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The magnitude and significance of macroeconomic variables in explaining regional housing fluctuations

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Abstract

This paper investigates the possible responses of housing returns to macroeconomic and global variables for four special municipalities in Taiwan (Taipei, New Taipei, Taichung and Kaohsiung) over the period 1991Q1 to 2010Q4. Two interesting results have been observed. First, the housing market shows distinct high-volatility and low-volatility cycles for each city due to idiosyncratic characteristics. The frequency of regime switches between high-volatility and low-volatility markets is strongest in Kaohsiung's housing market and is lowest in New Taipei and Taichung. Second, while the growth rate of GDP, aggregate stock return, the growth rate of CPI and aggregate housing return are able to affect regional housing returns, their effects are different in each city.

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1. Introduction

A considerable number of empirical studies have investigated the possible impacts of macroeconomic variables on national housing returns, and have pay less attention to regional housing markets. However, because regional housing markets have heterogeneous characteristics, their behavior has recently gained more attention. Moreover, exploring this behavior, while focusing particularly on the component of national housing prices, can provide valuable information in terms of comprehending national housing prices. This paper uses Taiwan's regional housing indexes (Taipei, New Taipei, Taichung and Kaohsiung housing indexes) in order to investigate whether there are differences between high-volatility and low-volatility cycles in regional markets due to differences in housing market structures and whether the principal factors affecting regional house returns differ.

Deciding which variables influence house price changes is an important topic. In studying house price changes, macroeconomic and global factors (such as inflation rates, mortgage rates, money supplies, stock prices, unemployment rates, gross domestic products, international oil prices, etc.) have been investigated by a number of researchers, including Anari and Kolari (2002), Giuliodori (2005), Adams and Fuss (2010), Beltratti and Morana (2010), Agnello and Schuknecht (2011), Igan et al. (2011), Tsai and Peng (2011) and Chang et al. (2012). The empirical results indicate that certain variables have a dramatic impact on house price changes, and that the determinants are not identical in different countries. Given this, it seems reasonable to conjecture that the predictive variables will change when different regional house prices are investigated.

Although the predictive variables of regional house price changes have been investigated in some empirical studies, the inadequacy of their econometric specifications can be attributed to a disregard for the multiple structural changes observed in housing markets. Briefly, the evidence of significant predictors found under specifications that did not consider structural changes may be misleading because the housing cycle is one of the most important characteristics of the housing market. Therefore, taking the fact that the impact of certain predictors may differ at different stages of the housing cycles into account is essential for distinguishing between the effects of different predictors in low-volatility and high-volatility markets. A regime-switching model has been adopted to explore the possible cyclical behaviors of the housing market in a variety of empirical analyses, such as those of Hall et al. (1997) and Crawford and Fratantoni (2003). Chen (2003) and Chen et al. (2004) use the structural time-series model of Harvey (1989) in order to determine the long- and short-run behavior of housing prices in Asian cities. Compared to the structural model, the regime-switching model is able to recognize the driving factors of cyclical patterns and to discuss the impacts of these driving factors.

Regional housing markets in Taiwan have developed vigorously. Some studies, such as those of Chien (2010) and Chen et al. (2011) investigate the interaction among regional housing markets in Taiwan. Chien (2010) explores the housing markets for Taipei, Taichung and Kaohsiung. Chen et al. (2011) examine the regional housing prices in four special municipalities in Taiwan (Taipei, New Taipei, Taichung and Kaohsiung). Tsai and Peng (2011) use housing prices in Taipei, New Taipei, Taichung and Kaohsiung in order to construct a bubble indicator of Taiwan's housing market. This study attempts to investigate the determining factors of house price changes for Taipei, New Taipei, Taichung and Kaohsiung by extending the time-varying transition probability Markov-switching model of Filardo (1994). The contributions of this paper are three-fold. First, following Ghent and Owyang (2010), a principal components analysis is used in order to reduce the number of predictive variables and extract leading components from macroeconomic and global variables. Second, this paper investigates the possibility that the impact of certain predictors may differ at different stages of house price changes. Third, this paper analyzes whether regime-switching patterns and predictors are the same in each city.

The rest of this paper is arranged as follows: section 2 discusses the econometric specification, section 3 reports the empirical results, and finally, section 4 provides the conclusions of the study.

2. The econometric methodology

This paper extends the Markov switching specification of Crawford and Fratantoni (2003) and Hall et al. (1997) in order to discover the regime-switching characteristics and possible determinants of housing returns. The empirical model is as follows:

$$hr_t = a_{0,s_t} + \sum_{i=1}^{m} a_{i,s_t} hr_{t-i} + b_{1,s_t} PC_{1,t-1} + b_{2,s_t} PC_{2,t-1} + \varepsilon_t, \quad \varepsilon_t \sim N(0, \sigma_{s_t}^2) \tag{1}$$

$$\sigma_{s_t}^2 = \exp(\omega_{s_t} + \alpha_{1,s_t} PC_{1,t-1} + \alpha_{2,s_t} PC_{2,t-1}) \tag{2}$$

where hr_t is the regional housing return at time t, ε_t is an innovation that has a normal distribution with a mean of zero and a variance of $\sigma_{s_t}^2$, $PC_{1,t-1}$ is the first principal component, and $PC_{2,t-1}$ is the second principal component. These two components are extracted from six macroeconomic variables: crude oil returns, aggregate stock returns, aggregate housing returns, the growth rate of the consumer price index (CPI), the growth rate of the gross domestic product (GDP) and the first difference in interest rates. The criterion concerning the construction of principal components and the choice of the number of principal components will be introduced in the next section.

Similar to the specification of Hall et al. (1997) and Crawford and Fratantoni (2003), the symbol s_t refers to the state variable and has two values, 1 and 2. The housing market exists in a low-volatility phase when $s_t=1$ and is in a high-volatility stage when $s_t=2$. The time-varying transition probability matrix, which is also controlled by two principal components, can be expressed as follows:

$$M=\begin{bmatrix} P_{11} & P_{21} \\ P_{12} & P_{22} \end{bmatrix}=\begin{bmatrix} \text{Prob}(s_t=1|s_{t-1}=1) & \text{Prob}(s_t=1|s_{t-1}=2) \\ \text{Prob}(s_t=2|s_{t-1}=1) & \text{Prob}(s_t=2|s_{t-1}=2) \end{bmatrix}$$

$$=\begin{bmatrix} \frac{\exp(\delta_1+\beta_{11}PC_{1,t-1}+\beta_{21}PC_{2,t-1})}{1+\exp(\delta_1+\beta_{11}PC_{1,t-1}+\beta_{21}PC_{2,t-1})} & \frac{1}{1+\exp(\delta_2+\beta_{12}PC_{1,t-1}+\beta_{22}PC_{2,t-1})} \\ \frac{1}{1+\exp(\delta_1+\beta_{11}PC_{1,t-1}+\beta_{21}PC_{2,t-1})} & \frac{\exp(\delta_2+\beta_{12}PC_{1,t-1}+\beta_{22}PC_{2,t-1})}{1+\exp(\delta_2+\beta_{12}PC_{1,t-1}+\beta_{22}PC_{2,t-1})} \end{bmatrix} \quad (3)$$

When the two explanatory variables included in Equations (1)-(3) are discarded, the model reduces to the Markov switching specification of Crawford and Fratantoni (2003) who analyzed housing boom-bust cycles for five US states (California, Florida, Massachusetts, Ohio and Texas). Furthermore, compared to the restricted specification of Hall et al. (1997), which only considers the effect of macroeconomic variables on the conditional mean, the main contribution of this paper is that the econometric specification allows the macroeconomic variables to predict not only the regime-dependent housing returns but also the regime-dependent housing variance as well as the evolutionary process of high- and low-volatility states.

3. Empirical results

The housing characteristics of four special municipalities in Taiwan are analyzed here. They are Taipei, New Taipei, Taichung and Kaohsiung. The first two cities are in the north of Taiwan, the third city lies in central Taiwan and the last city is located in southern Taiwan.[1] Obviously, geographical location is one of the idiosyncratic features. A sample period from 1991Q1 to 2010Q4 is selected for this study.[2]

An increase in crude oil prices induces a raise in the prices of raw materials. As pointed out by Chen et al. (2004), crude oil price is one of the most important causes of Taipei's housing cycles. Macroeconomic variables, such as aggregate stock prices, aggregate housing

[1] Before the execution of the Local Administrative Divisions Act on December 25, 2010, there were only two special municipalities in Taiwan (Taipei and Kaohsiung). After this date, however, Taiwan had five special municipalities (Taipei, New Taipei, Taichung, Tainan and Kaohsiung). The Sinyi Real Estate Development Company publishes the quarterly house price indices for Taipei, New Taipei, Taichung and Kaohsiung from the first quarter of 1991. No monthly house price indices are available from the Sinyi Real Estate Development Company. Given the limitations of available regional house price indices, only four special municipalities are analyzed in this paper.

[2] Because the total land areas for Taichung and Kaohsiung enlarged on December 25, 2010, the time series data for the house price index has a structural change. Hence, in this paper, the sample period starts in the first quarter of 1991 (the earliest starting date of released housing price indices) and ends in the fourth quarter of 2010.

prices, inflation rates, interest rates and GDP may be important predictors of housing prices. Stock and housing markets are the main investments in Taiwan. Hence, regional housing prices may be correlated with aggregate stock and housing prices. An increase in CPI growth rates will raise the prices of construction materials for building, causing an increase in housing prices (Anari and Kolari, 2002). Moreover, the interest rate will affect housing prices because the level of mortgage interest rate affects the expenditure of housing-purchasing loan (Reichert, 1990). The GDP reflects the economic condition. Housing prices will increase if economic conditions become better (Ashworth and Parker, 1997; Peng et al., 2008). Thus, one international variable and five macroeconomic variables are investigated here.

Table 1 Summary statistics

	Mean	Maximum	Minimum	Standard deviation	Skewness	Kurtosis	KPSS test
Panel A: Macroeconomic variables							
Oil return	7.207	83.272	-80.192	32.552	-0.281	3.331	0.127
Stock return	2.547	52.959	-64.264	27.075	-0.422	2.789	0.048
House return	2.141	18.206	-14.858	7.735	-0.103	2.273	0.558
CPI growth rate	1.644	5.789	-1.355	1.696	0.336	2.194	0.528
Interest rate	-0.084	2.537	-1.520	0.580	1.218	8.175	0.070
GDP growth rate	5.319	12.207	-8.984	4.558	-1.195	4.306	0.708
Panel B: Regional housing returns							
Taipei	4.331	23.802	-12.874	8.219	0.125	2.299	0.471
New Taipei	2.996	18.302	-10.339	7.303	0.378	2.196	0.470
Taichung	1.243	24.122	-24.356	10.106	-0.104	2.784	0.591
Kaohsiung	1.491	31.960	-28.567	12.344	0.185	2.949	0.335

Notes: The variables represent the annual growth rates, except for the interest rate. The interest rate represents the difference in interest rates between two consecutive periods. The asymptotic critical value for KPSS test is 0.739 at 1% significance level.

The WTI oil spot price was downloaded from the U.S. Energy Information Administration. The aggregate and regional housing indices were collected from the Sinyi Real Estate Development Company. The stock price index was obtained from the Taiwan Stock Exchange. The interest rate was downloaded from the Central Bank of the Republic of China. The CPI and GDP were collected from the National Statistics of the Republic of China.

Table 1 lists the descriptive statistics. For the purpose of handling stationary variables, the variables discussed here represent annual growth rates, except for the interest rate.[3] The first difference in the interest rate is employed here. The last column of Table 1 shows the unit root test results for macroeconomic variables and regional housing returns. All variables are stationary in terms of the KPSS tests.

Figure 1 displays these variables. Visually, the regional housing returns for the four cities are very distinct. As shown in Table 1, Taipei city has the highest average housing return; while Taichung city has the lowest return. The variance of regional housing return is highest for Kaohsiung and lowest for New Taipei.

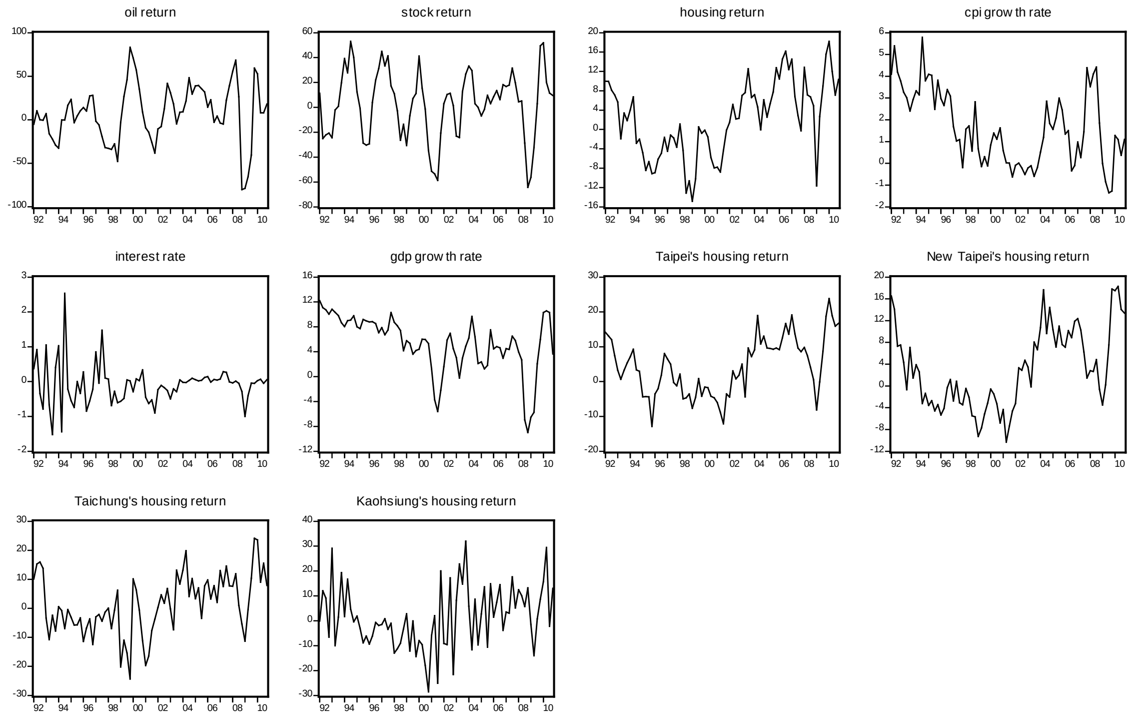

Figure 1 Time series plots for variables

In the time-series framework, when the set of explanatory variables is large and the sample size is not big enough, the coefficients are harder to estimate. An excellent way of reducing the number of predictive variables is by using the principal components technique. The advantage of this technique is that even though the number of regressors is reduced, the explanatory capability of the original regressors is still retained.[4] Hence, this paper uses the

[3] The authors wish to thank an anonymous referee for suggesting that we consider the growth rate of GDP per capita. Graphically, the two time series plots for the growth rate of GDP and growth rate of GDP per capita are almost coincident (not shown here but available upon request). The sample correlation coefficient between the above two variables is as high as 0.99. Hence, only the growth rate of GDP is investigated here.

[4] The principal components method has been used in order to analyze housing markets (Ghent and Owyang, 2010) and stock markets (Fifield et al., 2002).

Table 2 Estimation results

Parameter	Taipei		New Taipei		Taichung		Kaohsiung	
	State 1	State 2	State 1	State 2	State 1	State 2	State 1	State 2
a_{0,s_t}	-3.258***	4.888***	-0.499	6.867**	0.505	-0.343	6.752***	-1.615
	(0.706)	(0.736)	(0.488)	(3.054)	(1.010)	(2.779)	(0.643)	(2.240)
a_{1,s_t}	0.340***	0.176*	0.390***	0.151	-0.150	0.520**	-0.023	0.001
	(0.125)	(0.097)	(0.118)	(0.196)	(0.128)	(0.226)	(0.042)	(0.668)
a_{2,s_t}	0.412***	0.135*	0.111	0.050	0.246**	0.173	-0.145***	0.384***
	(0.099)	(0.071)	(0.147)	(0.243)	(0.106)	(0.193)	(0.043)	(0.145)
a_{3,s_t}					0.337	0.285**		
					(0.242)	(0.116)		
b_{1,s_t}	-1.268*	-3.346***	-0.806*	-0.860	-1.294***	1.829***	-2.887***	-1.928
	(0.507)	(0.724)	(0.464)	(0.905)	(0.443)	(0.632)	(0.206)	(2.776)
b_{2,s_t}	1.811***	1.703***	1.120*	2.103***	3.134***	7.149***	7.235***	-0.776
	(0.455)	(0.610)	(0.589)	(0.636)	(0.612)	(2.204)	(0.361)	(3.953)
ω_{s_t}	0.623	2.189***	1.798***	2.479***	2.966***	4.817***	1.395***	4.759***
	(0.612)	(0.181)	(0.226)	(0.545)	(0.178)	(0.256)	(0.287)	(0.232)
α_{1,s_t}	0.417	0.433***	0.010	-0.107	0.535**	-0.876***	0.770**	0.301
	(0.447)	(0.099)	(0.408)	(0.648)	(0.260)	(0.266)	(0.301)	(0.288)
α_{2,s_t}	-1.163*	0.747***	0.318	-0.147	0.848***	-0.403**	2.125***	0.135
	(0.598)	(0.228)	(0.312)	(0.511)	(0.242)	(0.205)	(0.252)	(0.282)
δ_{s_t}	1.006	2.263***	3.208***	2.857**	3.742***	2.714*	-6.742**	1.411***
	(0.682)	(0.762)	(0.588)	(1.272)	(0.680)	(1.399)	(3.381)	(0.502)
β_{1,s_t}	-0.424*	1.021*	-0.480	-0.682	-0.837***	0.137	1.126*	-0.660
	(0.240)	(0.523)	(0.343)	(0.674)	(0.266)	(0.395)	(0.601)	(0.469)
β_{2,s_t}	0.450	0.220	-0.634	-0.067	0.977**	-1.034	-7.033**	-1.571***
	(0.735)	(0.333)	(0.853)	(1.005)	(0.445)	(1.184)	(2.861)	(0.513)
lnL	-200.236		-191.579		-237.537		-259.760	

Notes: Figures in parentheses are standard errors. *, **, and *** indicates the rejection of the null hypothesis at 10%, 5%, and 1% significance levels, respectively.

principal components method in order to evade the famous econometric problem of insufficient sample observations. Following the criterion of Kaiser (1960), two principal components are chosen due to only two eigenvalue values being greater than 1. The first principal component, PC_1, has a negative relationship with the growth rate of GDP and stock returns, indicating that it captures a lot of information about the GDP growth rates and stock returns. The second principal component, PC_2, has a negative relationship with the growth rate of CPI and a positive relationship with the aggregate housing returns.

Table 2 reports the parameter estimates and the standard errors of parameters. Table 3 shows the Ljung-Box statistics of standardized error terms. The regime-switching AR(2) specification is suitable for Taipei, New Taipei and Kaohsiung, while the housing returns of Taichung need to be fitted by a regime-switching AR(3) specification. Moreover, it is worth emphasizing that the housing returns investigated here do not need to model the ARCH/GARCH effect due to no autocorrelation relationship between squared error terms.

Table 3 Ljung-Box statistics of standardized error terms

	Taipei	New Taipei	Taichung	Kaohsiung
Level	5.057	10.820	13.561	12.756
Square	5.894	8.896	4.633	2.461

Notes: Ljung-Box statistics of order 5 are reported. The critical value is 15.1 at 1% significance level.

Figure 2 displays the housing returns and smoothed probabilities of state 1 for Taipei, New Taipei, Taichung and Kaohsiung, respectively. The return patterns for each market show similar tendencies before 2000, whereas the patterns are very different for the period after 2000. In particular, the amplitude of fluctuation is relatively large for Kaohsiung city from 2000 onwards. The ex-post standard deviation is 1.365 in state 1 and 2.988 in state 2 for Taipei. It is 2.457 in state 1 and 3.454 in state 2 for New Taipei. The deviation is 4.406 in state 1 and 11.117 in state 2 for Taichung, while for Kaohsiung the fluctuation is 2.009 in state 1 and 10.900 in state 2. Obviously, the volatility of housing returns is highest in Taichung and lowest in Taipei for any given state. Moreover, the fluctuation is always higher in state 2 than in state 1. Subsequently, state 1 and state 2 can be called the low-volatility and high-volatility states, respectively.

The identification method of Hamilton (1989) is employed in order to infer the low-volatility and high-volatility periods. The periods occurring during state 1 are very different for the four cities. The persistence of low-volatility is significantly shorter in Kaohsiung than it is in Taipei, New Taipei and Taichung, indicating that the cyclical patterns are fastest in Kaohsiung's housing market. The speed of the cyclical patterns is second largest in Taipei. Compared to the housing market in Taipei, New Taipei and Taichung, Kaohsiung's housing market undergoes state 1 many times over the period 2001-2010, indicating that the housing market of Kaohsiung undergoes a number of turbulent periods. The proportion of low-volatility observations to total observations is approximately 30.67% for Taipei, 62.67% for New Taipei, 68% for Taichung and 30.67% for Kaohsiung.

As shown in Table 2, the magnitude and significance of each principal component identified above on housing returns is very different across the four special municipalities. For each city, the conditional mean is affected by two principal components, both of which have significant effects on housing volatility for Taipei, Taichung and Kaohsiung, but no effect on the conditional variance of New Taipei's housing market. These findings reveal that stock returns, the growth rate of GDP, the growth rate of CPI, and aggregate housing returns are able to affect the housing volatility of Taipei, Taichung and Kaohsiung. However, their effects on the volatility of New Taipei's housing market can be neglected.

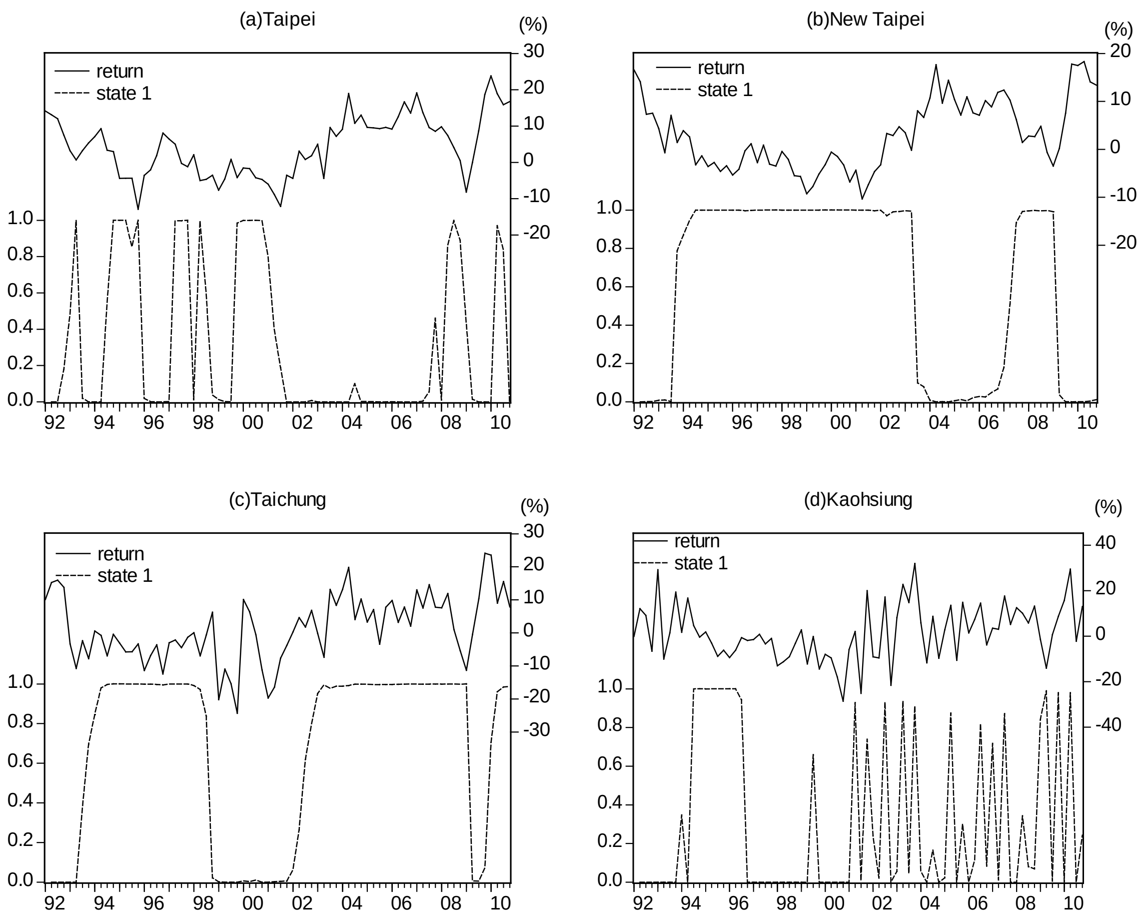

Figure 2 Housing returns and smoothed probabilities of state 1

The variable impact curve (VIC), which borrows the concept of a news impact curve introduced by Henry (2009), is implemented in order to understand the impact of the explanatory variable on conditional variance. Figure 3 displays the variable impact curves of PC1. For Taipei and Kaohsiung, the VIC for PC1 is an increasing function irrespective of states. Moreover, the VIC has a flatter slope in state 1 than in state 2. For New Taipei, the slope of VIC is very close to zero due to the insignificant effect of PC1.

The variable impact curves of PC2 are plotted in Figure 4. The impact curves here show a similar pattern for New Taipei and Taichung. For Kaohsiung, although the VIC is an increasing function in each state, the intensity of PC2 of equal size is stronger in state 2 than in state 1. For Taipei, the VIC shows a positive slope in the high-volatility state, and a negative slope in the low-volatility state.

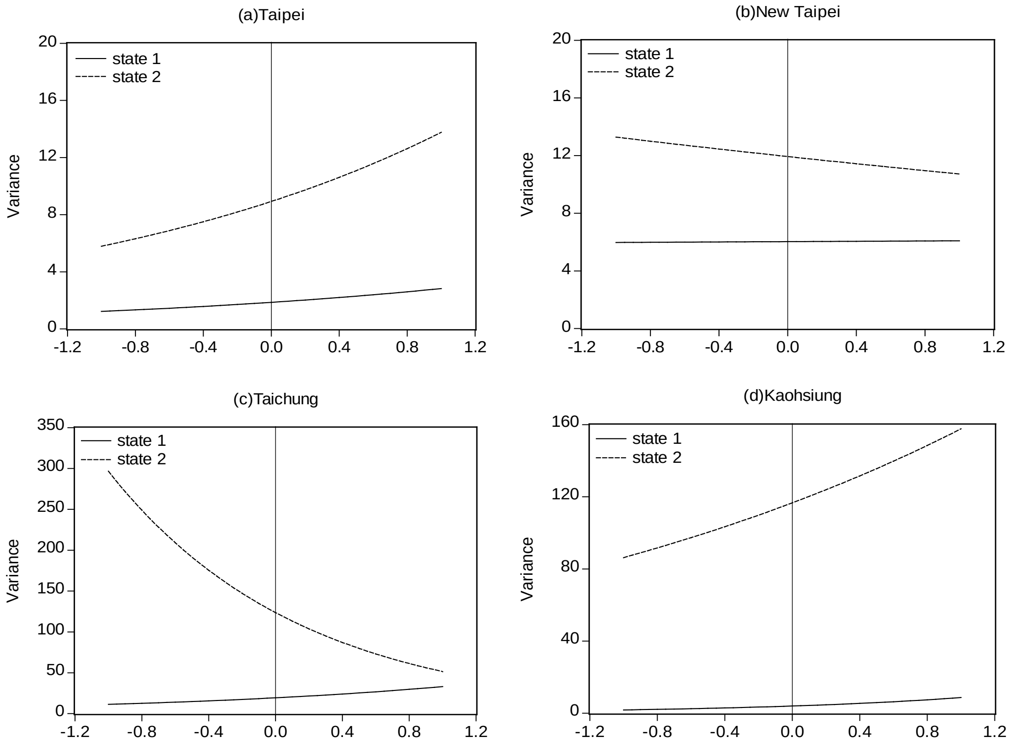

Figure 3 The variable impact curves of PC1

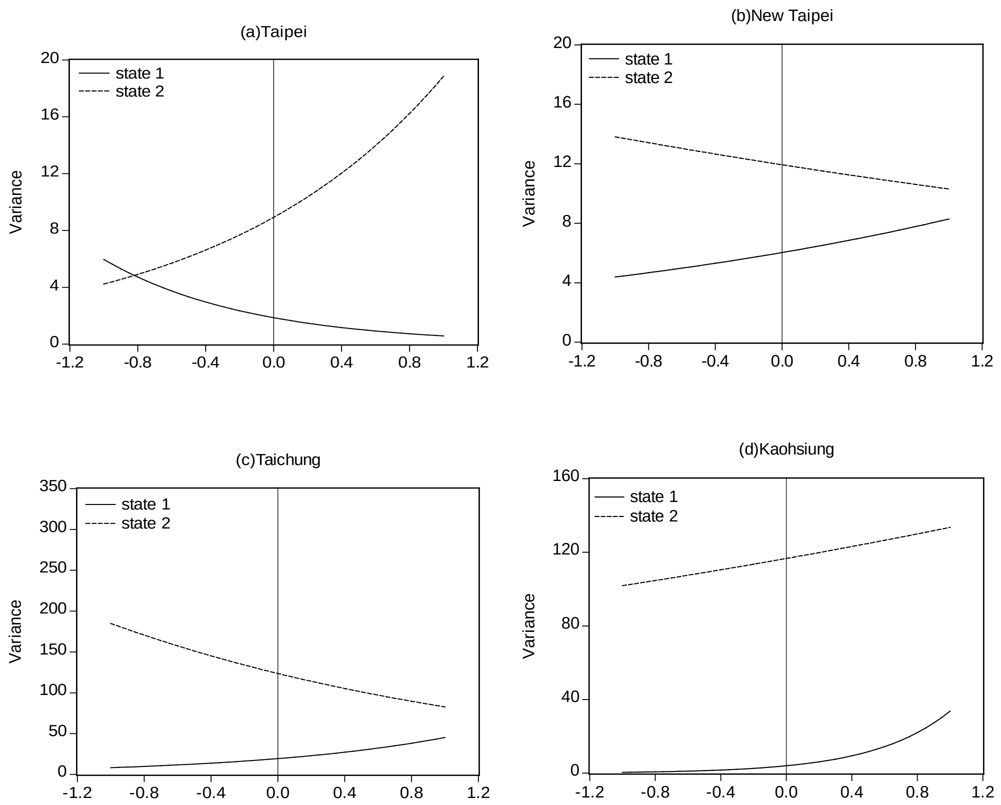

Figure 4 The variable impact curves of PC2

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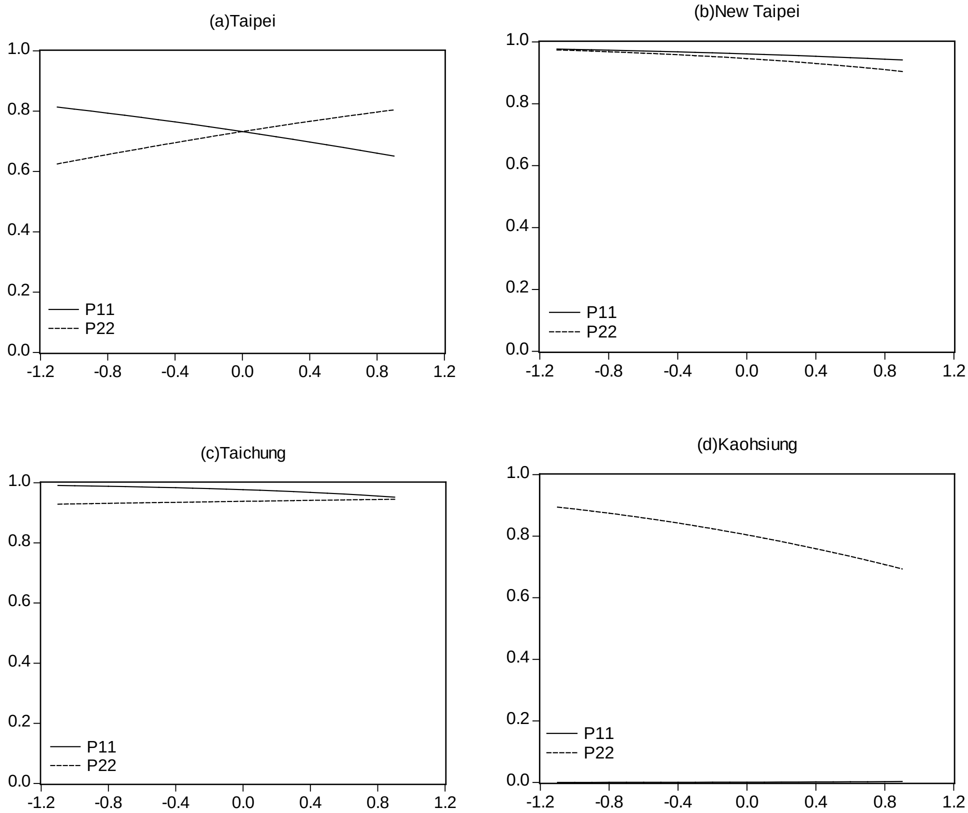

Figure 5 The transition probabilities of PC1

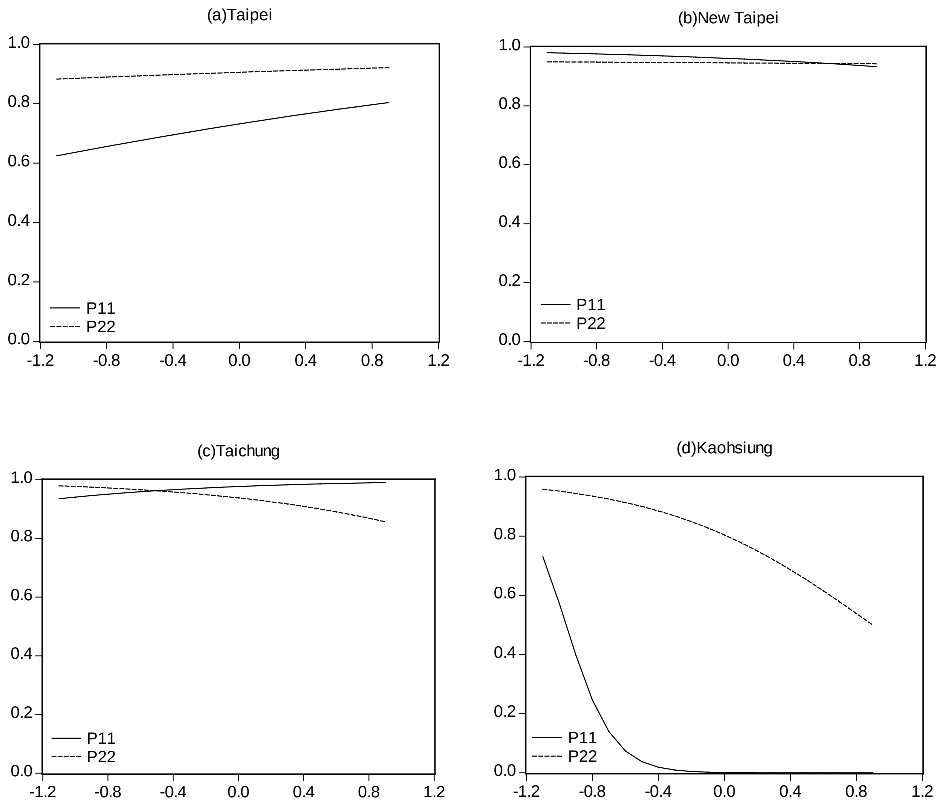

Figure 6 The transition probabilities of PC2

The transition probabilities for PC1 are shown in Figure 5. Obviously, the effect of the principal component on switching structure is very different for each city. Different responses of the housing market to PC1 are found in Taipei. New Taipei and Taichung have similar tendencies in terms of transition probabilities.

Figure 6 displays the transition probabilities of PC2. For Kaohsiung, the responses of transition probabilities to PC2 are negative for each state. For Taichung, the PC2 has a positive and significant effect on probabilities in a low-volatility housing market; however, its effect is negative and insignificant in a high-volatility market.

4. Conclusions

Recent empirical studies have paid attention to regional housing markets, since these markets may behave very differently from national markets. Moreover, regional housing markets may also be linked to the national and world economy, which indicates that both national and global macroeconomic factors may partially determine regional housing prices. The empirical results of this paper reveal some interesting findings. Due to the idiosyncratic characteristics of regional housing markets, the four special municipalities in Taiwan (Taipei, New Taipei, Taichung and Kaohsiung) show different patterns of housing cycles. The volatility cycle in the housing market occurs frequently in Kaohsiung city, and infrequently in New Taipei and Taichung. Some national variables, such as the stock return, the growth rate of GDP, the inflation rate and the national housing return, have important and significant effects on housing cycle patterns as well as on the volatility of housing returns.

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