주택가격과 거시경제변수 간의 순환관계에 관한 연구: Hodrick-Prescott Filtering 방법을 이용하여

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The Cyclical Relations between House Price and Macroeconomic Variables in Korea*

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국문요약: 본 연구는 경기변동이론분야에서 많이 사용되고 있는 Hodrick-Prescott filtering 방법을 사용하여 지난 19년 동안의 우리나라 주택가격의 순환변동과 경제변수들의 순환관계를 살펴보았다. 교차상관관계 분석결과, 실질생산(real GDP), 가계소득, 가계소비지출, 물가(CPI) 및 이자율 등의 순환은 주택가격의 순환과 양(positive)의 관계가 있는 것으로 나타났다. 한편, Granger 인과관계에 의하면, 경기변동(GDP) 순환이 주택가격의 순환에 일방적으로 영향을 주는 것으로 나타났으며, 가계소비의 순환변동 또한 주택가격의 순환변동에 일방적인 영향을 주는 것으로 밝혀져 주택가격의 상승에 따른 소비지출에 대한 자산효과(wealth effect)는 존재하지 않은 것으로 나타났다. 충격반응함수(generalized impulse response function)의 분석결과도 전반적으로 앞의 두 가지 분석과 비슷한 결과를 보여주고 있다. 즉, GDP 순환변동의 충격에 대한 주택가격 순환변동의 반응이 반대의 경우보다 훨씬 컸으며, 이자율과 주택가격의 순환변동은 각각의 충격반응에 대하여 일정한 시차를 두고 각기 반대의 반응을 보여주고 있다. 이러한 결과에 기초했을 때, 본 연구는 경제성장, 물가 및 금리와 같은 거시경제 변수의 운용이 주택시장의 안정을 위한 필요 수단으로써 작용할 수 있다는 점을 시사하고 있다.

Key word: Hodrick-Prescott Filter, House price, GDP, Consumption, Interest rate, CPI
키워드: 호드릭-프레스코트 필터, 주택가격, 조국내생산, 소비, 이자율, 소비자가격지수

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I. Introduction

During the last decades, a large group of international asset markets has experienced drastic fluctuations, and the housing market is one of the most volatile sectors of the asset markets. One common phenomenon relating these changes is that the house price cycle is generally believed to the product of the short-run deviations from the long-run upward trends. The long-run growth in house price is accompanied by the short-run fluctuations around the growth path. These short-run and long-run movements in house prices have been vastly related to the fluctuations in the macroeconomic variables such as GDP, inflation, interest rate and household consumption, etc. Consequently, changes in the house prices have been considered to be influenced by those economic variables. Since housing is a major sector of the national economy in most countries and housing constitutes a considerable share of household expenditure and of total wealth, the sharp fluctuations in housing price can also lead to significant movements in household wealth and consumption as well as the economic activities.[1)]

These features also apply to the Korea. An inspection of graphics shown in <Figure 1> in the section IV gives trend, cyclical pattern and irregularity as important features of the house price series. Similar to the movements in time-series such as gross domestic product (GDP), consumption or consumer price, the house price has increased for a long time. This long-run increasing trend in the house price is generally due to the fact that the falling supply of land has been followed by an increased demand for housing services. As a result, increase in demand for housing due to, for instance, raising income would lead to a rise in housing value as well as the stock of housing overtime. Thus, economic forces must have been the driving forces behind the increased trend in house prices. Korea has experienced fast economic growth during the past few decades, which has brought about growth in both income and monetary sector. This rapid economic growth, in turn, has boosted wealth and pushed up house prices, gearing with its higher demand.

On the other hand, it was once argued that the long-term cyclical fluctuation in Korean housing market was periodically occurred (i.e., every 10 years). This bygone prevailing belief seems to stem from the fact that the Korean housing market has been boomed and thus the house price sharply moved upwards every 10 years since late 1960s. However, it is not the simple belief or psychological expectation on the 10-year-cyclical-upturn in house price but the economic condition behind the boom in the housing market during the period. For example, the sharp rises in house prices were rooted in the economic boom accompanied with the enormous construction investment by Korean companies in East Asia in late 1970s and with Seoul Olympic in 1988, respectively. The collapse of house price following the Korean economic crisis in late 1997 and the latest housing price up-run caused by lowest interest rates and the expansion of consumer credit are other examples. Therefore, the

1) According to the World Bank, housing sector consists of 30% of world wealth, which is larger than those of bonds (27%) or equities (19%) in 1993.

cyclical patterns in both housing prices and macroeconomic variables are closely related to each other.

In this context, a number of house price studies have focused on the lead-lag or casual relationships between the house price cycle and the cyclical movements of macroeconomic variables in the past few decades. One of the main reasons on the growing body of research focusing real estate cycles is that the role of housing market in a nation's economy has been increased during the last decades.[2] Another reason is the global boom-and-bust experience of late 1980s and early 1990s. Accordingly, investors have put more weights into real estates for their multi-asset portfolios. This emphasizes even more the need for correct analysis of the real estate cycle. There have been also a number of researches concerned with the relationship between the house price and the macroeconomic variables using Korean economic data series, and most of the studies have used the raw time-series data.[3] A meaningful analysis of the cyclical properties of the house price in relation to the cycle of the macroeconomic time-series requires that variables are appropriately detrended in order to extract the relevant cyclical component from the raw data.

In this paper, using Hodirck and Prescott (1997) filtering method, we examine the cyclical movements of the house price and macroeconomic variables such as gross domestic product, interest rate, consumer price level, household consumption expenditure and household income. We first analyze the cross-correlations between the prespecified macroeconomic variables and house price to identify the long-run behavior of the variables. Then, this paper addresses the causality issue for the cyclical patterns of the variables, based on the vector autoregressive (VAR) model. In addition, this study employes a generalized impulse response function to explicitly explore the long-run dynamic structure of the cyclical patterns of the detrended variables.

To the best of our knowledge, this paper is the first attempt trying to clarify the cyclical relationship between house price and macroeconomic variables using detrended data series. The findings of the stylized facts of house price cycle in this study are expected to improve existing knowledge on the cyclical pattern of house price in Korean housing market. Furthermore, the findings would provide some implications on the government's housing policy to react the cyclical movements of the economic condition. The remainder of this study is organized as follows. A review of previous studies is presented in the next section. A discussion of the data and methodology is made in section III. Section IV and V explore the empirical results based on the cross-correlation and the VAR model, respectively. The final section presents summary and conclusions.

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2) For example, the 1997 survey of national wealth showed that the value of structure of residential housing was 55% of real wealth of consumers in Korea. During the last three decades housing investment has consisted of 3-9% of GDP and 14-31% of total investment in Korea.

3) See Seo (1999), Seo and Kim (2000) and Shon et al. (2003).

II. Literature Review

The previous empirical works are contingent on the methodologies, the data series and sample periods employed in driving the estimates. The studies that use Hodrick-Prescott filtering method to extract the cyclical components include followings. Brooks and Lee (2000) find that the cycles of U.K. macroeconomic variables such as GDP, interest rate, inflation and consumer expenditure are positively or inversely correlated with the property stock prices, and they document these variables can be used leading indicators of property stock prices. Witkiewicz (2002) also shows that Swedish real estate cycle is in large dependent on the real business cycle. Matysiak and Tsolacos (2003) examine firstly the cyclical relations between the retail, office and industrial rent series and the macroeconomic variables in U.K. Then, they use this lead-lag relationship to estimate the forecasted values of the retail, office and industrial rent series. Presenting a theoretical framework concerned with the positive correlation of income, housing prices and housing transactions over the business cycle in U.K., Ortalo-Magne and Rady (2004) provide evidence that housing demand fluctuations have been the key driver of housing transactions.

Meanwhile, several studies document the empirical results in relation to the issue of office market and the economic activity. By utilizing the 3SLS method, Dokko et al. (1999) test that the interrelationships between economic activity and real estate income and value cycles in twenty office markets in the U.S. Kling and McCue (1987) find evidence that the U.S. office construction is influenced primarily by nominal interest rates and output as well as money supply and prices. McGough and Tsolacos (1995)'s Granger causality test, based on a VAR model, provides following empirical evidence: a significance influence of office rents on the rate of new office construction; a small impact of service sector output on office development; and no relationship between office cyclical activity of office property and employment and interest rate in U.K.

III. Methodology and Data

1. Hodrick-Prescott Filter

An empirical study of the cyclical component between variables is conditioned on the way in which the analyst chooses to extract the trend from the observed data. There exist several methods to detrend the original series and obtain its stationary component. These methods include first differencing, the use of deterministic polynomial functions of time (e.g., quadratic trends), ARIMA models fitted to each individual series, exponential smoothing filter, or low-pass (LP) filters (Baxter and King, 1999), etc.

In this study, the two-sided filter proposed by Hodrick and Prescott (1997) is used to extract the trend component. This procedure is the most commonly used detrending method in applied econometric study. The Hodrick-Prescott (HP) filter is a smooth trend

that is fitted to the raw data. This filter decomposes a nonstationary time-series into growth and cyclical components $(y_t = y_t^g + y_t^c)$, where y_t is the natural logarithm of an observe time series and y_t^g and y_t^c are the growth and cyclical components respectively. The filter is given by:

$$min\{\sum_{t=1}^{T}(y_t - y_t^g)^2 + \lambda\sum_{t=2}^{T-1}[(y_{t+1}^g - y_t^g) - (y_t^g - y_{t-1}^g)]^2\}; \quad \lambda > 0 \tag{1}$$

Equation (1) is the Lagrange function for minimizing the variance of y_t^c subject to a penalty for variations in the second difference of the growth term, where the parameter λ controls the smoothness of y_t^g. The objective function (1) consists two terms. The first term is a measure of 'goodness-of-smoothness' which penalizes decelerations in the growth rate of trend component. Variations in the smoothing parameter λ alter the trade-off between the goodness-of-fit and the degree-of-smoothness. Thus one must decide how much weight to place on each goal. The weighting factor λ is the Lagrange multiplier associated with the smoothness constraint. The larger λ, the smaller the variations in the trend component will be. As λ approaches infinity, y_t^g approaches a linear trend. This factor must be set a priori. It has been, however, the practice to set the values λ as 400 annual data, 1,600 for quarterly data and 12,000 for monthly data.[4] As noted by Kydland and Prescott (1990), the HP filter has several attractive features. An appealing feature is that it can accomodate tims-series with changing mean growth rates. Moreover, the trend is a linear transformation of the original series that is identical for all series.

Initially, the HP procedure is used to fit a smooth trend to all data series. It is customary to define the cyclical component of each series as the deviation of the actual values from the HP trend fitted to the series. That is, the cycle is defined as actual value minus the HP trend. Further, the cyclical component of each series is required to be stationary.[5]

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4) Many previous works (e.g., Harvey and Jaeger (1993); Cogley and Nason (1995)) showed some problem with HP filter as well as Baxter-King (BK) (1999) filter because the filters may produce spurious cycles when filtering near-integrated time series (so-called Slutzky effect). It is, however, not possible to construct an ideal business cycle filter (high-pass filter or band-pass filter) in the time domain with only a finite number of observations so all filters are distorting. In this context, Pedersen (2001) pointed out that when filtering quarterly economic time series with a near unit root, the optimal value of the smoothing parameter lies in the range 1000-1050 but the distortionary effect of using the standard value λ=1600 is in most cases small. Further, Pedersen (2001) showed that the HP filter with the standard value of λ=1600 is in many cases less distorting than the other filters. We tested with λ=1000 but there is not a certain difference when using λ =1600. Thus, we examine with λ=1600.

5) The results of unit root tests are provided

2. VAR Model

When we conduct the test on causal relationship among the variables, we need to first check if the variables are stationary as the VAR model requires the variables to be stationary. Empirical works based on the time series data assume that the underlying time series are stationary in order to avoid the problem of spurious regression. If the HP cycles of the variables are all stationary, the usual Granger causality test can be performed. The estimation of a VAR model using stationary variables is appropriate as follows.

$$Y_t = \alpha_1 + \sum_{i=1}^{n} \beta_{1i}\, Y_{t-i} + \sum_{j=1}^{n} \gamma_{1j}\, X_{t-j} + \epsilon_{1t} \quad (2)$$

$$X_t = \alpha_2 + \sum_{i=1}^{n} \beta_{2i}\, X_{t-i} + \sum_{j=1}^{n} \gamma_{2j}\, Y_{t-j} + \epsilon_{2t} \quad (3)$$

where Y and X represent two endogenous variable series, house price cycle and the cyclical components of other economic variables, respectively. The disturbances ϵ_{1t} and ϵ_{2t} are assumed to be uncorrelated. Based on the above VAR models, Granger causality tests are performed whether house price cycle leads the cyclical components of other economic variables, or vice versa. The practical way to determine Granger causality is to consider whether the lags of one variable enter into the equation for another variable. For instance, in equation (2), if the null hypothesis that $\gamma_{11} = \gamma_{22} = \gamma_{33} = \cdots = 0$ is rejected, X is said to Granger-cause Y. If the null hypothesis is accepted, then Y is exogenous to X.

We also estimate dynamic interactions between the house price cycle and the cycles of other variables, using equation (2) and (3). The innovations in equation (2) and (3) may be contemporaneously correlated, meaning that shocks in variable Y may work through the contemporaneous correlation with innovations in variable X. Due to this contemporaneous correlation, isolated shocks to individual variables can not be identified, and thus the responses of a variable to innovations in another variable in the VAR system can not be appropriately represented. The common approach in solving this identification problem is to employ a methodology proposed by Sims (1980). In the study, Sims presented a VAR analysis using the orthogonalized impulse responses, where the shocks to variables in the system are orthogonalized based the Choleski decomposition before impulse response functions are computed. Namely, the Choleski decomposition is used to overcome under-identification problem by imposing some restrictions in the shocks of the estimated VAR system. However, the crucial shortcoming of this approach is that a prespecified causal ordering of the variables is required. That is, the results from impulse response analysis may be sensitive to the ordering of the variables particularly when contemporaneous

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in the next section.

correlations of error terms in the VAR are high. This means that the traditional impulse response analysis, which considers orthogonalized shocks based on the Choleski decomposition, would not be appropriate. In this context, there have been many attempts to show alternative reparametrizations that could be employed to compute orthogonalized impulse responses. There are, however, no clear criteria as to which one of these possible parameterizations should be selected.

Considering the disadvantage of traditional impulse response function, we adopt the generalized impulse response function proposed by Pesaran and Shin (1998). The generalized impulse response functions fully take account of the historical patterns of correlations among different shocks. Accordingly, the generalized impulse responses are unique and invariant to alternative orderings of the variables in the system.[6)]

3. Data

The model is estimated using quarterly data ranging from 1986:I through 2005:I for all variables since house price is available only from 1986:I. The house price index (HOUSE) is obtained from the Kookmin Bank, and the data for other variables are taken from the Bulletin of the Bank of Korea.[7)] To investigate the stylized facts of the house price cycle, the economic variables are selected, based on theoretical intuition and on the group of variables that have been used in related existing empirical works.[8)] The set of variables comprises both macroeconomic and financial time-series that are expected to track the changing economic condition and series which reflect housing market. That is, the selected variables are considered to contain information on economic and house market trends and consist of the following time series: gross domestic product (GDP), household income (INC), household consumption expenditure (EXP), consumer price level (CPI) and the yield rate of 3 year maturity corporate bond (IR: used as proxy for interest rate).[9)] All variables are seasonally adjusted using X-11 ARIMA method.[10)]

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6) Pesaran and Shin (1998) also illustrate empirical findings that the orthognalized and the generalized impulse response functions generate quite different results in both shape and size. We skip the theoretical explanation on the generalized impulse response function in this paper.

7) Housing data are reported in monthly basis. We transformed the data to quarterly series by averaging of three monthly values. The other time series can be available on the quarterly basis.

8) Some of the variables used in the business cycle literature are not adopted. For example, since wage and money supply are closely related to the household income (or consumption) and national price level (e.g., CPI) respectively, we do not employ wage and money as variables estimated. The omission of these variables does not affect the empirical results because techniques used in the current paper (i.e., cross-correlation, Granger-causality test, and VAR) are based on one to one estimation, rather than multiple regression.

9) For all data series, real values are used with an exception of CPI.

10) Many Korean economic time series contain periodic variations that appear repeatedly

Seasonal fluctuations contained in the original series could obscure the understanding of basic trend of the series. Furthermore, the similar seasonal fluctuations in the data might yield spurious problems in both business cycle analysis and causality test between unadjusted series. All time series data, but interest rates, are defined as the natural logarithm.

IV. Cross-Correlation Analysis

1. Unit Root Test

<Table 1> Unit-Root Test

	Original series		Cyclical component	
Variables	ADF test	PP test	ADF test	PP test
HOUSE	-2.495	-1.737	-3.68***	-3.07**
GDP	-2.099	-2.384	-3.41**	-3.54***
INC	-1.008	-1.683	-4.26***	-4.90***
EXP	-1.661	-1.481	-3.35**	-2.95**
CPI	-2.303	-2.370	-4.13***	-4.24***
IR	-2.675	-2.292	-5.63***	-3.16**

Note: 1. ** significant at 5% level, *** significant 1% level.
2. HOUSE: house price index, GDP: gross domestic product, INC: household income, EXP: household consumption expenditure, CPI: consumer price index, IR: yield rate of 3 year maturity corporate bond.

The proper interpretation of the HP filter's effects depends on the nature of original data. The HP filter was designed to decomposed a nonstationary series into a stochastic component, and a serially correlated deviation from trend or cyclical component that was stationary. Many previous studies on the HP filter, however, rely on theorems which assume that the original data are stationary. This assumption is problematic since the filter is typically applied to nonstationary data. That is, when applied to stationary series, the HP filter operates like a high pass filter, damping fluctuation which last longer than eight years per cycle (in quarterly data) and passing shorter cycles without change.[11] In this respect, we perform tests on the stationarity of the variables. For each time series, both augmented Dickey-Fuller (ADF) (Dickey and Fuller, 1981) and Phillips-Perron (PP) (Phillips and Perron, 1988) tests are used to determine the existence of unit roots, and the series tested include both a constant and a trend. The choice of lag length is carried by the Schwartz Criterion (SC) and Akaike Information Criterion (AIC). The results reported in <Table 1> show that the original data series are not stationary, whereas the results of ADF and PP tests suggest that all of the cyclical components (the HP cycles) are stationary.

2. Cyclical Components

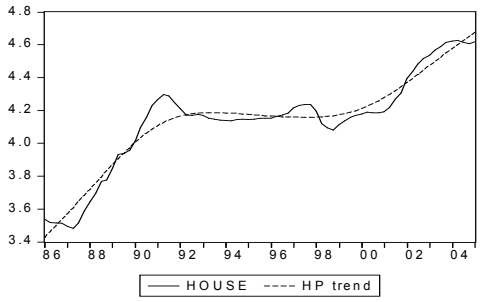
<Figure 1> plots the evolutions of the logarithm of the original series and the trend components of the series produced by the HP

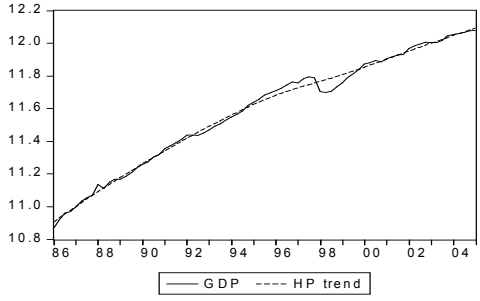
every year due to Sol (Lunar New Year's Day), Chusok (Korean Thanksgiving Day), national holidays, and so on. Especially house prices are largely fluctuated during moving season that spans from September through November.

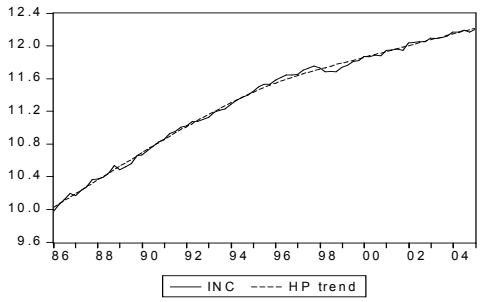
11) See Cogley and Nason (1995) for details on this issue.

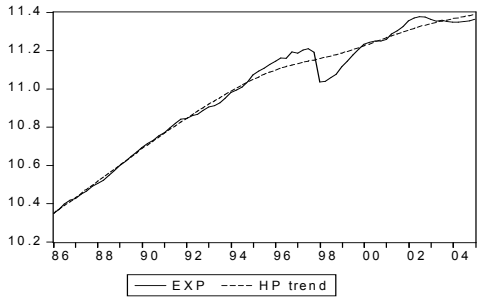
filter. The trend computed by the HP filtering is shown as a dotted line and the cyclical component is the difference between the dotted and real line.[12] All variables with exception of interest rate have increasing trends, and they oscillate around the period of the 1997 economic crisis. Trend and cyclical factor extracting by HP filtering lets the cyclical component avoid too much deviation from the trend because the trend changes procyclically.

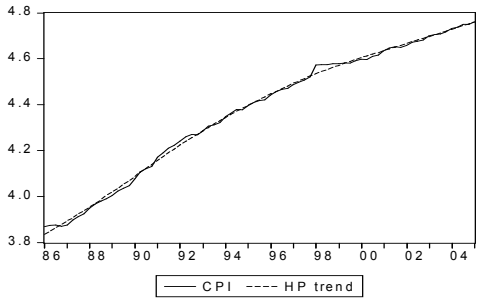
<Figure 1> Variables and HP filter trend











12) The cyclical component of each series is presented in <Figure 2>.

3. Cross-Correlation Results

The results of the cross-correlations to identify leading relationships between the prespecified variables and real estates are shown in <Table 2>. In the table, four lagged and four led values of the HP cycles of the macroeconomic variables are correlated with the contemporaneous values of the HP house price series. The strongest correlation coefficients are shown in italics. As expected, the cyclical movements of real GDP, household expenditure and household income are positively correlated with the turnover of the housing property sector, although some of the led values are negatively correlated with house price cycle.

The procyclical relationship between the house price cycle and the GDP cycle indicates that a higher turnover in real estates is the result of a buoyant economy that would lead to a rise in house price. It can be also observed that the highest correlations are at lag t-2, meaning the GDP cycle leads the house price cycle by two quarters. Therefore, it would be inferred that the revision of the GDP cycle currently incorporates economic information relating to the future cyclical trend of house price. As in the <Figure 2>, the house price cycle fluctuates more than GDP cycle in early 1990s and in 2000s during which periods the Korean housing market has been suspected of price bubbles.

However, two cycles are generally synchronous since 1992, and further inspection gives some feature that the GDP cycle seems to lead the house price cycle through 1990s. A possible explanation of this feature is that supply of housing is fixed in the short-run and thus an increase in housing demand driven by economic activity would lead to an increase in housing price.

Meanwhile, the cycle of household income is procyclical, a finding that also confirms to a priori expectation. Unlike the cycles of other variables which lead or lag the house cycle, the cross-correlation coefficients of between household income and house price cycles reveal that no phase shift is displayed in either direction over the sample period. The coefficients on lagged and led values in each quarter show symmetrical sizes. However, the largest coefficient is at time t, suggesting that the cycles of the household income and house price cycle are coincident. <Figure 2> also indicates that the cyclical components of house price and household income appear to be roughly in the same line since 1993 although the cycle of the former is more volatile.

The lead-lag linkage between the cycles of household consumption expenditure and the house price is unlikely to present the house price wealth effect on the expenditure because the house price cycle lags the consumption cycle. Of course, the previous empirical findings do not provide consistent results relating to the wealth effect.[13] <Figure 2> indicates that the house price is synchronized with the cycle of household consumption expenditure since 1992, but the former seems to lag the latter.

The consumer price (CPI) cycle shows an expected procyclical relationship with the

13) See Starr-McCluer (1998) and Ludvigson and Steindel (1999) for more detail.

house price cycle, and it lags the house price cycle by three quarters. As shown in <Figure 2>, the movements of house price cycle are generally followed by the changes in consumer price cycle. A change in housing price, however, can be also influenced by a change in the consumer price level. For instance, inflation affects the financial costs and expected capital gain, which in turn decreases user cost that is negatively related with demand for housing and thus increases in demand for housing. Hence, inflation would lead to a rise in housing price as well.[14)]

On the other hand, the interest rate cycle exhibits a procyclical behavior in relation to the house price cycle. The interest rate cyclical component could be either positively or negatively related to the house price cycle. A theoretical view is that as interest rates rise the economy and property markets are deflated, implying a negative relationship between interest rates and house price. However, the two variables could move in the same direction given the lagged response of the economy to interest rate changes, or vice versa. As a matter of fact, this result shed further light on the debate into the role of interest rates because many previous empirical works presented mixed findings. Some studies have found supportive (i.e., negative) evidence (Ling and Naranjo, 1997; Lizieri and Satchell, 1997; Brooks and Lee, 2000) but other studies have not found support for systematic effects (Chen and Tzang, 1988; Mueller and Pauley, 1995). Meanwhile, the cyclical fluctuations of interest rate and house price appear to be synchronous as shown in <Figure 2>.

<Table 2> also shows that the interest rate cycle lags the house price cycle, as the contemporaneous values of the house cycle are more strongly correlated with the led values of the cycle of interest rate than its lagged values. A possible explanation on which house price cycle leads interest cycle is that Korean government has used interest rate to choke off house price fluctuations. For instance, the movements of two cyclical components show obviously idiosyncratic behaviour when the house price cycles largely fluctuated during 1986-1993 and during recent few years.

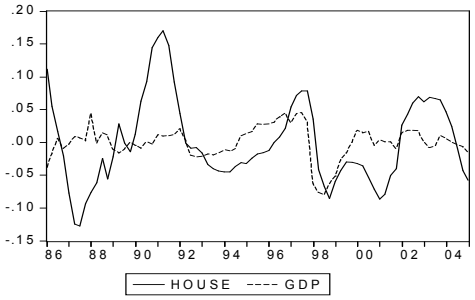
<Table 2> Cross Correlations with House Price Cycle

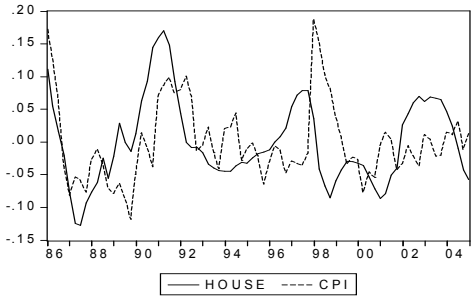
Variables	$t-4$	$t-3$	$t-2$	$t-1$	t	$t+1$	$t+2$	$t+3$	$t+4$
GDP (+)	0.18	0.23	*0.30*	0.29	0.22	0.14	0.00	-0.16	-0.27
INC (+)	0.03	0.10	0.20	0.27	*0.30*	0.29	0.21	0.07	-0.09
EXP (+)	0.30	0.39	0.43	*0.44*	0.35	0.17	-0.00	-0.17	-0.31
CPI (+)	-0.28	-0.17	-0.04	0.11	0.30	0.40	0.46	*0.51*	0.50
IR (+,-)	-0.07	-0.02	0.06	0.23	0.44	0.57	*0.59*	0.49	0.31

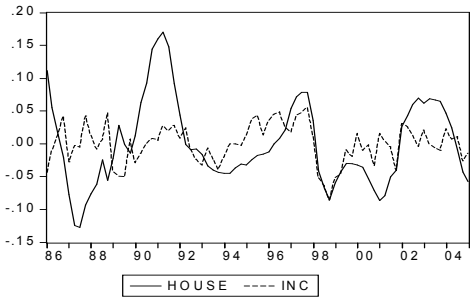
Note: The signs in parentheses indicate the expected relationships between the cycles of the variables and the house price cycle.

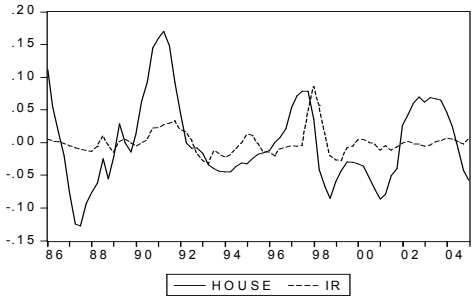
<Figure 2> The HP cycles of the variables with house price cycle

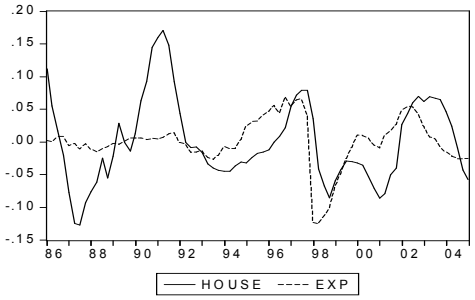
14) We discuss this issue more in next section.











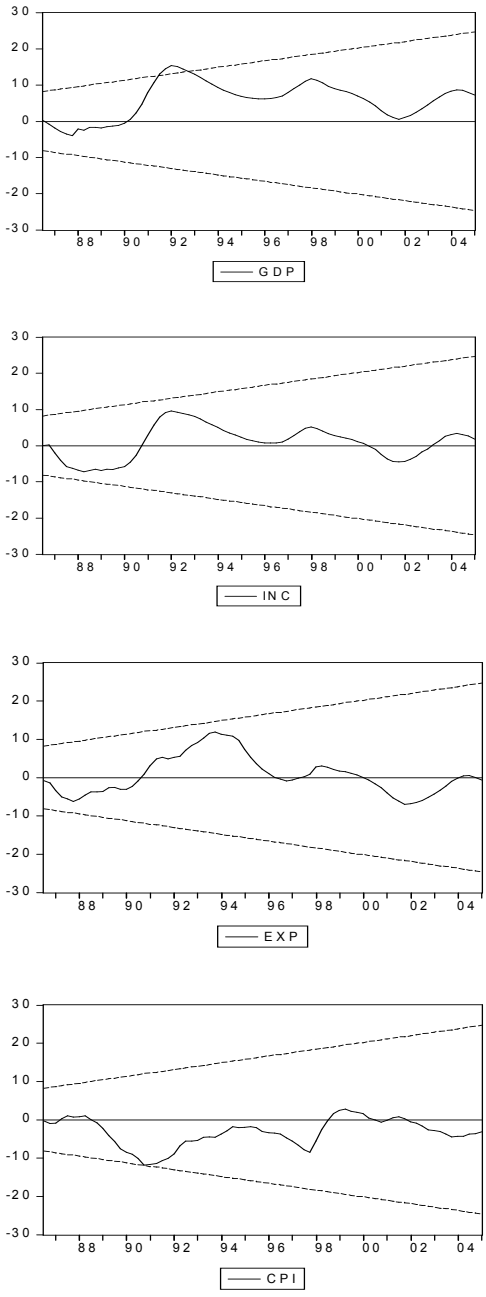
4. CUSUM Test

<Table 2> reported the cross-correlations between the house price cycle and a set of aggregate time-series over the full sample periods for each variable. An issue which arises is whether these cross-correlations are stable over time. The implicit assumption of time invariant relationships may not represent the true dynamics of the cyclical relationships. For instance, the effect interest rates on house price might be different in periods of high and low interest rates. Further, the value of housing has experienced big deflation in accord with the Korean economic crisis in 1997. It is, therefore, appropriate to test within the framework of the existing study the stability of the cross-correlations reported in <Table 2>. This can be done by examining the constancy of the correlation coefficients

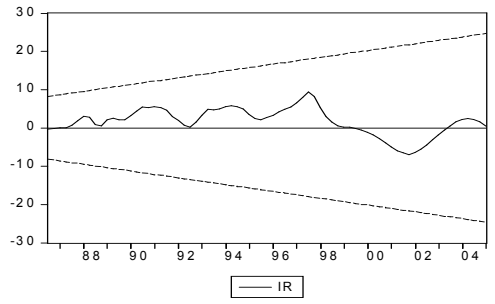
over the full sample periods. Many previous studies have examined the stability of cross-correlation using different methods.[15] In this study, the cumulative sum of recursive residuals (CUSUM) test proposed by Brown et al. (1975) is adopted. <Figure 2> indicates that GDP is unstable. The stability of the correlation between the cyclical GDP and the house price cycle, however, begins to instantaneously revert back into the bands at the beginning of 1992. The other cycles indicate the absence of any instability of the correlations between house price cycle because the plot of the CUSUM statistics is confined within the 5% critical bounds. Overall, the stability tests show that the cyclical variation in the variables and the house price cycle is stable.

Although the analysis based on the cross-correlation method is simple measures to check whether there is one-way or feedback causality between variables, the methodology is generally regarded as a primer. Instead, Granger causality test is more extensively used and is considered as more sophisticated methodology. In addition, the causal relationships between house price cycle and the cyclical components of other macroeconomic variables could be closely verified by Granger causality test based on the VAR models since all variables are seasonally adjusted using X-11 ARIMA method and the data are also detrended by the HP filter. Moreover, the VAR methodology provides an explicit understanding of dynamic structure between the cycles.

<Figure 3> Plots of CUSUM test



15) For example, Chow breakpoint test is used in the studies of Blackburn and Ravn (1992) and McGough and Tsolacos (1997).



V. VAR Analysis

1. Causality Results

We conduct the usual Granger causality tests to confirm the cross-correlation results of the variables represented in the form of HP cycles. The result of Granger causality tests of the variables is given in <Table 3>.

There exists a causal relation from GDP cycle to house price cycle whereas the reverse hypothesis that house price cycle Granger-causes GDP cycle is rejected, confirming the cross-correlation result. This result indicates that housing is a follower of fluctuation of the GDP cycle, and it is in line with the result of Chi (1999) who have found a significant effect of current movement of GDP on the predictable variation in house sale price in Korean market. Kim (2004) also reports that housing is not a driver of GDP but a follower of fluctuations of the wider economy in Korea. As previously noted, a buoyant economy would lead to rising house price. Another possible explanation on which house price cycle is influenced by the GDP cycle is that government has taken measures in housing market to counter business fluctuations.

Our results show a channel of bi-directional causal relationship between the house price cycle and the household income cycle, which is not consistent with the finding of cross-correlation. In general, the demand for housing is believed to increase, as household income goes up. This is because the rentes try to purchase their own houses and the homeowners have a tendency to seek better places as their income increases (i.e., filtering process). Thus, increase in housing demand leads to a rise in house price. Meanwhile, house price can also affect the household income. During the last several decades, the values of real estates in all forms have been increasing more rapidly than those of other financial assets in Korea. Accordingly, the Korean households' economic wealth improved as real property values increased, which led to further investment in real estate market. The households have profited by this re-investment and ended in higher income. By this chain, house price and household income could be influenced by each other. The cyclical components of house price and household income roughly move together since early 1992 as in <Figure 2>.

The cyclical movement of household consumption expenditure has exerted an unidirectional causal impact on house price cycle, which also supports the result of cross-correlation. As previously stated, this finding implies that relationship between house price cycle and the cycle of household consumption expenditure does not present the house price wealth effect on consumption expenditure. The household consumption

<Table 3> Causality Test

Variables	F-statistics		Opt.
	HOUSE → Variables	HOUSE ← Variables	lag
GDP	0.493	2.953*	1
INC	2.408*	4.357**	2
EXP	1.623	3.809**	2
CPI	5.652***	0.931	2
IR	6.220***	6.052***	3

Note: 1. *significant at the 10% level, **significant at the 5% level, ***significant at the 1% level
2. Optimal lag is selected by Akaike Information Criterion (AIC)

expenditure on the housing has been broadly considered as a main fraction of total consumption expenditure in Korea. For example, the rapid expansion of consumer credit since 2000 are thought to have been a major contributing factor to soaring apartment prices in Seoul. The rapid expansion of consumer credit is likely to have had a strong impact on the housing market because a large portion of this credit expansion is considered to flow into the Korean housing market. According to the survey by the Bank of Korea, 68% of consumer loans were collateralized by houses and about 56% of the loans were used to finance home purchases in 2002. <Figure 2> shows that the fluctuations in the cycle of household consumption expenditure are followed by the house price cycle through 1990s up to recent years, suggesting a suspicious speculative investment behavior in the housing market.

<Table 3> also present the significant causal relations from the cyclical component of house price to CPI cycle, but not vice-versa. The fact that a rise in housing price affects worker's demand for wages provides useful information in predicting the change in CPI (i.e., inflation). Further, inflationary expectation can have an effect on the demand for assets like housing and hence housing price. Thus, this increase in housing price often makes inflationary expectation end in actual inflation. In fact, the changes in housing price appear to have strong impacts on the consumer price level, as Korean housing market has experienced considerable fluctuations in house price during the early 1990s, late 1990s, and after 2001. As in <Figure 2>, sharp fluctuations in housing cycle are followed by the big waves of CPI cycle.

Finding in <Table 3> shows that there is a bi-directional causality between house price cycle and the interest rate cycle. The changes in interest rate usually have impacts on both housing suppliers and demanders, due to increase or decrease in the borrowing costs for housing construction and for purchasing house. This change in the interest rate affects both housing demand and supply and thus house price. House price and interest rate could be also influenced by each other through the substitute relationship between real estate and financial markets. Recent studies (Seo and Kim, 1999; Kim, 2004) find

that while there was a causal relationship from house price to interest rate before the economic crisis in 1997, the causality direction has been reversed after the economic crisis. This suggests that an increase in house price could indirectly raise the interest rate via the transmission channel from house price to the national price level like CPI. Put differently, housing market seemed to be much more ruled by the supply and demand in housing market and by government policy, rather than by macroeconomic conditions such as changes in GDP or interest rate before 1997. Chang and Sim (2004) also report that the effect of interest rate on the housing price increased after the 1997 economic crisis.[16] The findings of the earlier works reflect the fact that two markets have been more closely related because Korean financial market has been extensively liberalized and the housing market has been also deregulated through 1990s. In sum, the bi-directional causal relationships between house price cycle and the interest rate cycle appear to be reflected by these reasons.

To some degree, the causality results support the cross-correlation patterns between the cyclical components of house and other macroeconomic variables.

2. Impulse Response Analysis

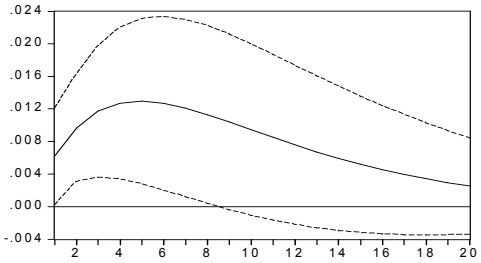
<Figure 4> depicts a generalized impulse responses of house price cycle to one standard deviation shocks in the cyclical components of macroeconomic variables as well as the cyclical responses of these variables to shock of house price cycle. The figures also include two standard error (SE) confidence bands.

One standard deviation shocks given to GDP cycle produces immediate positive responses in house price cycle, and the responses gradually decrease. Although the house cycle also has instantaneously positive impact on the GDP growth, the impact is largely dominated by the influence of innovations to GDP cycle through all periods. That is, the size of the responses in house price cycle is always much greater than the size of the responses in cyclical GDP. This finding is consistent with the results of cross-correlation and causality test, supporting again the general conception that the house price cycle lags GDP cycle. It is also worth stating that the responses of house price cycle to GDP cycle are significantly different from zero up to eight quarter, and the impulse responses do not die down even after twenty quarter of the cycle.

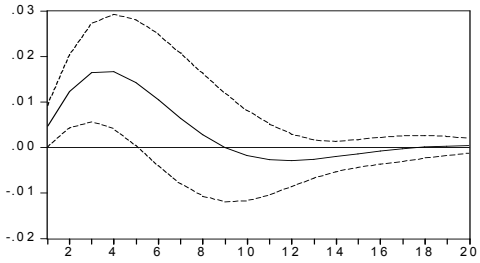
<Figure 4> Generalized Impulse Responses

16) Further investigation should be required on this result. For example, the sample period in our study needs to be divided into two sub-periods, before and after the Korean economic crisis in 1997, in order to see what the economic crisis has impact on the cyclical relationship between the house price and the macroeconomic variables. We remain this work for the future study.

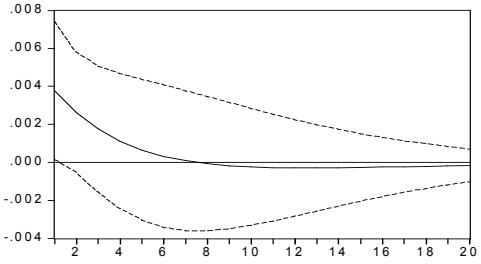
Response of HOUSE to GDP



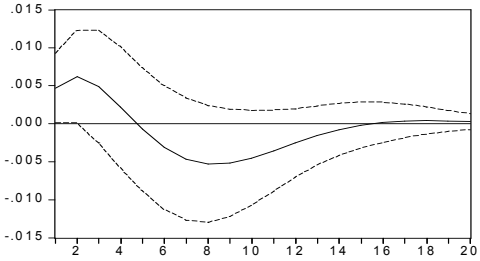
Response of HOUSE to EXP



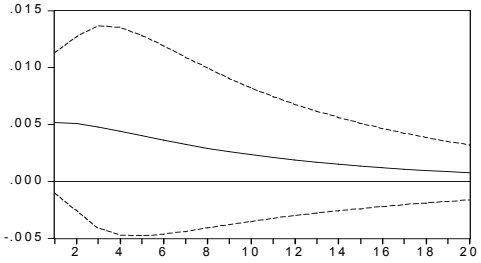
Response of GDP to HOUSE



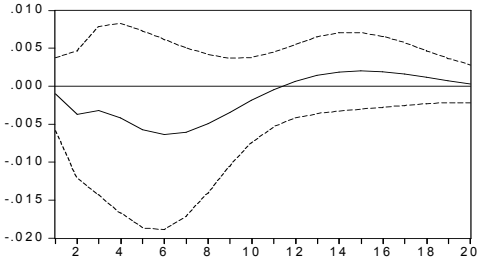
Response of EXP to HOUSE



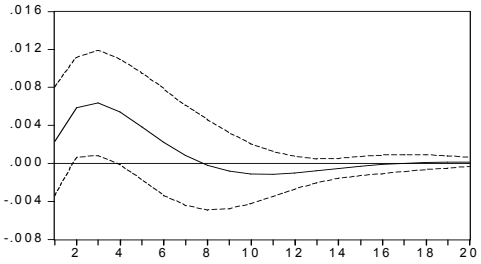
Response of HOUSE to INC



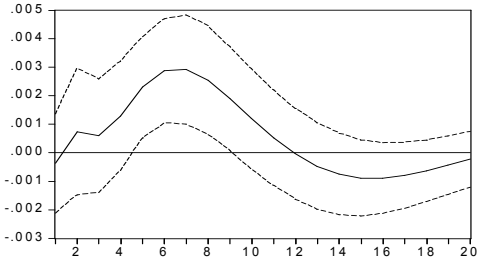
Response of HOUSE to CPI

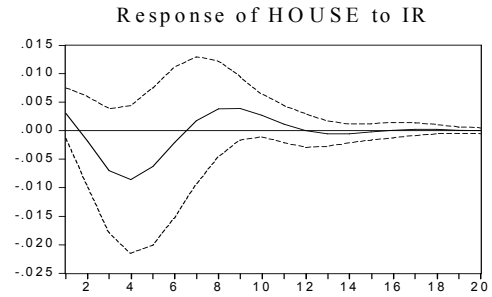


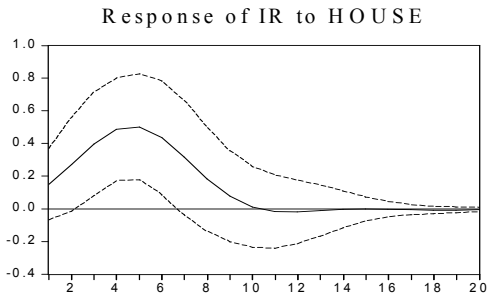
Response of INC to HOUSE



Response of CPI to HOUSE







The cyclical component of household income has initial positive impacts on house price cycle and the impacts hold steady until they converge at their original steady states, whereas the responses of the household income to innovations in house price cycle increase up to the third quarter and gradually decrease. The magnitude of response in household income cycle at the peak is greater compared with any size of the response in house price cycle. Overall, the responses in household income cycle are more instantaneous and the responses in house price cycle are more persistent.

The innovations in both house price cycle and the cycle of household consumption expenditure generate similar dynamic responses to their counter shocks, respectively. However, the reponses in house price cycle is largely dominated by the influence of shocks to the cyclical pattern of household expenditure through whole periods. The magnitude of the responses in house price cycle are much larger than those of the response in cyclical consumption. Additionally, the responses of house price cycle to consumption cycle are significantly different from zero up to five quarter. This finding seems to agree with the causality result documented in <Table 3>.

The cyclical component of house price has positive impacts on CPI cycle up to twelfth quarter after which period, however, it produces negative effects. The peak is found around seventh quarter. In contrast, the responses of the house price cycle to shocks in CPI cycle remain below zero up to the eleventh quarter, and the lowest level is at sixth quarter. However, the house price cycle positively react to the shocks in CPI cycle after the eleventh quarter onwards. This result has somewhat interesting feature. The reaction of house price cycle to innovations in the CPI cycle appears to be more sluggish than that of CPI cycle to shocks in house price cycle. This finding could be explained by the following ground. In general, CPI inflation is more likely to affect the real economy such as housing in the long run than in the short run. Moreover, the continuous excess demand (and/or speculative demand) for housing itself, rather than inflation, has been considered as a main factor in raising house price especially in Korean housing market. On the contrary, the change in CPI is deemed to be more response to the house price than to the other durable goods prices, bearing in mind the caveat that the

value of the former is much larger than that of the latter. A shock in house price cycle, therefore, instantaneously produces inflationary responses in the CPI cycle.

One standard deviation shocks given to interest rate cycle produces immediate positive responses in house price cycle but the responses gradually decrease until reaching their lowest level at the fourth quarter of the cycle. The responses in house price cycle, however, hold positive values from the sixth quarter cycle. On the contrary, the cyclical component of interest rate reacts positively to the shocks of house price cycle with the peak around fifth quarter of the cycle. This finding could be explained by a channel between interest rate and house price cycles. As a general rule, the changes in interest rate usually have impacts on both housing suppliers and demanders, due to increase or decrease in the borrowing costs of housing construction and of purchasing house. However, as the supply of housing is fixed in the short run, decrease in interest rate boosts the demand for housing and thus its price as well. Meanwhile, an increase in house price could raise the interest rate via the transmission channel from house price to the national price level like CPI. Overall, the results of impulse responses, however, is more likely to imply the existence of substitute relationship between real estate and financial markets in accordance with liberalization in financial market and deregulation in housing markets through 1990s.

VI. Summary and Conclusion

The main objective of this paper is to examine the cyclical patterns of the house price and macroeconomic variables over a nineteen-year period in Korea. Using Hodirck and Prescott (1997) filtering method, the cross-correlation analysis is first presented to identify the long-run behavior of the variables. Then, based on the vector autoregressive (VAR) model, this paper addresses the causality issue. In addition, a generalized impulse response function is employed to explicitly explore the long-run dynamic structure of the cyclical movements of the detrended variables.

As expected, the cyclical movements of GDP, disposable income, consumption expenditure and CPI are positively correlated with the turnover of the housing property sector. While the cycles of GDP and consumption expenditure lead the house price cycle by one and two quarter, respectively, the cycles of CPI and interest rate lag the house price cycle. However, the lead-lag relationship with house price cycle is not clear in case of the disposable income. Especially, the cycle of interest rate exhibits a procyclical behavior in relation to the house price cycle, and this result could further shed light on the debate into the role of interest rates because many previous empirical works presented mixed findings.

To some degree, the findings of VAR analysis support the results of cross-correlation. Namely, there exist unidirectional causal relations from the cycles of GDP and household consumption to the house price cycle, but the result presents a significant causal relation from the cyclical

component of house price to the CPI cycle. However, unlike the results of cross-correlation, the causality tests present a channel of bi-directional causal relationship between the house price cycle and the cyclical components of the household income and interest rate. This study also presents the dynamic analysis, using a generalized impulse response function. In most cases, shocks given to house price cycle generate immediate positive responses in the cycles of the macroeconomic variables. In contrast, the house price cycle responds negatively to both the CPI and interest rate cycles over the first several quarters. In particular, the impacts of house price cycle on the cycles of the GDP and consumption expenditure are largely dominated by the influences of innovations to the cycles of the GDP and consumption on the house price cycle through whole periods. This finding agree with the results of the causality test. The house price cycle responds inversely to shocks of the CPI and interest rate cycles and vice versa.

Overall, our results show a consistent cyclical relationship between house price and GDP, corroborating the general conception that the GDP cycle leads the house price cycle. In addition, this study finds that the cyclical relationship between the house price and the household consumption does not support the house price wealth effect on consumption expenditure. This implies that increased household income rooted in economic activity of household sector, rather than a mere increase in house price, could be a main factor to raise consumption expenditure. Based on the VAR analysis, it could be also inferred that there exists a substitute relationship between housing and bond markets (via interest rate). This result indicates that the two markets have become more closely in accordance with liberalization in financial markets and deregulation in housing market through 1990s.

Especially, the relationship between housing price cycle and the cycles of interest rate and GDP suggests that the market fundamentals play important roles on determining in housing price in the long run. Further, this finding gives some policy implications for the housing market. The long-term housing policy to stabilize housing markets should be considered in accordance with the macroeconomic policy (including interest rate) as well as with the condition of supply and demand in housing market. Further direction for this line of research could explicitly examine the direct contribution of the Korean economic crisis in 1997 to the cyclical relationships between housing and the macroeconomic sectors.

References

1. Baxter, M. and R. G. King, "Measuring Business Cycles: Approximate Band-pass Filters for Economic Time Series", Review of Economics and Statistics 81, pp. 575-593, 1999.
2. Blackburn, K. and M. Ravn, "Business Cycles in the United Kingdom: Facts

and Fictions", Economica 59, pp. 383-401, 1992.
3. Brooks, C. and S. Lee, "The Cyclical Relations between Traded Property Stock Prices and Aggregate Time-Series", Journal of Property Investment & Finance 18, pp. 540-564, 2000.
4. Brown, R. L., J. Durbin and J. M. Evans, "Techniques for Testing the Constancy of Regression Relationships Over Time", Journal of the Royal Statistical Society, Series B 37, pp. 149-192, 1975.
5. Chang, B. K. and S. H. Sim, "The Effects of Macroeconomic Fundamentals on Housing Market: Considering Structural Breaks", The Korean Spatial Planning Review 41, pp. 83-100, 2004.
6. Chen, K. C. and D. D. Tzang, "Interest Rate Sensitivity of Real Investment Trusts", Journal of Real Estate Research 3, pp. 13-22, 1988.
7. Chi, H. J., "Circulative Relation of Stock, Bond and Real Estate Markets to Business Cycle", Korean Management Review 25, pp. 1277-1296, 1998.
8. Cogley, T. and J. M. Nason, "Effects of the Hodrick-Prescott Filter on Trend and Difference Stationary Time Series: Implications for Business Cycle Research", Journal of Economic Dynamics and Control 19, pp. 253-247, 1995.
9. Dickey, D. A. and W. A. Fuller, "Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root", Econometrica 49, pp. 1057-1072, 1981.
10. Dokko Y., R. H. Edelstein, A. J. Lacayo and D. C. Lee, "Real Estate Income and Value Cycles: A Model of Market Dynamics", Journal of Real Estate Research 18, pp. 69-95, 1999.
11. Harvey, A. C. and A. Jaeger, "Detrending, Stylized Facts, and Business Cycle", Journal of Applied Econometrics 8, pp. 231-247, 1993.
12. Hodrick, J. and C. Prescott, "Postwar U.S. Business Cycles: An Empirical Investigation", Journal of Money, Credit, and Banking 29, pp. 1-16.
13. Kim, K. Y., "Housing and the Korean Economy", Journal of Housing Economics 13, pp. 321-341, 2004.
14. Kling, J. and T. McCue, "Office Building Investment and the Macroeconomic: Empirical Evidence, 1973-1985", Journal of the American Real Estate and Urban Economics Association 15, pp. 293-304, 1987.
15. Kydland, F. E. and E. C. Prescott, "Business Cycles: Real Facts and a Monetary Myth", Federal Reserve Bank of Minneapolis. Q. Rev. Spring, 1990.
16. Ling, D. and A. Naranjo, "Econometric Risk Factors and Commercial Real Estate Returns", Journal of Real Estate Finance and Economics 14, pp. 289-307, 1997.
17. Lizieri, C. and S. Satchell, "Property Company Performance and Real Interest Rates: a Regime Switching Approach", Journal of Property Research 14, pp. 85-97, 1997.
18. Ludvigson, S. and C. Steindel, "How

Important is the Stock Market Effect on Consumption?", Federal Reserve Bank of New York Economic Policy Review 5, pp. 29-52, 1999.

19. Matysiak, G. and S. Tsolacos, "Identifying Short-Term Leading Indicators for Real Estate Rental Performance", Journal of Property Investment & Finance, 21, pp. 212-232, 2003.
20. McGough, T. and S. Tsolacos, "Property Cycle in the UK: An Empirical Investigation of the Stylized Facts", Journal of Property Finance 6, pp. 45-62, 1995.
21. McGough, T. and S. Tsolacos, "The Stylized Facts of the U.K. Commercial Building Cycles", Environment and planning A 29, pp. 485-500, 1997.
22. Mueller, G. and K. Pauley, "The Effect of Interest-rate Movements on Real Estate Investment Trusts", Journal of Real Estate Research 10, pp. 319-325, 1995.
23. Ortalo-Magne, F. and S. Rady, "Housing Transactions and Macroeconomic Fluctuations: a Case Study of England and Wales", Journal of Housing Economics 13, pp. 287-303, 2004.
24. Pedersen, T. M., "The Hodrick-Prescott Filter, the Slutsky Effect, and the Distortionary Effect of Filters", Journal of Economic Dynamics and Control 25, pp. 1081-1101, 2001.
25. Pesaran, H. H. and Y. Shin, "Generalized Impulse Response Analysis in Linear Multivariate Models", Economics Letters 58, pp. 17-29, 1998.
26. Phillips, P. and P. Perron, “Testing for Unit Root in Time Series Regression,” Biometrica 75, pp. 335-346, 1988.
27. Seo, S. H., "Foreign Exchange Crisis and Behavioral Changes in Real Estate Prices", Housing Studies 7, pp. 5-24,1999.
28. Seo, S. H. and K. S. Kim, "An Empirical Study on the Behavioral Changes in Real Estate Prices", Housing Studies 8, pp. 5-25, 2000.
29. Shon, J. S., K. Y. Kim and Y. S. Kim, "A study on the Forecasting Model of Real Estate Market : The Case of Korea", Housing Studies 11, pp. 49-74, 2003.
30. Sims, C., "Macroeconomics and Reality", Econometrica 48, pp. 1-49, 1980.
31. Starr-McCluer, M., "Stock Market Wealth and Consumer Spending", Federal Reserve Board of Governors, Working Paper, April, 1998.
32. Witkiewicz, W., "The Use of the HP-filter in Constructing Real Estate Cycle Indicators", Journal of Real Estate Research 23, pp. 65-87, 2002.