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學術論著

Time-Series Properties and Modelling of House Prices in Taipei Area: An Application of the Structural Time-series Model

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台北地區住宅價格之時間序列特性與模型：結構性時間序列模型之應用

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ABSTRACT

This paper analyses the unobserved components of Taipei house prices based on the Structural Time-series Model. It shows how stochastic and deterministic trends characterise long-run behaviour of Taipei house prices. Stochastic cycles were found in this price series around 2 and 7 years. Although Taipei housing market is though to have 7-year cycle, model suggests that the cycle is stochastic rather than deterministic. Using statistically specified unobserved components, we tested the long-run and short-run structural time-series house price models. These models all have good forecasting powers and acceptable diagnostic test statistics.

Keywords: House Prices, Structural Time-series Model, Unobserved Components

摘　要

本研究採用結構性時間序列模型以分析台北地區住宅價格中不可觀察的時間序列成分。本研究以隨機性與確定性的趨勢成份來展現台北地區住宅價格長期的變動行爲。本研究也發現台北地區住宅價格隱含二年與七年的隨機性循環變動成分，雖然台灣住宅市場有七年一循環之說，但此循環不是固定長度的。我們使用這些不可觀察的時間序列成分來估計住宅價格長短期模型，這些模型通過統計檢定並且有不錯的解釋能力，而樣本內與樣本外的預測也都有相當的穩定度。

關鍵詞：住宅價格、結構性時間序列模型、不可觀察成分

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1. Introduction

Over the last few decades, sustained long run growth in house price and its recurrent fluctuations around the growth path seems to be a common phenomena in many countries in the world (Chen, Kawaguchi and Patel, 2004). The behaviour of house price has attracted many attentions of research to investigate their causes. However, cyclical fluctuations in GNP, interest rate or consumption seem to have been relatively moderate in comparison. This may partly account for the failure of existing economic models to come up with a satisfying explanation of the boom and bust behaviour of the housing markets. It is therefore important to understand the nature of trend and cyclical fluctuations in price series before attempting to study their underlying macroeconomic causes.

In this paper, we investigate Taipei house price behaviour by using the Structural Time-series (STS) methodology suggested by Harvey (1989) and Harvey and Shephard (1993). We first tried to characterise the long-run behaviour of the house prices based on the various specifications of the long-run trend models in the STS method in order to understand the long-run movement. We then tried to characterise the short-run cyclical behaviour of the house prices in order to discover the hidden cyclical behaviour. Although many have argued that there exists 7-year cycle in the Taiwan housing market, no study has used a well-defined statistical model to test whether it indeed exists. Therefore, we test this hypothesis and also expect to observe some distinct time-series behaviours of prices.

The significance of this study can be found in its elucidation of trend and cycle behaviour in Taipei house price series, which would help governments make policies and property investors create more effective property management strategy. Since the causes of the house price fluctuations in the Taipei housing markets have been examined and clearly described by many studies, this paper focuses analysing the house price behaviour.

This paper proceeds as follows. Section 2 describes Taipei hosue price behaviour historically. Section 3 outlines the theoretical framework of time-series components and the STS model. Section 4 tests the time-series components of house price series. Section 5 presents STS model estimates for Taipei house prices and shows how well the model performaned. Concluding remarks follow in the final section.

2. Background Discussion

2.1. Causes of House Price Fluctuations in Taipei Area

The Taiwan housing market experiences very high rate of growth in house prices for past few decades. During the past 34-year period, the nominal and real average annual price in Taipei area (details of our data series are given in section 4 and appendix) increase was 14.0 and 5.0 percent respectively. The standard deviation of the average nominal house prices was almost 34.5 percent over the sample period indicating that house prices are highly volatile. There were three major boom periods from 1970s: 1972-74, 1978-80 and 1987-89. The rises in house prices in the first and second booms were commonly seen to have been caused by the oil embargo (Chen, 1990; Wu, 1994). Being a small open economy, Taiwan is readily affected by external shocks caused by changes in international prices and currencies. The effects of the oil embargo were worldwide and were especially severe in oil-importing countries. Because 75 percent of energy and all oil is imported, the housing market as well as the whole economy was seriously affected by this crisis. The sudden increase in oil prices led directly to high inflation in most commodities and a sharp rise in the cost of construction, which triggered the expectation of house price increases. Money supply is believed to be another important factor behind the first and second booms. Before the booms, Taiwan had a few years of high economic growth that maintained a high rate of around 12 to 13 percent. The trade surplus caused foreign money expansion and also led to increases in domestic money supply. Lower interest rates further caused an expansion of domestic money supply and stimulated investment in the housing market. The main cause of house price increases during the third boom was in the rapid expansion of money supply (Chen, 1990; Wu, 1994). The inflation rate at general price level was relatively stable and did not play a significant role in this boom compared with the previous booms. The primary reason behind the increase of money supply was continuing high economic growth around 12 to 13 percent, and also a number of other factors. For example, the credit restrictions were relaxed in 1987, causing the expansion of lending volume to housing by banks. In addition, a change in the foreign exchange rate regime and liberalisation of foreign exchange control (removal of foreign exchange limitations) induced speculative activity in the foreign exchange market, causing foreign money flow into and out of domestic financial markets. Because Taiwan's currency finally appreciated almost 40 percent, this raised the level of domestic money supply.

Historically it can be argued that long-term house prices in Taiwan are greatly influenced by demographic pressure, the availability of land, income and accumulated wealth. However, in the short-run, the housing market behaves more like an asset market. Taiwan house price behaviour seems to be characterised by sustained long-run growth and the recurrent fluctuations around the growth path.

2.2. Review of House Price Time-series Studies

Only few of hose price studies of past few decades address magnitudes and durations in house price time-series behaviour. Literatures from the UK on property markets have reported various magnitudes and durations of cyclical patterns between 4 years and 18 years duration. In the UK for the Post-War period, Barras and Ferguson (1985) identified a short building cycle of 15 to 18 quarters (3.75 to 4.5 years) and a longer major building cycle of 26 or 35 quarters (6.5 or 8.75 years). Rosenthal (1986) suggests that there might be a cycle of 6-8 years in the UK house prices. Alexander and Barrow (1994), using spectral analysis, found a quarterly seasonal cycle in UK regional house prices and also suggested that there were 5 to 10-year cycles in house prices across different regions in the UK. Brown (1990) indicated that UK residential market has generally followed the business cycle, which seemed to be about 8 to 10 years in length.

For Taiwan, Chen (1980), investigating fluctuation in construction activity in Taiwan between 1956 and 1978, and reported three major cycles and seven minor cycles, with major cycle lasting 8 years and minor cycles 2.5 to 3 year. House price cycles in Taiwan are also generally believed to last around 7 years. Chen and Patel (1995) suggested that there were 1 to 7-year cycles in Taipei house price series.

The problem with previous empirical studies of house prices is that they are mainly based on spectral analysis with the cycles assumed to have a fixed length1. Therefore, they cannot assess whether the cycles change over time.

3. Theoretical Framework and Methodology

3.1. Time-series Properties in the House Prices

Visual inspection of graphics of a time-series can usually reveal trends, cycles, seasonal and irregularity as important features. A trend indicates the general direction in which the series is moving. Most time-series such as GNP or money supply exhibit a persistent upward trend over time. Similarly, house prices have continuously increased. As noted in previous section, Taipei house prices in real term shown a clear upward trend with a rate of 5.0% during our sample period between 1968 and 2002. The price increases in Taipei have been inevitable because the falling supply of houses has been accompanied over the years by an increasing demand for home-ownership. Consequently, the upward long-run trend has been fuelled by demand sustained by rising income and demographic factors which account for both the increase in value as well as the stock of housing overtime.

House price cycles are generally believed to be the product of the short run deviations from long run upward trends reflecting lag response of supply to changes in effective demand. More precisely, the endogenous causal factor of price cycles is the long production period between new building orders and completions. A delayed supply response can initially cause prices to overshoot the level that would be justified by increase in effective demand. This overshooting is more likely to prompt housebuilder to increase the stock of new developments beyond the level justified by the higher effective demand, subsequently causing price and development activity to decline until the excess stock approximates demand. A tendency of cyclical fluctuations in development is thus endogeneously propagated. Burn and Mitchell (1946) define business cycles as a type of fluctuation found in the aggregate economic activity of nations that organise their work mainly in business enterprises. That is a cycle consists of expansions occurring at about the same time as many economic activities and is, followed by their own general recessions, contractions, and revivals which merge into the expansion phase of the next. In addition to the endogenous production lag, cycles generated by changes in monetary policy play an important role in stimulating and dampening housing market activity. Given the nature of housing finance, variable short-term interest rates significantly affect households cash flow position. While interest rates fall, competition to capture the market share amongst building societies and banks have resulted in overexertion of credit in the housing market. These monetary cycles have tended to correspond with increase in effective demand in the housing market. Apart from those endogenous and exogenous cycles, the seasonal cycles should certainly exist because of the seasonal fluctuations in building activities.

Intervention also usually affects the movement of house price series. The impact of exogenous shocks and macro economic policy changes on the housing market can be either temporary or more permanent. The effects of exogenous factors such as the oil crises in 1970s, financial liberalisation, or the change in the system of interest tax relief, are likely to create irregular short-term in house prices.

Household expectations are also important factors in house price behaviour. They cause rapid price adjustments and further increases in magnitude and duration of house price fluctuations, at times making the fluctuations in the housing market larger than those in other economic sectors. According to the rational expectations theory, agents make full use of relevant available information to form their expectations and do not make systematic forecasting errors. However, the rational expectations hypothesis does not apply to the inefficient housing market. In the housing market, expectations are clearly not formed rationally especially on the demand sides because of imperfect information and other market distortions. Hence, individuals tend to over or under react to the price signals, which might explain why house prices usually show relatively greater fluctuations than other economic activities.

3.2. The Structural Time-Series Model

Economists have shown interest in unobservable components for some time. For trend, seasonal and cyclical components deterministic specifications, such as fixed polynomials in time or cosine function, were used initially. These purely deterministic approach were replaced later by moving average methods, the most prominent example of which is the X11 for seasonal adjustment and the Hodrick-Prescott (HP) filter for trend removal. While these ad-hoc filters are simple and easy to use, they also have serious disadvantaged and limitations[2]. To overcome the problems associated with ad-hoc filtering, the structural time-series model, based on parametric models, has been developed. The advantage of working with STS model is that all the underlying assumptions are clear, making it possible to adapt signal extraction to the particular characteristics of the series and test the adequacy of the model to the available data. In forecasting, the STS model is unlike such early ad-hoc forecasting methods as exponential smoothing, which are implemented with no regard to properly defined statistical model. As an alternative to the traditional Box-Jenkins (1976) methodology, Harvey and Todd (1983) compared the forecasts made by a basic form of the structural model with the forecasts mad by autoregressive integrated moving average (ARIMA) models, they concluded that there are strong arguments in favour of using structural models in practice.

In this section we outline the STS models of Harvey (1989), and Harvey and Shephard (1993). These models can be used to decompose observed house price series into trends, cycles seasonals, and irregular components. A standard structural time series model is expressed

, , ...T .... (1)

where is the logarithm of the observed value of the series, is the trend component, is the cyclical components, is the seasonal components and is the irregular component. The trend, cyclical and seasonal components are assumed to be uncorrelated while is assumed to be white noise.

A trend may take a variety of forms. Normally, we refer to the trend in the time-series as stochastic or deterministic. This distinction makes a great difference in series estimation and forecasts. The deterministic linear tend model can be represented as follows:

.... (2)

There are many various types of deterministic trends as the linear one specified in equation (2). The trend may not be linear if we replace with or . A deterministic linear trend could be made stochastic by letting and follow random walks. According to Harvey (1989), a model can be specified by working directly with the current level, , rather than with the intercept, , since may be obtained recursively:

.... (3)

with , stochastic terms may be introduced as follow:

.... (4)

with .... (5)

where is the slope or gradient of the trend . The normal white-noise disturbances, and all other disturbance, are independent of each other. The effect of is to allow the level of the trend to shift up and down and allows the slope to change.

The stochastic properties of the model as a whole depend on the full set of the disturbances that are assumed to be mutually and serially independent. Basically, the trend components in a STS model are reduced to deterministic functions of time when their stochastic parts are removed. The final forecast function for this trend component has the same form as this deterministic function of time. Thus, in the local linear trend model, setting and equal too zero for all in (4) and (5) leads to and the forecasting function is a straight line.

According to Harvey, the statistical specification of a cycles , is given by

, ,........T .... (6)

where , in the range *0<* *≤1*, is a damping factor, is the frequency, in radians, in the range *0* < ≤ ; and are two mutually uncorrelated NID disturbances with zero mean and common variance . Note that the period of the cycles is equal to . There may be some additional cycles of this form incorporated in the model.

The seasonal component has the dummy variable form or the trigonometric form. The number of seasonal frequencies in a period (e.g. a year) is given by integer s. When s is even, *[s/2] = s/2*, and when s is odd, *[s/2] = (s-1)/2*. The seasonal dummy is given by

, ... (7)

The trigonometric seasonal form is

.... (8)

where each is generated by

$j=1,....,[s/2],\ t=1,\ ....T$ .... (9)

where is the frequency, in radians, and the seasonal disturbance and are two mutually uncorrelated NID disturbance with zero mean and common variance . For s even, the component at $j=s/2$ collapse to

The extent to which these components evolve over time can be examined by the values of , and . The zero value for the parameter indicates that corresponding component is deterministic. These parameters can be estimated by maximum likelihood procedure in the time or frequency domain once the model has been written in a state space form. Such estimates were then placed within the state and error system matrices so that Kalman filter could be used to compute the unobserved components.

4. Examination of Time-series Properties in House Price Series

House price movement is characterised by a long-run trend with a degree of short-run variability. In the long-run, household number, income, construction costs and supply of houses are the most important variables. In the short-run, money supply or stock prices are likely to have a stronger influence (see Chen and Patel, 2002). Because the long-run is a steady state relationship representing an equilibrium state in the housing market and the short-run represents the house price adjustments towards a new equilibrium, previous studies usually analyse house price determinations and empirically verify them in both ways (see Giussani and Hadjimatheou, 1990; Milne, 1991; Breedon and Joyce, 1992, etc.). Therefore, our study, based on the STS model, examines house price series for their long-run movement and short-run fluctuations.

We use the house price index from Construction and Planning Administration is because this data can allow us to do a long-term analysis (more than 30 years) in quarterly form. The other price indices such as Cathay or Shinyi price indice are only ten years, which is too short to analyse cyclical behaviour. The house prices used are also the primary data sources for tracking house prices historically. Our sample period is from 1968Q1 to 2002Q4 (please see the appendix for detail) and our data are converted to natural logarithms.

Because some possible structural changes have been identified by previous studies, our models have to assume structural breaks in the series in order to eliminate their influence. Just as other studies have found such structural breaks (Lin, 1996a,b; Peng and Chang, 2000; Chen and Patel, 2002; Yang 2003, Tsai and Chen, 2003; for example[3]), so has our sample been assumed to have possible structural changes. Among these possible structural changes, the three-fold jump in the late 1980s was the most significant because it was the highest price jump in Taiwan in history and it was also received consistent agreement of structural change by most studies. Therefore our study treats it as a structure changes[4]. Our model takes the value 1 during 1987Q2 to 1988Q4 and zero elsewhere as suggested in Chen and Patel (2002).

4.1. Examination of Long-run Trend in House Price Series

A quick glance at the data would show that thee house price series is clearly non-stationary and we might imagine the Taipei house prices series to have certain trend behaviours. Although visual inspection does have its perils, formal testing is necessary to substantiate any impressions. Therefore, using the STS models, we examine four possible types of time-series bahaviours as follows:

I Stochastic level and stochastic slope

II Deterministic trend type A: linear trend

III Deterministic trend type B: non-linear trend

IV Deterministic trend type C: non-linear trend

Table 1 summarises the results of the trend specifications I - IV, and Figure 1 shows the graphical description of the original series with the fitted deterministic or stochastic trends[6]. A number of points emerge from the results. First, the estimations of parameters and indicate that the level and slope of house prices appear to evolve over time (i.e. , > 0), suggesting that the trend can be stochastically specified. As can be seen in Figure 1-A, the stochastic level and slope of the trend estimated by the STS model appears to characterise house price behaviours very closely. Third, the linear deterministic trend appears to characterise the long-run movement of house prices quite well (Figure 1-B). The coefficients of the fixed slope (model II, III and IV) suggest a trend rate of around 0.013 to 0.024 per quarter (5.2% to 9.6% annually) in different trend specifications. Fourth, the two non-linear deterministic trends also appear to characterise the trend in house prices well as they were shown (Figure 1-C and 1-D), although these two models suggest a dampening trend in future house price movements.

Nelson and Plosser (1982) argue that the trends in most macroeconomic time-series are stochastic. Although the deterministic trend model show good perspectives as far as the long-run movement in house prices, it does not seem reasonable to assume that the trend is deterministic since it implies that house price is constrained to move for ever around a deterministic function of time. However, it is still possible to theoretically or empirically justify a trend in Taipei house price series because the trend can pick up the effects on house prices of gradual improvements in quality.

4.2. Examination of Short-run Dynamics in House Price Series

This section analyse the short-run cyclical behaviour of house prices. Since the specification of trend in STS model will affect the estimation of cycles, we have to remove the trend in the house price series. However, whether the non-stationary series is Trend Stationary Process (TSP) or Differenced Stationary Process (DSP) needs to be distinguished because, if a TSP series is differenced for stationarity, a negative autocorrelated moving error term will occur. Therefore, we start by testing whether we should detrend or difference the house prices. We use the Kwiatkowski, Phillips, Schmidt and Shin (KPSS) (1992) tests[6], which provides a higher power than Dickey-Fuller (1979) test when testing whether a deterministic trend is present in a time-series (Table 2). The values of the (t test statistics for trend stationary decrease as l increases. Using the values of l=0 to 8, we can all reject the null hypothesis of trend stationary for Taipei house prices. The values of KPSS ( ) test statistic confirm that, after the first difference, the house prices

Table 1. Test Results for the Trend Components in House Price Series

Parameter	I	II	III	IV
	0.003632			
	0.000438			
Regression Analysis				
Stochastic Level	12.681			
	(2151.3)			
Fixed Level		10.572	10.304	10.431
		(196.0)	(144.0)	(96.0)
Stochastic slope	-0.023			
	(-0.61)			
Fixed slope (T)		0.013	0.024	0.014
		(12.90)	(10.9)	(2.08)
Deterministic Trend - T^2			-0.000071	0.000011
			(-5.18)	(0.93)
Deterministic Trend - T^3				$-7.97*10^{-7}$
				(-1.56)
Dummy		0.492	0.532	0.424
		(5.61)	(6.59)	(3.98)
R^2	0.992	0.903	0.919	0.921
DW	1.783	0.103	0.128	0.116

Figures in parenthesis are t-statistics

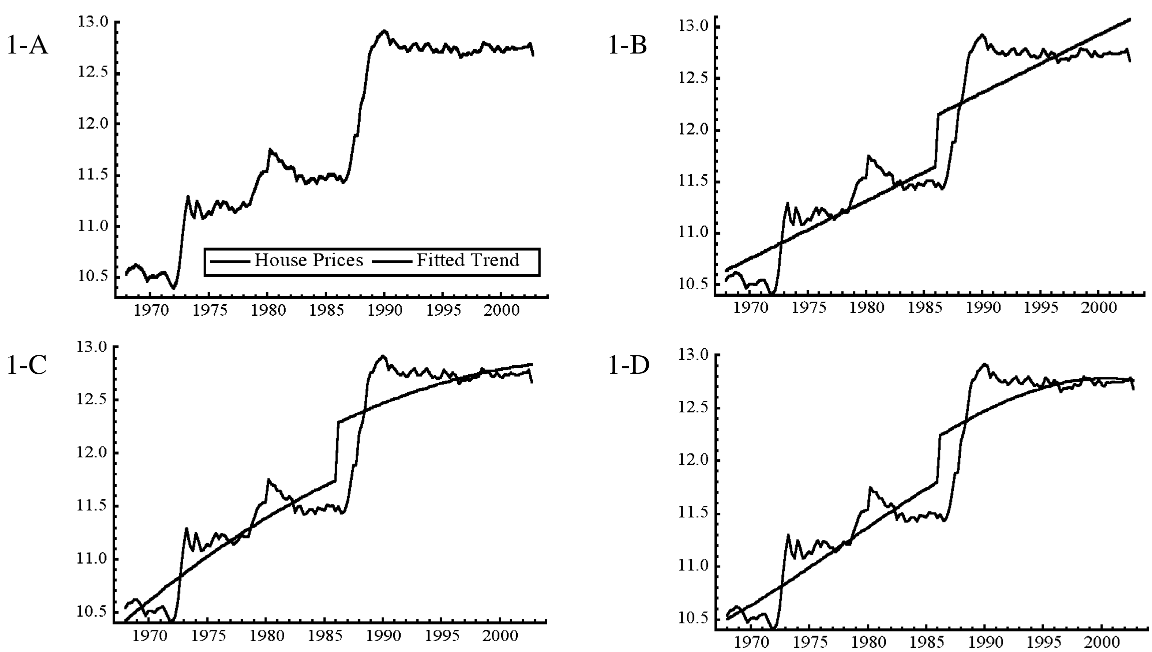

Figure 1 Trend Components in Taipei House Price Series

are stationary. Therefore, we assume the house price series contain a stochastic linear trend which is removed for the following analysis[7].

The STS model testing here also assume the same structural break in the series. Table 3 shows the results, and Figure 2 shows the graphical description of the original series with the estimated cycles. The estimated model suggests 1.2 year cycle, 2.5-year, 6.9-year cycle and (trigonometric) seasonal cycles. The extent to which the cycle component evolve over time can also be examined by the values of , , and . The parameters appear to suggest 2.5-year and 6.9-year cycles are stochastic and changing over time (Figure 2-B and 2-C). On the other hand, the short-term cycles (seasonal and 1.2-year) are deterministic (Figure 2-A and 2-F). The finding of stochastic cycles is consistent to the generally belief that the property cycle is a recurring but irregular fluctuation.

Compared with previous house cycle studies, in which cycles are usually examined by spectral technique, the length of cycles are very similar to ours. For example, Rosenthal (1986) suggests that there might be a cycle of 6-8 years in UK house prices. Alexander and Barrow (1994) found 5 to 10-year cycles in house prices across different regions in the UK. However, the problem in those studies is that they can only identified fixed length cycles by spectral analysis, which is inappropriate in analysing irregular cycle.

A number of points also emerge from the results of our analysis. First, as noted in the section 2, the causes of cyclical behaviour in Taipei markets are basically strong investment demand induced by an increase of money supply. The continuous economic growth over the past few decades results in monetary

Table 2. KPSS Tests for Stationarity

Variables	KPSS ( ): Lag Truncation Parameter (*l*)									Inference
	0	1	2	3	4	5	6	7	8	
ph	0.870	0.448	0.306	0.236	0.194	0.167	0.147	0.133	0.123	DSP
	KPSS ( ): Lag Truncation Parameter (*l*)									
	0	1	2	3	4	5	6	7	8	
ph	13.22	6.693	4.506	3.411	2.753	2.314	2.001	1.765	1.582	non-stationary
ph	0.432	0.313	0.264	0.230	0.209	0.197	0.190	0.186	0.185	Stationary

1. ph: house price in level, ph: house price in first difference.

2. KPSS test ( ): null hypothesis: contain a unit root (not trend stationary), ( ): null hypothesis: stationary, Critical value for : 5%=0.119, for : 10%=0.347. Number underlined indicates significant at 10% level. Eight lags of KPSS test, which is suggested by Kwiatkowski et al. (1992) as the maximal value, are tested.

Table 3. Estimation of parameters for Cyclical components

Cycle Duration	1.2 year	2.5 year	6.9 year	Seasonal
parameters				
Value	0.00	$6.45*10^{-6}$	$3.28*10^{-3}$	0.00

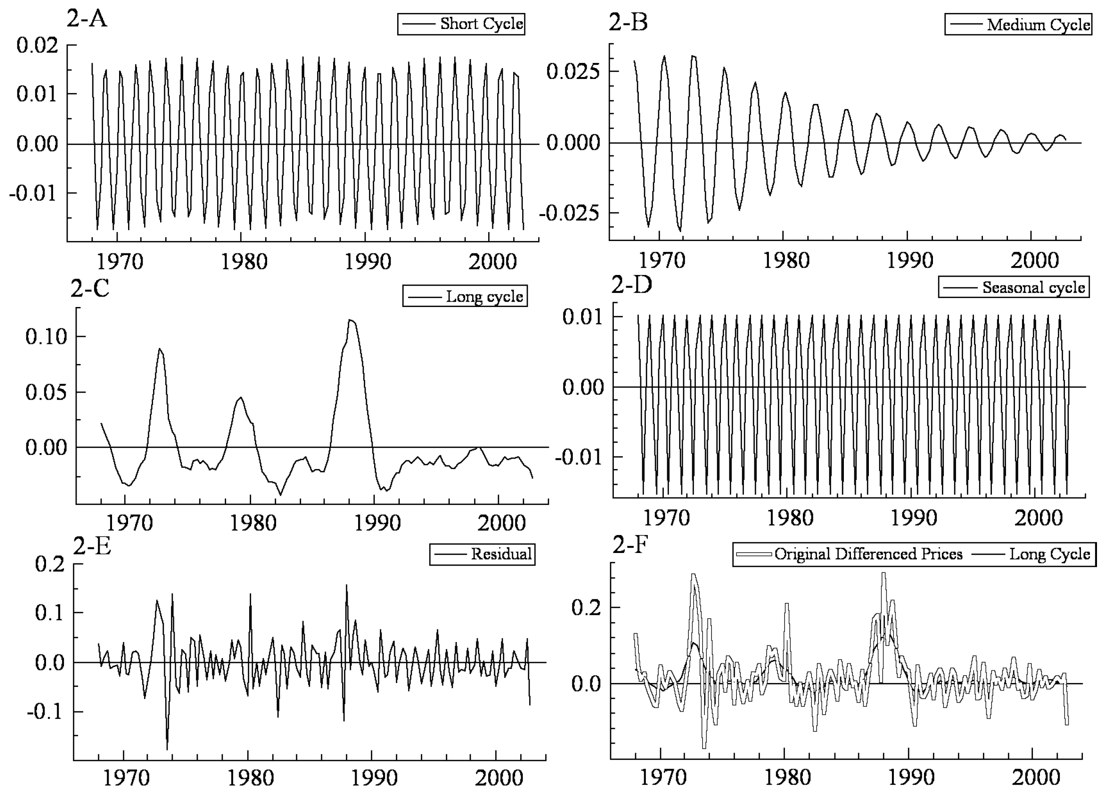

Figure 2. The Cyclical Components in Taipei House Price Series

growth and certainly increases the demand for houses. Previous studies suggest the house price fluctuation follow the economic growth. Therefore, it seems that we could return to the fundamental cycle theory that the business cycles indeed exist in economic activity as well as in the housing market. Besides, our results are consistent with the general belief that the property cycle is irregular. Burn and Mitchell (1946) define the business cycles as recurrent but not periodic because almost all the cycles are stochastic, also suggesting that Taipei markets are not in steady state and are still changing. Second, although residential demand is the fundamental cause for pushing up the house prices in the long run, the economic growth is the major factor behind the residential demand. Third, the Taipei housing market has a great magnitude of short-run fluctuation. This may be result from the fact that the government does not have a well functioning house financing system, which could be used to keep house prices at the equilibrium level, resulting in larger cycles in house price series. Fourth, the housing market is not efficient. This argument has been put forth by many studies, including the one done by Evans (1995). In efficient market, information is widely known and quickly distributed to all participants. However, given the belief that housing market is unlikely to be efficient, individual tends to over or under react to the price signals, which may explain the greater fluctuations in house prices. Since such information in these housing markets is not well known, price deviation may be relatively high.

5. Structural Time-series House Price Models

As these unobserved components have been identified in the previous section, it seems desirable that we model these characteristics explicitly. Therefore, this section presents the estimated long-run (level of house prices) and short-run (difference of house prices) using the STS model, and assesses the performance of models. The STS model is pure time-series methodology involving the use of only past values of a particular variable to project into the future. It assumes influence of economic factors implicit in the historical data. On the other hand, econometric models utilise economic phenomena to identify theoretical models that relate the degree of influence of underlying factors on some particular variables in order to generate future values. Some studies argue that the time-series model neglects relevant information on existing economic structure that may profoundly influence the behaviour of the data; others have argued that time series model were more accurate than econometric models. However, any consideration of time-series properties should improve the model.

Although goodness of fit for the model can be assessed with estimated prediction error variance for frequency domain estimation, it does not allow us to compare the performance with previous house price models using typical R-square and standard error. Therefore, only results estimated by traditional time domain regression analysis are presented here.

The models are based on the above components estimated in the last seciton, but are enhanced by considering some autoregressive terms. As many previous house price studies have reported inertia in house price series (see for example Case and Shille, 1989), an increase in price during any year tends to be followed by an increase in the subsequent period. This suggests that there is serial correlation in price changes and, therefore, autoregressive specification is essential. Therefore, the specification of our long-run and short-run regression equations is as follows:

Long-run Model

.... (11)

Short-run Dynamic Model

....(12a)

.... (12b)

where are the proxies cycle component of the house price series, is seasonal factors, *D* is the dummy parameter for exogenous factor relevant for period 1987Q2-1988Q4, and are the house price determinants.

Table 4 summarises the results of the STS regression model specified in equation (11) and (12a,b)[8]. The overall performance of the long-run model is represented by the value of the R^2 which is 0.99 with 6.6% standard error. The model passes all the diagnostic tests. A long-term cycle (16.2 year) is found to be significant in the estimated long-run model. The long-run model appear to fit house prices very well because of high R^2. Compared with previous house price long-run models (for example, Hsieh, 1990; Wu, 1994), our model works very well.

The overall performance of the short-run-run models are represented by the values of the R^2 which are 0.25 with 5.2% standard error and 0.40 with 4.7% standard error. The short-run model 1 (12a) includes are all the cycles, autoregressive term and structural change dummy, but medium cycle, long cycle and structural change dummy are insignificant. Only the short-term cycle (around 1.2 year) is found to be significant because the other cycles might be captured by autoregressive term in the models. Therefore, in the short-run model 2, we drops out the insignificant cycles and structural change dummy but includes some house price determinants. These two short-run models appear to fit house prices fairly. Previous short-run house price models generally explain from 40 to 80 percent of house price changes, which can be regarded as fairly satisfactory estimations. In the UK's studies, the R^2 ranged from 0.57 to 0.86 and the corresponding standard errors are between 1.37% and 1.65%[9]. In comparison, our model has a lower R^2, and does not reach the performance level as well as these previous models. Compared with previous Taiwan's models (for example, Chen and Patel, 2002)[10], the performance of short-run model 2 is close and has fewer variables, although our short-run model 1 has a lower predictive power due to the pure time series specification. The performance of the short-run model 1 can be easily enhanced by incorporating some explanatory variables as shown in the short-run model 2.

To assess the forecasting ability of the STS models, we forecasted prices using the last 8 quarters of the sample period as a one-step ahead zone by using the long-run model and short-run model 2. Table 5 shows that the forecasting errors appear to be quite reasonable with around 4.5% to 0.05% and Root mean square error (R.M.S.E) are around 6.7% for the long-run models. For the short-run model, forecasting errors are around 2.6% to 0.05% and Root mean square error (R.M.S.E) are around 5.7%. Figure 3 shows the actual and fitted values of the models. Overall the estimated model fits the actual values fairly well, following the fluctuation in the actual values very closely without any significant bias. At the 10% level of significance, the cumulative sum (CUSUM), which is designed to assess whether the mean of dependent variable changes over time, does not cross boundary lines in the both two models. In examining biases in this forecast zone, we observe that the Chow F-test value of 0.547 and CUSUM test of -1.674 for long-run model, and Chow F-test value of 0.712 and CUSUM test of -0.424 for short-run model, are statistically insignificant indicating that the models maintain the overall stability and have a satisfactory forecasting power.

6. Conclusion

This paper has examined the unobserved components of Taipei house prices. Because the traditional decomposition methodologies have serious disadvantages and limitations, our paper uses the STS method to explore the time-series nature of house price series. It is possible to observe how the trend, seasonal and cycle components evolve over time and capture the changes in the behaviour of Taipei house prices. This approach enables us to identify the stochastic properties of house series more accurately, permitting the estimation of more reliable coefficients than can be obtained using traditional methods.

Table 4. Results of the Structural Time-series Model

	Long-run Model		Short-run Model 1		Short-run Model 2	
Dependent Variable	ph_t		Δph_t		Δph_t	
Independent Variable	Coef.	StdErr	Coef.	StdErr	Coef.	StdErr
Constant	9.932	**1.104	-0.0432	*0.0260	0.0004	0.005
Slope (T)	0.0138	**0.002				
1.2 year ($\cos(2\pi t/4.88+34.4^{\circ})$)			0.0180	**0.0084		
1.2 year ($\cos(2\pi t/28.2-40.4^{\circ})$)					0.0118	*0.0071
2.4 year ($\cos(2\pi t/9.7-75.2^{\circ})$)			0.0037	0.0388		
7.0 year ($\cos(2\pi t/28.2-8.1^{\circ})$)			0.1086	0.1026		
16.2 year($\cos(2\pi t/64.7-5.4^{\circ})$)	0.371	*0.217				
ph_{t-1}	0.243	**0.083				
Δph_{t-2}			0.5137	**0.0804	0.1421	**0.0762
Δph^3_{t-3}			-5.3488	**1.6391	-6.5539	**1.7966
Δph^2_{t-4}			-2.6410	*1.6044		
Δcci_{t-1}					0.9214	*0.2067
Δfr_{t-4}					0.2580	*0.0714
Δir					0.6423	**0.2835
Dummy 87, D_1			0.0042	0.0350		
Adjusted R^2		0.993		0.253		0.404
Information Criterion of Akaike		-5.343		-5.317		-5.864
of Schwartz		-5.217		-4.999		-5.857
Standard Error		0.0662		0.0521		0.0470
Normality		51.86		2.669		13.37
H(46)/H(45)/H(45)		0.328		0.3398		0.44576
r(1)		-0.00059		-0.00059		0.021851
r(10)/r(15)/r(9)		0.04543		0.00501		-0.17595
DW		1.968		1.974		1.889
Q(10,7)/Q(15,6)/Q(10,7)		7.540		7.112		12.30
Prediction error variance		0.00438		0.003946		0.002441
Prediction error mean deviation		0.00317		0.002800		0.001830

1. *Significant at the 10% level, **Significant at the 5% level.
2. H() is the heteroskedasticity statistic. r() is the statistic for serial correlation. DW is the Durbin-Watson statistic. Q() is the Box-Ljung statistic and should have a distribution.
3. Sort-run model 3 includes some house price determinants suggested in Chen and Patel (2002). cci is construction price index, fr is foreign exchange reserves, ir is interest rates.

Table 5. Forecast within Sample

	Long-run Model					Short-run Model				
Period	Error	R.m.s.e.	Residual	Cusum	Cusum^2	Error	R.m.s.e.	Residual	Cusum	Cusum^2
2001.1	-0.00689	0.06789	-0.10144	-0.10144	0.01029	-0.0060	0.0517	-0.1157	-0.1157	0.0134
2001.2	-0.04121	0.06781	-0.60765	-0.70909	0.37952	0.0160	0.0518	0.3096	0.1940	0.1092
2001.3	-0.02777	0.06790	-0.40888	-1.11800	0.54670	0.0207	0.0516	0.4011	0.5951	0.2701
2001.4	-0.02277	0.06787	-0.33551	-1.45300	0.65927	0.0132	0.0518	0.2549	0.8499	0.3351
2002.1	-0.01149	0.06783	-0.16931	-1.62300	0.68794	0.0084	0.0514	0.1631	1.0130	0.3617
2002.2	-0.03421	0.06779	-0.50471	-2.12700	0.94267	-0.0052	0.0514	-0.1004	0.9127	0.3718
2002.3	-0.00536	0.06784	-0.07898	-2.20600	0.94891	0.0077	0.0512	0.1494	1.0620	0.3941
2002.4	-0.04455	0.06777	-0.65738	-2.86400	1.38100	-0.0260	0.0513	-0.5065	0.5556	0.6506

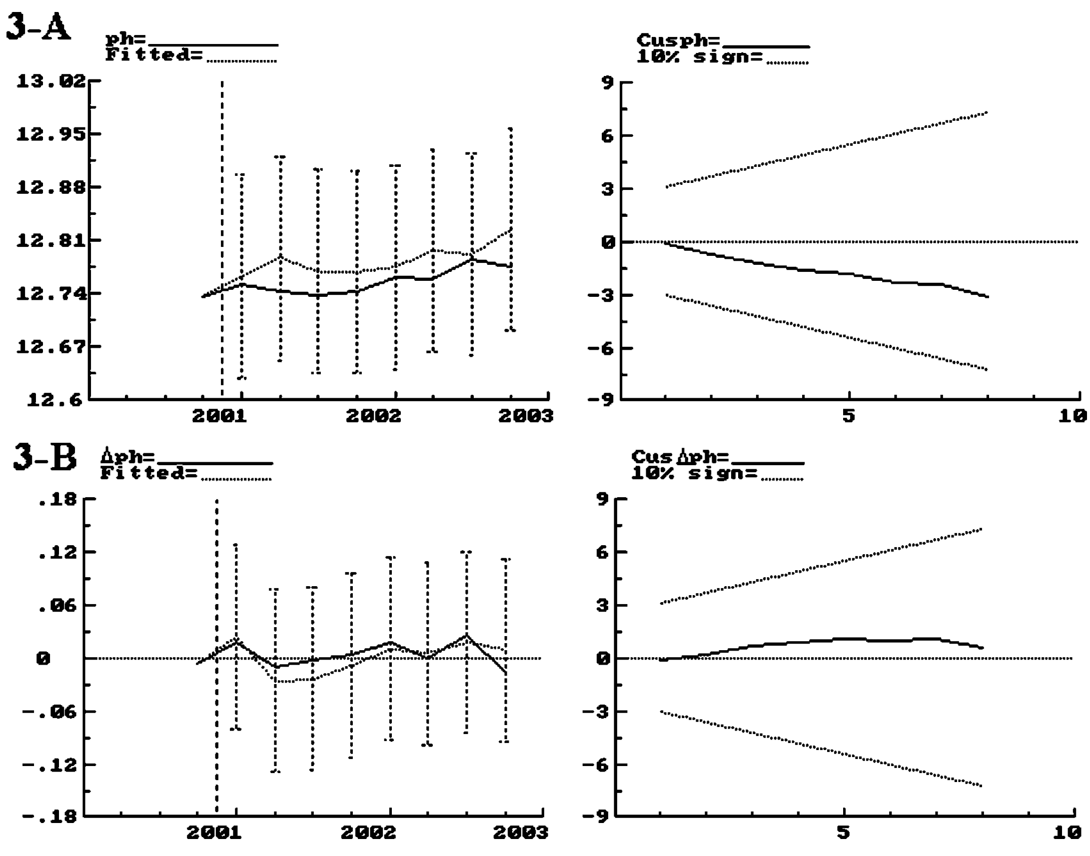

Figure 3. The Actual and Fitted Values of the Model

The results of decomposition shows that stochastic level and slope of the trend model appear to characterise Taipei house prices in the long-run quite well. If the deterministic trends are assumed in the series, the linear trend appears to characterise house prices better than non-linear trend visually. Our STS estimations indicate stochastic cycles lasting around 2 and 7 years. Although the duration of price cycles are generally believed to be around 7 year in Taiwan housing market, the STS model suggests that the cycle is stochastic rather than deterministic. The seasonal effects are also significant and appear to be deterministic.

We also compared the performance of our STS model against other models that include explanatory variables. The estimated long-run STS model performed as well as previous models. The short-run models were as good as those in previous studies, especially for the model with explanatory variables. One of the main arguments in favour of the pure STS models, which is, they can reduce the costs of forecasting, is clearly supported by the overall performance of our model.

From our results we have some implications. First, the STS results of trend analysis imply a dampening trend in house price series. The slowing down of house price movement suggests that we may not expect to see continuing high asset appreciation in the housing market, which people seem to expect. Hence, future abnormal profits in this markets is unlikely. Second, the presence of 7-year cycle has also implications for both government and property investors. For the government, the fluctuation of house prices puts into perspective the current housing problems and the effects of government policy created to deal with them. Revealing the duration and magnitude of cycles allow for better understanding of the course of house prices, which, in turn, helps government policy-makers take the best stance in reaction to the house price changes. Taiwan housing market is characterized by a lot of speculative activities. Knowing this can allow the government to monitor the short-run house price behaviour and control the speculation activities that cause dramatic changes. For investors, the found cycles might increase the possibility of diligent investor in the housing market to reap abnormal profits by using a trading rule mainly based on the observed behaviour of house prices.

There are some limitations in this study. First, data collection for a good long-term house price series presents a number of difficulties. The house price index provided by Construction and Planning Administration, Ministry of Interior is complied by weighting averaged method. A better adjustment for quality change in the series is desirable, but it is not an option available in this study. In addition, the house price index provided by Construction and Planning Administration starts from 1973Q2. In order to present the first boom in the early 1970s for Taiwan, this paper has to use a different source house price data as a proxy. Second, although this paper has tried to identify the behaviour of house prices and also looked for some basic explanations for these behaviours, these underlying causes of the fluctuations could form the hypothesis for empirical testing. Finally, the problem of structural change in house price series represents an important area of research. As most previous studies, our paper uses dummy variables to capture the effects of structural change. This only solves problem of structural change within sample period. There are some new techniques, such as time-varying coefficient approach or markov-switch model (see Tsai and Chen, 2003) that can be used deal with structural change outside sample period. Thus, further research is needed with these.

Notes

1. For the amplitude-frequency domain time-series analysis, such as spectral analysis, requires rather large samples for efficient estimation. Granger and Hatanaka (1964) argue that a desirable minimum number of observation is 200, but many economic series are not able to meet this requirement. They suggest that to confidently detect significant cycles, one should set the sample length to be as much as seven times the length of the longest cycle one wants to determine, although Klotz and Neal (1973) suggest that the series need only be three times the cycle length.
2. For example, Harvey and Jaeger (1993) argue that mechanical detrending techniques such as the HP filter can lead to spurious cyclical behaviour.
3. Chen and Patel (2002) use the Perron (1989) test for the structural change in the unit root process by using the period of the 1987Q2 as the point of structural change. Yang (2003) uses the Bai and Perron test (1998) and found there to be several possible structural changes in the late 1980s and the 1990s.
4. We do not consider all possible structural breaks in our analysis, because inclusion of too many breaks will lead to invalid estimation of the cycles. Also, these breaks will substantially increase of the explanatory power (R square) of our STS model, leading to spurious results.
5. The results of this paper are estimated by the STAMP 6.0 (Koopman, Harvey, Doornik and Shephard, 2000).
6. Kwiatkowski, Phillips, Schmidt and Shin (KPSS) (1992) propose a test of the null hypothesis that an observable series is stationary around a deterministic trend. The series is expressed as the sum of deterministic trend, random walk, and stationary error, and the test is the LM test of the hypothesis that the random walk has zero variance. The asymptotic distribution of the statistic is derived under the alternative that the series is difference-stationary. Finite sample size and power are considered in a Monte Carlo experiment. The test is applied to the Nelson-Plosser data, and for many of these series the hypothesis of trend stationarity cannot be rejected.
7. Although previous studies suggest that the structural change could alter the results of unit root tests, Chen and Patel (2002), and Yang (2003) use the Perron tests (1989, 1997) for structural change in the unit root process and both reach the results of an unit root in Taipei house price series.
8. We adopt the general to specific approach suggested by Hendry (1979) to arrive our final models.
9. For example, the equation with R^2 of 0.57 and standard error of 1.6% in Nellis and Longbottom (1981), R^2 of 0.73 and standard error of 1.6% in Dicks (1990), and R^2 of 0.86 and standard error of 1.4% in Peterson et al (1997).
10. Although there are many house price empirical studies in Taiwan, most of their models are long-run basis. In addition, the estimations are still hard to compare because different methodology, different functional form, data series and frequency are used.

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Appendix: Data Sources

Our sample period is from 1968Q1 to 2002Q4. House prices figures from 1972Q2 to 1999Q1 are taken from the pre-sale new house price index compiled by Construction and Planning Administration, Ministry of Interior. For presenting the boom in the early 1970s, we take the data from other source. The earlier series from 1968Q1 to 1972Q1 are continued by using Taipei annual apartment prices taken from Chuo (1994). Quarterly figures are then obtained by interpolation. The data after 1999Q2 are collected and complied by our study by using the same methodology as Construction and Planning Administration.