DOI: 10.6277/TER.201906_47(2).0001

Predicting House Prices with Real-Estate-Related Stocks

Tzu-Yu Lin*

This paper investigates the forecasting content of real-estate-related stock prices for house prices. Using both in- and out-of-sample tests, this paper shows that real-estate-related stock price indices have extremely robust power in predicting US house prices. The empirical results are highly valuable for investors and policy makers because real-estate-related stock prices are shown to be a reliable predictor reflecting timely market information and are readily available to forecast real estate market movements.

Keywords: real-estate-related stock prices, house prices, in- and out-of-sample prediction
JEL classification: R31, G17

1 Introduction

This paper investigates the predictive content of real-estate-related stock price indices for house prices using in- and out-of-sample tests. I show that real-estate-related stock price indices predict US house prices and generally outperform the benchmark predictive regression model without real-estate-related stock prices in pseudo out-of-sample forecast exercises. The novelty of the paper is that it provides evidence that real-estate-related stock prices are a reliable predictor reflecting timely market information and are readily available to forecast real estate market movements. As stock prices are not

*Department of Economics, National Cheng Kung University. E-mail: tylin@mail.ncku.edu.tw. I would like to thank two anonymous referees for comments and suggestions on an earlier version of this paper. Any remaining errors are my own.

經濟論文叢刊 (*Taiwan Economic Review*), 47:2 (2019), 159–182。
國立台灣大學經濟學系出版

臺灣大學學術期刊資料庫

subject to revisions, the proposed predictor can be used with real-time data forecasts, and is valuable to market investors and policy makers.

The recent US subprime mortgage crisis, which commenced in 2007, has revealed the important role of the housing market in affecting the behavior of economic aggregates, and has therefore attracted considerable attention. For example, it has been shown in Case, Quigley, and Shiller (2013) that housing wealth has a statistically significant and large effect on household consumption, and that the effect is consistently larger than that of stock market wealth upon consumption. Iacoviello and Neri (2010) show that housing market spillovers are nonnegligible and that the average spillovers from the housing market to the rest of the economy have become more important over time. Given that housing price movements have such a significant effect on economic activity and financial stability, the forecasting of house prices has become the focus of many economists and decision makers.

Several variables have been proposed to help predict house price movements in the previous literature. First, as an analogy to the present-value relation in stock markets,[1] the rent–price ratio (the cap rate) in real estate markets plays a similar role to the dividend–price ratio for stocks. Hence, a number of studies examine the forecasting content of the rent–price ratio. In general, the rent–price ratio has been shown to have forecasting power; for example, see Gallin (2008), Campbell et al. (2009), and Plazzi, Torous, and Valkanov (2010). Other than the rent–price ratio, demographic variables, which affect residential housing demand, may also have forecasting power. Using quarterly data, Case and Shiller (1990) show that changes in the adult population are a strong predictor for excess returns or price changes over the subsequent year. Finally, numerous works show that house prices are strongly influenced by business cycles and that macroeconomic variables, including income growth, interest rates, and unemployment rates, are important determinants of housing markets. For example, considering four key macroeconomic variables, namely mortgage rates, the consumer price index, employment growth, and the money supply, Baffoe-Bonnie (1998) find that swings in housing prices are significantly influenced by macroeconomic variables. Iacoviello (2005) estimates a VAR model and shows that shocks to monetary policy and inflation have significant impacts on house prices. Negro and Otrok (2007) find that a monetary shock has a statistically significant impact on house prices for the US, although the impact is small

[1] See Campbell and Shiller (1988).

臺灣大學學術期刊資料庫

in comparison with the magnitude of the fluctuations in house prices. Sutton (2002) presents empirical evidence that shocks to national income, stock prices, and interest rates influence US house prices. For a recent comprehensive survey of the literature on real estate price predictability, see Ghysels et al. (2013).

In a recent study by Chen (2014), which demonstrates that oil-sensitive stock price indices, particularly those in the energy sector, have strong power in predicting nominal and real crude oil prices at short horizons. Chen (2016) further investigates a broad range of commodity prices, and shows that the forecasts based on commodity-sensitive stock price indices are able to significantly outperform naive no-change forecasts. Hence, following the ideas in Chen (2014, 2016), this paper proposes to use real-estate-related stock indices to forecast house prices. This predictor is motivated by the close link between the stock and real estate markets documented in the previous literature. In an early work, Gyourko and Keim (1992) show that real estate prices (drawn from the Russell National Council of Real Estate Investment Fiduciaries (NCREIF) property index) and equity real estate investment trust (REIT) returns are related and reflect at least some of the same economic fundamentals. Okunev, Wilson, and Zurbruegg (2000) examine the dynamic relationship between the US real estate market and S&P 500 stock markets from 1972 to 1998, and show that a strong unidirectional relationship exists, running from the stock market to the real estate market. However, to my knowledge, no study examines the forecasting content of real-estate-related stock price indices via both in- and out-of-sample, long-horizon forecast tests.

There are several reasons for considering stock prices as predictors of house price movements. First, as stock prices are a reliable leading indicator of economic booms and busts,[2] which result in active and passive housing activities, respectively. I therefore expect stock prices to predict house prices well. Furthermore, stock prices appear superior as a leading indicator because timely stock price data are readily available for forecasting purposes. As stock prices are not subject to revision, the proposed predictor can be used in real-time data forecasts. Finally, given the slow adjustment of house prices to fundamentals, in contrast to the stock price, which incorporates the fundamental news rapidly, a lead–lag relationship between stock prices and

[2]See, for example, Fama (1981), Moore (1983), Fischer and Merton (1984), Barro (1990), Schwert (1990), and Choi, Hauser, and Kopecky (1999).

臺灣大學學術期刊資料庫

house prices should be expected. In particular, I propose to construct a cap-weighted index for real-estate-related stock prices to forecast house prices. As house prices are key fundamentals for real-estate-related stock prices, it is expected to find that the real-estate-related stock prices contain forecasting power for house price movements via the asset pricing mechanism discussed in Chen, Rogoff, and Rossi (2010, 2012). The proposed indices consist of 8 leading residential construction firms. To maximize the sample size, I use 3 of them to construct a RealEst-3 index to obtain main empirical results, and use all of them to construct a RealEst-8 index for a robustness check.

I conduct a forecasting exercise using in- and out-of-sample tests. The in-sample tests are based on the t-test statistic from a long-horizon predictive regression model, whereas the out-of-sample prediction performance is measured using the mean squared prediction error (MSPE) ratio of the forecasts. The empirical results show that the proposed RealEst-3 index predicts house prices well and generally outperforms the regression model without real-estate-related stock in pseudo out-of-sample forecast exercises. For example, the reduction in the MSPE is shown to be between 0.2% and 7.9%. In general, the results are robust with respect to a variety of specifications. The findings of this paper are then of particular interest to market investors and policy makers, given that valuation ratios and macroeconomic variables fail to provide accurate out-of-sample predictions, as shown in Ghysels et al. (2013).

The structure of the paper is as follows. Section 2 presents the empirical framework. Section 3 describes the data and Section 4 details the key empirical results. Section 5 provides some robustness checks. Finally, I offer a conclusion in Section 6.

2 Econometric Framework

2.1 In-sample predictive regression model

In this paper, I intend to use monthly data to investigate house price predictability based on real-estate-related stock prices. I consider the following long-horizon predictive regression model:

$$p_{t+k} - p_t = \alpha + \beta\,(s_t - s_{t-k}) + \rho\,(p_t - p_{t-k}) + \gamma' \mathbf{Z}_t + u_{t+k}, \qquad (1)$$

where p_t is the log real house price, and s_t is the log real-estate-related stock price index in real term. The real prices of houses and related stocks are

臺灣大學學術期刊資料庫

deflated by the U.S. consumer price index. $\mathbf{Z}_t$ denotes a vector of control variables including relative interest rates, output growth, changes in housing starts, changes in unemployment rates, and general aggregate stock market returns. The forecast horizon k is one, three, six, nine, and 12 months.

I conduct the in-sample test as a test of the null hypothesis of no predictive power for future house price movements: $\beta = 0$ against the alternative hypothesis, $\beta > 0$. Thus, I evaluate the in-sample predictability of real-estate-related stock prices using the t-statistic corresponding to $\hat{\beta}$ with Newey–West Heteroskedasticity and Autocorrelation Consistent (HAC) standard errors to account for correlation induced by the overlapping nature of the dependence variable. Moreover, to provide more concrete evidence of house price predictability, I also construct a 95% bootstrap confidence interval for β.[3]

2.2 Out-of-sample prediction

To conduct an out-of-sample forecasting exercise, the total sample of T observations is divided into in- and out-of-sample portions. There are R in-sample observations, $t = t_0, ..., R$, and P out-of-sample observations, $t = R + 1, ..., R + P$. Obviously, $R + P = T$. Consider the following nested models:

$$p_{t+k} - p_t = \alpha_\tau + \rho_\tau (p_t - p_{t-k}) + \gamma_\tau' \mathbf{Z}_t + u_{t+k}, \tag{2}$$

$$p_{t+k} - p_t = \alpha_\tau + \beta_\tau (s_t - s_{t-k}) + \rho_\tau (p_t - p_{t-k}) + \gamma_\tau' \mathbf{Z}_t + u_{t+k}. \tag{3}$$

It is clear that the unrestricted model (3) nests the restricted model (2) under the no-predictability null hypothesis: $\beta_\tau = 0$.

Let $\hat{\alpha}_\tau$ and $\hat{\beta}_\tau$ be the coefficients estimated by a recursive scheme through period $t = t_0, \cdots, \tau$. To evaluate the relative out-of-sample forecasting accuracy, I use the mean squared prediction error (MSPE) as a measure of prediction performance. Letting $\mathcal{M}^{\mathcal{SP}}$ and $\mathcal{M}^{RM}$ denote the predictive regression model with the housing-related stock prices and the restricted model without housing-related stock prices, respectively, I compute the MSPE ratio as:

$$\frac{\text{MSPE}\left(\mathcal{M}^{SP}\right)}{\text{MSPE}\left(\mathcal{M}^{RM}\right)}.$$

[3]The bootstrap procedure is provided in the Appendix 1.

臺灣大學學術期刊資料庫

Clearly, if the housing-related stock price index has a lower MSPE than the restricted model, the MSPE ratio will be less than one. It is worth noting that the MSPE ratio is related to the out-of-sample R^2 proposed by Campbell and Thompson (2008) as

$$R^2_{oos} = 1 - \frac{\text{MSPE}\left(\mathcal{M}^{SP}\right)}{\text{MSPE}\left(\mathcal{M}^{RM}\right)}.$$

Therefore, a lower MSPE ratio indicates a higher out-of-sample R^2, which suggests that the predictor variable $(s_t - s_{t-k})$ outperforms the restricted model in out-of-sample forecasts.

To assess whether the difference between MSPE($\mathcal{M}^{SP}$) and MSPE($\mathcal{M}^{RM}$) is statistically significant, I formally test the null hypothesis of equal forecasting accuracy that MSPE($\mathcal{M}^{SP}$) = MSPE($\mathcal{M}^{RM}$) against the alternative hypothesis that the candidate model is more accurate than the benchmark-restricted forecast: MSPE($\mathcal{M}^{SP}$) < MSPE($\mathcal{M}^{RM}$), using the Clark and West (2007) MSPE-adjusted test statistic. The Clark–West test is an approximately normal test for equal predictive accuracy in nested models. The null hypothesis is rejected if the test statistic is sufficiently positive.

3 Data

Monthly data from 1976:M1 to 2013:M12 are used, given considerations of data availability. The house price data that I consider are the CoreLogic Home Price Index (single-family home). The real-estate-related stocks I consider are 8 leading companies involved in the residential construction sector with market capitalization larger than $800 million. Details about the individual indices are provided in Table 1. To obtain maximum sample size (i.e., 1976:M1–2013:M12), I construct a cap-weighted (value-weighted) price index, which I call the "RealEst-3 Index", using the stock prices of the following 3 companies: PulteGroup Inc. (PHM), Lennar Corporation (LEN), and Ryland Group Inc. (RYL). I will later construct the "RealEst-8" with a shorter sample period (1987:M1–2013:M12) by adding other 5 companies into the RealEst-3 for robustness check.[4] All the stock prices are obtained from Center for Research in Security Prices (CRSP) Databases.

[4]See Appendix 2 for details of the construction of the real-estate-related stock price indices.

臺灣大學學術期刊資料庫

Table 1: Leading Residential Construction Company

	Company Name	Symbol	Market Capitalization	Sample Span
(1)	PulteGroup Inc.	PHM	7.7B	1976M01–2013M12
(2)	Lennar Corporation	LEN	7.6B	1976M01–2013M12
(3)	Toll Brothers Inc.	TOL	6.5B	1987M01–2013M12
(4)	Standard Pacific Corp.	SPF	2.5B	1987M01–2013M12
(5)	Ryland Group Inc.	RYL	2.0B	1976M01–2013M12
(6)	KB Home	KBH	1.5B	1987M01–2013M12
(7)	MDC Holdings Inc.	MDC	1.5B	1987M01–2013M12
(8)	Hovnanian Enterprises Inc.	HOV	870M	1987M01–2013M12

Notes: The RealEst-3 Index is constructed using stocks (1), (2), and (5) for the main empirical results. The RealEst-8 Index is builded using stocks (1) to (8).

As for other control variables, I use industrial production growth to be a proxy of output growth. Following Ghysels et al. (2013), the relative interest rate is measured by the three-month Treasury bill rate minus its 12-month moving average. The CRSP value-weighted NYSE/AMEX/NASDAQ index (CRSP Index) is used to be the measure of general aggregate stock market prices. Unemployment rates and housing starts are measured by the civilian unemployment rates, and the new privately owned housing units started, respectively. All the data are available from the Federal Reserve Economic Data (FRED) except the CRSP stock price index, which is obtained from the CRSP databases.

Figure 1 shows both nominal and real house prices. The shaded areas indicate the US housing market booms identified by Igan and Loungani (2012) and Bracke (2013).[5] Moreover, Figure 2 depicts the RealEst-3 index and the CRSP index, and Figure 3 plots all of the individual real-estate-related stock price indices.

[5]During the sample period considered in the current paper, the housing market peaks are 1979Q1, 1989Q4, and 2006Q4, while the troughs are 1982Q4 and 1995Q1.

臺灣大學學術期刊資料庫

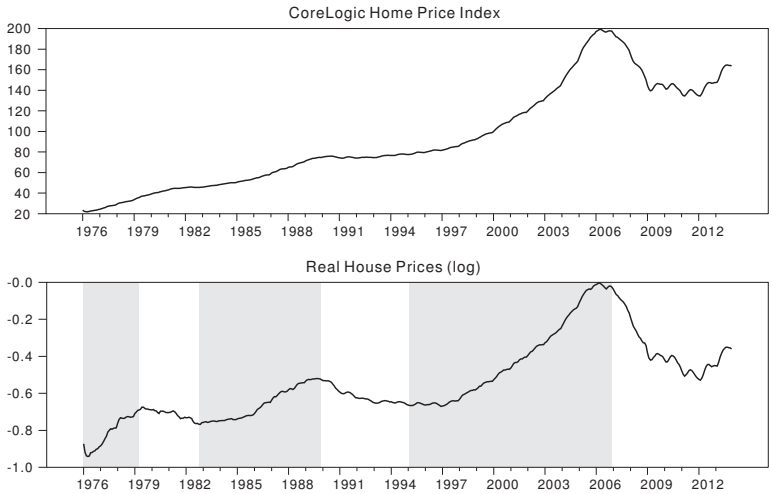


Figure 1: Nominal and Real House Prices. The shading areas indicate the US housing market booms identified by Igan and Loungani (2012) and Bracke (2013).

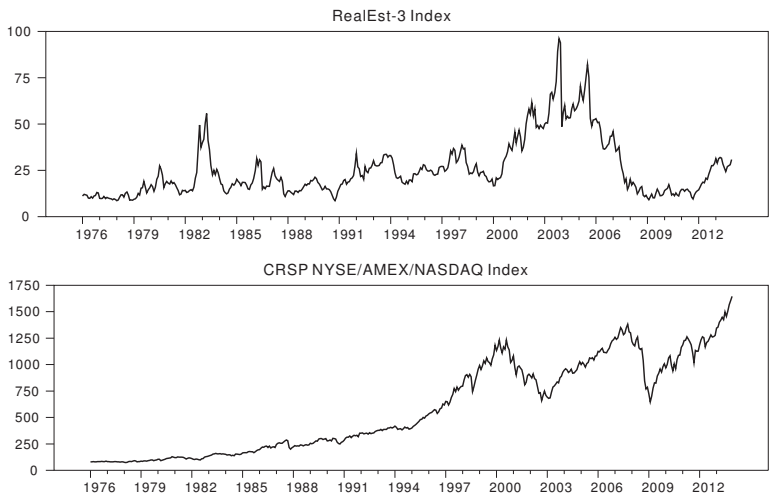


Figure 2: RealEst-3 Index and CRSP Index: The RealEst-3 Index is a cap-weighted index of the three leading companies involved in the residential construction sector.

臺灣大學學術期刊資料庫

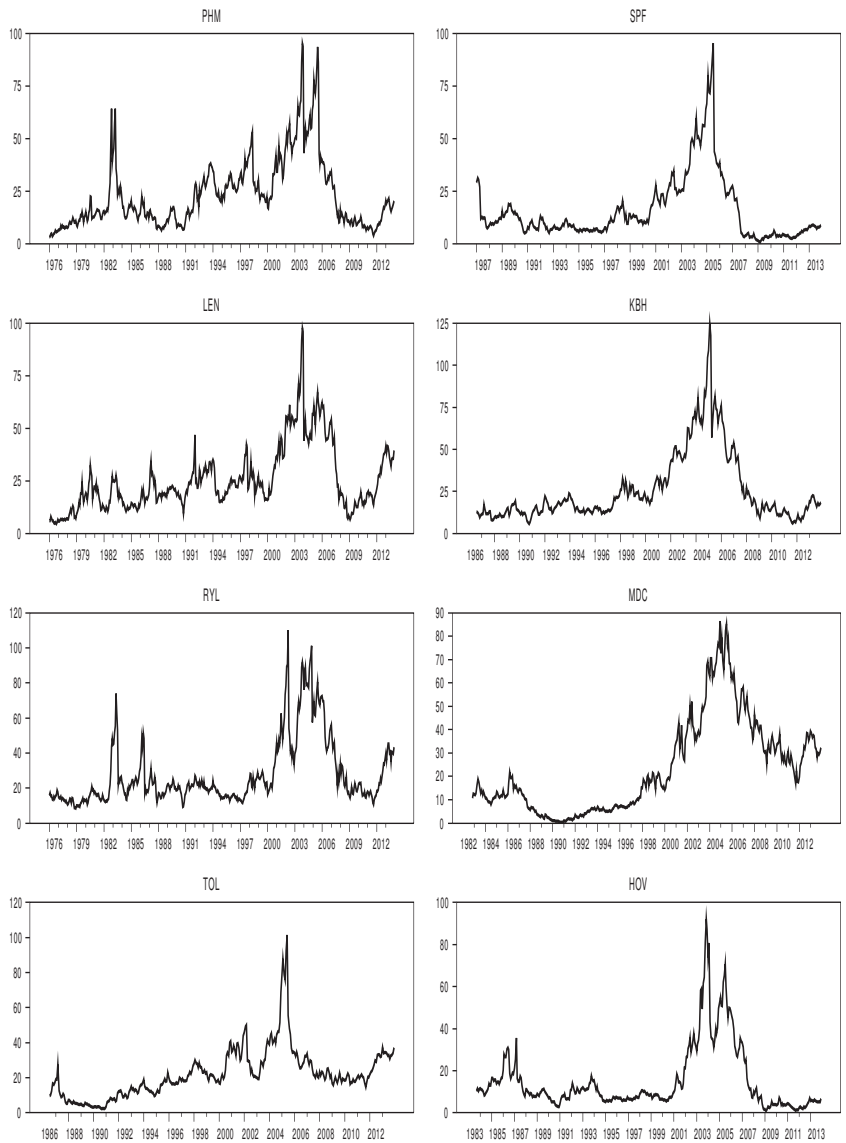


Figure 3: Real-Estate-Related Stock Prices: PulteGroup Inc. (PHM), Lennar Corporation (LEN), Ryland Group Inc. (RYL), Toll Brothers Inc. (TOL), Standard Pacific Corp. (SPF), KB Home (KBH), MDC Holdings Inc. (MDC), Hovnanian Enterprises Inc. (HOV).

臺灣大學學術期刊資料庫

4 Empirical Results

4.1 In-sample predictive regression results

The estimates of the predictive regression model in equation (1), including coefficient estimates, t-statistics, in-sample adjusted R^2, and bootstrap confidence intervals for β are reported in Table 2.

First, it can be observed that the estimates of β are all positive, which suggests that lagged real-estate-related stock returns are positively correlated with house price changes. The positive dynamic correlation is consistent with what we expect because stock prices are strongly forward-looking. An expected positive shock (for instance, good news about future economic fundamentals) that increases current real estate related stock returns will boost booms in the housing market, and result in higher housing prices. Moreover, although short-run forecasting performance (one month ahead) is dismal, the real-estate-related stock returns have statistically significant predictive power for house price movements over longer horizons (three, six, nine, and 12 months). The 95% bootstrap confidence intervals contain zero for $k = 1$ only. That is, the null hypothesis of predictability can be rejected for long horizons. Finally, I use the six-month forecasting horizon to illustrate the economic significance of the estimates of β. For $k = 6$, $\hat{\beta} = 0.037$ suggests that a one percent change in log real-estate-relative stock prices from time $t - 6$ to time t, predicts a 0.037 percent change in the future movements of log house prices from time t to $t + 6$. For example, from 2005:M1 to 2005:M7, the percentage change in the RealEst-3 Index is 25.67%, which provides an estimated percentage change of house prices of 0.95%(= 0.037×0.2567) from 2005:M7 to 2006:M1. During that time period, the actual percentage change of house prices is 2.80%. Hence, real-estate-related stock prices are able to predict 33.93%(= 0.95/2.8) of the change in house prices.

Additional control variables provide some predictive power in different forecasting horizons. The aggregate stock returns are in general negatively correlated with future housing returns, and the predictability is statistically significant for longer horizons ($k = 6$, 9 and 12). Changes in housing starts predict higher future returns in the short run ($k = 1$ and 3), while a higher relative interest rate predicts a lower housing return in the long run ($k = 9$ and 12). Unsurprisingly, high unemployment rates and low output growth are associated with lower future house prices, although the results are not

臺灣大學學術期刊資料庫

Table 2: In-sample Predictability of House Prices

	Horizon				
	$k = 1$	$k = 3$	$k = 6$	$k = 9$	$k = 12$
β	0.000	**0.012**	**0.037**	**0.026**	**0.033**
	[−0.087]	[1.722]	[3.174]	[2.626]	[2.699]
ρ	**0.747**	**0.393**	**0.377**	**0.815**	**0.758**
	[19.440]	[4.605]	[3.104]	[7.360]	[4.971]
CRSP	−0.002	0.020	**−0.048**	**−0.071**	**−0.092**
	[−0.411]	[0.983]	[−2.125]	[−2.687]	[−2.950]
IP	−0.030	−0.024	0.167	0.141	0.196
	[−0.853]	[−0.275]	[1.310]	[1.130]	[1.581]
UNRATE	−0.217	−0.345	−0.148	0.156	−0.025
	[−1.175]	[−0.537]	[−0.146]	[0.239]	[−0.035]
HSTART	**0.002**	**0.012**	0.019	−0.015	−0.026
	[1.708]	[2.212]	[1.554]	[−0.805]	[−0.903]
RTB	−0.015	0.008	−0.010	**−0.465**	**−0.730**
	[−0.774]	[0.070]	[−0.045]	[−2.074]	[−2.264]
Constant	0.026	0.244	**0.868**	0.198	0.249
	[1.050]	[1.564]	[2.419]	[0.334]	[0.230]
$\bar{R}^2$	0.604	0.319	0.363	0.602	0.534
Boot-CI	(−0.002, 0.004)	(0.004, 0.022)	(0.028, 0.058)	(0.018, 0.049)	(0.024, 0.062)

Notes: The predictive regression model is $p_{t+k} - p_t = \alpha + \beta(s_t - s_{t-k}) + \rho(p_t - p_{t-k}) + \gamma'\mathbf{Z}_t + u_{t+k}$, where p_t is the log real house price, s_t represents the log real real-estate-related stock price index, and $\mathbf{Z}_t$ is a vector including the general aggregate stock returns (CRSP), industrial production growth (IP), changes in unemployment rates (UNRATE), changes in housing starts (HSTART), and relative interest rates (RTB, 3-month Treasury bill rate minus its 12-month moving average). Monthly data from 1976:M1 to 2013:M12 are used. Numbers reported in square brackets are t-statistics corrected for heteroskedasticity and autocorrelation by using the Newey-West HAC estimator. Boot-CI represents the 95% bootstrap confidence interval for β. Values in bold type indicate statistical significance at the 10% level; 0.000 indicates the value is smaller than 0.0005.

臺灣大學學術期刊資料庫

statistically significant.

To summarize, empirical evidence shows that real-estate-related stock returns measured by the proposed RealEst-3 Index provide useful information for forecasting real house price changes via in-sample predictive regressions.

4.2 Out-of-sample forecasting performance

I now turn to the evidence obtained from the out-of-sample forecasting. It is well documented in the literature, see Inoue and Kilian (2005) for instance, that in-sample predictability does not necessarily translate into out-of-sample forecasting ability. Moreover, it has been shown in Ghysels et al. (2013) that popular predictors such as valuation ratios and macroeconomic variables fail to provide accurate out-of-sample predictions. Therefore, I examine whether the in-sample house price predictability shown above holds in the out-of-sample forecasting exercise. The out-of-sample results are obtained by setting the out-of-sample period to 1991:M3–2013:M12 (the sample size for the in-sample estimation $R = 182$) so that the in-sample period includes the first housing market cycle, and the out-of-sample period contains the second cycle.

I report baseline out-of-sample test results including the MSPE ratio, and the Clark and West (2007) MSPE-adjusted statistic in Panel (A) of Table 3. According to panel (A) of Table 3, the out-of-sample test results for real house prices generally exhibit patterns similar to the in-sample evidence in Table 2. It is clear that, at long horizons (three to 12 months), the forecasts for housing returns based on the RealEst-3 index produce lower MSPEs than the forecast from the restricted model. For example, the forecasts for house price changes that are based on the RealEst-3 index provide reductions in the MSPEs by 7.9% (for the six-month-ahead forecasts), by 5.4% (for the nine-month-ahead forecasts), and by 5.1% (for the twelve-month-ahead forecasts). These results are statistically significant at the 5% level. However, for the shorter forecast horizon, such as $k = 1$, the RealEst-3 index fails to beat the benchmark forecast from the restricted model.

Using six-month forecasting horizon as an example, I show the time-varying point estimates of β_τ with a 95% confidence interval in Figure 4. The estimates of β range between 0.009 and 0.035 with mean value of 0.016. I also plot the predicted values (dashed line) versus the actual values (solid line) of the regression in Figure 5, where the shaded area represents the out-of-sample period. It can be observed that the estimates are all significant

臺灣大學學術期刊資料庫

Table 3: Out-of-sample Predictability Test Results

	(A) Baseline		(B) Under $\gamma_\tau = 0$	
	MSPE Ratio	Clark-West	MSPE Ratio	Clark-West
$k = 1$	1.004	−0.709	1.002	−0.938
3	0.998	0.542	0.974	**2.597**
6	0.921	**2.503**	0.952	**2.541**
9	0.946	**2.178**	0.965	**2.022**
12	0.949	**2.097**	0.980	**1.171**

Notes: The forecast evaluation period is 1991:M3–2013:M12, and the initial estimation window is 1976:M1–1991:M2. A recursive estimation scheme is used. The MSPE ratio represents (MSPE($\mathcal{M}^{SP}$))/(MSPE($\mathcal{M}^{RM}$)), where $\mathcal{M}^{\mathcal{RM}}$ and $\mathcal{M}^{SP}$ denote the benchmark forecast based on the restricted model (equation (2)), and the predictive regression model based on the real-estate-related stock returns (equation (3)), respectively. Panel (A) reports the baseline results, while results in panel (B) are obtained under the specification $\gamma_\tau = 0$. The statistical significance of the MSPE ratio is inferred from pairwise tests of the null hypothesis of equal predictive accuracy with the benchmark forecast. Values in bold type designate the statistical significance at the 10% level using Clark–West test statistics. The critical values for the Clark–West test statistic are 1.282 (10%) and 1.645 (5%).

and the predictions are quite accurate.

Finally, I further investigate the out-of-sample forecasting performance under the case that $\gamma_\tau = 0$, which excludes other additional control variables. According to such a specification, the restricted model becomes a simple AR model. Clearly, empirical results in panel (B) of Table 3 suggest that my baseline findings of out-of-sample house price predictability using real-estate-related stock prices remain to hold.

5 Robustness Checks

In this section, I make a series of changes to the forecasting exercise to check the robustness of the empirical results. First, I consider different index constructions of the real-estate-related stock prices. Second, I examine

臺灣大學學術期刊資料庫

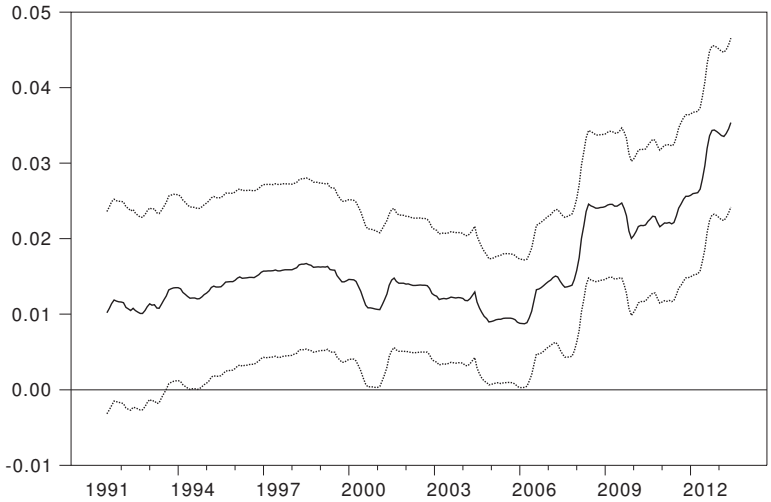


Figure 4: Time-Varying Estimates of β_τ with 95% Confidence Interval

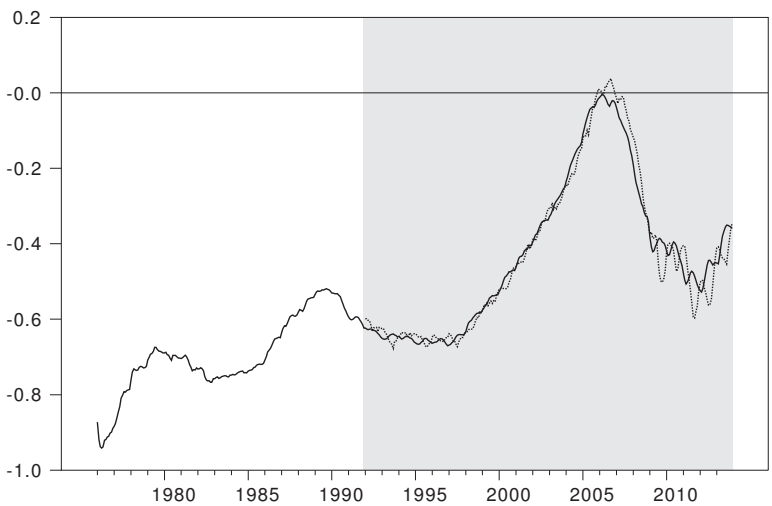


Figure 5: Real House Prices: Actual (solid) versus Forecast (dashed)

whether the predictive power remains highly significant for forecasting nominal house price movements. Finally, I consider an alternative estimation scheme.

臺灣大學學術期刊資料庫

5.1 Alternative stock price index construction

In the main empirical investigation, the RealEst-3 index was constructed using market capitalization as a weight. Now I consider a price-weighted index for robustness check. Moreover, only three stock prices were included for the RealEst-3 index in order to construct a time series with a long sample span. Now, I add five additional real-estate-related stock prices (i.e., TOL, SPF, KBH, MDC and HOV) to build a broad cap-weighted price index with a shorter sample period starting from 1987:M1, which I refer to as the "RealEst-8" index. The out-of-sample tests are conducted with in-sample period from 1987:M1 to 1994:M11, and out-of-sample period from 1994:M12 to 2013:M12.

The results reported in Tables 4 and 5 show that, for both the in-sample predictive regressions and the out-of-sample forecast comparisons, the previous main conclusions remain significant.

5.2 Forecasting nominal house prices

The main focus of the current paper is to investigate the real house price predictability using real prices of real-estate-related stock. In this section, I examine whether nominal stock prices have predictive power for nominal house prices. Clearly, the results in Table 6 provide evidence that my main conclusion remains unchanged when aiming at forecasting nominal house prices. However, it should be notice that evidence for $k = 12$ in out-of-sample forecasts is somewhat weaker.

5.3 Alternative estimation scheme

The out-of-sample forecasting exercise has been implemented with a recursive estimation scheme. I now use the rolling estimation to check if the main findings are robust to different estimation schemes. The empirical results are reported in Table 7. It can be observed that using an alternative estimation scheme does not change the main conclusion.

6 Conclusions

This paper focuses on the dynamic relationship between house price movements and real-estate-related stock returns. I investigate the predictive content of real-estate-related stock price indices for house prices using in- and

臺灣大學學術期刊資料庫

Table 4: Robustness Check: Price-weighted RealEst-3 Index

	Horizon				
	$k = 1$	$k = 3$	$k = 6$	$k = 9$	$k = 12$
β	−0.001	**0.016**	**0.044**	**0.030**	**0.040**
	[−0.319]	[2.204]	[3.499]	[2.909]	[3.113]
ρ	**0.748**	**0.387**	**0.357**	**0.798**	**0.731**
	[19.384]	[4.485]	[2.862]	[7.186]	[4.860]
CRSP	−0.001	0.014	**−0.060**	**−0.078**	**−0.101**
	[−0.252]	[0.669]	[−2.460]	[−2.848]	[−3.108]
IP	−0.031	−0.013	0.185	0.151	**0.209**
	[−0.876]	[−0.143]	[1.440]	[1.227]	[1.718]
UNRATE	−0.215	−0.343	−0.167	0.123	−0.087
	[−1.164]	[−0.538]	[−0.169]	[0.190]	[−0.118]
HSTART	**0.002**	**0.012**	0.019	−0.015	−0.025
	[1.702]	[2.255]	[1.589]	[−0.796]	[−0.894]
RTB	−0.016	0.025	0.040	**−0.437**	**−0.677**
	[−0.796]	[0.213]	[0.165]	[−1.979]	[−2.153]
Constant	0.026	0.256	**0.908**	0.238	0.336
	[1.027]	[1.630]	[2.484]	[0.402]	[0.315]
$\bar{R}^2$	0.604	0.325	0.379	0.607	0.541
Boot-CI	(−0.003, 0.004)	(0.010, 0.029)	(0.036, 0.068)	(0.022, 0.055)	(0.030, 0.074)
MSPE Ratio	1.006	0.995	0.898	0.931	0.931
Clark-West	−0.898	0.897	**2.626**	**2.392**	**2.314**

Notes: See notes to Tables 2 and 3 for more details. Values in bold type designate the statistical significance at the 10% level; 0.000 indicates the value is smaller than 0.0005.

out-of-sample tests. Using the monthly data from 1976:M1 to 2013:M12, I constructed a cap-weighted price index of three leading companies in the residential construction sector, which I called the RealEst-3 index. In-sample predictive regression results show that the RealEst-3 index is a significantly powerful predictor for US house prices. Furthermore, I split the data into two parts to conduct an out-of-sample test. The forecasts for long-horizon

臺灣大學學術期刊資料庫

Table 5: Robustness Check: RealEst-8 Index (1987:M1–2013:M12)

	Horizon				
	$k = 1$	$k = 3$	$k = 6$	$k = 9$	$k = 12$
β	0.003	**0.021**	**0.059**	**0.036**	**0.044**
	[1.189]	[2.158]	[3.916]	[2.567]	[2.506]
ρ	**0.802**	**0.431**	**0.369**	**0.892**	**0.866**
	[22.677]	[4.813]	[2.738]	[7.002]	[4.726]
CRSP	−0.004	**0.041**	**−0.050**	−0.084	−0.128
	[−0.593]	[1.778]	[−1.704]	[−2.562]	[−3.312]
IP	−0.055	−0.131	0.082	0.015	0.181
	[−1.217]	[−1.004]	[0.450]	[0.065]	[0.643]
UNRATE	−0.050	−0.021	0.234	0.125	−0.008
	[−0.226]	[−0.023]	[0.170]	[0.156]	[−0.008]
HSTART	0.001	**0.010**	0.015	−0.029	−0.052
	[1.077]	[1.718]	[1.144]	[−1.354]	[−1.512]
RTB	0.031	0.261	0.652	−0.128	−0.406
	[0.930]	[0.970]	[1.071]	[−0.231]	[−0.506]
Constant	0.055	**0.380**	**0.841**	−0.399	0.379
	[1.446]	[1.745]	[1.889]	[−0.582]	[0.532]
$\bar{R}^2$	0.672	0.370	0.379	0.630	0.569
Boot-CI	(0.001, 0.009)	(0.013, 0.042)	(0.045, 0.090)	(0.028, 0.068)	(0.029, 0.089)
MSPE Ratio	1.004	0.997	0.937	0.965	0.957
Clark-West	−0.740	0.665	**1.840**	**1.643**	**1.494**

Notes: See notes to Tables 2 and 3 for more details. Values in bold type designate the statistical significance at the 10% level; 0.000 indicates the value is smaller than 0.0005.

housing returns (three-, six-, and nine-, and twelve-month-ahead forecasts) based on the RealEst-3 index showed a reduction in MSPEs ranging from 0.2% to 7.9%, beating the forecast from the benchmark predictive regression model without real-estate-related stock prices. Finally, the empirical results (from both the in- and out-of sample tests) in this paper remain robust with respect to changes in index constructions, an alternative estimation

臺灣大學學術期刊資料庫

Table 6: Robustness Check: Forecasting Nominal House Prices

	Horizon				
	$k = 1$	$k = 3$	$k = 6$	$k = 9$	$k = 12$
β	−0.001	**0.012**	**0.036**	**0.027**	**0.041**
	[−0.582]	[1.922]	[3.244]	[2.476]	[2.759]
ρ	**0.788**	**0.425**	**0.387**	**0.786**	**0.717**
	[23.114]	[5.052]	[2.994]	[6.606]	[5.750]
CRSP	**0.009**	0.026	**−0.041**	**−0.062**	**−0.092**
	[1.876]	[1.291]	[−1.711]	[−1.989]	[−2.677]
IP	0.023	0.034	−0.069	−0.092	−0.026
	[0.549]	[0.257]	[−0.388]	[−0.438]	[−0.099]
UNRATE	−0.070	−0.007	−0.548	−0.555	−0.880
	[−0.385]	[−0.011]	[−0.637]	[−0.835]	[−1.086]
HSTART	0.002	**0.014**	**0.024**	−0.007	−0.012
	[1.586]	[2.530]	[2.156]	[−0.420]	[−0.552]
RTB	0.007	0.167	0.367	−0.151	−0.257
	[0.451]	[1.321]	[1.220]	[−0.440]	[−0.587]
Constant	**0.082**	**0.735**	**2.006**	1.040	1.626
	[2.578]	[3.007]	[2.928]	[0.964]	[1.038]
$\bar{R}^2$	0.697	0.409	0.414	0.629	0.589
Boot-CI	(−0.003, 0.001)	(0.005, 0.022)	(0.026, 0.059)	(0.018, 0.053)	(0.029, 0.073)
MSPE Ratio	1.003	0.994	0.943	0.969	0.974
Clark-West	−0.912	0.806	**2.186**	**1.530**	1.049

Notes: See notes to Tables 2 and 3 for more details. Values in bold type designate the statistical significance at the 10% level; 0.000 indicates the value is smaller than 0.0005.

scheme, and nominal house prices.

The main finding of this paper is that the real-estate-related stock prices provide reliable predictability for housing prices. The novelty of this paper, however, arises not only from the good predictive performance reported, but also in two superior characteristics of the newly proposed predictor. First, the ready availability of timely data makes stock prices an appealing predictor

臺灣大學學術期刊資料庫

Table 7: Robustness Check: Rolling Estimation

	(A) Baseline		(B) Under $\gamma_\tau = 0$	
	MSPE Ratio	Clark-West	MSPE Ratio	Clark-West
$k = 1$	1.006	−1.090	1.006	−1.155
3	0.971	**1.963**	0.940	**2.436**
6	0.904	**1.984**	0.874	**2.871**
9	0.947	**2.118**	0.917	**2.830**
12	0.964	**1.593**	0.941	**2.265**

Notes: A rolling estimation scheme is used. See notes to Table 3 for more details. Values in bold type designate the statistical significance at the 10% level using Clark–West test statistics. The critical values for the Clark–West test statistic are 1.282 (10%) and 1.645 (5%).

for house prices. Second, stock prices can be used in real-time data forecasts because they are not subject to revision. Therefore, the evidence provided in this paper is valuable to investors and policy makers who are concerned with the predictability of the housing market.

Appendix 1 The Bootstrap Procedure

I use the following procedure to construct a 95% bootstrap confidence interval for the coefficient β in equation (1).

(S1) Use data to estimate

$$p_{t+k} - p_t = \alpha + \beta\,(s_t - s_{t-k}) + \rho\,(p_t - p_{t-k}) + \gamma'\mathbf{Z}_t + u_{t+k},$$

and obtain the coefficient estimates $\hat{\alpha}$, $\hat{\rho}$, $\hat{\beta}$, $\hat{\gamma}$ and residuals $\{\hat{u}_{t+k}\}$.

(S2) Use the residuals to estimate an AR(q) model,

$$\hat{u}_{t+k+q} = \delta_0 + \delta_1\hat{u}_{t+k+q-1} + \cdots + \delta_q\hat{u}_{t+k} + v_{t+k+q},$$

and obtain the coefficient estimates $\hat{\delta}_j$ and residuals $\{\hat{v}_{t+k+q}\}$. The optimal lag length q is chosen via Akaike information criterion.

臺灣大學學術期刊資料庫

(S3) Generate the bootstrap residuals $\{\hat{v}^*_{t+k+q}\}$ by resampling from the set of residual $\{\hat{v}_{t+k+q}\}$. The bootstrap sample is then constructed recursively by:

$$\begin{aligned}\hat{u}^*_{t+k+q} &= \hat{\delta}_0 + \hat{\delta}_1\hat{u}^*_{t+k+q-1} + \cdots + \hat{\delta}_q\hat{u}^*_{t+k} + \hat{v}^*_{t+k+q},\\ p^*_{t+q+k} - p^*_{t+q} &= \hat{\alpha} + \hat{\rho}\left(p^*_{t+q} - p^*_{t+q-k}\right) + \hat{\beta}\left(s_{t+q} - s_{t+q-k}\right)\\ &\quad + \hat{\gamma}'\mathbf{Z}_{t+q} + \hat{u}^*_{t+q+k}.\end{aligned}$$

(S4) Use the bootstrap data $\{p^*_{t+q+k} - p^*_{t+q}\}$ as well as actual data $\{s_{t+q} - s_{t+q-k}\}$ and $\{\mathbf{Z}_{t+q}\}$ to estimate

$$\begin{aligned}p^*_{t+q+k} - p^*_{t+q} &= \alpha + \beta\left(s_{t+q} - s_{t+q-k}\right) + \rho\left(p^*_{t+q} - p^*_{t+q-k}\right)\\ &\quad + \gamma'\mathbf{Z}_{t+q} + u_{t+q+k},\end{aligned}$$

and obtain the bootstrap estimate $\hat{\beta}^*_b$.

Repeat steps (S2) to (S4) for $B = 5000$ times, and obtain $\{\hat{\beta}^*_b\}_{b=1}^{5000}$. The 95% bootstrap confidence interval is then obtained by the 2.5th and 97.5th percentiles from the bootstrap distribution of $\hat{\beta}^*_b$.

Appendix 2 The Construction of the Real-Estate-Related Stock Indices

Let $P_{i,t}$ and $Cap_{i,t}$ denote the stock price and associated market capitalization of firm i at time t.

1. The cap-weighted price index is constructed by

$$\text{RealEsr-3}_t = \sum_i \frac{P_{i,t}Cap_{i,t}}{\sum_i Cap_{i,t}},$$

for $i = \{\text{PHM, LEN, RYL}\}$.

$$\text{RealEsr-8}_t = \sum_i \frac{P_{i,t}Cap_{i,t}}{\sum_i Cap_{i,t}},$$

for $i = \{\text{PHM, LEN, RYL, TOL, SPF, KBH, MDC, HOV}\}$.

臺灣大學學術期刊資料庫

2. The price-weighted price index is constructed by

$$\text{RealEsr-3}_t = \sum_i \frac{P_{i,t}}{3},$$

for $i = \{\text{PHM, LEN, RYL}\}$.

$$\text{RealEsr-8}_t = \sum_i \frac{P_{i,t}}{8},$$

for $i = \{\text{PHM, LEN, RYL, TOL, SPF, KBH, MDC, HOV}\}$.

References

Baffoe-Bonnie, John (1998), "The Dynamic Impact of Macroeconomic Aggregates on Housing Prices and Stock of Houses: A National and Regional Analysis," *Journal of Real Estate Finance and Economics*, 17(2), 179–197.

Barro, Robert J. (1990), "The Stock Market and Investment," *Review of Financial Studies*, 3(1), 115–131.

Bracke, Philippe (2013), "How Long do Housing Cycles Last? A Duration Analysis for 19 OECD Countries," *Journal of Housing Economics*, 22(3), 213–230.

Campbell, John Y. and Robert J. Shiller (1988), "The Dividend-Price Ratio and Expectations of Future Dividends and Discount Factors," *Review of Financial Studies*, 1(3), 195–228.

Campbell, John Y. and Samuel B. Thompson (2008), "Predicting Excess Stock Returns Out of Sample: Can Anything Beat the Historical Average?" *Review of Financial Studies*, 21(4), 1509–1531.

Campbell, Sean D., Morris A. Davis, Joshua Gallin, and Robert F. Martin (2009), "What Moves Housing Markets: A Variance Decomposition of the Rent-Price Ratio," *Journal of Urban Economics*, 66(2), 90–102.

Case, Karl E., John M. Quigley, and Robert J. Shiller (2013), "Wealth Effects Revisited: 1975–2012," NBER Working Papers, No. 18667.

Case, Karl E. and Robert J. Shiller (1990), "Forecasting Prices and Excess Returns in the Housing Market," *Real Estate Economics*, 18(3), 253–273.

Chen, Yu-Chin, Kenneth S. Rogoff, and Barbara Rossi (2010), "Can Exchange Rates Forecast Commodity Prices?" *Quarterly Journal of Economics*, 125(3), 1145–1194.

臺灣大學學術期刊資料庫

Chen, Yu-Chin, Kenneth S. Rogoff, and Barbara Rossi (2012), "Predicting Agri-commodity Prices: An Asset Pricing Approach," in Bertrand R. Munier (ed.), *Global Uncertainty and the Volatility of Agricultural Commodities Prices*, Amsterdam and Berlin: IOS Press, 45–71.

Chen, Shiu-Sheng (2014), "Forecasting Crude Oil Price Movements With Oil-Sensitive Stocks," *Economic Inquiry*, 52(2), 830–844.

——— (2016), "Commodity Prices and Related Equity Prices," *Canadian Journal of Economics*, 49(3), 949–967.

Choi, Jongmoo Jay, Shmuel Hauser, and Kenneth J. Kopecky (1999), "Does the Stock Market Predict Real Activity? Time Series Evidence from the G-7 Countries," *Journal of Banking and Finance*, 23(12), 1771–1792.

Clark, Todd E. and Kenneth D. West (2007), "Approximately Normal Tests for Equal Predictive Accuracy in Nested Models," *Journal of Econometrics*, 138(1), 291–311.

Fama, Eugene F. (1981), "Stock Returns, Real Activity, Inflation, and Money," *American Economic Review*, 71(4), 545–565.

Fischer, Stanley and Robert C. Merton (1984), "Macroeconomics and Finance: The Role of the Stock Market," *Carnegie-Rochester Conference Series on Public Policy*, 21(1), 57–108.

Gallin, Joshua (2008), "The Long-Run Relationship Between House Prices and Rents," *Real Estate Economics*, 36(4), 635–658.

Ghysels, Eric, Alberto Plazzi, Rossen Valkanov, and Walter Torous (2013), "Forecasting Real Estate Prices," in Graham Elliott and Allan Timmermann (eds.), *Handbook of Economic Forecasting*, vol. 2, Elsevier, 509–580.

Gyourko, Joseph and Donald B. Keim (1992), "What Does the Stock Market Tell Us About Real Estate Returns?" *Real Estate Economics*, 20(3), 457–485.

Iacoviello, Matteo (2005), "House Prices, Borrowing Constraints, and Monetary Policy in the Business Cycle," *American Economic Review*, 95(3), 739–764.

Iacoviello, Matteo and Stefano Neri (2010), "Housing Market Spillovers: Evidence from an Estimated DSGE Model," *American Economic Journal: Macroeconomics*, 2(2), 125–164.

Igan, Deniz and Prakash Loungani (2012), "Global Housing Cycles," IMF Working Papers, No. 12/217.

臺灣大學學術期刊資料庫

Inoue, Atsushi and Lutz Kilian (2005), "In-Sample or Out-of-Sample Tests of Predictability: Which One Should We Use?" *Econometric Reviews*, 23(4), 371–402.

Moore, Geoffrey H. (1983), *Business Cycles, Inflation, and Forecasting*, 2nd, Cambridge, MA: National Bureau of Economic Research, Inc.

Negro, Marco Del and Christopher Otrok (2007), "99 Luftballons: Monetary Policy and the House Price Boom Across U.S. States," *Journal of Monetary Economics*, 54(7), 1962–1985.

Okunev, John, Patrick Wilson, and Ralf Zurbruegg (2000), "The Causal Relationship between Real Estate and Stock Markets," *Journal of Real Estate Finance and Economics*, 21(3), 251–261.

Plazzi, Alberto, Walter Torous, and Rossen Valkanov (2010), "Expected Returns and Expected Growth in Rents of Commercial Real Estate," *Review of Financial Studies*, 23(9), 3469–3519.

Schwert, G. William (1990), "Stock Returns and Real Activity: A Century of Evidence," *Journal of Finance*, 45(4), 1237–1257.

Sutton, Gregory D. (2002), "Explaining Changes in House Prices," *BIS Quarterly Review*, September, 46–55.

投稿日期: 2017年3月27日, 接受日期: 2018年1月9日

臺灣大學學術期刊資料庫

使用房地產相關股票之價格預測房價

林姿妤
國立成功大學經濟學系

本文探討房地產相關股票之價格是否有助於預測房價。透過樣本內與樣本外預測分析, 結果發現, 房地產相關股票的價格對於美國房價的預測表現極佳。根據此實證結果, 由於股票價格可及時反應市場資訊, 且無資料修正問題, 因此對於投資人及政策制定者而言, 房地產相關股票之價格不失爲房價之良好預測指標。

關鍵詞: 房地產相關之股票價格, 房價, 樣本內與樣本外預測
JEL 分類代號: R31, G17

臺灣大學學術期刊資料庫