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Does the building cycle co-move with property cycle – Empirical evidence from Hong Kong

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Reconciliation statement

More labeling of figures and direct references in the text has been made in this version of the paper, as requested by the reviewer.

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Abstract: This study investigates the cyclical behaviour of the building cycle and how building cycle interacts with property cycle in Hong Kong. We have employed spectral analysis to relevant time series data in Hong Kong. We found that cycle(s) for demand for new building works (building cycles) have various periods ranging from 1.7 to 5.3 years. We also found that there is a strong co-movement between residential building cycle and the private residential property price cycle. However, there is only a weak correlation between the price series of the other three sectors (retail, office and industrial) and the non-domestic building activity in Hong Kong. The findings are not only useful for Hong Kong construction companies in formulating their business strategies, but are also useful for policy makers in making decisions with regard to land and housing policies..

Key words: Building cycle, property cycle, co-movement

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Introduction

Mainstream construction management concentrates on the application of various specialized management techniques such as value management, constructability, benchmarking, re-engineering, total quality management, supply chain management and partnering and alliancing (McGeorge and Palmer 2002) to various construction related processes such as procurement, tendering etc. It is job specific, i.e. the various management techniques are applied to and worked within the confines of a given construction related process, normally with the sole purpose of reducing cost and/or time. The good thing about these specialized management techniques is that they are transferable from one job to another. The drawback, however, is that they are microscopic and operational in nature, even in the context of management at the company level. It is a well established management principle that even at company level; the management should not only be concerned about operational decisions but also tactical and strategic ones.

Construction management can certainly be looked at in a macroscopic way, for example, at a company or even an industry level. This will obviously depart from the well established paradigm of considering construction / building as a cost centre in the whole development process. It is argued that the amount research into construction management at the company and industry levels are insufficient. If the revenue side of the equation is not examined, the profit of the company is still unknown no matter how hard we cut the costs. This area is however greatly under researched. It is argued that oversight of the big picture would be harmful to construction firms or even the whole industry. Expansion of facilities or manpower at the wrong time would certainly bring misery to the management and hardships to workers of construction firms. It is against this background that study is pursued with a view to providing empirical findings on certain important constraints within which construction companies operate. The objective of this paper is to identify the main cycle in building activity in Hong Kong and its relationship with the local property cycle. This paper consists of four sections. Section one provides a brief literature review of building cycle studies elsewhere. The two hypotheses to be tested are developed in Section two. Section three gives a description on the methodology used. Section four is on data analysis and interpretation and Section five gives conclusions and discussion on future research directions.

Section I: Literature Review

As mentioned in the introductory section, there is much less research on macroscopic aspects of the construction industry than on the microscopic aspects. As to research specifically on the building cycle, the amount of relevant literature is even less. In the first place, we wish to define the term "building cycle" as referred to in this paper: it does not mean the "building life cycle" appeared in construction management literature but building activity level over time. Barras (1983) and Barras and Ferguson (1985, 1987a and 1987b) undertook probably the most comprehensive study of the building cycle in the United Kingdom. One reason for the lack of this kind of macroscopic study is that long time series is required to make any meaningful study. Also the collection of relevant data can only be made by government or public agencies and collection of data would require the passage of time.

Barras and Ferguson (1985) rightly point out that all building and construction activities are linked to economic developments and when a place is in the process of urbanization, a steady upward swing can be expected that could cover a period of 20 years or more. A shorter period cycle related to the business cycle is also anticipated. "Cycles in different types of building sometime reinforce and sometimes counteract each other. The combined effect is that major booms in building and construction occur periodically, with a sustained phase of rapid development expanding the supply of housing or industrial and commercial floor space, leading to increases in the stock of vacant property and a subsequent phase of low building activity."

Sampson and Skinner (1996), with the financial backing of the Construction Research Sub-Committee of the RICS, published a final report of a pilot study on 'Construction Forecasting' in which both time and frequency domain analysis were performed. The authors claim that they "out-perform previous forecasts by using methods that appear to work better than alternatives."   Specifically, they used Vector Error Correction Modeling (VECM) for their time domain analysis and Spectral Analysis for their frequency domain analysis.

Tsolacos (1999) studied the UK retail building cycles in the time domain and developed an econometric model of the volume of new development starts for retail buildings. He found that "a dynamic specification based on changes in real retail rents and total consumer spending appears to adequately capture the cyclical variation in retail development… However, there is some indication of a changing economic relationship between new retail development and retail rents after mid-1995 …"

As far as the authors are aware, no frequency domain analysis of the building cycle has been conducted in Hong Kong. In this study, the authors shall study the stylized facts of the building cycle and then the interaction of property cycle and building cycle.

Section II: Development of Hypotheses

It is argued in Man (2007) that due to the influence of Political Business Cycle (PBC) in the United States, the property prices in Hong Kong have a four year cycle, followed the presidential cycle of 4 years of the United States.

Property price is the result of the market clearing of supply and demand of the completed building/ units. Any changes in property price will send a signal to all market participants on the likely future movement of the market of completed building/ units. If the developers are convinced that the property price is going to move up, they may kick off the building (production) process, although at a time lag, in order to take advantage of the good time ahead. Likewise, if the developers are convinced that the property price is going to fall, they may withhold any intended but not yet commenced building plans or even slow down the pace of development already in place. It is therefore logical to conclude that current market value (property price) has a bearing on the building (production) activity (measured by commencement of new constructions). In a number of econometric modeling and explanation of the building cycle (Barras and Ferguson 1987a, RICS report 1994, Barras 1994, McGough et al. 1995), current property price was used as one of the independent variables. We therefore posit that, first, building (production) activity follows cyclical variation and secondly, that it co-moves with the property price. This leads to our two refutable hypotheses: first, there is a building (production) cycle and secondly, there is a co-movement between real estate price and building (production) cycle.

It should be noted that the asserted co-movement between real estate price and building (production) activity does not imply that there is also a 4 year building cycle since there would be a time lag between the decision to increase supply (build more buildings) and the actual realization of such decisions. If the time lag is similar for all projects, then it is reasonable to expect a 4 year building cycle since the building cycle are just lagged price cycles. However when a significant variation in the time lags across projects, it would be unlikely to observe a 4-year building cycle. Building development in Hong Kong is subject to lease control[15], in addition to the decision of the Building Authority and the consent of Town Planning Authority; hence time required to negotiate with the Lands Department (if the development involves lease modification and payment of a premium) is crucial. Depending on the individual characteristics of the sites planned to be developed, the lead time for obtaining all necessary approvals for development varies greatly.

The sites obtained from government auction can be developed immediately and in fact, it is generally subject to one of the most important positive covenants in the lease: the Building Covenant (B.C.) clause. The said clause stipulates the maximum time allowed for development, failing which the site will be re-entered upon by government as the lessee of the land is in breach of the lease conditions. The B.C. period imposed will usually vary from two to five years, depending on the scale of development. However, it can be further extended up to a maximum of six (6) years with good cause and payment of a fine. We speculate that the B.C. period may have a significant influence on the development activity and building cycles around 2, 3 and 5 years and this may be revealed from the data/ results.

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[15] All lands in Hong Kong are held under leasehold, except the parcel on which St. John's Cathedral stands.

Vacant agricultural land and other developed lands can also be developed/ redeveloped respectively for more intensive, alternative user. However, the lease has to be varied (modified) and the time taken and the premium paid for the variation of the lease may differ from case to case, depending upon the nature and complexity of the individual case. In conclusion, the building (production) activity depends on both the scale of development and the lead time for obtaining the necessary approvals, which is highly uncertain and unpredictable. We argue that this institutional structure aspect of building (production) activity will greatly reduce any influence of PBC in the US on the building activity in Hong Kong. This leads to a modification of our first refutable hypothesis: building (production) cycle exists but it does not follow a four year cycle which is stated formally as follows:

H1a: Hong Kong building (production) cycle exists.

H1b: Hong Kong building (production) cycle does not follow a 4 year cycle.

H2: There is a co-movement between real estate price and building (production) cycle.

Section III: Methodology

Frequency domain analysis (FDA), a branch of time series analysis, is commonly used in the study of business cycle and other areas of knowledge where there are apparent cyclical phenomena. We shall use it here to study building cycle and property cycle.

One of the criteria of the application of FDA is that the concerned time series have to be stationary. There are two types of FDA: one concerns a single time series (univariate process) and the other concerns the co-movement of two stationary time series (bi-variate process).

Analysis of a time series would naturally require the decomposition of it into seasonal, trend, cyclical and residual components. The most obvious way of analyzing time series data is to look at the plotted diagram of the same. To an experienced eye, it can identify whether a seasonal pattern and an obvious trend exists or not. Removal of seasonality is therefore the first step if it does exist. Secondly if a trend component does exist in the data series, the data has to be de-trended before further analysis. There are a number of de-trending techniques; the common ones are first differencing, second-order (or even third-order) polynomial regression, and Hodrick-Prescott filtering. The de-trending procedure is equivalent to putting the data through a (linear) filter, which may or may not affect the frequency characteristic of the original time series. We have also had low band and high band filters which have the property of allowing low frequency and high frequency components to pass through more easily. The residual series after de-trending would be the one that will be subjected to spectral analysis and tested for the existence of cycles.

There are a number of complications relating to the de-trending process. Chan, Hayya and Ord (1977) point out different trend removal methods may have different effects on the residuals of the series subject to trend removal process. Nelson and Kang (1981) further raise the possibility that there may be spurious periodicity in an inappropriately detrended time series. Another complications, which both Baxter (1991) and Canova (1998) have found is, that the stylised facts are not robust to the choice of de-trending method. As pointed out by King and Rebelo (1993), Cogley and Nason (1995) and Park (1996), the generally acclaimed HP filter has some inherent deficiency as it may introduce spurious cycle into the original data. The fact that it may turn any original integrated series, of order less than four, into stationary time series might limit its use as a proper filter for de-trending purposes. Cogley and Nason (1995) also find that HP filter is subject to the Nelson-Kang criteria when it is applied to an integrated process. As a result of this, the HP filter has to be used with care, or used in conjunction with other de-trending processes. In this study, it is used in conjunction with the first differencing (FD) and Baxter-King band-pass (BP) filter. One should note that one's view of the stylised facts of the cyclical phenomenon may be coloured by the filters chosen; this reflects the dependence of the 'stylised facts' on de-trending methods. To have a reliable 'stylised fact', we must therefore check the results from each of the three filters and ensure that they are consistent with each other.

Uni-variate analysis

For uni-variate spectral analysis, we assume that the realization of the underlying data generating process, which may be deterministic or stochastic in nature, can be adequately represented as a sum of sinusoidal oscillations of different amplitudes and related frequencies, i.e. the realization is a combination of sinusoidal functions of different, but somehow related frequencies.

By Wiener-Khintchine theorem, for any stationary stochastic process with auto-covariance function $\gamma(k)$, there exists a monotonically increasing function $F(\omega)$ such that

$$\gamma(k) = \int_0^\pi \cos\omega k \, dF(\omega) \qquad (1)$$

Equation (1) is called the spectral representation of the auto-covariance function. $F(\omega)$ has an important physical interpretation: it is the contribution to the variance of the series by components with frequencies in the range $(0, \omega)$.

If we use $f(\omega)$ (assuming it exists) to denote the derivative of $F(\omega)$, i.e.

$$f(\omega) = \frac{dF(\omega)}{d\omega}$$

then we have come up with a very important function for spectral analysis. It is the (power) spectral density function or shortened to 'spectrum'. Equation (1) can then be rewritten as:

$$\gamma(k) = \int_0^\pi \cos\omega k \, f(\omega) \, d\omega \qquad (2)$$

The physical meaning of the spectrum is that $f(\omega) \, d\omega$ represents the contribution to variance of components with frequencies in the interval $(\omega, \omega+d\omega)$. Equation (2) expresses $\gamma(k)$ in terms of $f(\omega)$ as a cosine transform. The inverse relationship is given by

$$f(\omega) = 1/\pi \sum_{k=-\infty}^{\infty} \gamma(k)e^{-i\omega k}$$

The spectrum is thus the **Fourier transform** of the auto-covariance function. Spectrum is normally estimated by periodogram. However, the periodogram is deficient in the fact that it is not a consistent estimator of spectral density function although it is asymptotically unbiased. This means that as N goes to infinity, the variance of $I(\omega)$ does not go to zero.

In order to have a consistent estimate of the (power) spectral density function, one has to go through some sort of smoothing procedure. It is noted that the periodogram is the discrete Fourier transform of the complete sample auto-covariance function. An estimate of the following form would normally be used.

$$\overset{\circ}{f}(\omega) = 1/\pi \left\{ \lambda_o c_o + 2 \sum_{k=1}^{M} \lambda_k c_k \cos\omega k \right\}$$

where $\{\lambda_k\}$ are a set of weights called the lag window and M is called the truncation point. Different types of window have been developed such as Tukey, Parzen, and Hanning etc.

Bi-variate process

When we want to look at the relationship between two time series, we have bi-variate processes to deal with. There are two different types of situation when this issue will arise. In the first situation, the two series arises on an equal footing, with the possibility that both arise from the same underlying disturbances. In the second

situation, one of the series is regarded as the input, whilst the other the output of a linear system. The first type can be said to be the equivalent of the correlation and the second type, that of regression.

Suppose we have N observations for two different series $\{x_t\}$ and $\{y_t\}$ at unit time intervals over the same period. The observations may be denoted by (x_1, y_1), …, (x_N, y_N). These observations may then be regarded as a realization of a discrete bi-variate process (X_t, Y_t). Similar to the uni-variate case, we have up to second order moments i.e. mean and auto-covariance functions for each of the two components. In addition, we have a new function called the cross-covariance function, given by:

$$\gamma_{xy}(t, k) = \text{Cov}(X_t, Y_{t+k})$$

The complementary function in the frequency domain is called **cross spectral density function** or **cross-spectrum**. Similar to the uni-variate case, the cross-spectrum of a discrete bi-variate process, measured at unit intervals of time as the Fourier transform of the cross-covariance function, is defined as:

$$f_{xy}(\omega) = 1/2\pi[\Sigma\gamma_{xy}(k)\, e^{-i\omega k}]$$

over the range of $(0, \pi)$. It is observed that $f_{xy}(\omega)$ is a complex function and the inverse relationship is

$$\gamma_{xy}(k) = \int_{-\pi}^{\pi} e^{-i\omega k}\, f_{xy}(\omega)\; d\omega$$

To give a proper interpretation of the cross-spectrum, let us look at both the real and imaginary part of it. The real part of the cross-spectrum is called the **co-spectrum** and is given by:

$$c(\omega) = 1/\pi[\Sigma\gamma_{xy}(k)\, \cos\omega k]$$

The imaginary part of the cross-spectrum, with a minus sign, is called the **quadrature** spectrum and is given by:

$$q(\omega) = 1/\pi\,[\Sigma\gamma_{xy}(k)\, \sin\omega k]$$
$$\text{and } f_{xy}(\omega) = c(\omega) - i\, q(\omega)$$

Another function derived from the cross-spectrum is the (squared) **coherency**, which is given by:

$$C(\omega) = [c^2(\omega) + q^2(\omega)]/[f_x(\omega)\, f_y(\omega)]$$
$$= \alpha_{xy}{}^2(\omega)/\, f_x(\omega)\, f_y(\omega)$$

,where $f_x(\omega)$, $f_y(\omega)$ are the power spectra of the individual processes. It can be shown that $0 \leqq C(\omega) \leqq 1$ and it measures the square of the linear correlation between the two components of the bi-variate process at frequency ω. It is therefore analogous to the square of the usual correlation coefficient. This property makes it suitable for the measurement of the co-movement of the components of the bi-variate process.

Furthermore, according to Malinvaud (1970), the coherence $C(\omega)$ can be proved to have the following property: the quantity $\dfrac{2mC(\omega)}{1 - C(\omega)}$ is distributed as an F-variable with 2 and 4m degrees of freedom.

For example, the 5% critical value F_0 of the F-distribution with 2 and 12 degrees of freedom is, from the F statistics table, 3.89 and the critical value of $C(\omega)$ is given by 0.39, according to the above formula.

Section IV: Data analysis and interpretation of results

Data employed in this study were taken from public records: use was made of the number of 'consent to commence' records kept by the Buildings Department as our measure of the amount of building activity. Data kept by Building Department are most reliable and comprehensive as no works can commence without its approval. Since most of the consents from Buildings Department will actually lead to building works, this statistic measures in a consistent manner the intention of the developers / builders and the actual building works.   The completed floor area was not used as a measure of building activity; it is understood that the completed floor area at any time t could be a combination of building activities which commenced anytime from 2 years to up to well over 10 years ago. As a result, this variable is not instrumental in measuring the desired level of new building activities.

Monthly data of 'consent to commence' records were obtained for the study running from May, 1982 to December of 2004.   No seasonality is observed in the data series and hence only the trend, if any, needs subtracting before subjecting the data for spectral analysis. As mentioned in the methodology section, it is necessary to check whether the series is stationary or not. The abbreviations of the various data time series are in Table 1.   The standard unit root tests were performed and it was established that the data series is stationary as indicated in Table 2.
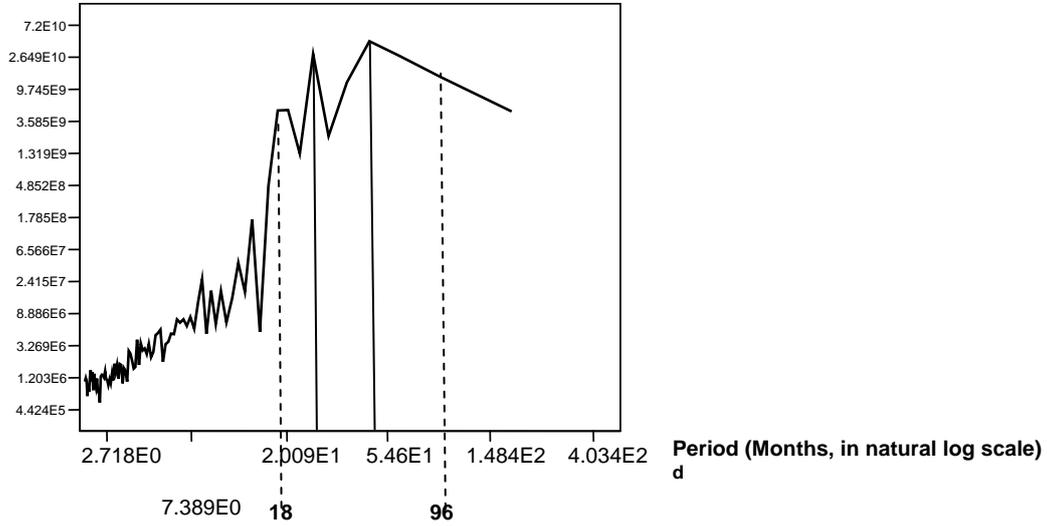
4.1   Existence of Building Cycles
We perform the uni-variate spectral analysis on the Domestic, Non-domestic and Aggregate CTC time series and find the existence of three cycles. The results for testing building cycles are set out in the following diagrams. Our empirical results find the existence of three cycles; however, there is no 4 year cycle for the building (production) market. A table showing the summary of results for the two sub-sectors (domestic and non-domestic) and their aggregate is shown below.
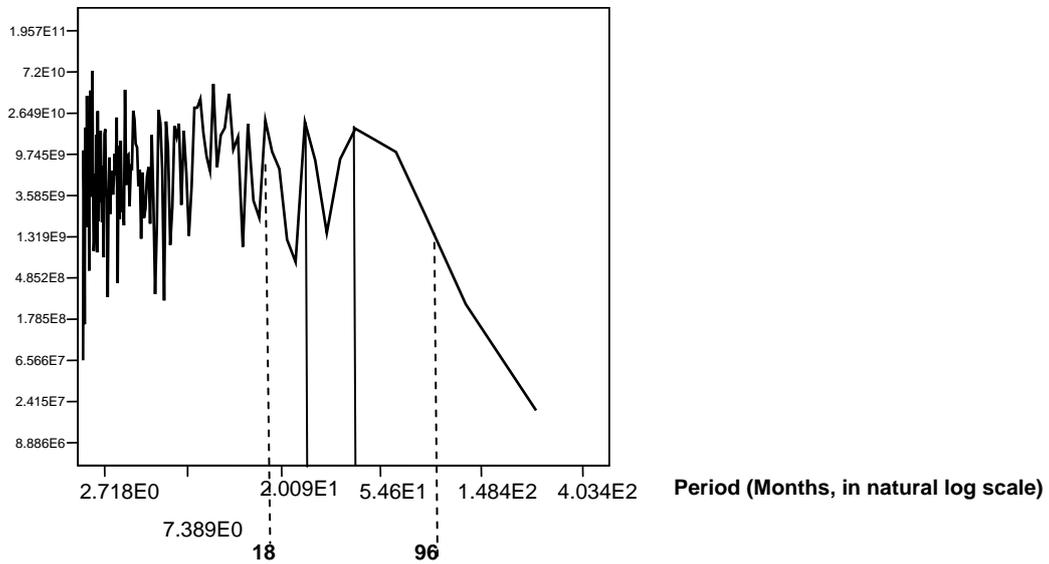
Building (production) cycle	Cycle (in years)				
	1.7	2.2	3	3.7	5.3
Domestic		✓		✓	
Non-domestic	✓	✓	✓		✓
Aggregate		✓	✓		✓

The existence of the observed cyclical phenomenon has confirmed our first hypothesis as we find no 4 years cycle in building activities of Hong Kong. The observed cycles are about 2, 3 and 5 years in periods, reflecting the influences of the building   covenant   periods   on   the   building   activity.
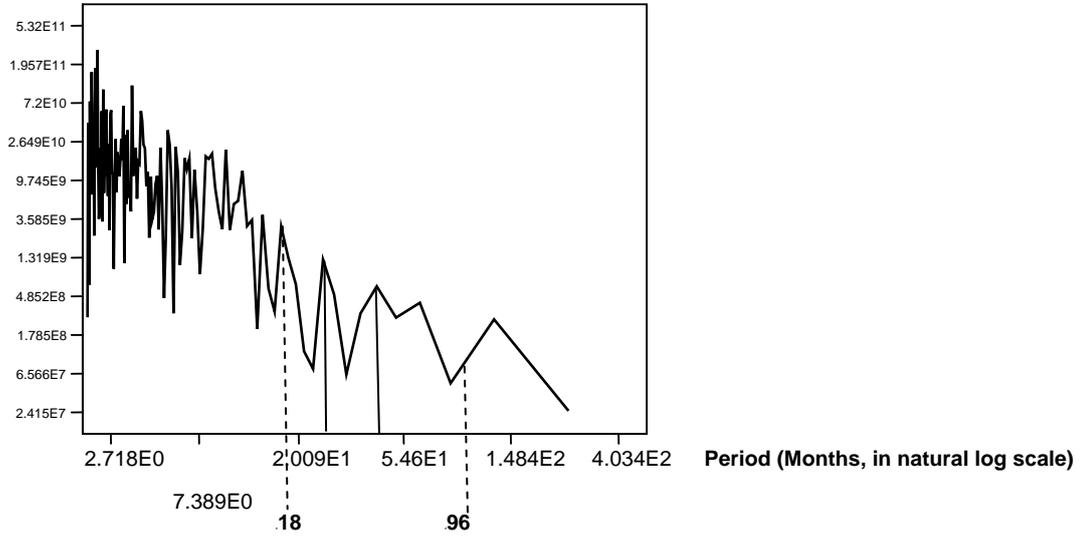
Periodogram of CTC_DOM_BP[2] by Period

7.2E10	
2.649E10	
9.745E9	
3.585E9	
1.319E9	
4.852E8	
1.785E8	
6.566E7	
2.415E7	
8.886E6	
3.269E6	
1.203E6	
4.424E5	

2.718E0   2.009E1   5.46E1   1.484E2   4.034E2   **Period (Months, in natural log scale)**
                                                      d

7.389E0   **18**   **96**

Periodogram of CTC_DOM_HP[3] by Period

1.957E11	
7.2E10	
2.649E10	
9.745E9	
3.585E9	
1.319E9	
4.852E8	
1.785E8	
6.566E7	
2.415E7	
8.886E6	

2.718E0   2.009E1   5.46E1   1.484E2   4.034E2   **Period (Months, in natural log scale)**

7.389E0   **18**   **96**

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2 This is to denote the "Consent to commence (domestic) data series after seasonality and trend (band pass filter treatment) removal".

3 This is to denote the "Consent to commence (domestic) data series after seasonality and trend (HP filter treatment) removal".

Periodogram of CTC_DOM_FD[4] by Period
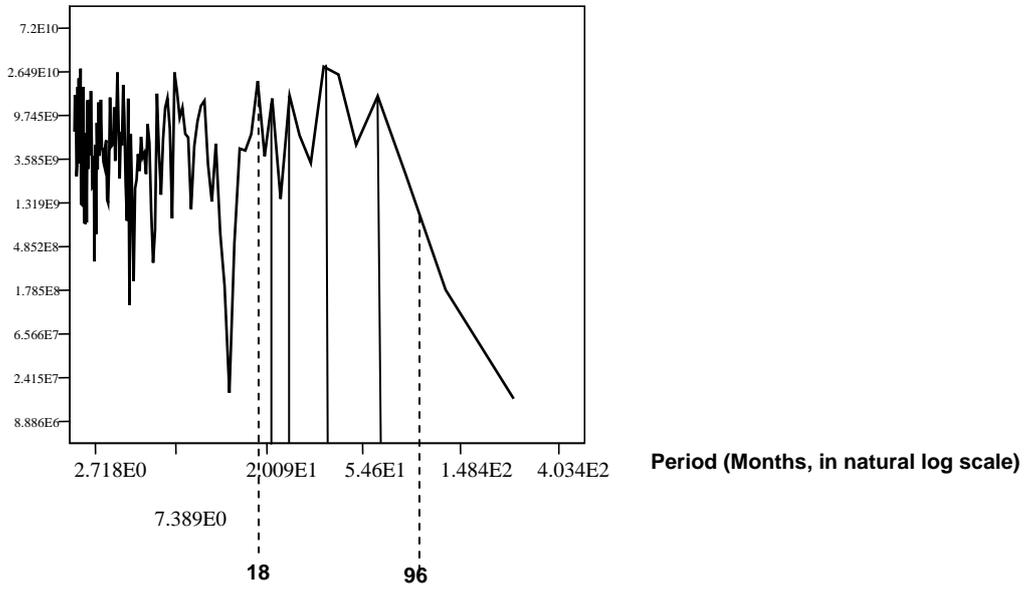

Period (Months, in natural log scale)

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4 This is to denote the "Consent to commence (domestic) data series after seasonality and trend (First Differences filter treatment) removal".
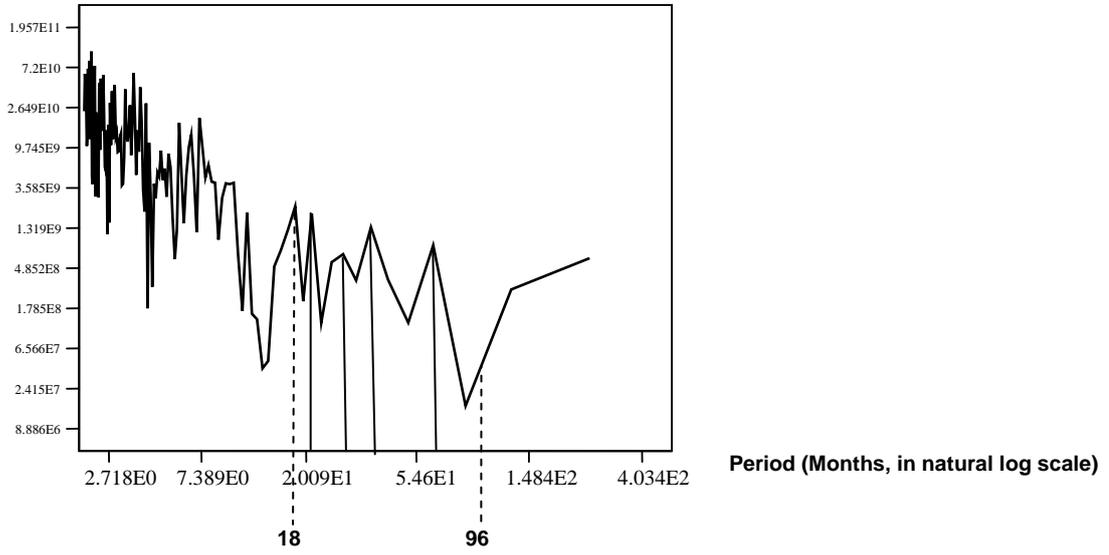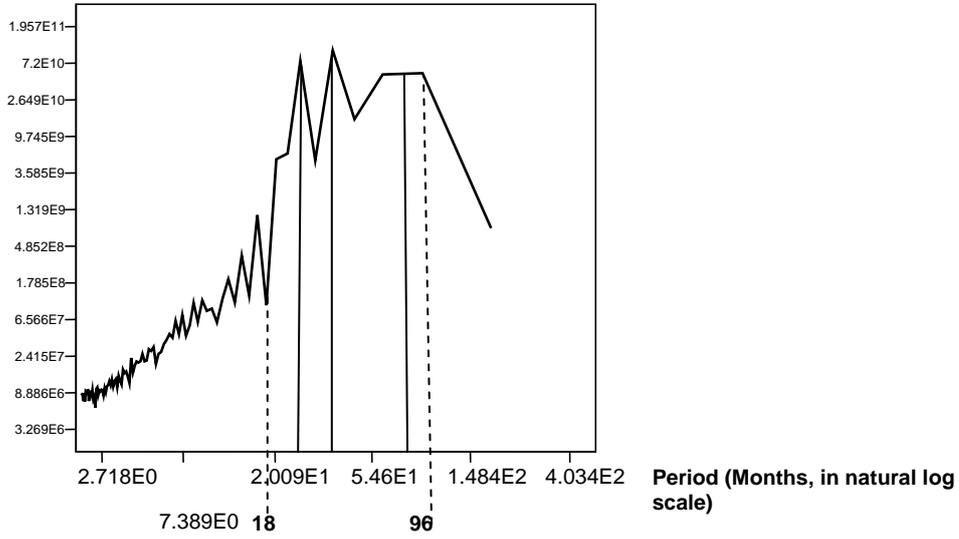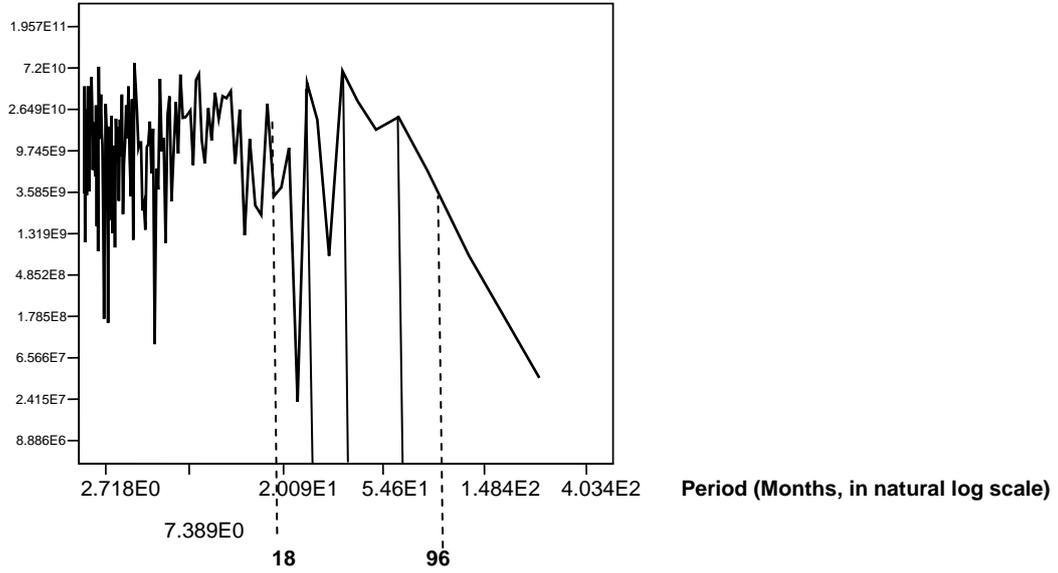
Periodogram of CTC_NDOM_BP[5] by Period

Period (Months, in natural log scale)
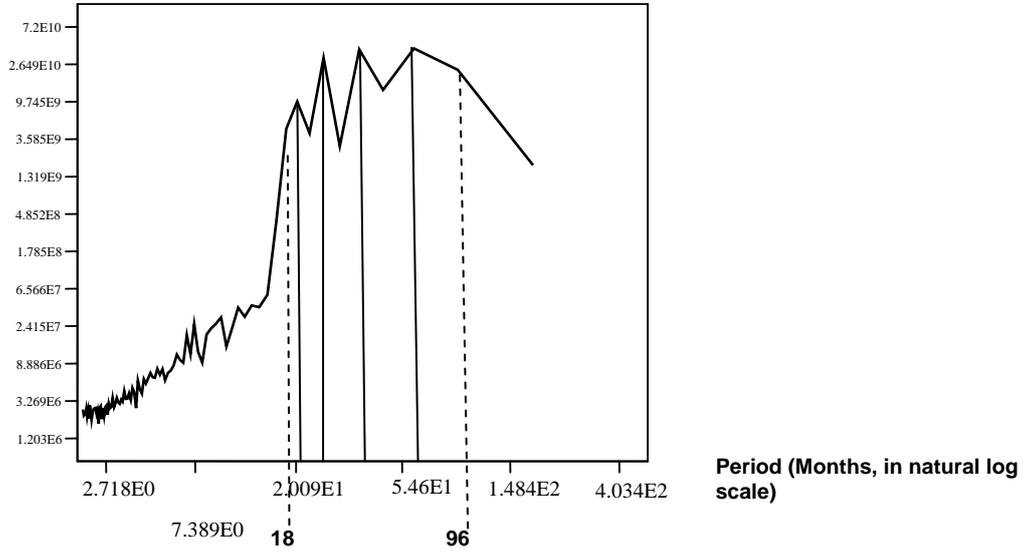
Periodogram of CTC_NDOM_HP[6] by Period

Period (Months, in natural log scale)

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5 This is to denote the "Consent to commence (non-domestic) data series after seasonality and trend (band pass filter treatment) removal".

6 This is to denote the "Consent to commence (non-domestic) data series after seasonality and trend (HP filter treatment) removal".

Periodogram of CTC_NDOM_FD[7] by Period

Period (Months, in natural log scale)

---

7 This is to denote the "Consent to commence (non-domestic) data series after seasonality and trend (First Differences filter treatment) removal".

Periodogram of CTC_AGG_BP[8] by Period

1.957E11	
7.2E10	
2.649E10	
9.745E9	
3.585E9	
1.319E9	
4.852E8	
1.785E8	
6.566E7	
2.415E7	
8.886E6	
3.269E6	

2.718E0   2.009E1   5.46E1   1.484E2   4.034E2   **Period (Months, in natural log scale)**

7.389E0 **18**   **96**

Periodogram of CTC_AGG_HP[9] by Period

1.957E11	
7.2E10	
2.649E10	
9.745E9	
3.585E9	
1.319E9	
4.852E8	
1.785E8	
6.566E7	
2.415E7	
8.886E6	

2.718E0   2.009E1   5.46E1   1.484E2   4.034E2   **Period (Months, in natural log scale)**

7.389E0

18   **96**

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[8]This is to denote the "Consent to commence (aggregate) data series after seasonality and trend (band pass filter treatment) removal".

[9]This is to denote the "Consent to commence (aggregate) data series after seasonality and trend (HP filter treatment) removal".

Periodogram of CTC_AGG_FD[10] by Period

Period (Months, in natural log scale)
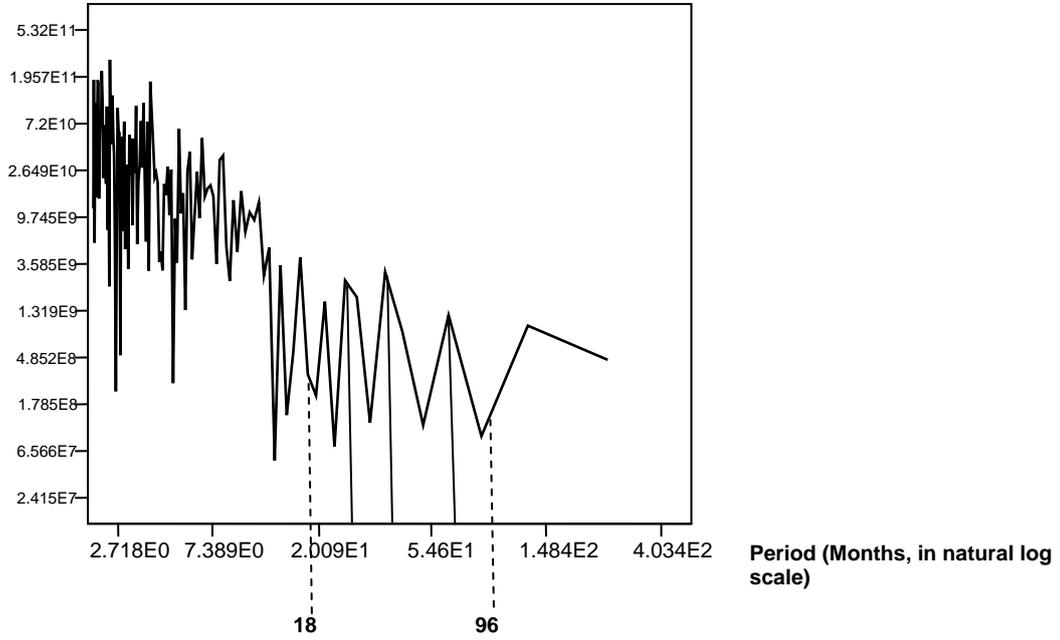
10 This is to denote the "Consent to commence (aggregate) data series after seasonality and trend (First Differences filter treatment) removal".

4.2   Co-movement of Property Cycle and Building Cycle

In order to explore the interaction of building activity and the property price movement, the stationarity of the relevant time series had to be checked, details at Table 2. Bi-variate spectral analyses were then performed on the filtered building activity and the related property price series. The results are shown in the following diagrams.

In this section, we will present the co-movements (co-cycle movements) of the direct real estate market, as measured by the price indexes of the four different market segments, and the building (production) market, as measured by the number of monthly consent to commence works for domestic and non-domestic buildings. [22]Results between direct real estate market and building (production) market are presented in sections (4.2.1), (4.2.2), (4.2.3) and (4.2.4).

Co-movement measures such as coherence, quadratures etc. were to measure the correlation between the two data series at an individual frequency (ω) level. Coherence is the most useful measure of the correlation of two data series as it is the correlation coefficient of the two data series at an individual frequency (ω) level. The closer the coherence value to 1; the greater the correlation is the two data series at an individual frequency (ω) level.

On examining the coherence value diagrams between direct real estate segments and the respective building (production) activities, we find that while a reasonable strong correlation exists between residential price series and the domestic building activity, it is not the case for the other three sub-sectors. For the other three sub-sectors, the coherence values at certain periods are less than the respective critical values, indicating that only a weak correlation exists between the price series of the three segments and the non-domestic building activity.
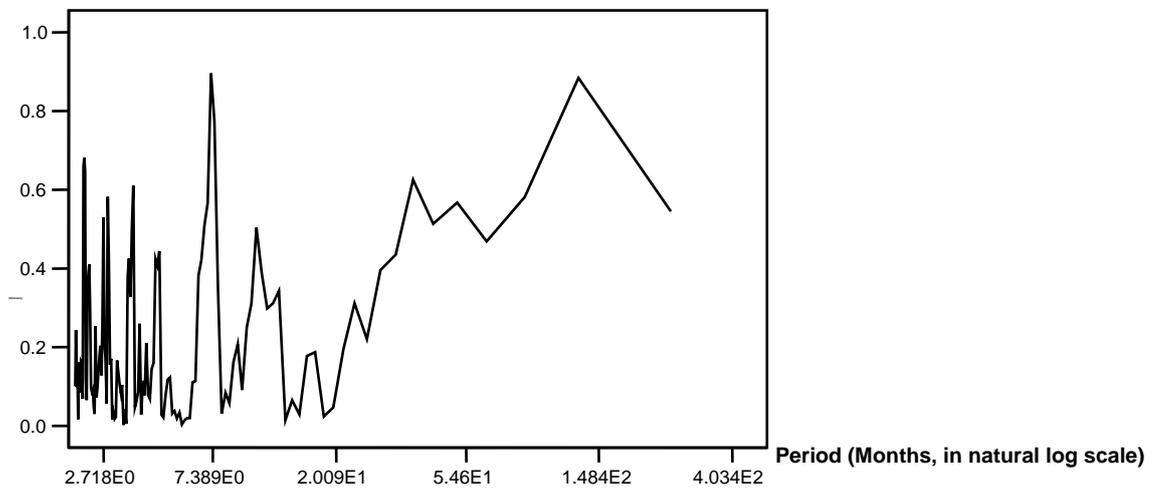
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[22]

4.2.1 Residential sub-sector

Coherency of RES_P_BP[12] and CTC_DOM_BP[2] by   Period

Period (Months, in natural log scale)
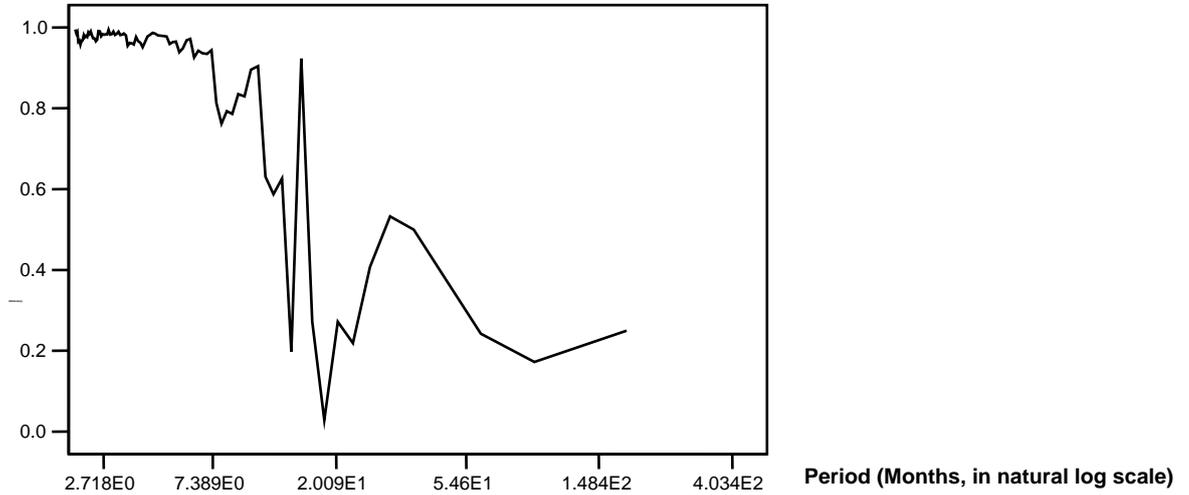
Window: Tukey-Hamming (5)

Coherency of RES_P_HP[13] and CTC_DOM_HP[3] by   Period

Period (Months, in natural log scale)

Window: Tukey-Hamming (5)

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12 This is to denote the "Residential real estate price data series after seasonality and trend (band pass filter treatment) removal".

2   This is to denote the "Consent to commence (domestic) data series after seasonality and trend (band pass filter treatment) removal".

13 This is to denote the "Residential real estate price data series after seasonality and trend (HP filter treatment) removal".

3   This is to denote the "Consent to commence (domestic) data series after seasonality and trend (HP filter treatment) removal".

4.2.1 Residential sub-sector

Coherency of RES_P_FD[14] and CTC_DOM_FD[4] by Period
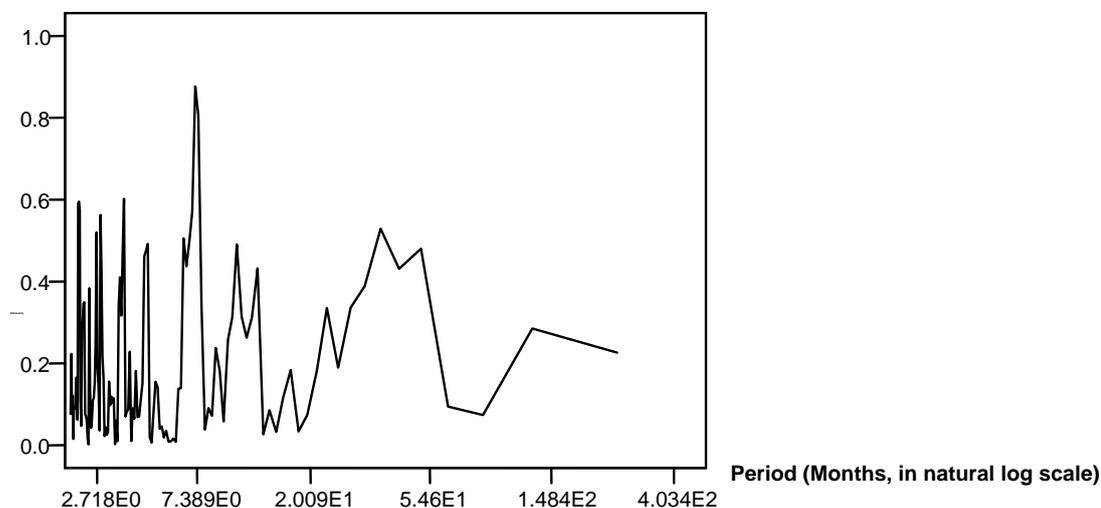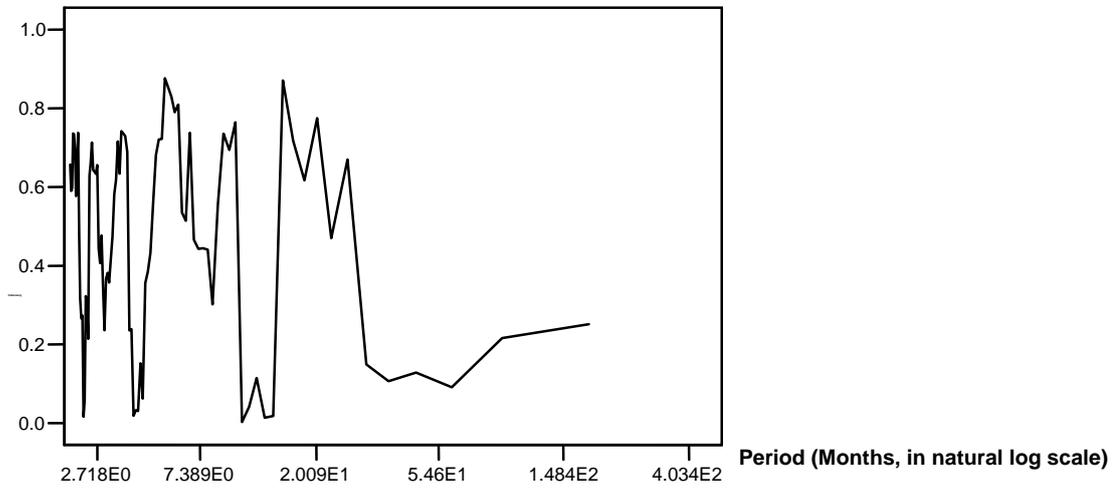

Window: Tukey-Hamming (5)

In the above, we show the coherency diagrams of the two series, namely, residential price series and the domestic development series, namely, CTC (Dom). The two series have gone through seasonal adjustment, trend removal process before subject to the bi-variate spectral analysis procedure. The stationarity checking of the relevant filtered series are at Table 2. There were 183, 255 and 254 data points from both series and the related coherency critical value, according to the formula shown in section (3.2) were calculated to be 0.049, 0.034 and 0.035 for the bp, hp and fd filters respectively. It is observed that over the entire relevant range, the coherency value is above the relevant critical value for all three filters, indicating that there is a reasonably strong correlation between these two series over the relevant range. The relevant range is referred to adopted business cycle period, i.e. from 1.5 years to 8 years.

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14 This is to denote the "Residential real estate price data series after seasonality and trend (First Differences filter treatment) removal".

4   This is to denote the "Consent to commence (non-domestic) data series after seasonality and trend (band pass filter treatment) removal".
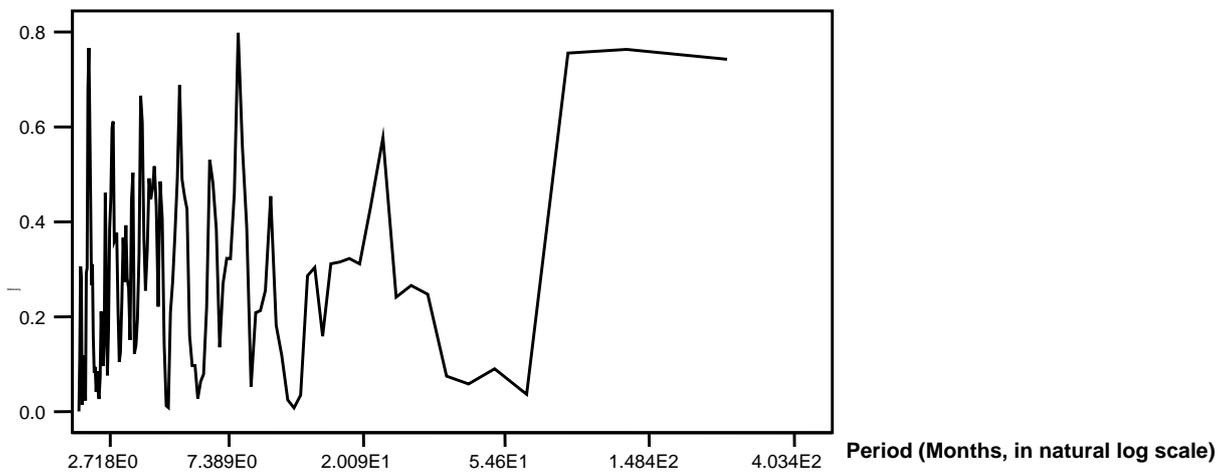
4.2.2 Industrial sub-sector

Coherency of IND_P_BP[15] and CTC_NDOM_BP[2] by Period

Period (Months, in natural log scale)

Window: Tukey-Hamming (5)

Coherency of IND_P_HP[16] and CTC_NDOM_HP[6] by Period

Period (Months, in natural log scale)

Window: Tukey-Hamming (5)

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15 This is to denote the "Industrial real estate price data series after seasonality and trend (band pass filter treatment) removal".

2 This is to denote the "Consent to commence (non-domestic) data series after seasonality and trend (band pass filter treatment) removal".

16 This is to denote the "Industrial real estate price data series after seasonality and trend (HP filter treatment) removal".

6 This is to denote the "Consent to commence (non-domestic) data series after seasonality and trend (HP filter treatment) removal".

4.2.2 Industrial sub-sector

Coherency of IND_P_FD[17] and CTC_NDOM_FD[7] by Period
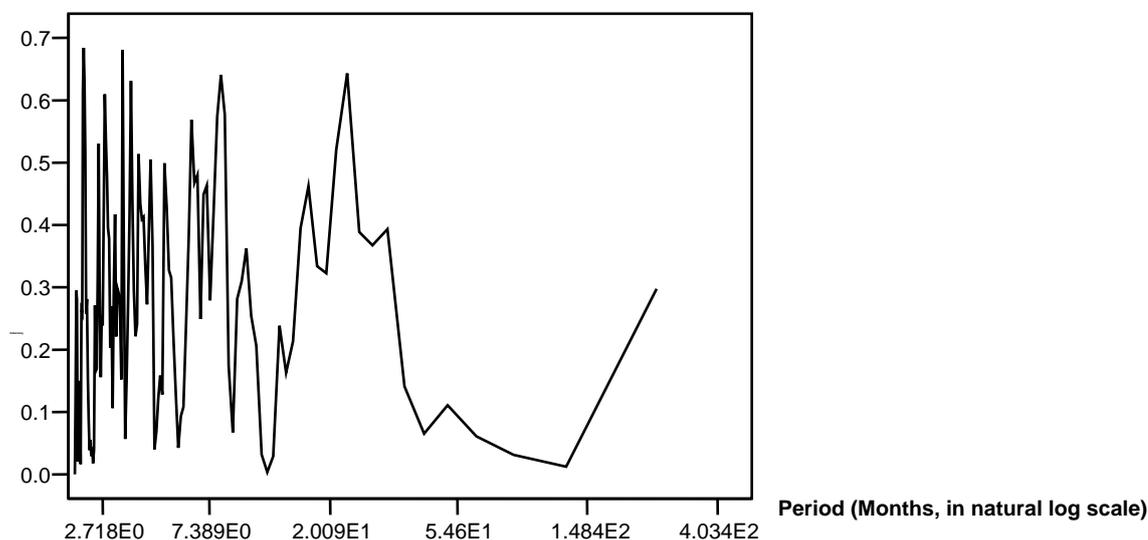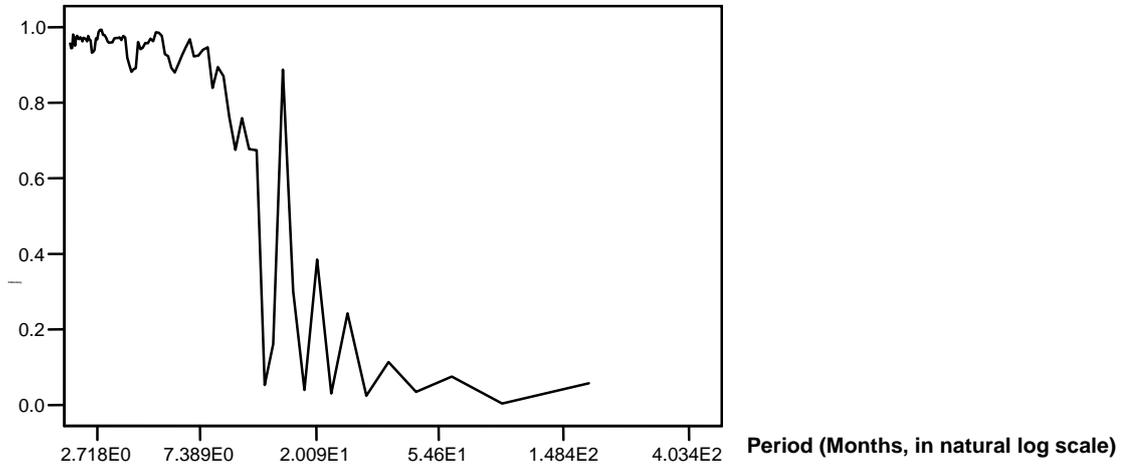

Window: Tukey-Hamming (5)

In the above, we show the coherency diagram of the two series, namely, industrial price series and the development series, namely, CTC (NDOM). The two series have gone through seasonal adjustment, trend removal process before subject to the bi-variate spectral analysis procedure. The stationarity checking of the relevant filtered series are at Table 2. There are 182, 254 and 253 data points for the three respectively filtered series and the related coherency critical value, according to the formula shown in section (3.2) were calculated to be 0.049, 0.035 and 0.035 for the bp, hp and fd filters respectively. It is observed that over most of the relevant range, the coherency values were greater than the relevant critical value for all three filters except for some period values. This indicates that there is a reasonable correlation between these two series over most of the relevant range. However, the corresponding coherence values were not as great as in the correlation between residential price series and domestic building activity. The relevant range is referred to adopted business cycle period, i.e. from 1.5 years to 8 years

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17This is to denote the "Industrial real estate price data series after seasonality and trend (First Differences filter treatment) removal".

7 This is to denote the "Consent to commence (non-domestic) data series after seasonality and trend (First Differences filter treatment) removal".

4.2.3 Retail sub-sector

Coherency of RET_P_BP[18] and CTC_NDOM_BP[5]
by   **Period**
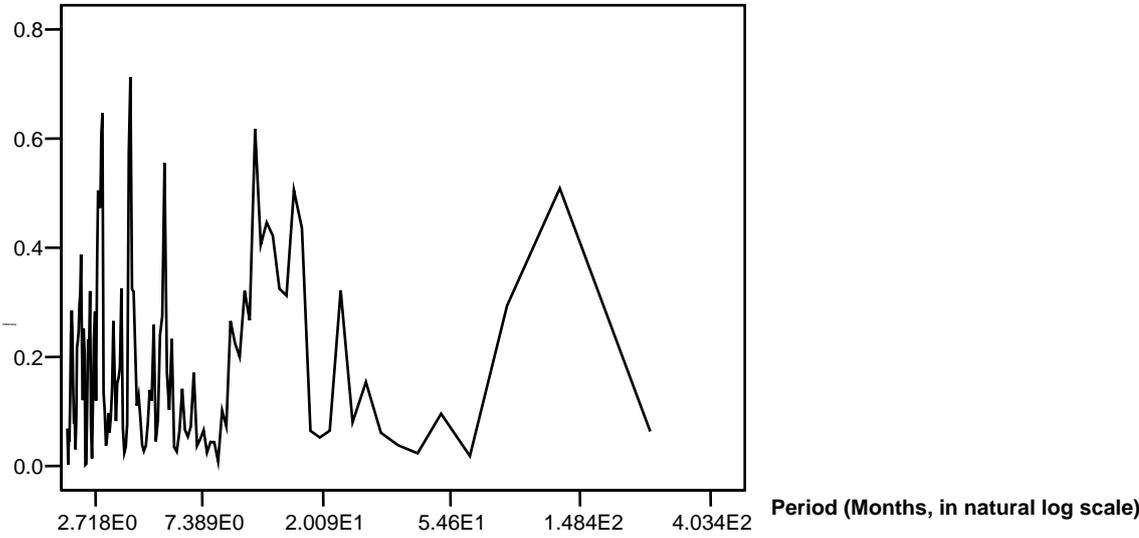

Window: Tukey-Hamming (5)

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18 This is to denote the "Retail real estate price data series after seasonality and trend (band pass filter treatment) removal".

5   This is to denote the "Consent to commence (non-domestic) data series after seasonality and trend (band pass filter treatment) removal".

19 This is to denote the "Retail real estate price data series after seasonality and trend (HP filter treatment) removal".

6   This is to denote the "Consent to commence (non-domestic) data series after seasonality and trend (HP filter treatment) removal".
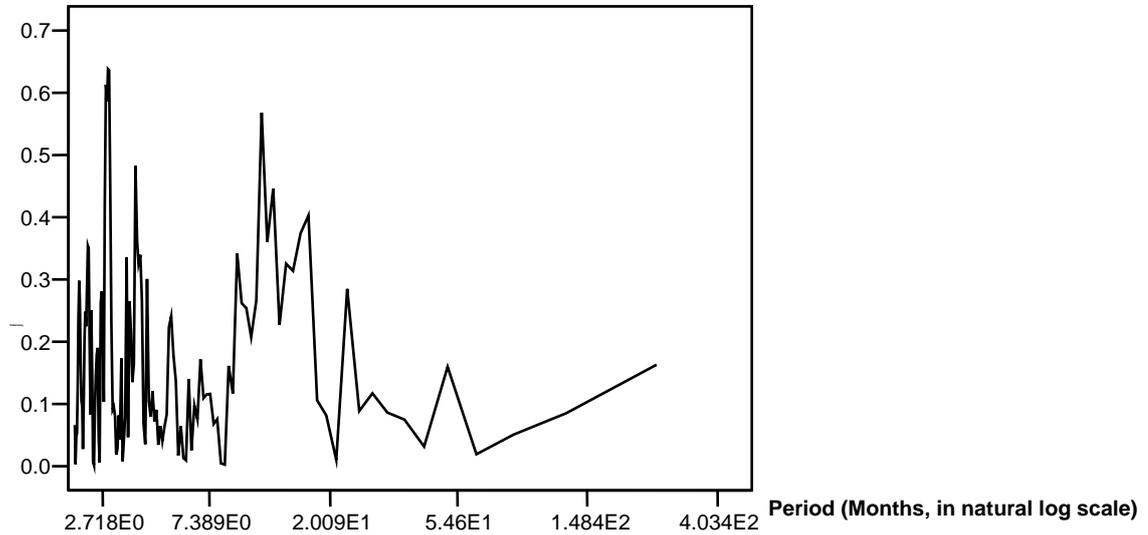
Coherency of RET_P_HP[19] and CTC_NDOM_HP[6] by Period

Window: Tukey-Hamming (5)

4.2.3 Retail sub-sector

Coherency of RET_P_FD[20] and CTC_NDOM_FD[7] by Period

Period (Months, in natural log scale)
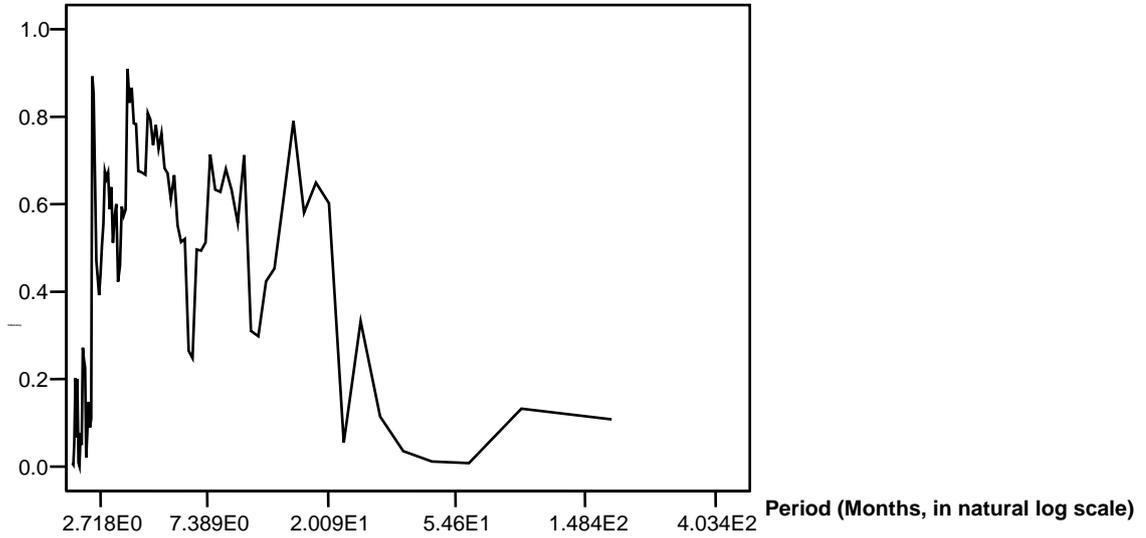
Window: Tukey-Hamming (5)

In the above, we show the coherency diagrams of the two series, namely, retail price series and the non-domestic development series, namely, CTC (NDOM). Results are similar to that of industrial sub-sector.

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20 This is to denote the "Retail real estate price data series after seasonality and trend (First Differences filter treatment) removal".

7 This is to denote the "Consent to commence (non-domestic) data series after seasonality and trend (First Differences filter treatment) removal".
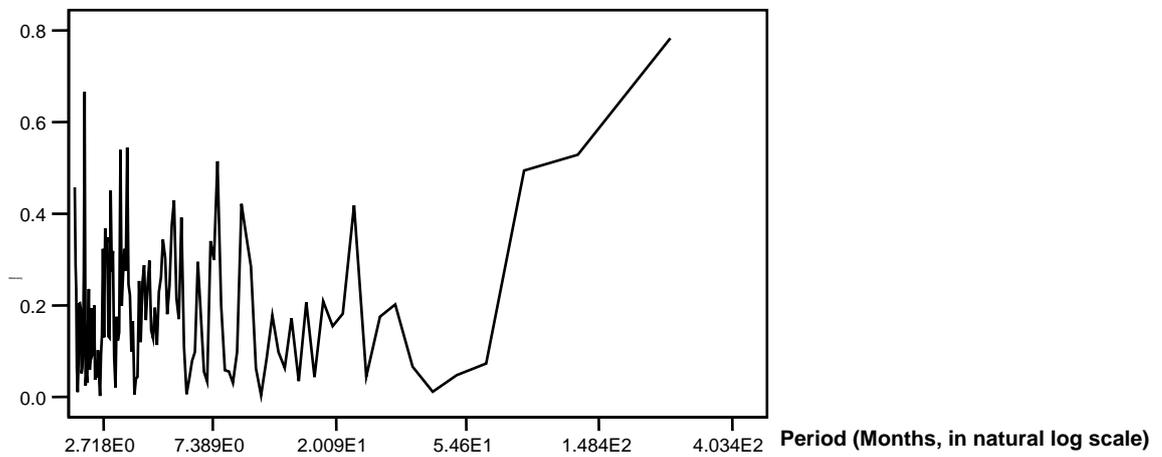
4.2.4 Office sub-sector

Coherency of OFF_P_BP[21] and CTC_NDOM_BP[5] by   Period

Window: Tukey-Hamming (5)

Coherency of OFF_P_HP[22] and CTC_NDOM_HP[6] by Period

Window: Tukey-Hamming (5)

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21 This is to denote the "Office real estate price data series after seasonality and trend (band pass filter treatment) removal".

5 This is to denote the "Consent to commence (non-domestic) data series after seasonality and trend (band pass filter treatment) removal".

22 This is to denote the "Office real estate price data series after seasonality and trend (HP filter treatment) removal".

6   This is to denote the "Consent to commence (non-domestic) data series after seasonality and trend (HP filter treatment) removal".

4.2.4 Office sub-sector

Coherency of OFF_P_FD[23] and CTC_NDOM_FD[4] by Period
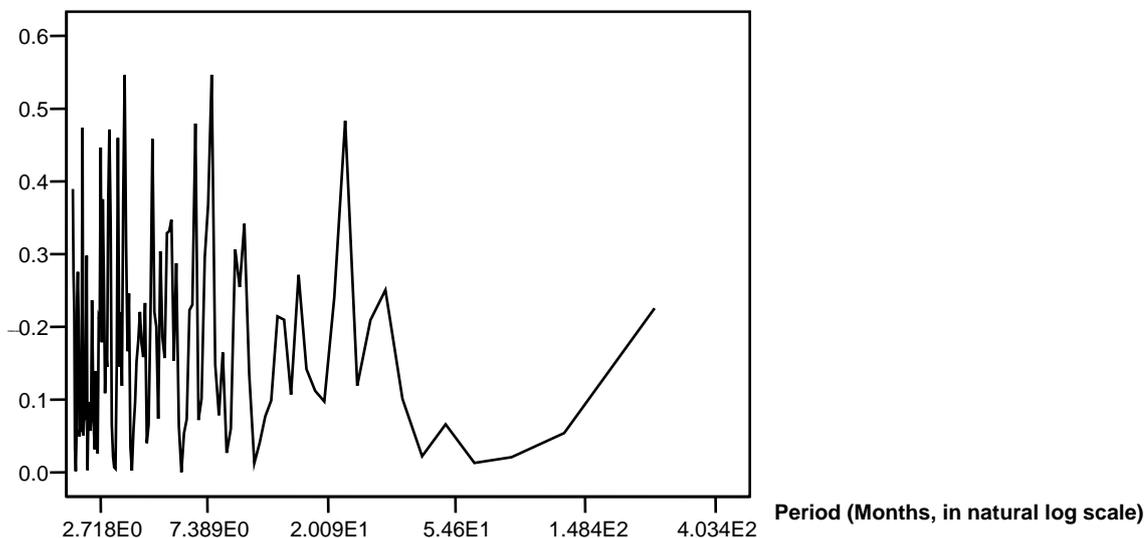
Window: Tukey-Hamming (5)

In the above, we show the coherency diagrams of the two series, namely, office price series and the Non-domestic development series, namely, CTC (NDOM). Results are similar to that of the industrial sub-sector.

It is found that a stronger coherence exists between residential building activity and private residential price over the relevant period range. This is no surprise as private residential building activity is a significant proportion of the total building activity. This is particularly the case as the infrastructural works component of the total construction works in Hong Kong becomes smaller with all the major infrastructural works such as new airport, tunnels and major trunk roads were completed in the past decade.

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23 This is to denote the "Office real estate price data series after seasonality and trend (First Differences filter treatment) removal".

4 This is to denote the "Consent to commence (domestic) data series after seasonality and trend (First Differences filter treatment) removal".

Section V: Conclusions and Implications

This is the first study of the building cycle in Hong Kong. It is considered that the establishment of its existence is important to the construction industry and construction firms and practitioners.   The construction industry should bear its existence in mind because of the critical implication for the resources requirements, training of staff etc.

Building cycle has a great implication for the construction industry in particular to the resources requirements of the same. When the building cycle is on its upswing, the industry would undoubtedly experiences a good time. However, it would suffer from a shortage of competent workers. This will put pressure on the completion time and quality of works to be done. A better co-ordination of the procurement process, in fact all other construction processes as well, becomes mandatory in order to have the jobs done on time. This would have an implication on the training of construction professionals such as engineers, architects, surveyors, builders etc.   On the other hand, when the building cycle is on its downswing, the existing construction professionals and workers would be put in precarious positions. As it takes substantial resources and time to train up and maintain the competency of the construction professionals and workers, it would be a gross misallocation of economic resources if they have to change jobs during the downswing. This has great social policy implications as great social cost is at stake. Intakes of educational institutes for construction professionals and workers should definitely take this into consideration.

To play the role of a stabilizer of the economy, the government can actively pursuit a contrarian stance with the private sector by way of implementation of, say, its land and public housing policy. For example, government can actively purchase land and implement public housing policy while the private sector retreats from the market and vice versa. This will, in the long run, lowers the cost of construction of public building projects and serve the purpose of providing job opportunities while it is most needy by its people.

At a company level, the observance of the existence of building cycle is of strategic importance. Over-expansion of the capacity of a construction firm in terms of machinery and equipment or over-hiring of core staff in an inappropriate time might cause cash flow and profitability problem to the firm. In the extreme case, it might push it closer to bankruptcy. However, over conservatism may hinder the growth and profit prospects of the firm when the building cycle begins to move into the next upswing. A proper understanding and estimation of where the approximate position the building cycle is along its trajectory would therefore be of great importance to the financial position and future of the firm.

TABLE 1

List of Symbols

RES_P_BP	Residential real estate price data series after seasonality and trend (band pass filter treatment) removal
RES_P_HP	Residential real estate price data series after seasonality and trend (HP filter treatment) removal
RES_P_FD	Residential real estate price data series after seasonality and trend (First Differences filter treatment) removal
IND_P_BP	Industrial real estate price data series after seasonality and trend (band pass filter treatment) removal
IND_P_HP	Industrial real estate price data series after seasonality and trend (HP filter treatment) removal
IND_P_FD	Industrial real estate price data series after seasonality and trend (First Differences filter treatment) removal
RET_P_BP	Retail real estate price data series after seasonality and trend (band pass filter treatment) removal
RET_P_HP	Retail real estate price data series after seasonality and trend (HP filter treatment) removal
RET_P_FD	Retail real estate price data series after seasonality and trend (First Differences filter treatment) removal
OFF_P_BP	Office real estate price data series after seasonality and trend (band pass filter treatment) removal
OFF_P_HP	Office real estate price data series after seasonality and trend (HP filter treatment) removal
OFF_P_FD	Office real estate price data series after seasonality and trend (First Differences filter treatment) removal
CTC_DOM_BP	Consent to commence (domestic) data series after seasonality and trend (band pass filter treatment) removal
CTC_DOM_HP	Consent to commence (domestic) data series after seasonality and trend (HP filter treatment) removal
CTC_DOM_FD	Consent to commence (domestic) data series after seasonality and trend (First Differences filter treatment) removal
CTC_NDOM_BP	Consent to commence (non-domestic) data series after seasonality and trend (band pass filter treatment) removal
CTC_NDOM_HP	Consent to commence (non-domestic) data series after seasonality and trend (HP filter treatment) removal
CTC_NDOM_FD	Consent to commence (non-domestic) data series after seasonality and trend (First Differences filter treatment) removal
CTC_AGG_BP	Consent to commence (aggregate) data series after seasonality and trend (band pass filter treatment) removal
CTC_AGG_HP	Consent to commence (aggregate) data series after seasonality and trend (HP filter treatment) removal
CTC_AGG_FD	Consent to commence (aggregate) data series after seasonality and trend (First Differences filter treatment) removal

TABLE 2

Results of Unit Root Tests (Stationary check of data series)

	ADF Test Statistics	Phillips-Perron Test Statistics
RES_P_BP	-4.122428***	-3.949601***
RES_P_HP	-9.068375***	-5.154309***
RES_P_FD	-7.135943***	-18.22011***
IND_P_BP	-4.677116***	-3.148629**
IND_P_HP	-6.069965***	-16.64058***
IND_P_FD	-19.87647***	-37.25417***
RET_P_BP	-5.267790***	-3.726989***
RET_P_HP	-6.666420***	-16.04530***
RET_P_FD	-17.40722***	-41.88483***
OFF_P_BP	-2.648708*	-3.601836***
OFF_P_HP	-6.722322***	-9.198939***
OFF_P_FD	-26.48058***	-26.53892***
CTC_DOM_BP	-2.203246	-2.882843*
CTC_DOM_HP	-15.11022***	-15.25065***
CTC_DOM_FD	-12.31235***	-100.6211***
CTC_NDOM_BP	-4.191372***	-3.112742**
CTC_NDOM_HP	-15.86921***	-15.89832***
CTC_NDOM_FD	-11.93095***	-82.63301***
CTC_AGG_BP	-2.443911	-3.019276**
CTC_AGG_HP	-15.41763***	-15.41025***
CTC_AGG_FD	-11.39742***	-109.5262***

Note:

***, **, * indicates rejection of the hypothesis of a unit root at the 0.01, 0.05 and 0.1 levels respectively.

References

Barras, R., (1983), *A simple theoretical model of the office development cycle,*
   Environment and Planning A, 15, 1381-1394

Barras, R., and Ferguson, D., (1985), *A spectral analysis of building cycles in Britain,*
   Environment and Planning A, 17, 1369-1391

Barras, R., and Ferguson, D., (1987a), *Dynamic modeling of the building cycle: 1. Theoretical Framework,*
   Environment and Planning A, 19, 353-367

Barras, R., and Ferguson, D., (1987b), *Dynamic modeling of the building cycle: 2. Empirical Results,*
   Environment and Planning A, 19, 493-520

Baxter, M., and King, R., (1999), *Measuring business cycles: approximate band-pass filters for economic time series,*
   The Review of Economics and Statistics, November 1999, 81(4), 575-593

Chan, K., Hayya, J., and Ord, J., (1977), *A note on trend removal methods: the case of polynomial regression versus variate differencing,*
   Econometrica, 45(3), 737-744

Chatfield, C., (1996), "The analysis of time series: an introduction," 5th edition, Chapman & Hall/CRC,

Cogley, T., and Nason, J., (1995), (1995), *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, 253-278

Hannan, E., (1958), *The estimation of the spectral density after trend removal,*
   Journal of the Royal Statistical Society (B), 20, 323-333

Hatanaka, M., and Howrey, E., (1969), *Low frequency variation in economic time series*
   ,Kyklos, 752-766

King, R., and Rebelo, S., (1993), *Low frequency filtering and real business cycles,*
   Journal of Economic Dynamics and Control, 17, 207-231

Man K.F. (2007) Unpublished Phd thesis, University of Hong Kong

McGeorge, D., and Palmer, A., (2002), "Construction Management: New Directions," 2nd edition, Blackwell Publishing

Park, G., (1996), *The role of detrending methods in a model of real business cycles,*
   Journal of Macroeconomics, 18(3) 479-501

Priestley, M.B. (1981), "Spectral Analysis and Time Series". Elsevier, UK

Sampson, A., and Skinner, D., (1996), *Construction forecasting: a new approach to construction industry forecasting,*
   RICS research report, April 1996.

Tsolacos, S., (1999), *Retail building cycles: evidence from Great Britain,*
   Journal of Real Estate Research, 18(1), 197-217