.0848*	0.4466*	−0.0237
	(1.3749)	(2.4114)	(3.6812)	(−0.3108)
D(LOGSP(−2))	−0.0911	0.0125	0.1826	−0.0403
	(−0.7548)	(0.3523)	(1.5262)	(−0.5354)
D(LOGRHP(−1))	0.7262	0.0652	0.7051	−0.1663
	(1.6800)	(0.5130)	(1.7883)	(−1.0468)
D(LOGRHP(−2))	1.3112	0.1629	1.1641	−0.0665
	(1.8644)	(1.3275)	(1.4457)	(−0.4038)
C	−0.0914	−0.0187	−0.0237	−0.0092
	(−1.8717)	(−1.2993)	(−0.9260)	(−0.5717)

Note: *t*-statistics are in parentheses. Coefficients marked with asterisks (*) are significant at the 5% level.

b. Chow breakpoint test: 1986:Q1 (probability in the parentheses)		
Dependent Variable	DLOGSP	DLOGRHP
Log likelihood ratio	31.1998(0.0010)	20.6733(0.0485)

1973:Q3 and 1977:Q4 are filled by fitting a linear trend. Next, I use the Central Bank rediscount rates (RDISRATE) to stand for the change in monetary policy by way of changing interest rates directly. Rediscount rates was one of the most important monetary policy tools during the sample period in Taiwan. A change in the rediscount rate usually indicates a shift in monetary policy and immediately affects bank interest rates and other financial market rates. Real loans, discounted by the consumer price index, then take up a logarithm (LOGRLOANS). I now estimate a four-variable VAR (RDISRATE, LOGRLOANS, LOGSP, LOGRHP) representing rediscount rates, bank loans, stock prices, and housing prices to assess the interaction of bank lending, interest rates and asset prices.

Diagnostic tests show that there are unit roots in all variables. Two cointegrating vectors are also found at the 1% significance level under various specifications. Therefore, the VAR estimations are corrected by adding the residuals from the cointegrating equations. Table 5 and 6 present the results of the multivariate VAR. There are several notable findings. Firstly, changes in the rediscount rate, representing the monetary policy stance by changing interest rates, are not significant in explaining the movement of asset prices, whereas changes in bank loans are much more important in predicting both stock and housing prices. For example, the innovations in bank loans explain the forecast error variance of housing and stock prices up to 41% and 54% respectively, while the innovations in rediscount rates account for at most

Table 6
Granger causality tests (after error-correction adjustment, lags: 2)

From	To	1973:Q3 1992:Q1 F-stat	Prob	1973:Q3 1985:Q4 F-stat	Prob
RDISRATE	LOGRLOANS	1.8092	0.1717	3.5365	0.0381
RDISRATE	LOGSP	0.3330	0.7179	2.1889	0.1247
RDISRATE	LOGRHP	1.6749	0.1951	1.6089	0.2122
LOGRLOANS	RDISRATE	0.0928	0.9115	0.1873	0.8299
LOGRLOANS	LOGSP	2.5695	0.0757	1.4653	0.1664
LOGRLOANS	LOGRHP	4.9133	0.0102	3.3426	0.0450
LOGSP	RDISRATE	1.2816	0.2843	1.4519	0.2217
LOGSP	LOGRLOANS	0.7423	0.4799	0.0064	0.9936
LOGSP	LOGRHP	3.9857	0.0213	0.7348	0.4857
LOGRHP	RDISRATE	1.8250	0.1692	2.2283	0.1203
LOGRHP	LOGRLOANS	0.9726	0.3834	1.5861	0.2168
DLOGRHP	LOGSP	2.0050	0.1417	2.0127	0.1463

4% of the forecast error variance of either housing or stock prices (see Fig. 3). Granger causality tests (after error-correction adjustment) yield the same qualitative results. This implies that asset prices play a much more important role in amplifying the bank lending channel than they do the interest rate channel in Taiwan.[17]

Secondly, the causality from stock prices to housing prices remains significant as was found in the bivariate VAR. According to the transmission mechanisms described at the beginning of this section, the causality relationship between these two asset prices should be understood as either stock prices or housing prices being the important amplifier in the bank lending channel. Thirdly, Chow's breakpoint tests detect a structural change in the relationships between the transmission channels and asset prices: the interest rate channel remained unimportant across the subsamples, whereas the bank lending channel became more significant from 1986 to 1992 than in the period 1973 to 1985.

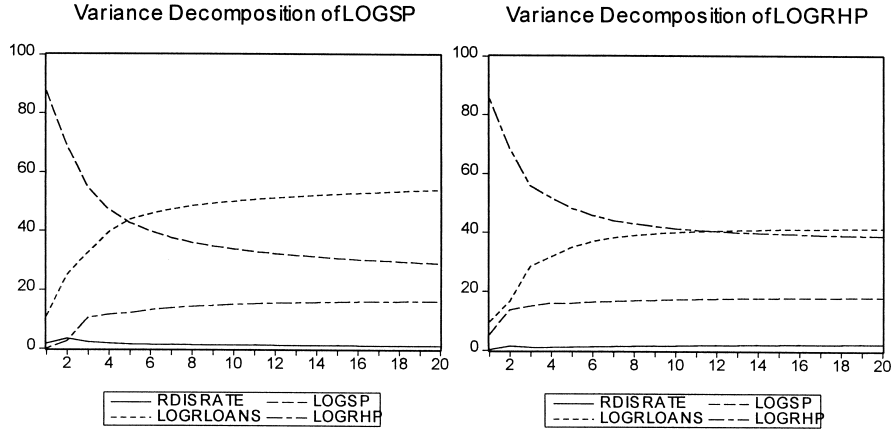

Fig. 3. Variance decomposition of stock and housing prices.

Table 7
Determinants of bank loans

a. Coint. vectors: 4, D.W.: 2.3086, Adj. Sq. R: 0.6828, *F*: 16.7139, Prob (*F*): 0.0000						
Constant	DLOGRHP	DLOGSP	DLOGRGNP	DLOGPI	DLOGRM1B	DRDISRATE
0.0366*	0.0694	0.0189	−0.5699	−0.3156*	0.2792*	0.0008
(9.5616)	(1.6563)	(1.4729)	(−1.7984)	(−2.7088)	(6.6451)	(1.5740)

b. Coint. vectors: 4, D.W.: 2.067, Adj. Sq. R: 0.6503, *F*: 8.8768, Prob (*F*): 0.0000							
Constant	DLOGRLOANS	DLOGRHP	DLOGSP	DLOGRGNP	DLOGPI	DLOGRM1B	DRDISRATE
0.0389*		0.0922	0.0192	−0.5247	−0.2746*	0.2908*	0.0010
(4.8080)		(1.9362)	(1.3853)	(−1.4309)	(−2.1694)	(6.0927)	(1.4029)
One period lag							
	−0.1703	−0.0165	−0.0135	−0.1377	0.0293	0.1253	0.0002
	(−1.2262)	(−0.7054)	(−1.0193)	(−1.2424)	(0.2236)	(1.8778)	(0.3933)

Note: *t*-statistics are in parentheses. Coefficients marked with asterisks (*) are significant at the 5% level.

3.2. What affects bank lending?

Because changes in bank lending are significant in affecting stock and housing prices, the next step would be to examine the determinants of bank loans. According to the story outlined at the beginning of this section, I choose the following variables, in addition to asset prices, to regress on bank loans: real GNP (LOGRGNP), real money supply M1B (LOGRM1B), rediscount rate (RDISRATE), and GNP deflator (PI).[18] These variables are found to have unit roots and are cointegrated. After adjusted for cointegration, Tables 7 and 8 show the results. In Table 7, it is clear that M1B is the only variable that is significant in explaining changes in bank loans under various specifications. Table 8 also shows that M1B Granger-causes bank loans.

In sum, the quantity variables, bank loans and money stock, are much more important in explaining movements of asset prices than the rediscount rate. Fig. 4 plots the growth paths of M1B and bank lending. The significance of the price index (LOGPI) with a negative sign reflects the observation that the general price level in Taiwan, which does not include the transaction of existing assets, remained stable during periods of asset inflation.

The results in this section suggest that Taiwan's asset price fluctuations support the theory of lending constraints by Kiyotaki and Moore (1997) and Chen (2001). An increase in bank loans precedes the rise in asset prices. The increase in bank loans is indeed more likely to be caused by monetary policies that directly lead to a credit expansion rather than by adjusting the rediscount rates (or interest rates). Furthermore, this bank-lending channel was more important during the second half of the sample, 1986 to 1992.

Table 8
Granger causality tests (lags: 4)

From	To	*F*-statistic	Probability
LOGRM1B	LOGRLOANS	9.6057	4.3E−06
LOGRLOANS	LOGRM1B	1.3578	0.2591

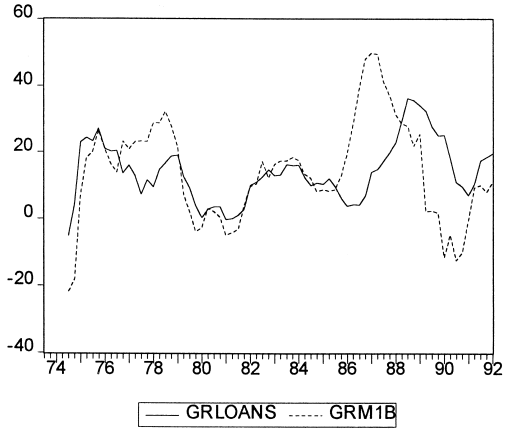

Fig. 4. Growth rates of real bank loans and M1B.

3.3. Rational stochastic bubble theory and asset prices

Note that both frameworks of Kiyotaki and Moore (1997) and Chen (2001), even though allowing for the effect of expectations of future asset prices on current prices, exclude the existence of bubbles. Therefore, the estimations conducted in Section 3.1 to 3.2 do not regard the accelerating prices as the consequence of the speculators' activities. Still, the estimations above fit their models rather well in which the balance sheet position of credit-constrained firms and collateral value are important in determining bank lending and investment.

It is often suggested, however, that Taiwan's big boom in asset prices in the late 1980s cannot be justified by economic fundamentals, which may be either due to over-optimism or speculators' activities. The existence of bubbles has always been a controversy. Part of the reason is that their fundamentals may be stochastic. In theory an asset's fundamental value can be obtained by discounting the asset's future earnings stream, but the difficulties in estimating the earnings stream and in proper discounting make the identification of bubbles very hard.[19] Nevertheless, the specification of the rational bubble theory provides a convenient way to illustrate a bubble path, which can be used to compare with observed asset prices to see if they are consistent with the theory of rational bubbles.

According to Blanchard (1979) and Blanchard and Watson (1982), a stochastic rational bubble can be added to the usual asset pricing formula, expressed as $q_t = E_t\sum_{i=1}^{\infty}\rho^i d_{t+i} + b_t$, where q_t is the date t price of an asset, d_t is the period return of the asset, $\rho = 1/(1 + r)$ is a discount rate, and

$$b_{t+1} = \begin{cases} b_t/\rho\pi + e_{t+1} & \text{with probability } \pi \\ e_{t+1} & \text{with probability } 1 - \pi. \end{cases}$$

Note that for each period the bubble may burst with a positive probability π. The random variable e_t is a white noise with zero mean and thus $b_t = \rho E b_{t+1}$, meaning that this specification does not allow for arbitrage even with the existence of a bubble. Following Ito and Iwaisako (1996), I calculate the crash probabilities of the asset prices implied by the

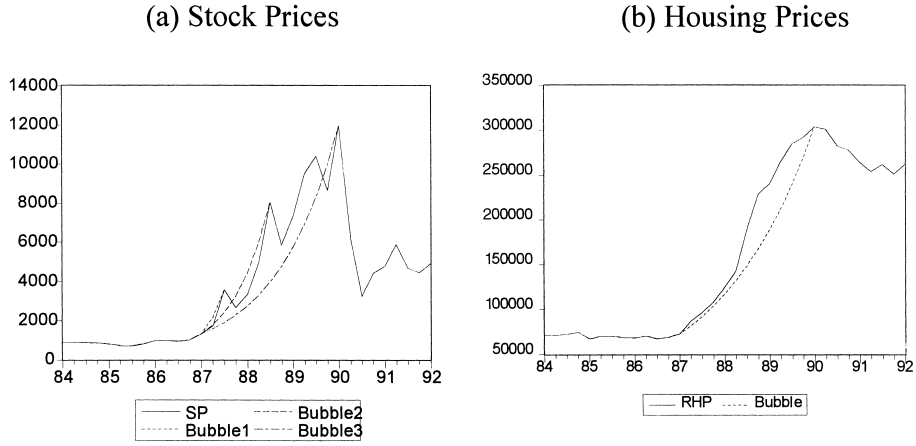

Fig. 5. Stochastic bubble paths. Stock prices (a) housing prices.

stochastic rational bubble theory. According to the specification, the probability of a bubble surviving in the next period is $\pi = (b_t/b_{t+k})^{1/k}/\rho$.

I consider the 1987:Q1 stock price index as the beginning of bubble b_t and 1990:Q1 price b_{t+k} as its highest price before the crash. The interest rate r is set at 5.66%, which is the average of the short-term rates in Taiwan. The probability that the bubble can survive for another quarter is then $\pi = 0.8434$. This is Bubble 3 in Panel a of Fig. 5. Therefore, this bubble path can be supported from the 12th to 13th quarter with a probability of 0.1093. As for housing prices, $\pi = 0.9$ and the probability that this bubble path can survive is 0.2542. These probabilities are summarized in Table 9. The probabilities that the calculated bubble paths can be maintained are not sensitive to the choice of b_t. For example, if I use 1986:Q1 as b_t then the probabilities that stock price Bubbles 1 to 3 can be supported are 0.2388, 0.1129, and 0.087, respectively.[20] If I allow for a switch of bubbles, say, from Bubble 2 to

Table 9
Survival probability of bubble path

a. Stock prices, t = 1987:Q1, b_t = 1312				
	$t = k$	b_{t+k}	π	Probability that this bubble path can be supported
Bubble 1	1987:3	3567	0.6151	0.2327
Bubble 2	1988:3	8039	0.7497	0.1331
Bubble 3	1990:1	11983	0.8434	0.1093
b. Housing prices, t = 1987:Q1, b_t = \$72,512				
$t + k$	b_{t+k}		π	Probability that this bubble path can be supported
1990:1	\$303,785		0.9000	0.2542

Table 10
Growth rates of real GNP, real housing prices and stock prices

	Real GNP	Housing	Stock		Real GNP	Housing	Stock
1985:Q1	7	−6	−10	1988:Q1	9	72	155
1985:Q2	5	−2	−21	1988:Q2	7	64	185
1985:Q3	4	−3	−20	1988:Q3	8	96	125
1985:Q4	6	−7	−5	1988:Q4	9	112	121
1986:Q1	11	2	21	1989:Q1	8	93	119
1986:Q2	11	1	37	1989:Q2	7	86	92
1986:Q3	13	−4	32	1989:Q3	9	50	29
1986:Q4	16	0	25	1989:Q4	8	28	48
1987:Q1	13	6	37	1990:Q1	7	26	53
1987:Q2	14	23	79	1990:Q2	5	14	−35
1987:Q3	13	44	287	1990:Q3	4	−1	−69
1987:Q4	9	56	162	1990:Q4	6	−5	−49

Bubble 3 for stock prices, then this hypothetical bubble path can be sustained with a probability of 0.0497.

Given these probabilities, there is no criterion to judge whether the observed asset price paths are consistent with the stochastic bubble theory. However, when comparing the probabilities that the bubble paths can be supported for the asset prices, housing prices are more consistent with the stochastic bubble theory than stock prices according to Fig. 5. All in all, both asset prices seem to be more consistent with the stochastic bubble theory before mid-1988; after that, the simulated bubble paths cannot even catch up with the rise in asset prices.

Examining the growth rates of real GNP and asset prices during the late 1980s, as in Table 10, there are some notable observations. Firstly, the movements of asset prices seem to be consistent with the changes of real GNP (representing the fundamentals) before the 4th quarter of 1987. After that, the asset prices move farther and farther away from the fundamentals. Combining the discussions above, it may be argued that the initial rise in bank lending and asset prices was justified by fundamental valuations placed on the asset due to the economic boom in the early 1980s. However, these price movements began to be extrapolated by market participants and then higher prices were realized to fulfill market anticipation. In this way, the price movements became a self-reinforcing process and deviated from the fundamentals. This description is consistent with the experience for many other countries described in Higgins and Osler (1997) and Ito and Tokuo (1996).

4. Concluding remarks

This paper examines the relationship of Taiwan's stock and real estate prices and tries to identify in which channel the asset prices play a role in amplifying the transmission mechanism. I find that stock prices tend to lead housing prices. An expansion of bank credit, rather than a lower rediscount rate, is likely to be the cause of asset price fluctuations. Stock and real estate prices then reinforce each other in accordance with the theory that emphasizes

the importance of balance sheet position and collateral value to credit-constrained firms. A tentative experiment simulating the surge of asset prices in the late 1980s suggests that during mid-1988 and 1991:Q1, even the stochastic bubble theory could not fully capture the movements of asset prices.

Several issues need to be addressed for future studies. Firstly, it is well known that the informal credit markets in developing countries play an important role in financing investment and consumption. It was estimated that Taiwan's informal credit market provided more than one third of the total amount of loans to private enterprises during our sample period (Tang, 1995). It will be of great interest to study how the informal financial sector interacted with the formal financial sector in transmitting shocks to asset prices. Second, our sample is restrained due to the lack of consistently estimated real estate prices. Taiwan's financial markets, however, have advanced rapidly since the early 1990s. A notable development is the increase of direct financing relative to indirect financing. A reasonable conjecture is that the availability of more sources of funds may lessen the monetary policy effect that directly affects the amount of bank loans on asset markets. It is important for both researchers and policymakers to identify the relative significance of different transmission channels along the evolution of the financial structure.

Notes

1. Although the Asian crisis of 1997 adds another spectacular example of fluctuations in asset prices, our sample period covers up to only 1992, for reasons to be explained below.
2. A moral hazard explanation is that deregulation gives the market participants more power to compete and pursue higher profits, but does not require them to bear the responsibility corresponding to the risk that is involved; in particular, an appropriate incentive mechanism was not in place to curb the financial institutions from excessive risk-taking. Krugman (1998) and many others argue that government guarantees led to over-lending and excessive risk-taking in Asian countries.
3. For example, the collapse in oil prices helped burst the bubble in Norway. In Finland, the central bank increased interest rates and imposed reserve requirements to moderate credit expansion. Together with a fall in trade with the Soviet Union, the asset markets collapsed. The central banks of Sweden and Japan tightened credit and raised interest rates to curtail credit expansion (Heiskanen, 1993; Allen and Gale, 2000).
4. Very often there is a tradeoff between defending a currency and alleviating a banking crisis by the choice of interest rate level. Higher interest rates worsen a financial crisis, but can ease the currency attack.
5. Notably the new risk-based bank capital adequacy requirement under the Basle Accord came into effect in many countries in the early 1990s. The increase in regulatory capital requirement at a time when huge loan losses depleted bank capital, dubbed a "capital crunch," forcing banks to rebuild their capital positions by heavily cutting back on lending.
6. The former abstracts from intermediaries and concentrates on the issue of non-

enforceable contracts between lenders and borrowers, while the latter stresses the moral hazard problem among banks, depositors, and borrowers.

7. The only alternative to the residential housing price index can be found in Chang (1995) from 1971 to 1992. The series is quality-controlled, butis also an annual data set.
8. Beyond 1993 to 1994, the to-be-constructed housing market was almost replaced by the finished housing market due to an over-built and high vacancy rate. There is a substantial gap between these two market prices. This is an unexpected advantage of consistency when confining us to this study's sample period. However, a problem of this series is that it is not quality controlled and the prices may be different from market prices due to the time-to-build lag.
9. As noted in Lin et al. (1997) the former boom was due to high growth together with oil price surge in 1979. On July 1, 1980 several restrictions in land development were imposed to slow down the rise of real estate price. The latter was due to extremely lax monetary policy. Because February 28, 1990, the central bank imposed selective credit control programs and the real estate prices started to turn downward.
10. Lag lengths are chosen by using Akaike (AIC) and Schwarz (SI) information criterion.
11. The lag length used in Johansen's maximum likelihood procedure is predetermined by running unrestricted VARs with various lag lengths and conducting likelihood ratio tests. The test statistics have a χ^2 distribution with degree of freedom equal to the number of coefficient restrictions. The tests prefer the parsimonious model with only 2 lags. Furthermore, both AIC and SI select VAR(2) in favor of VAR(4).
12. The Breusch–Godfrey serial correlation LM test indicates that the residuals from the estimations are not serially correlated.
13. The results come from the model with the ordering (DLOGSP, DLOGRHP). The reverse order produces qualitatively similar results.
14. Various channels have been identified through which effects of exogenous shocks might be transmitted to the real sector. One is by way of the interest rate channel whereby low interest rates reduce the user cost of capital and stimulate demand for funds to invest in other high yield assets. The other is by way of the credit channel, which emphasizes the importance of a shift in bank loans supply (bank lending channel) and/or the deterioration of the net worth position of borrowers (balance sheet channel) in the transmission of exogenous shocks (Kashyap et al., 1993; Kashyap and Stein, 1994; Bernanke and Gertler, 1995).
15. The analysis explains why banking crises often coincide with depressions in asset markets (particularly, real estate and stock markets) as we have observed since the late 1980s in various regions of the U.S. and countries in Scandinavia and East Asia.
16. All financial institutions include Depository Institutions, Postal Savings System, Investment and Trust Companies, and Life Insurance Companies. The reason we use this broad measure of loans is that most financial institutions do not clearly categorize the purposes for which the loans are made. Moreover, it is widely believed that those non-depository institutions are active participants in stock and real estate markets, and thus I also include the amount of loans made by these institutions.

17. The definition of the bank lending channel means the transmission of an exogenous shock by way of changes in the supply of bank loans. However, it is well known that it is extremely difficult to identify the change in loans due either to a shift in the supply or the demand schedule. More and more studies used is aggregate data and take into account the heterogeneity of borrowers and banks to solve this problem. See Kashyap et al. (1993) and Kashyap and Stein (1994). For most of the time within our sample period 1973:Q3 to 1992:Q1, there were few alternative sources (except informal financial markets) of short-term funds other than bank loans due to underdeveloped money markets. Many firms heavily relied on bank loans and were subject to credit constraints. Primary rates of banks were also much lower than those in the informal credit markets. Ample evidence shows that credit rationing was also prevalent. These observations suggest that changes in the amount of bank loans would most likely owe to shifts in the bank loan supply.
18. The purpose of adding the price index is to capture the effect of a shock due to changes in inflation expectations, which are not explicitly modeled.
19. Arguments have been made, for example, in which even the Tulip mania, the South Sea Bubble, and the Mississippi bubble can be explained by rationally justifiable expectations from the point of view of market participants at the time (Garber, 1990).
20. If the interest rate is changed to 8%, the probabilities for the three stock bubble paths to sustain themselves do not change much: 0.2367, 0.1385, and 0.1178, respectively.

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