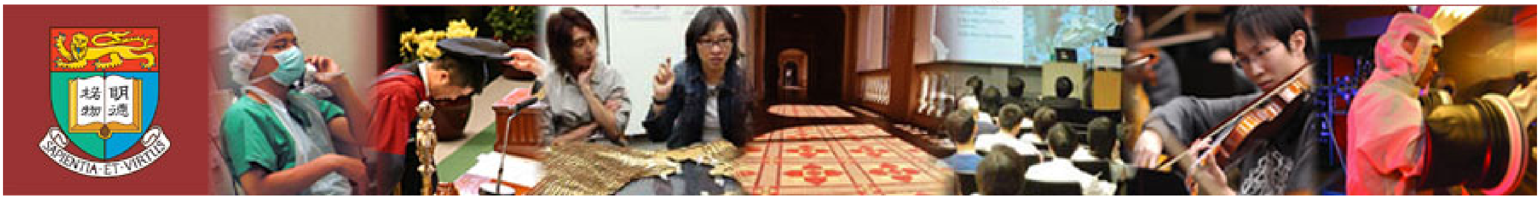

Title	The effects of rental growth expectation on real estate return : a term structure model and an empirical test in Hong Kong
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THE UNIVERSITY OF HONG KONG

THE EFFECTS OF RENTAL GROWTH EXPECTATION ON REAL ESTATE RETURN

---- A TERM STRUCTURE MODEL AND AN EMPIRICAL TEST IN HONG KONG

Submitted by

Yishuang Xu

For the degree of Doctor of Philosophy
at The University of Hong Kong
in May 2012

ABSTRACT

The investor's expectation is instinctively to be linked to the asset's return by the finance experts and analysts. However why and how it affects the return are poorly understood and explained. Can the investor's expectation really move the market? How much the influence does it have? This study looks at this well-known puzzle between real estate returns and investors' expectations on rental income growth of real estate assets. Based on the theoretical model in this study, the questions whether, why and how the investors' expected rental income growth has effects on the real estate returns are answered. The study focuses on both private and public real estate (REITs) returns and examines whether they can be explained by the facts in Hong Kong.

The theoretical model is derived from the Gordon Growth Model. The novelty of the model is to define the term structure of interest rate on the expected rental income. Empirically, the linkage between the two markets is identified through the REIT's dividend, which is specified to be distributed from 90% of the real estate asset's income. Under this specification, strong evidence is found for expected rental income growth predictive power. In this study, the relationship between the monthly end-of-period REIT's return and monthly expected rental income growth of corresponded real estate asset is tested by panel model, which does the superb job in fitting both cross-sectional and time-varied return patterns of REITs. As the REITs in Hong Kong had just launched since the end of year 2005, the sample period of this study is from November, 2005 to April, 2010. Unlike the standard asset pricing model, this study adds the investor's expectation as one of the factors which determine the REIT's return to adjust the out-performance tendency of certain asset.

The study also confirms the hypothesis in private real estate market by finding that investors' expectation on rental growth imposes a positive and significant impact on the real estate return in Hong Kong. The quarterly data series of macro-economic factors, such as Gross Domestic Production, Inflation rate, Interest rate, Employment rate are tested to confirm their effects on the real estate return together with the investor's expectations on both future rental income and inflation. All four real estate sectors, including residential, office, retail and industrial property sectors, are inclusively tested in this study.

For both private and public real estate markets in Hong Kong, the investor's expectation has positive effects on the corresponding asset's return. The evidence in this study shows that the change of investor's expectation would cause positive change of REIT's return. It reveals that the investors' expectation plays a vital role in the movement of both private and public real estate markets. When most investors expect a tendency of increasing earning, the real estate return tends to rise with controlling of other economic factors.

Though the conclusion of this study is well-known and frequently used to explain or predict the movement of real estate market, the theory behind it is commonly ignored. This study looks deeper into it by improving Gordon Growth Model to capture the investor's expected rental income growth without econometric forecasting or questionnaire investigation. The series derived in this study is more reliable

with clear logic and theory, and confirmed by the facts in Hong Kong real estate market. The derivation and application of the investor's expected income growth of certain asset will be helpful to provide insightful implications on future asset pricing, finance prediction and analysis.

THE EFFECTS OF RENTAL GROWTH EXPECTATION ON REAL ESTATE RETURN

---- A TERM STRUCTURE MODEL AND AN EMPIRICAL TEST IN HONG KONG

Submitted by

Yishuang Xu

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR
THE DEGREE OF DOCTOR OF PHILOSOPHY
AT THE DEPARTMENT OF REAL ESTATE AND CONSTRUCTION
THE UNIVERSITY OF HONG KONG
HONG KONG
May 2012

DECLARATION

I declare that this thesis represents my own work, except where due acknowledgment* is made, and that it has not been previously included in a thesis, dissertation or report submitted to this University or to any other institution for a degree, diploma or other qualification.

Signed :______________

Name : **XU, YISHUANG**

Date : ______________

*__Relevant work in this thesis is under review by the journal on this stage.__

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It occurred to me that one decision completely changed the track of my life. Five years ago, I decided to terminate my former job in the real estate industry in China that I had been enjoying so much for the past four years, and chose to achieve higher degree in this area in Hong Kong. Four years later, here I am with a PhD thesis completed in Real Estate Economics and Finance, and ready to pursue an academic career in Hong Kong. Certainly, I have been a motivated and hard-working student for, at least, the past four years, but that would serve as, at best, a necessary condition for what I have achieved so far. It is the opportunity being the sufficient condition, which cannot be taken for granted. At this final stage of my PhD, I would like to take a moment to express my deepest appreciation and extend my gratitude to those who have offered me all kinds of opportunities along the way.

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May, 2012 in Hong Kong

CONTENTS

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LIST OF SYMBOLS

P	price index of property
r	rent index of property
Pg	Property price growth
Rg	Property rent growth
Pg_off	office property price growth
Rg_off	office property rent growth
Pg_ret	retail property price growth
Rg_ret	retail property rent growth
Pg_ind	industrial property price growth
Rg_ind	industrial property rent growth
Pg_res	housing price growth
Rg_res	housing rent growth
EGg	expected rental income growth based on Gordon Growth Model (A)
⊿EGg_off	change of expected office property rent growth (A)
⊿EGg_ret	change of expected retail property rent growth (A)
⊿EGg_ind	change of expected industrial property rent growth (A)
⊿EGg_res	change of expected housing rent growth (A)
Erg	expected rental income growth based on Term Structure Expected Growth Model (A)
△Erg_off	change of expected office property rental income growth (A)
△Erg_ret	change of expected retail property rental income growth (A)
△Erg_ind	change of expected industrial property rental income growth (A)
△Erg_res	change of expected housing rental income growth (A)
EGg'	expected rental income growth based on Gordon Growth Model (B)
⊿EGg'_off	change of expected office property rent growth (B)
⊿EGg'_ret	change of expected retail property rent growth(B)
⊿EGg'_ind	change of expected industrial property rent growth(B)
⊿EGg'_res	change of expected housing rent growth(B)
Erg'	expected rental income growth based on Term Structure Expected Growth Model (B)
△Erg'_off	change of expected office property rental income growth(B)
△Erg'_ret	change of expected retail property rental income growth(B)
△Erg'_ind	change of expected industrial property rental income growth(B)
△Erg'_res	change of expected housing rental income growth(B)
$\overline{R(g)_{off}}$	3-month average office property rent growth

Erg_off (A)	change of expected office property rent growth (A)
Erg_off (B)	change of expected office property rent growth (B)
$\overline{R(g)_{ret}}$	3-month average retail property rent growth
Erg_ret(A)	change of expected retail property rent growth (A)
Erg_ret(B)	change of expected retail property rent growth (B)
$\overline{R(g)_{ind}}$	3-month average industrial property rent growth
Erg_ind(A)	change of expected industrial property rent growth (A)
Erg_ind(B)	change of expected industrial property rent growth (B)
$\overline{R(g)_{res}}$	3-month average residential property rent growth
Erg_res(A)	change of expected residential rent growth (A)
Erg_res(B)	change of expected residential rent growth (B)
$\hat{R}g_{offt}$	estimated office property rental changes
$\hat{R}g_{rett}$	estimated retail property rental changes
$\hat{R}g_{indt}$	estimated industrial property rental changes
$\hat{R}g_{rest}$	estimated residential property rental changes
i	cost of capital for one year
S	spread between long-term and short-term costs of capital
G	annual growth of the cost of capital
GDP_g	seasonal adjusted GDP growth
UNE	unemployment rate
RINT	real interest rate, calculated as the amount by which the nominal interest rate is higher than the inflation rate
INF	the inflation rate is a measure of inflation, the rate of increase of a consumer price index. The calculation is: $\text{inflation rate}_t = \frac{P_t - P_{t-1}}{P_{t-1}} \times 100\%$, P_t and P_{t-1} represents the current average price level and the price level one year ago respectively. In this study, we used Consumer Price Index (CPI) – Series A for non-luxury commodities Index from the Census and Statistics Department, HKSAR (http://www.censtatd.gov.hk/). We then transfer the inflation rate per annum into rate per month by dividing it with 12 in this study.
hibor	Hongkong InterBank Offered Rate. Here in this study, we used the percent rate per month based on the percent rate per annum from HKMA (http://www.info.gov.hk/hkma/eng/statistics/msb/index.htm), the calculation is based on $rate\ \text{per month}_t = \frac{rate\ \text{per annum}_t}{12}$
RI	return Index of REIT, accessed from DATASTREAM
ln_R	Total return of REIT, which is equal to $\ln(RI_t/RI_{t-1})$
HSI	HANG SENG Index

ln_HSI	average return of stock market, which is equal to ln (HSI_t/HSI_{t-1})
BETA	the risk premium for REITs Market, BETA=(REIT's return – 10-year exchange fund note's yield)/(stock return – 10-year exchange fund note's yield)
Eg_{it}	the derived expected rental income growth of the portfolio of each REIT at time t

CHAPTER 1 INTRODUCTION

1.1BACKGROUND AND MOTIVATIONS

It should be admitted that when the investors are investing in certain assets, they are looking forward to the future gain on cash-flow, appreciation or both. Concerning the real estate asset, its price has long been regarded as the discounted sum of a stream of net future rental income since Fisher (1930a) or even earlier. Numerous research papers, theories and models are developed on this fundamental premise. One of its direct implications is that the future price depends on future rent. From a simple but naive angle, it may indicate that the rent changes should lead price changes. However, our empirical observations on the lead-lag relationship between the movements of rent and price would provide the contrary evidence (in Chapter 6). Lai and Van Order (2010) on the expected future rental income is helpful to explain the reversed empirical facts.

In Lai and Van Order (2010)'s work, the future rent is proxied by the expected rental income, and they explained lead-lag relationship between future rent and price with their model on the fundamentals of housing price growth, according to which the value of the real estate asset can be expressed by a function of its rent and discounted price at the ending period. Thus the property price should be determined by the rental income it would gain and the discount rate during the whole holding period. However, as for the covariance among property price, rent and the discount rate, the equation is kind of difficult to be estimated in real world. In this case, the Gordon Growth model was employed in Lai and Van Order (2010)'s study and the property price can be expressed by the rent, discount rate and expected rental income growth. It makes sense in both mathematical and logical aspects. On one hand, Lai and Van Order (2010) built the mathematical model to illustrate that the price of real estate asset is determined by the rent, discount rate and expected rental income growth. On the other hand, the logic behind the model is clear. With the concept of time value of money, the asset's present value is equal to the discounted sum of its ***future income***. As the ***income*** will be gained in the future, the investor would be reasonable to have expectation on its growth (either positive or negative). When the transaction of the asset is going to be made, the purchaser will evaluate the asset with its future income and discount rate. Then the acceptable price will be made based on these fundamentals, including the investor's expectation on its future income. Thus with the success of the transaction, the expected rental income growth has just completed the procedure of affecting the asset's price. Then with all the successful transactions, are the real estate asset's market price changes leaded by the movements of investor's expected rental income growths? Why the expectation movement would lead the asset's price changes?

Unfortunately, Lai and Van Order (2010) did not took the empirical test on the lead-lag relationship between housing price and expected rental growth, which would investigate the arguments and answer my questions above. So in this study, some preliminary observation with the empirical market data will be provided first to seek the answer to my questions.

As stated in Lai and Van Order (2010)'s work, the relationship between the expected rental income growth and the price growth can be expressed as:

$$Pg_t = rg_t - \Delta ln(\alpha I_t - \beta g_t) \quad (1.1)$$

where Pg_t refer to the property price growth at time t. I_t still represents the discount rate; g_t refers to the expected rental growth of the property and rg_t refers to the real rental growth of the property. α β are the coefficients that were equal to one in the standard Gordon Growth Model.

Then they assume the change of expected rent growth (Δg_t) to be a function of the past levels of the change of real property rent growths (Δrg_t) (the detailed assumption can be found in their work) and estimate the lagged approximations to equation (1.1) further.

Our preliminary observations with the empirical market data will be provided in detail in Chapter 5 and Chapter 6. The results support Lai and Van Order (2010)'s theoretical work about the rent and property price changes. But the observations based on Gordon Growth Model weakly provided the empirical evidence supporting their theory about the expectation. Thus we are motivated to explore an improved model which can capture the market expectation better than Gordon Growth Model.

1.2 ABOUT THE EXPECTATION

The expectation effects in asset pricing can be dated to the beginning of last century in Franks et al. (1974)'s book. Professor Fisher had taken into account the existence of differing rates of profits and stressed that the cost of production is very important for determining its value. In Fisherian theory, the past cost of production would affect the value through adjusting the supply and future cost while the expected cost of production would be discounted to directly determine the value. As the investment of asset to be concerned, it is more appropriate to call the cost of production as the cost of capital. Later in 1930, in Fisher (1930b), the Discounted Cash Flow method of asset pricing was formally expressed in modern economic terms for the first time. Since then, the ancient method had been frequently used in asset pricing process.

However there are some limitations lying in Fisher's theory of interest. The assumptions of the theory are too restrictive to be true. As based on investment opportunity, human impatience and market exchange, the assumptions underlying the general Fisherian theory are as follows:

(1) The individual investor is assumed to be free to choose the investment assets which will produce the maximum present value with risk taken into account;

(2) The actual growth of income might be different with the expected one due to the widely discrepant risk over the time.

Years later, Fisherian Theory had been developed into Discounted Cash-Flow (DCF) Model (expressed below as equation 1.2) to evaluate the price of asset within certain holding period. The proposition of discounting all the income within the holding period into the price of asset is the key idea of the DCF model. After being first formally expressed in Fisher (1930b) and Williams (1938)'s work, the concept of discounted cash flow (DCF) had been applied in host of finance and economic researches.

$$P_t = \sum_{t=0}^{n} \frac{D_t}{(1+i)^t} \tag{1.2}$$

Where *P* refers to the asset's value or price at time *t*, *D* and *i* represent the cash flow (income) and the interest rate at ending period time *t*. Through DCF method, certain asset's value can be estimated based on its time-varying cash flow. For its reasonability of considering the time-varying nature of the money, DCF method is popularly adopted in the asset appraisal area, especially real estate asset and stocks.

However the assumptions of DCF model are the obstacle for it to be closer to the real world. There are two assumptions in DCF model for asset pricing:

(1) the cash-flow is assumed to be constant during the holding period;

(2) the cost of capital (interest rate) is assumed to be constant during the holding period.

Obviously, neither of the two factors is constant in our real world. To improve this, in 1950s, Gordon (1959) relaxed the first assumption to allow the cash-flow of asset change over time with constant growth during the period. Comparing with DCF model, Gordon Growth Model came closer to the real world for adding the constant growth rate to the income of the asset, which is usually called expected cash-flow growth.

Still with the constant cost of capital, the standard version of the present-value model turned into the formula as follows:

$$P_t = \sum_{t=0}^{n} \frac{D_0(1+g)^t}{(1+i)^t} \tag{1.3}$$

where *g* represents the expected growth of the asset's income (cash flow). There are two important assumptions for the construction of Gordon Growth Model: (1) it assumes that the asset has income with current value of *D* and the income is expected to change at a constant rate *g*; (2) it also assumes that the cost of capital still remains constant at *i*. Though in formula (1.3), the model involves in summing the infinite series, in practice, it usually use the next value of income $D_1 = D_0(1+g)$. In this way, the model can be stated as:

$$P_0 = \frac{D_1}{i-g} \tag{1.4}$$

There is a variant of Gordon Growth Model as well, which is called Multiple Growth Model (MGM) and was constructed in Franks et al. (1974)'s paper. With similar concept of the time value of money, the assumption in MGM changed a little closer to the practice. The growth of asset's income is assumed to be inconstant and unpredictable during certain period, and after that period, the income growth would be expected to be constant. Therefore the cash flow of asset can be divided into two stages in this model: first stage involves the inconstant income growth while income growth is expected to be constant in the second stage. Assuming the division time point is T, the price of certain asset can be interpreted through two steps:

Step 1: Before time *T*: the income growth is inconstant

According to DCF model, the sum of present value of the asset's cash flows before time *T* is calculated in the formula as follows:

$$P_{T-} = \sum_{t=0}^{T} \frac{D_t}{(1+i)^t} \tag{1.5}$$

Step 2: After time *T*: the income growth is constant

According to GGM, the price of the asset is calculated in the formula as follows:

$$P_T = \frac{D_{T+1}}{i-g} \tag{1.6}$$

As the investor needs to determine the price of the asset at time *0* but not *T*, the second stage value of asset need to be discounted. Therefore the formula (1.6) can be interpreted as follows:

$$P_{T+} = P_T \times \frac{1}{(1+i)^T} = \frac{D_{T+1}}{(i-g)(1+i)^T} \tag{1.7}$$

Combining formula (1.5) and (1.7), the price of the asset with inconstant growth rate during period until time *T* can be interpreted as follows:

$$P = P_{T-} + P_{T+} = \sum_{t=0}^{T} \frac{D_t}{(1+i)^t} + \frac{D_{T+1}}{(i-g)(1+i)^T} \tag{1.8}$$

The advantage of MGM is mainly about consideration of unstable cash flow change before the asset grows “mature”. If the asset is mature or is evaluated when it is mature, MGM formula (1.8) will be just the same with GGM formula (1.4).

Both advantages and disadvantages of Gordon Growth Model will be discussed in detail in Chapter 3. Among those weaknesses, the constant discount factor in the model results to some bias in asset valuation. Till 1980s, Campbell and Shiller (1988a) solved the problem by incorporating the dynamic discount factor to relax both assumptions of DCF model in their research of dividend-price ratio model. The Campbell-Shiller model is log-linearized for the possible non-linear relationships among the asset price, dividend (cash-flow) and returns, referring to Chapter 3 (section 3.1) for the derivation of their model. However the Campbell-Shiller model is difficult to capture the expected income growth of the asset with market data because of its infinite equation.

So far, there is no model allowing both future cash-flow and cost of capital to be dynamic over time while with capability to be estimated with updated market data. The problem will be solved in this study by deducing a novel model based on Gordon Growth Model to illustrate the present value relationship better.

Generally speaking, after formulating by Fisher, the DCF method had been widely adopted when the investment of asset or company was appraised. However the one of the most important things for the application of DCF method is the judgment on selection of the discount rate. Thus the shortcomings of the method are substantially exhibited: 1) The discount rate assumption relies on the market for competing investments at the time of the analysis, which would likely change, perhaps dramatically, over time, and 2) straight line assumptions about income increasing over ten years are generally based upon historic increases in market rent but not factors in the cyclical nature of many real estate markets. Most loans are made during boom real estate markets and these markets usually last less than ten years. Using DCF to analyze real estate during any but the early years of a boom market will lead to over-estimation of the asset’s value.

We can find that Campbell and Shiller (1988c) constructed their model to improve the present value model by incorporating the time-varying discount rates theoretically. The Campbell-Shiller model expressed the dividend-price ratio as an infinite discounted sum of expected returns and expected dividend growth and can be tested through vector autoregressive method with observable ex post discount rates. By allowing both dividend and discount rate to change over time, the Campbell-Shiller model, which is the one that closest to the real world, is also called dynamic Gordon Growth Model. However the only approach to estimate the return and cash-flow expectations is the predictive regression method, i.e. Vector Autoregressive method. As only statistical method can be adopted in the model to predict the expected dividend growth, it has been long applied to test the relationship between d/p ratio and the future discount rate and future expected return while scarcely used for capturing the expected income growth of the asset.

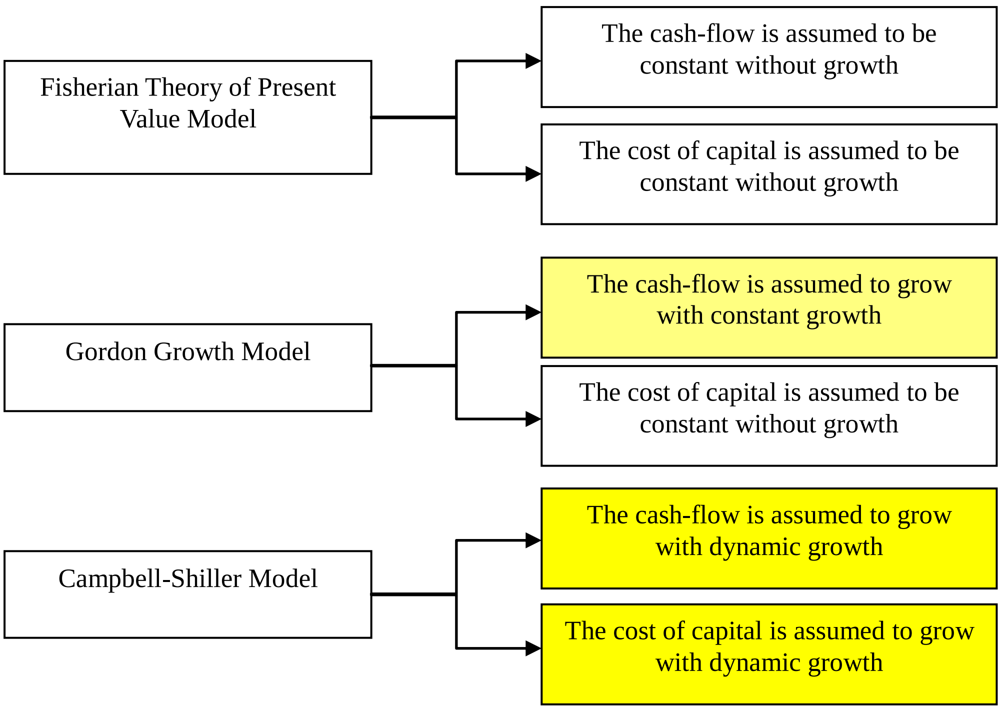

Figure 1.1 the Development of Present Value Model

By looking back the whole development of the Present Value Model till now; which is shown in Figure 1.1, it is found that Gordon Growth Model does not consider market term structure of interest rate, and the Campbell-Shiller Model considers discount rate as cost of capital. Therefore this study then aims at deriving an appropriate model to capture the expected income growth of the asset based on all the previous works to fill this gap. The need is obvious after the illustration of the development of asset pricing models with expectations: (1) there are restrictive assumptions in both Fisher and Gordon's works, which would push the theory far away from the reality; (2) though Campbell-Shiller's model relieved the assumptions and allowed the expected income growth and the cost of capital to change which is most closed to the real world, the model is hardly able to capture the expected income growth of the asset with market data because of its infinite equation. More importantly, our research question whether the investors' expected rental income growth has effects on real estate returns will be investigated with the newly-capture series. In this way, an approach with both assumptions closed to the reality and the adoptability with the market data set is in urgent need for research. In Chapter 3, the derivation of the model will be detailed presented. The answer to our first research question will be provided based on the investigation with empirical data in Chapter 5 & 6. After the expected income growth of asset is derived and its leading effect on real estate asset price changes has been confirmed, naturally the next question is followed: why does the investor's expected rental income growth has effects on private real estate returns? The model derived in Chapter 3 will explain the reason in a theoretical way and the empirical tests thereafter will support the explanation with empirical data.

It should be admitted that when the investors are investing in certain assets, they are looking forward to the future gain on the income (cash-flow), appreciation or both. Thus this is widely agreed that much of the variation of the asset's price can be explained by the movements of economic uncertainty and expected cash-flow growth. According to previous studies (summarized in Chapter 2), there are several macro-economic factors (including GDP, real interest rate and unemployment rate etc,.) that may determine the price of real estate asset's return.

However it's often found that the macro-economic fundamentals cannot completely explain the return of real estate asset, especially before and after some important events happening. Some researchers blamed this to the investors' irrational actions while some others just take this as the noise for granted. The investors' expectations are seldom concerned in previous work and commonly they are ignored or misestimated during the process of asset pricing.

It is obvious that the effects of the investors' expectations cannot be neglected or replaced by other variables in the asset pricing process. The ignorance or mis-estimation of the expectations would lead to the occurrence of mispricing. Actually the discounted present value model has already shown the dramatic importance of the investors' expectations on future income of the assets. However the model was unable to explain the dramatic run-ups or subsequent crashes in asset prices, i.e. the financial crises in 2008 and other price anomalies. This called for the development of the behavioral finance, which explained the asset prices with the investor sentiment or irrationality as one of the independent variables. In the behavioral finance research area, the investor sentiment or irrationality was defined as a misguided belief about the growth of future income or risk of their investments based on the current information set (see in Gosset (1908), Edwards (1961) and so on). However it is a pity that neither behavior nor belief can be quantified in research works. As a consequence, it is hard to test whether the sentiment or irrationality really lead to the asset pricing. As it is found that the movements of expected rental income growth of real estate asset lead its price changes in this study, we are motivated to investigate why the expectation has leading power.

The procedure of deriving the theoretical model derived in Chapter 3 explains the reason of the expectation's leading power and also reveals that the investor's expected rental income growth has effects on the real estate asset's returns. The theory will be applied with empirical data from Hong Kong in Chapter 5 & 6. Further we wonder how it would affect the real estate returns. The final research question of this study will be answered in Chapter 5 & 6. As REITs market is one important branch of real estate investment market, which is tightly connected to the private real estate market by its regulations, we intent to explore the implications of the theory on REITs market. To be more specific, this study argues that due to the dividend and investment portfolio regulations on REIT, its dividend, which is regulated to be 90% of the yield of the underlying property portfolio, would depend on the yield of the assets. In addition, by investing in a REIT, the investors would concern more on its dividend in the long term, so that, concern more on the future (expected) yield the REIT will gain from the real estate assets in its portfolio. Then the price of REIT will also change with the movement of the expected rental income on private real estate market. According to the theory of this study, it is implied that the total return of REITs would be explained by the expected rental income growth of its property portfolio rather than the capital or rental return of that. This implication may help us to understand further on how the investor's expected rental income growth affects the public real estate returns. Also the empirical investigation of the implication indicates that the public and private real estate markets are linked by the investors' expectations. This suggests that the information between public and private real estate markets is shared well. The new perspective will guide the research into a new phase and contribute to a more concrete understanding of the relationship between public and private real estate markets.

1.3 AIMS AND OBJECTIVES

The aim of the study is to derive theoretical model for dynamic present value relationship of asset value, expected cash-flow and cost of capital in real estate asset pricing analysis. Therefore it allows the estimation of the effect of the expected rental income growth on both private and public real estate returns.

With the accomplishment of the aim, there are three major objectives to be achieved in this study (Figure 1.2):

1. To develop a theoretical model to illustrate the investor's expected rental income growth's influences on real estate returns (Chapter 3);

2. To apply the theory with empirical data from private real estate market in Hong Kong (Chapter 5 & 6);

3. To test the theory with empirical data from public real estate market in Hong Kong (Chapter 5 & 6).

The first objective highlights that so far there is no applicable solution to include the dynamic expectation into the present value model. By deriving a new adoptable theoretical model mathematically, the present value relationship of asset value, expected cash-flow and expected cost of capital is illustrated meanwhile the expected cash-flow growth can be captured with updated market data.

The second objective shows the importance of the expected rental income growth in real estate asset pricing. By applying the theoretical model with empirical data from Hong Kong private real estate market, the theory of this study will be supported with evidence.

The last objective addresses the application of the theory introduced in this study. With the help of the empirical investigation on public real estate market, the theory can be examined further without the limitations from private real estate market. In this way, the induction of the theory will be completed.

Achieving all three objectives in this study, the importance and contributions of the study will be demonstrated clearly.

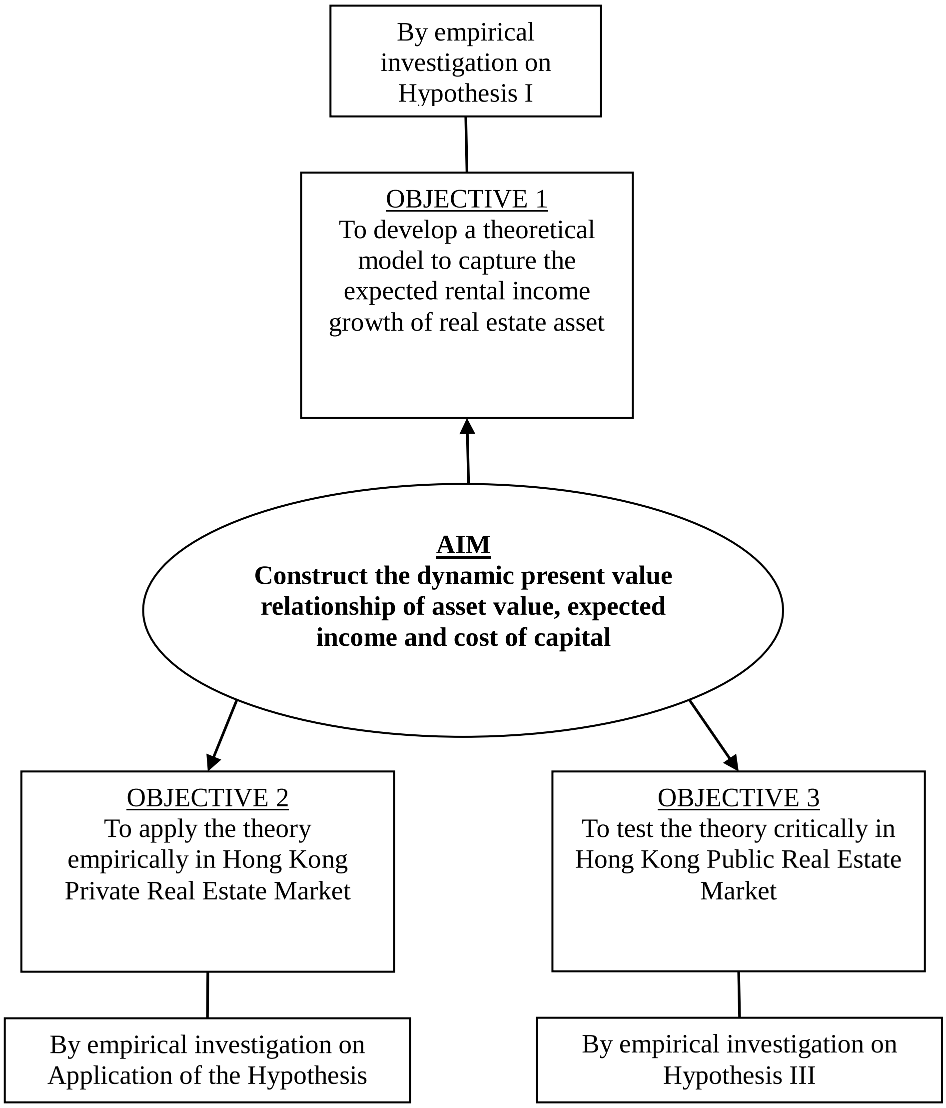

Figure 1.2 Aim and Objectives

1.4THE IMPORTANCE OF THE STUDY

The construction of the expected income growth model for asset pricing will have pivotal implications as shown in Figure 1.3

In terms of practical implications, the measurement of asset's present value is important for the investors. The calculations are widely used in business and economics to provide a method to determine the asset's value with cash flows and time value of money. Though the expectations are concerned in the model, there are very few studies capturing the expected growth of cash flows with market term structure of interest rate (discount rate). That is, can the market information reflect what the investors expect? If yes, how much does the ***market investor's expectation*** affect the asset's value? This study adopts a quantifiable measure of capturing the investor's expectation on basis of actual updated market data.

Concerning about the improvement of modeling the present value of asset, a realistic and adoptable present value model with expectation factors is in need for the study. The present value relationship between asset price, discount rate and expected cash-flow (income) growth has been widely regarded as a valuable lens for explaining the asset price movement. To understand the changes of asset prices amounts to understanding the dynamic behavior of the investors' expectations on both future cash-flow and cost of capital. As stated in the above sections, the easy-to-apply Gordon Growth Model ignores the expected growth of capital cost (discount rate) while the more realistic Campbell-Shiller Model, which allows both future cash-flow and discount rate to be dynamic, is difficult to estimate with market data. Thus the model derived in this study might fill the gap by allowing both expectation to change in certain growth and being able to be estimated with market proxies.

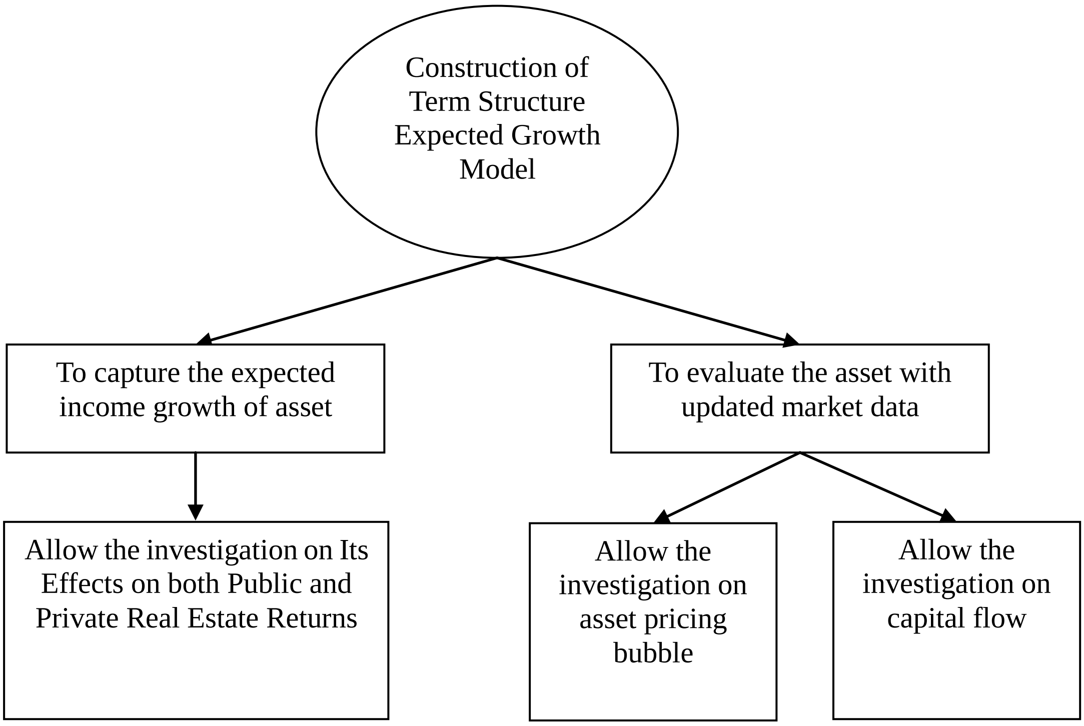

Figure 1.3 Importance of the Study

Besides the importance of asset's present value measuring, the implications of the captured expected growths of cash flow are important as well. If we can estimate the expected cash-flow growth of asset, more light can be shed on the asset pricing area for both investors and appraisers. The valuation of asset would be more accurate and updated with the market condition. In this way, the bubble of asset price might be diagnosed and avoided, which is helpful for the government to keep the economy to grow in a healthy way.

Last but not least, the captured expected cash-flow growth reflects the investors' expectations. This allows the direct observation on the capital flow for different assets, which would be helpful for the investors and governments to audit the hot money's speculative behaviors.

On the research level, this study fills in the research gap by improving the present value model for asset pricing. By capturing the investor's expected future income growth of certain asset; its effects are also revealed by the theoretical model. Furthermore, it allows future investigations on varies of asset markets with the captured expected cash-flow growth of the asset.

1.5DEFINITIONS

The term expectation originally referred to what is considered the most likely to happen under the case of uncertainty. In financial economics, it is usually presents a theory that long-term interest rates can act as a predictor of future short-term interest rates. The theory[3] assumes that the various maturities are perfect substitutes and suggests that the shape of the yield curve depends on market investors' expectations of future interest rates. These expected rates, along with an assumption that arbitrage opportunities will be minimal, is enough information to construct a complete yield curve. The theory connects the investor’s expectation and the interest rate movements to each other. With the change of the investor’s expectation, the yield curve will change as well. This theory perfectly explains the observation that yields usually move together. However, it fails to explain the persistence in the shape of the yield curve.

Now, in this study, specifically the term is often used to refer to:

The average observable degree of how much the cash-flow of asset or cost of capital will grow in long-term, which is not observable.

In other words, the expectation here is referring to an expected growth that may or may not be equal to the real growth within a given period of time. However the predictive and effect of the expectation is conventionally admitted by both practitioners and researchers.

The terms *cash-flow* and *cost of capital* are used in their meanings with financial specifications. *Cash-flow* refers to the movement of cash into or out of an asset. It is usually measured during a specified and finite period of time with regular frequency, i.e. monthly, quarterly or annually. *Cost of capital* refers to the cost of an asset’s funds or the investor’s required return on this asset (as defined by Shimizu et al. (2010)). From the investor’s point of view, the expected return rate is in minimum to be equal to the cost of capital together with alternative equivalent risk. Therefore, usually the lowest cost of capital for the investment asset is regarded as the discount rate, especially in the calculation of Weighted-Average Cost of Capital (WACC).

The estimated expected cash-flow growth in this study is therefore defined as:

The expected cash-flow growth is the measure of the degree, to which the asset’s income stream will change during the specific holding period;

Similarly, the estimated expected cost of capital growth in this study is defined as:

The expected growth of the cost of capital is the measure of the degree, to which the cost of the investment of asset will change during the specific holding period.

1.6SCOPE OF THE STUDY

This study develops a theoretical model to estimate the expected cash-flow (income) growth and tests it with the empirical data in Hong Kong. The real estate asset is regarded as the long-term-holding asset, by investing in which, the investor may look upon the income stream. Thus the real estate asset pricing should be the most suitable for the present value relationship among all other investment assets. The empirical study is confined on the real estate market (both public and private) in Hong Kong as it is one of the most booming markets with sufficient number of transactions with price, rent, yield and return datasets for the analysis.

By design, this study provides a review of status and developments of the present value

[3] The detailed explanation of the theory will be presented in section 3.2.1 of Chapter 3.

relationship. Then motivated by the willingness of explain the changes of real estate asset prices, the expected cash-flow growth of real estate asset is investigated and further modeled. The newly captured expected cash-flow growth is examined to have effect on both public and private real estate markets in the followed sections. Therefore the problem of dynamic changes of the expectations in present value relationship can be categorized into three modeling approaches:

(1) Model construction;

(2) Empirical model specification; and

(3) Critical test with empirical applications

Constructing the model means re-specification of the present value model by adding the constant growths to the cash-flow and cost of capital separately. It can be regarded as a refined version of Gordon Growth Model. The detailed development and improvement of the present value model will be discussed in Chapter 3.

The empirical tests with specification in private and public real estate markets will be carried out in Chapter 6. Not only the effects of the captured expected rental income growth of asset will be examined in the empirical tests, but also the application of the newly-constructed Term Structure Expected Growth Model examined.

1.7 HYPOTHESES

As to make use of the correlation of the market expected rental income growth of the real estate asset, several hypotheses have to be established first. The hypotheses are:

Hypothesis 1 (H1):

The change of expected rental income growth of the real estate asset leads the changes of real estate asset price.

Application of Hypothesis 2 (H2):

The change of expected rental income growth has a positive correlation with the corresponding real estate price movement, ceteris paribus.

Hypothesis 3 (H3):

The change of expected rental income growth of the underlying real estate asset has positive correlation with the fluctuation of REIT's return, ceteris paribus.

The first hypothesis has been derived theoretically by Lai and Van Order (2010) and is tested empirically in Chapter 6 with the expected rental income growth calculated by Gordon Growth Model and Term Structure Expected Growth Model respectively. The testing results of our first hypothesis will answer our first research question: whether the investor's expected rental income growth has effects on real estate returns. Also the testing result of the first hypothesis will be suggestive of the investor's expected rent growth component that can lead the changes of the real estate price.

The Application of the Hypothesis (H2) will be illustrated theoretically in Chapter 3 during the process of Term Structure Expected Growth Model construction and tested empirically in Chapter 6. It will be tested by the time-series data of private real estate market in Hong Kong over ten years (1999 -- 2010). The testing results of the Application of the Hypothesis (H2) will answer our second research question: why the investor's expected rental income growth has effects on real estate returns. It is the application of the Term Structure Expected Growth Model on the private real estate market.

The third hypothesis will be tested by the panel data of public real estate market in Hong Kong of almost 5 years time (2005 -- 2010) as for the accessibility of the data source. The exploration of the third hypothesis is based on the theory deducted in this study. As there would be several limitations[4] during the process of the investigation in Hong Kong private real estate market, we further examine the theory on public real estate market through testing our third hypothesis. By testing the theory on public real estate market with the third hypothesis, the theoretical model derived in this study has been examined without the limitations from private real estate market. The testing results of the third hypothesis answer our third research question: how the investor's expected rental income growth has effects on real estate returns. These three hypotheses in a whole accomplish the three research objectives of the study.

1.8ORGANIZATION STRUCTURE OF THE THESIS

The organization of this study is clearly shown in Figure 1.3. The core regimes of my proposition can be segregated into three parts: the importance, difficulties and the implications with two empirical studies. In each part, the literature will be reviewed while theoretical elucidation and empirical studies will be also discussed and interpreted.

The first and last chapters of the thesis introduce and conclude the study respectively with précising words. Chapter 2 reviews the related literature to indicate the research gap which this study will fill. Chapter 3 will focus on the deduction of the present value model with dynamic expectations on future cash-flow and cost of capital. The development of present value model will be reviewed in this chapter to illustrate the difficulties to capture the expected cash-flow growth with existed models. The motivation to develop the new model will be illustrated by the importance of including the expectation effects into real estate asset pricing. The reversed lead-lag relationship between real estate price and rent movements can be explained by the omission of the expected cash-flow (rental income) growth factor.

The general picture of Hong Kong real estate market is provided in Chapter 4.

Chapter 5 analyzes the data and demonstrates the research design of this study.

Chapter 6 will then provide the empirical evidence to support the theory deducted in this study.

Furthermore, Chapter 7 will present some supplementary tests, which are helpful to understand the investigations of this study.

Chapter 8 will conclude this study with its contributions, limitations and the further research which can be carried out in the future.

[4] The price change of private real estate asset in Hong Kong would be affect by some non-market factors, such as the political policy, the government land supply, the transaction cost, the public-housing plan and so on.

The analysis on the investor's expectation has attracted quantity of research in both economic and finance areas. The current commonly-used approaches to find out the investor's expectation are mainly two streams: the behavioral research method (i.e. survey) and the econometric estimation method (i.e. VAR), which is to be reviewed in Chapter 2. However the applicable method to estimate the present value with dynamic investor's expectation is still absent in existed studies and actually in urgent need for both practical and academic applications.

This study will fill the gap by constructing a new model to illustrate the present value relationship of asset price, expected future cash-flow and cost of capital. Besides, the implications will also be presented by identifying the effect of expected cash-flow growth on both public and private real estate markets with updated data empirically. This introductory chapter precisely addresses the motivations, contributions and implications of the study. It also highlights the importance, the aims and objectives of the study briefly.

CHAPTER 2 LITERATURE REVIEW

This chapter reviews the literature concerning the investor's expectation critically to outline the research gap this study will fill. On one hand, the historical development of the measurement and application of investor's expectation is reviewed. On the other hand, the empirical investigations of the investor's expectation in private and public real estate investment market are also presented. Figure 2.1 shows the master framework of the previous studies, which are reviewed in this chapter. In this way, the research gaps will be found easily.

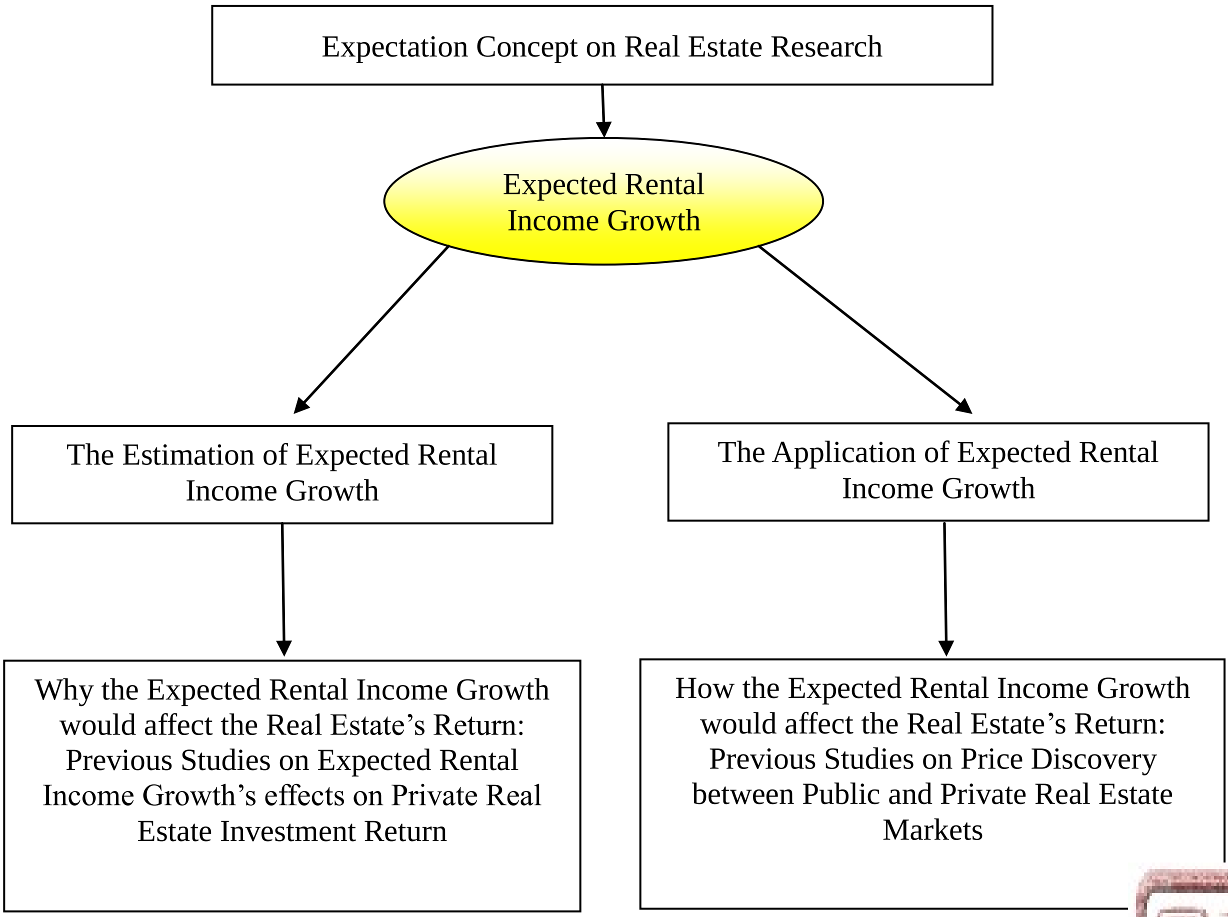

Figure 2.1 the Master Framework of Previous studies

2.1 EXPECTATION CONCEPT IN REAL ESTATE RESEARCH

The development of time discounting concept on the rent-price relationship can be traced back to Rae (1834), Eugen von Böhm-Bawerk (1890 [1970]), Fisher (1930b) and Samuelson (1937). It is nowadays regarded as one of the major economic fundamentals in explaining the housing price change. For example, Himmelberg et al. (2005), Franks et al. (1974) and Yiu et al. (2009). Housing price is also found by Wong et al. (2008) to be very sensitive to the change of discount rate over time. Furthermore, the rent-to-price (r/p) ratio, or the cap rate of real estate asset, is one of the commonly used market indicators of the yield rate. For instance, Shiller (2006) and Smith and Smith (2006) studied the r/p ratio to examine the risk of housing price growth. Then the DiPasquale and Wheaton (1992)'s (DW) model is very well received in the industry that housing supply and demand determines housing rent in the first quadrant, and then housing rent and discount rate determines housing price in the second quadrant, and so forth. The simple but naive understanding of this model may imply that the property rent should lead its price.

However, there is vast of empirical evidence that housing price leads rent instead. This mismatch between theory and empirical evidence has not yet been explained reasonably. The DW model on housing rent-price relationship has been criticized for ignoring the investor's expectation on future rent income, such as Colwell (2002). Unfortunately, Colwell (2002) does not provide any empirical evidence. More recently, Lai and Van Order (2010) derived the future rental growth based on the Gordon model and incorporated it into the housing price growth model, but they do not test directly on the lead-lag relationship between price and rent. The lead-lag relationship analysis is a simple but widely conducted helpful method in economics and finance research. Despite the differences of data frequency or period, similar analyses had been explored between spot and future market, such as Zeng (2008), Bloomberg Glossary) , Yiu et al. (2005), Wong et al. (2007) etc., one country and another, such as Capello (2002), Shimizu et al. (2010) etc., trading volume and price, such as Edwards (1961), securitized and unsecuritized real estate assets, such as Newell and Chau (1996), Tse and Webb (2000), Yavas and Yildirim (2009) etc., the real estate and stock markets, such as Okunev et al. (2002). In general, the lead-lag analysis is helpful for understanding of the causal-effect relationship between the two objects.

2.2 THE APPLICATIONS OF EXPECTED CASH-FLOW (INCOME) GROWTH

As a vital factor in DCF model and Gordon Growth Model, there are quantities of literature mentioned the expected income growth of certain asset. Among all these literature, mainly three factors, namely expected excess return, expected income (dividend) growth and dividend yield (or say, d/p ratio) are studied and the relationships between any two of the three factors have been examined.

It comes to conventional wisdom to use the VAR (Vector Auto Regressive) model to estimate the expected income growth rather than derive it through any mathematical methods.

During the period of 1970s, the major views of the relevant research came to consensus that the equity returns were nearly unpredictable and the optimistic expected future dividend would be embedded in the high equity prices. However later in 1980s, the main stream of views changed. Patches of empirical findings (see, i.e. Campbell and Shiller (1988b), Campbell and Shiller (1988c), Fama and French (1988), Hodrick (1992), Keim and Stambaugh (1986), Poterba and Summers (1988), Rozeff (1984) etc,.) show that though dividends could not predict the equity returns, the dividend yields could do the job.

Comparing to the historical research, modern views on the predictability of equity or real estate return has not changed a lot. Anyway, one of the most significant differences is taking expected dividend growth into account when equity return is predicting or asset value is pricing. Although being a key variable for predicting the equity return or valuating real estate asset, the expected dividend growth had not been derived through any mathematical methods. To be contradict, usually the expected dividend growth is proxied by other economic indicators, or estimated through econometric models (i.e. auto-regressive model) based on the historical growth rate of dividend. Nevertheless, the effect, or say, predictive power of the expected dividend growth was commonly accepted in various studies. The literature on the equity return predictability and real estate valuation is vast. Several among them that adopted the expected dividend growth will be reviewed in this chapter.

The recent research applied the expected income growth in various cases. Among all the cases, the relationships between expected income growth and either expected return or d/p ratio (dividend yield) are the major research objectives. Based on these two main relations, the expected income growth is applied in variety of fields, such as to evaluate the performance and to predict the return of certain asset. The previous studies (i.e. Fama and French (1988), Campbell (1991), Hodrick (1992), Plazzi et al. (2004), Campbell and Yogo (2006) and so on) claimed that the dividend-price ratio (dividend yield) can predict excess returns well, the longer horizon the better predictability. Moreover the pro forma dividends were examined following the step of the researches mentioned above. Fama (1990a), Kothari and Shanken (1992), Schwert (1990), Shilling and Sing (2007), Sing et al. (2007) and other studies finds that the proxies of expected dividends/cash flow can explain the return of asset very well. The expected dividend growth is one of those proxies in their investigations.

As the expected dividend growth also plays an important role in the asset pricing equation, its predictive power has been examined in previous studies as well. For example, Bansal and Yaron (2004), Lettau and Ludvigson (2005), Menzly et al. (2004), Plazzi et al. (2008) and so on (see in Table 2.1). Among all of them, the finding that expected dividend growth significantly contributes to the fluctuations of the stock prices while dividend yield only weakly predict dividend growth is the consensual point of view.

Regarding to the well-accepted predicting power of expected cash-flow growth, we believe that it is one of the key variables in the process of asset pricing and return forecasting.

2.3 COMMON APPROACHES TO ESTIMATE THE EXPECTED CASH-FLOW (INCOME) GROWTH

To apply the expected income growth for either evaluation or prediction, a researcher is confronted by a major problem: how to calculate it or estimate it. The measuring method of expected income growth had not been found in previous studies. Most of them made estimations or forecast of this variable while adopting it (see in Table 2.1). It is obvious that most previous research estimate the expected income growth was usually estimated by the auto-regressive model with data of ex-post dividend growth rate or forecasted by dividend yield.

VAR model was first applied for estimating the expected dividend growth of stock in Campbell and Shiller (1988b)'s research. For almost 20 years, this estimation method has been widely-accepted. However, several studies found the flaws of this method as well. First of all, the Campbell-Shiller intuition relies on the linear approximation relationship between dividend yield and expected return or expected dividend growth. Contrarily, the true present value relation is not exactly linear and the nonlinearity of the present value model may result in the positive relationship between dividend yield and expected dividend growth, which is not consistent with the proposition in Campbell-Shiller intuition.

Secondly, similar with all other reduced form models, the VAR model can be a good forecasting model, but in a sense it is not a theoretical model. Fair and Shiller (1990) had compared the forecasting models (Fair Model, VAR model and AC model) of GNP growth and their results could be interpreted in two aspects: (1) the Fair Model does a better job than other models on capturing the information in the components of the forecasting objective; (2) the forecasts of these models are based only on the information available prior to the forecasted period (namely quasi ex ante requirement), which means that the forecast of VAR model is based on the ex-ante real dividend growth. In this way, the forecasting result of expected dividend growth is based on the variance of the historical real growth but not the ex-ante expectations. Even the two are so close that the difference between them can be ignored; the instant market information is missing in such kind of forecast model. Plus whenever misspecification exists in the model, such as the change of parameters over time, the model may carry different information from the rolling estimating dataset. This would result to the mis-forecast of the expected income growth as well.

Lastly, the predictability of expected income growth has been critically examined in Ang and Bekaert (2007)'s paper based on U.S. S&P data from 1935 to 2001, the pooled data across the U.K., U.S. and German from 1953 to 2001 and the pooled data across the U.K., U.S., Germany and France during the period of 1975 to 2001. The results indicate that the dividend yield can hardly predict the linear cash flow or the growth of income. To be specific, they found that in the long U.S. sample, the dividend yield fails to forecast the ex-post real dividend growth while in the shorter sample, with pooled data across four countries, the dividend yield and real dividend growth have significant negative relationship. Additionally, other research (for examples, Menzly et al. (2004), Lettau and Ludvigson (2005), etc) concludes same findings with Ang and Bekaert (2007) on that the dividend yields were found fail to predict the dividend growth.

All in all, the expected income growth has been studied as a vital variable in asset pricing and return predicting research. Though the two main methods (both estimating and forecasting) for computing this variable are widely-used in previous studies, there are some inevitable shortcomings in the models. In this way, a novel mathematical model for improving them will be contributable for future research in this area.

TABLE 2.1: THE APPLICATIONS AND ESTIMATIONS OF EXPECTED INCOME GROWTH						
Article	**Assets examined**	**Applications**	**Data**	**Estimating Methods**	**Testing Methods**	**Time period**
Ang and Bekaert (2007)	equities	to examine the predictability of future stock return and cash flow	S&P 500 stock price return and total return	VAR model	OLS , VAR	1935 – 2001
Bansal and Yaron (2004)	equities	to test the relationship between expected dividend growth rate and risk premium	Equity prices and realized consumption growth data	VAR model	VAR	1929 – 1999
Chen et al. (2004)	real estate	to evaluate the real estate asset as one of several factors in the model	NOI index by NCREIF	VAR model	OLS	1982 – 2003
Chiang (2008)	REITs	to test the relationship between dividend yield and dividend growth	Center for Research in Security Prices (CRSP) / Ziman Real Estate Database for REITs' returns	VAR model	OLS , VAR	1980 – 2006
Fama (1990a)	equities	to explain the variance of total return by the combined strength of change of expected cash flow, time-varying expected returns and expected returns	annual NYSE value-weighted return	VAR model	OLS	1953 – 1987
Fama and French (2001)	equities	to test the effect from the change of dividend pay-out ratio on the characteristic of the stocks	CRSP and Compustat	VAR model	Logit regression	1926 – 1999
Hung and Glascock	REITs	to find out the momentum return of REITs when dividend yield is shocked	REITs' returns from the CRSP database	VAR model	VAR	1997 – 2000

(2008)						
Johnson (2002)	equities	to test the momentum effects in stock returns under condition that the expected dividend growth varying over time	Equity (especially real estate stocks) returns from the CRSP database	VAR model	VAR	1993 – 2000
Kothari and Shanken (1997)	equities	to test track the time-variance of stock return from two aspects: BM ratio and expected dividend growth	equal- and value-weighted CRSP indexes	VAR model	OLS	1926 – 1991 (BM ratio) and 1941 – 1991 (dividend growth)
Lettau and Ludvigson (2005)	equities	to test the relationship between expected dividend growth and expected return	Stock dividend and return from CRSP	VAR model	VAR, OLS and Pooled Regression	1947 – 2001
Menzly et al. (2004)	equities	to test the predictability of stock return	CRSP value-weighted stock market index	VAR model	Multivariate regression	1948 – 2001
Plazzi et al. (2008)	commercial real estate	to measure the risk of commercial real estate investment	Returns and growth in rents of commercial real estate on U.S. metropolitan areas	VAR model	VAR	1986 – 2002
Shilling and Sing (2007)	real estate	to predict the return of real estate asset	Return from NEREIF data base and ex-ante return from Korparz Survey	VAR model	VAR	1988 – 2006
Sing et al. (2007)	property and property stock	to predict the returns of both property and property stock	Real estate return (URA of Singapore) and property stock return (SGX-PTYS)	VAR model	VAR	1988 – 2006

Schwert (1990)	equities	to decompose the variance of the stock return	NYSE value-weighted returns	VAR model	VAR	1889 – 1988

2.4 WHY THE EXPECTED RENTAL INCOME GROWTH WOULD AFFECT THE REAL ESTATE'S RETURN

Among various theoretical and empirical work on real estate returns, we choose three main streams based on the expected rental income model which will be derived in the next chapter. Empirical studies concerning the former two factors are legion while on the contrary the theoretical work on them is limited. Despite the numerous applications of expected cash-flow growth on equity market, there are barely previous studies directly investigating the relative effects of expected rental income growth on the real estate returns. In this study, the reason why the expected rental income growth would affect the real estate return will be investigated to fill the related research gap.

2.4.1 Interest Rate Risk

The interest rate is volatile with both economic and financial market movements, thus it represents an important source of risk for the asset investment. One of the traditional streams of traditional interest rate research had focused on its effects on the inflation rate. Fisher (1930a)'s pointed the one-period nominal interest rate is the equilibrium real return plus the expected inflation rate under the condition of perfect foresight and well-functioning capital market. Several studies supported Fisher's proposition and extensively tested the relationship between interest rate and inflation. Among them, some are focused on the investigation of the interest rate determinants and combine the Fisherian analysis with their model, thus confirm the relationship between interest rate and the inflation rate posited in Fisher(1930)'s research. For instance, Feldstein and Eckstein (1970) constructed a model of interest rate determinants by integrating Keynes's liquidity preference theory with Fisher's theory of interest. Both Yohe and Karnosky (1969), Sargent (1969) and Anderson and Carlson (1970) incorporated the Fisherian distributed lag measure of expected inflation in their work to investigate the determinants of the interest rate. Yohe and Karnosky (1969) focused on the change in expected inflation while Sargent (1969) and Anderson and Carlson (1970) constructed a loan-able funds model to confirm Fisher's views about the interest rates. Though different price variables were modified in different studies, similar findings were concluded.

Contrary to the Fisherian view, the Gibson's Paradox proposed that there is a positive relationship between the nominal interest rate and the level of commodity prices, rather than its rate of change (inflation rate). The proposition was probably first noticed by Tooke (1844) and was named by Keynes (1930). It was called a "Paradox" because the absence of theoretical reason to explain the indication found by the data and the reasons which expect there should be no relationship between level interest rate and price level. Later studies which tried to explain this positive correlation revealed the predicting power of interest rate on expected inflation.

In the early age, Keynes (1930) explained the relationship in the context of the demand of loans. By generalizing Keynes's explanation, Sargent (1973) empirically found that the positive correlation of interest rate and price is caused by the changes of the aggregate supply and demand. Similar empirical literature had been produced to make the proposition replete with empirical evidence.

Later the research of this branch was continued with new findings. The expected inflation had been involved into the investigations and the “Paradox” got more explanations. Harley (1977) found evidence in Great Britain during the period from 1873 to 1913 to confirm the positive relationship between interest rate and prices level through the expected inflation. Shiller and Siegel (1977) even claimed that they had rejected Fisher’s hypothesis by finding the correlation between interest rates and prices persisting for almost a quarter of a millennium. They related this correlation to the governments’ characteristic behavior during the World War I and the unanticipated inflation. Also Friedman and Schwartz (1982) presented empirical evidence that interest rates can positively affect the expected inflation during sub period.

During 1980s, the research on the informative features of interest rate did not stop, and new explanation had been proposed. The money stock was introduced in the explorations and competed with the interest rate as the indicator of future economy. Sims (1980)’s study might be the provocation on this topic. He found that M1 money stock could explain 37% of the future variance of industrial production at a horizon of 48 month through VAR system. There is another interesting findings in Sims (1980)’s work that when commercial paper rate was added to the VAR model, almost all predictive power of M1 for output was absorbed by the interest rate. Litterman and Weiss (1985) got similar results with Sims’ by replacing the commercial paper with the Treasury bill. On one hand, both Sims (1980) and Litterman and Weiss (1985) concluded that the predictive power of monetary stock was weaker and can be instead by the interest rate. On the other hand, some other researchers (i.e. McCallum (1983) and Bernanke and Blinder (1989)) argued that the interest rate might be a better indicator than money stock about the future real economy, but it cannot be evidence to against the predictive power of monetary policy because the interest rate is most closely associated with the policy.

Besides, the research of the interest rate’s effects also spread to the stock markets. The first try might be Schumpeter (1912)’s work on the linkage between stock market and macro-economic variables. Then Merton (1973) not only deduced an inter-temporal capital asset pricing model, but also suggested that the market interest rates may act as one of the instrumental variables, which would explain the shifts of future investment opportunity. During the recent decades, numbers of researchers explored further on this issue (i.e. Fama (1981), Poterba and Summers (1988), Hamao (1988), Fama (1990b), Chen (1991), MacDonald and Power (1991), Thornton (1993), Kaneko and Lee (1995), Cheung and Ng (1998), Darrat and Dickens (1999) and so on). In both Chan et al. (1985) and Chen et al. (1986)’s investigations, the interest rate was studied as one of the observable variables at the macro level for equity pricing. Sweeney and Warga (1986) empirically found that the interest rate was priced as the risk premium of its changes in stock market, especially significant for those firms in utility industries. Also Choi et al. (1992), Turtle et al. (1994), Song (1994) and Elyasiani and Mansur (1998) concluded that interest risk is one of the priced variable for the stocks. Not only the developed market but also the emerging market (for example, Mookherjee and Yu (1997) and Maysami and Koh (2000) for Singapore, Kwon and Shin (1999) for South Korea, Ibrahim (1999) for Malaysia, Charkravarty (2005) for India, Saleem (2007) and Ihsan et al. (2007) for Pakistani) had been investigated on the linkage between interest rate and the stock return/price. The findings are consistent on the issue that the interest rate risk is priced on stock's price, or say the interest rate has some impact on the stock's return.

As one of the important asset investment instruments, the real estate had been investigated in the context of the interest rate influence as well. The previous work on this area is not large scale or diversified. Most of them are focused primarily on the interest rate sensitivity of real estate. On research level, the sensitivity is usually measured by the beta coefficient of the interest rate and estimated by the regression function of ex post real estate returns/prices on several explanatory macroeconomic variables (including interest rate). For instance, Liu and Mei (1992) investigated the predictability of the equity REIT's return by taking interest rate as one of the sources of time-varying risk premiums based on a multifactor latent variable model. Similar works had been done and confirmed the hypothesis that the interest rate change was one of the risk factor for real estate investment and the pricing of the real estate asset contained the premium from its movements. Also there are some papers focused on the relationship between REIT's return/price and movements of interest rate. Though the previous findings are conflicting, the interest rate's impacts on REIT's return/price are confirmed. For instance, Chen and Tzang (1988) found that equity REITs were not sensitive to interest rates while mortgage REITs are sensitive to it by investigating a small sample of both REITs during period of 1973—1979 and 1980—1985. In Bharati and Gupta (1992)'s work, the interest rate was regarded as one of the financial market variables to predict the future returns of mix asset (stock, bond, real estate) allocation model. As the active strategy was found to outperform the passive one, they concluded that some capital market factors affect real estate returns. Further Gyourko and Keim (1993)'s study revealed that the correlation between equity REITs and long-term interest rates were 0.43 during 1978—1990. Mueller and Pauley (1995) extended the previous work by analyzing the movement of REIT price during a whole interest rate cycle to clear the air. They found that during the rising interest rate period the relationship between REIT price and interest rate is low and negative while the prices of both REITs and private real estate behaved like bond during the falling interest rate period. Therefore, the investigations on the relationship between interest rate and real estate prices are not consistent yet. And the mixed previous conclusions are the provocations for us to explore on this issue further.

Reviewing the previous studies we can find that the interest rate sensitivity had been usually examined without the expectation variable. Thus we cannot help to argue that the absence of important explanatory variable(s) may affect the investigation findings of the research. Although this study might not be able to assert the relationship between interest rate risk and real estate return, we can at least explore the relationship with all explanatory variables based on the Term Structure Expected Growth Model in this study.

2.4.2 Term Structure of Interest Rate (Interest Rate Spread)

The term structure of interest rate had been playing a central role ---- both theoretically and practically in the economy. Before the research on term structure, there's a stream of studies concerning on the duration of interest rate. Macaulay (1938) explored the risk exposure of interest rate by proposing the duration as a more meaningful measure of life than its term to maturity first. Similar analyses and confirmed results were investigated by Hicks (1939) and Samuelson (1945). Hicks (1939) found that the duration was the elasticity of the financial instrument with respect to the discount factor. Later Samuelson (1945) rediscovered that the financial institutions could profit by the greater average disbursement time period of when the interest rate increased.

As mentioned in the beginning of this chapter, the investor's expectation has been frequently used to illustrate the state of financial market on either academic or practical level. The expectation lies mostly in two aspects, the future income and the risk will be taken. Both of them had been studied in previous studies but it is difficult to distinguish the two. On one hand, the interest spreads are taken for granted to measure the health of the banking system and the general economy. For instance, the LIBOR-OIS[5] spread shows how risky the lending bank felt about the borrowing bank while the TED[6] spread indicates the perceived credit risk the lender felt about to lending money to commercial banks. Though the measurement of risk varies between different parties, still the theories are the same. On the other hand, the expected future income growth of certain equity is regarded to be one of the most important factors of equity pricing and future return forecasting. For example, Gordon (1959) constructed a model based on DCF appraisal method to demonstrate the pricing of equity with future income. Campbell and Shiller (1988a) used the VAR (vector auto regressive) model in their research to estimate the expected dividend growth so that its importance can be judged. Clayton et al. (2009) employed the survey-based investor's expected rental income growth of commercial real estate asset to investigate whether the expectation had been priced in commercial real estate. However the investor's expectation on future income of certain asset had been mixed with the risk expectation (risk premium) in all previous studies. The impure expectation might lead to mispricing of the asset and the misunderstanding of the economy state.

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5 LIBOR here is short for the London Inter-Bank Offered Rate, which is a daily reference rate based on the interest rates at which banks borrow unsecured funds from other banks in the London whole sale interbank lending market. OIS is short for overnight indexed swap, the interest rate swap where the periodic floating rate of the swap is equal the geometric average of an overnight index (i.e., a published interest rate) over every day of the payment period. The index is typically an interest rate considered less risky than the corresponding interbank rate. The spread between the two rates is an important measurement of risk and liquidity in the money market (Zeng (2008, (2009)). LIBOR is risky in the sense that the lending bank loans cash to the borrowing bank, and the OIS is considered stable as both counterparties only swap the floating rate of interest for the fixed rate of interest. The spread between the two is therefore a measure of how likely borrowing banks will default.

6 TED spread refers to the difference between the interest rates on interbank loans and T-bills. T-bill is the short-term US government debt while ED is the ticker symbol for the Eurodollar futures contract, which is represented by LIBOR in the calculation. The TED spread is an indicator of perceived credit risk in the general economy (Bloomberg)). This is because T-bills are considered risk-free while LIBOR reflects the credit risk of lending to commercial banks.

In line with the findings that level of interest rates was important for forecasting the economy, there are a number of papers concerning the information contained in the term structure of the interest about the future economy, real interest rate, inflation rate and the fiscal policy. Fama (1984) found that the forward Treasury bill rates could predict the correct direction of short-term rates movements through the investigation of one- to six-month T-bill rates during the period of 1959 to 1982. Mankiw and Miron (1986) used three- to six-month rates to find consistent results and attribute the predictive power to the forecast able seasonal pattern of the interest rates.

The predictive power of term structure had been examined directly in some studies. Hardouvelis (1988) explored this issue across several monetary regimes and the predictive power of the spread had increased significantly after October 1979. Stock and Watson (1989) compared a wide variety of possible leading indicators of the real economy and found the spread of interest rates played as a vital factor. To interpret the forecasting ability of spread of interest rate, Shiller et al. (1983) constructed a linear model of the spread of interest rates and concluded that the expectation theory of term structure is acceptable with proper measures of time-varying risk premiums to be introduced. Campbell (1987) and Chen (1991) argued that the term premium of interest rates had forecasting power of the market excess return by predicting the macro economy. Laurent (1988) examined the relationship between the growth in real GNP and the lags of the spread of 20-year bond rate to the federal funds rate without finding significant relationship. Estrella and Hardouvelis (1991) and Hardouvelis (1994) explored the predictive power of the spread of interest rates on the real economy and found that the spread had more power than the short-term interest rate on forecasting the changes of future economy.

Comparing to other indicators, the term structure had been found to have more power in forecasting. In general, the yield curve tends to perform quite well in comparisons with other leading indicators, including the traditional leading indexes and their components, and other variables with potential predictive power. Indicators such as stock prices and interest rates may have similar performance to the yield curve at some horizons, but none seem to dominate the yield curve as a predictor. For instance, Dueker (1997) and Dotsey (1998) compared the yield curve with a few other variables as a leading indicator of recessions, and find generally supportive statistical evidence. Stock and Watson (2003) examined a large number of competing indicators in forecasts of output growth and find that all of them fall short of ideal properties, but that within these limitations the spread "comes closest" to achieving those goals.

During the recent decades, the predictive power of spread of interest rate had been understood even better. Some important stylized facts have been captured based on several financially coherent models. Most of the models employed the unobserved or latent risk factors which is difficult to interpret (see Dai and Singleton (2003) for the review of literature on the constructions of those models). Later, another strand of the research is concerning a lot on the connections between latent risk factors driving the spread dynamics and the observed macro-economic variables (i.e. Ang and Piazzesi (2003), Rudebusch and Wu (2003), Hordahl et al. (2003) and so on). Similar empirical works are plenty without divaricating findings.

The relationship between stock return/price and the spread of interest rate also attracted lots of attentions in the previous studies. The researchers used the term structure to predict and explain the equity return or price. Campbell (1987) argued that both the prediction of excess return in the spread and stock would employ same variables by deducing a simultaneous analysis of the returns of T-bills, bonds and stocks. He found the evidence to support the predictive power of spread on excess returns of the US stocks. Campbell and Viceira (2005) further argued that the long-horizon investors' expected excess return on long-term returns are correlated to each other. They used a return dynamics model to explore the predictability of asset returns by the commonly-used return-forecasting variables including yield spreads, interest rates, and dividend yields, and then found that all the variables had considerable effects on the portfolio allocation among T-bills, stocks and bonds based on the correlations they issued. Kothari et al. (2006) investigate the spread of interest rate as one of the discount-rate proxies and found strong evidence to support correlation between the earnings growth of stock and all proxy variables they employed.

The previous works about the forecasting ability of spread on the real estate return/price are limited with mixed findings. For instance, Chan et al. (1990) found that the spread has impacts on the real estate returns while Liu and Mei (1992) did not find such evidence to support that view. To clear the air, Ling and Naranjo (1997) concluded that the spread could be important during specific periods. Later the related literature explored this issue in the context of the integration of capital and real estate markets. Ling and Naranjo (1999) regressed the risk premiums and several macro-economic factors which included growth of GNP, CPI and the spread of the interest rate, and found the significant correlation between REITs return and the spread so as to provide evidence of the market integration between REIT and stock markets. However no evidence was found from private real estate market, which is consistent with the findings of Liu et al. (1990)'s work years before. Besides REITs, it can barely find the factors from direct real estate market which is linked to the interest rate spread.

As one of the explanatory variables in the Term Structure Expected Growth Model, the interest rate spread is not a new comer. There are more than plenty of studies focusing on its predictive power. It had been examined to be a useful indicator and predictor for the real economy, expected inflation, future real interest rate on macro level while an important explanatory factor for the equity return and price. However the investigation on its forecasting and explaining abilities in real estate market is limited. Its impacts were evidenced to be existed in some research while not in some others. Especially in the private real estate market research, the spread seems have no effects on the asset's return or price. This is not reasonable regarding the Term Structure Expected Growth Model. The mixed and limited findings might be caused by the absence of the theoretical model to explain the relationship. This study will fill in this gap by investigating whether and why the spread would affect the real estate return.

2.4.3 the Expected Rental Income Growth Effects on Private Real Estate Return

Comparing to the research of expectation effect on equity return, the relevant work on private real estate market is unwonted. Mainly speaking, there are two streams concerning the investor's expectation with different terms, rationality and sentiment.

On one hand, some studies focused on the rationality of the investors, which is believed to have power to influence the real estate return. Clayton (1998) found strong empirical evidence in Vancouver and British Columbia to against market efficiency and blamed the sharp increase of apartment price to the investor's irrational expectations partly. Their findings implied that the market value of real estate asset might be over-estimated in a booming market because of the investor's expectation. On the contrary, Hendershott et al. (2003)'s study presented the arguments against the theory that the irrational expectation leads to asset pricing bubble. Their arguments turned for the rational bubbles, which referred to the temporary up or down of the property price under specific conditions. Especially for the commercial property, they found that the investor would rationally take the mean reversion in actual cash-flow into account when they were valuing the asset. They insisted that though there is bubble in commercial real estate market, the bubble is rational. Shilling (2003) employed the Korpacz survey of institutional investors dataset to explore the risk premium of real estate market. His findings suggested that the investor's expected returns were higher than the actual returns which implied that the risk premium may be mis-estimated by using the historical averages. Hendershott and MacGregor (2005a) and Hendershott and MacGregor (2005b) empirically confirmed that the real estate investors in both US and UK were irrational during the period of the existence of negative relationship between cap rate and rent growth. Shilling and Sing (2007) extends the research by investigating whether the investor's rational and irrational expectation on future return of real estate asset had been incorporated in the return formulation process. Under the help of Campbell-Shiller's VAR framework, they found that the investor's irrational expectation affected the real return negatively with one period lead.

On the other hand, a small bunch of researchers were attracted by the investor sentiment (which is included in the expectation in this study) and explored its effects on real estate markets. Clayton (2003) reviewed the existing behavioral finance literature of investor sentiment with a focus on their implications on real estate market. Later Clayton et al. (2009) explored the role of investor sentiment in commercial real estate pricing process and concluded that the investor sentiment did affect the pricing after controlling other fundamentals.

2.5 HOW THE EXPECTED RENTAL INCOME GROWTH WOULD AFFECT THE REAL ESTATE'S RETURN

There have already been plenty of research investigating how the expected dividend growth predict the return or price of the equity. Section 2.1 provided a comprehensive review of them. Also the literature concerning why the expectation would affect the real estate asset return had also been presented in last section. In this section, literatures involving one particular type of equities, Real Estate Investment Trusts (REITs), will be sorely reviewed.

There used to be a wealth of studies exploring the explanatory variables of the REITs' returns. In previous studies, the relationship between REITs' returns and property market variables (appreciation of both price and rents), stock market variables (stock price index), bond market variables and other macroeconomic variables (i.e. rate of interest, inflation, etc,) had been examined. Most of them confirmed that return of REIT has dependence on the stock market and macroeconomic variables while few studies could find the significant or clear relationship between REITs and direct real estate markets. Table 2.2 lists some of the previous studies focusing on the explanatory variables of the return of REIT.

Table 2.2

Previous studies on the return of REIT and its explanatory variables

Author(s)	Variables	Method(s)	Finding(s)
Giliberto (1990)	REITs return vs. unsecuritized real estate return and stock/bond market returns	Comparing the residual series of REITs return and unsecuritized real estate return by kick off the factor common to real estate and financial asset market (stock/bond return)	1. REITs return has strong dependence on the stock/bong market movements while unsecuritized real estate return has few of that. 2. Removing the financial market effects, there is common factor in both REITs and unsecuritized real estate return series.
Joseph L. Pagliari and Webb (1995)	REITs return vs. income and appreciation returns of property	1. To compare the REIT dividends and direct-property income 2. To compare REIT share prices and direct-property appreciation	1. Short-run relationship between the REITs and property market is weak. 2. In the long-run, the relationship between the appreciation return of property and capital returns of REITs was found to be strong.
Li and Wang (1995)	REITs return vs. other common stocks return, the risk premium of stock and bonds	The study employed the multifactor asset pricing model to evaluate the predictability of return of REITs and other common stocks	The predictability of both kind of stocks are similar. And it offered further evidence to show the integration of REITs and general stock market.
Clayton and MacKinnon (2001)	Equity REIT return vs. returns on other asset classes, including unsecuritized real estate, bonds, small cap stocks and large cap stocks	The flexible least square (FLS) estimation method was employed in the study to derive the time-varying coefficient estimates in REITs returns regression model.	REITs returns show greatest sensitivity to bond and stock market movement while little dependence on real estate during 1978 to 1998. However the sensitivity of REITs return changed over time. After 1992, the sensitivity of REITs returns to large cap stock returns declined

			and the relationship between returns of REITs and real estate became significant positive.
Glascock et al. (2002)	REIT returns vs. perverse inflation behavior	VECM to test the relationship among REIT return, real activity, monetary policy and inflation	The study found the negative relationship between the REIT return and inflation. However it concluded that is partially because of the information of monetary policy changes, which affects the expected and unexpected inflation.
Clayton and MacKinnon (2003)	REIT return vs. major stock, bond and real estate-related return indices	Variance decomposition was employed in the study to separate REIT return variability into components of stock, bond and real estate.	Significant real estate risk factor, other than stock or bond market risk factors, was found emerging for REITs after 1990, especially for the small ones.
Ling and Naranjo (2003)	REIT return vs. REIT capital flow	Dynamic VAR model was employed in the study to examine the interrelationship and short- and long-run dynamics among capital flows to the REIT sector and returns.	There is positive momentum in REIT flows, which reversed after two quarters. And REIT equity flows have positive relationship with prior return with a two-quarter lag.
Ewing and Payne (2005)	REITs return vs. the unexpected changes of macroeconomic factors, such as the real output growth, the inflation, the default risk premium, and the stance of monetary policy.	The vector auto regression model was employed in the study to estimate the effects from all macroeconomic factors to REITs returns.	The study found the extent and the magnitude of the relationship between REIT return and the changes of macroeconomic factors. To be more specific, the expected return of REIT had negative relationship with movements of monetary policy, economic growth and the inflation while had positive relationship with the shock to the default risk premium.
Larson (2005)	Price of REITs vs. information of reversal of stock prices (such as	3 steps were taken in the study to test the hypothesis:	The one-day price of REIT is associated with the reversal of stock prices. And the degree of

	initial price decline, pre-event leakage, size, type of REITs, trading volume)	1) Z-statistic to find out the abnormal returns, 2) the VAR model to define all the variances 3) the cross-sectional regression to assess the degree of reversal.	reversal shows positive relationship with the initial price decline and degree of leakage while negative relationship with REIT's size and relative trading volume on the event day.
Muhlhofer (2008)	REITs return vs. property's rental return, appreciation return	Time-series regression model is employed to test the hypothesis and the critical test of UPREIT was applied to do the robust test as well.	Because of the trade constraint, EREIT's return show strong dependence on direct real estate asset's rental return rather than price return.

Regarding to the previous studies, the relationship between REITs and private real estate market has been unclear for decades. For the lack of conventional conclusions, this line of research becomes cooled down gradually. However the research question is still waiting to be answered. As one of implications of the expected rental income model, REIT's return would be explained by the expected rental income growth of its underlying real estate asset. The investigation on this implication will not only find a clue to the price discovery mystery between public and private real estate markets, but also provide the answer to our research question: how the expected rental income growth affects the real estate returns.

2.6 RESEARCH GAPS

The literature concerning the investor's expectation had been summarized in the above sections. In general, the literatures have shown that the investor's expectation on future cash-flow is very important for asset pricing and investment return, although the measurement of the expectation is not conventionally agreed. The previous studies have confirmed that the investor's expectation on future cash-flow growth is reasonably important to analyze the asset's price and return. Notwithstanding the efforts contributed by the previous studies, there are still several research gaps that need to be filled when the expected cash-flow growth is used to explain the real estate asset investment.

The most important one is the lack of a reliable method to capture the investor's expected cash-flow growth of the asset. The classic models which are commonly used to estimate the expected cash-flow growth have their own weaknesses. Their assumptions of the models are not using the market information but historical data. Though the survey method has also been used in several studies, the reliability of the survey results is still a question. This calls for the construction of the refined model to capture the investor's expected cash-flow growth of asset with updated market information

Another important gap is related to the implications of the expected cash-flow growth. Lots of previous researchers used the expected cash-flow growth of equity to measure the risk and predict the return or price. However the expected cash-flow growth of real estate asset investment has barely been paid attention to. As one of the most important and usual investment vehicles on the earth, the real estate asset is supposed to share the theories, which can be applied to other assets. As a result, there is obviously an urgent demand to analyze the real estate asset's return with the expected rental income growth.

The last gap is the linkage between public and private real estate markets. By regarding the REIT as equity, its expected dividend growth may explain and predict its return as discovered in the literatures. However as the underlying asset of REIT is the private real estate asset, its expected dividend growth should be the expected cash-flow growth of its underlying assets then. Although the linkage between public and private real estate markets had been investigated by quantities of researches, it has never been explored through the connection of the investor's expectation. This study, therefore, attempts to examine the relationship between public and private real estate markets with the expected rental income growth of real estate assets.

CHAPTER 3 THEORETICAL JUSTIFICATIONS

This chapter is to construct the Term Structure Expected Growth Model. In the first section, the development of Present Value Model together with the application and estimation approaches of the expected cash-flow growth of the asset is provided. The second section discusses in detail the problems of the Gordon Growth Model and Campbell-Shiller Model. In the third section, the novel model to capture the expected rental income growth of asset is proposed and derived under the urgent need for the adjustments of the popularly-adopted models. The final section makes some comparisons to show the empirical specification of the model.

3.1 THE DEVELOPMENT OF THE PRESENT VALUE MODEL

As demonstrated in the second section of Chapter 1, the Discounted Cash Flow method of asset pricing was formally expressed in modern economic terms on the basis of their research. Since then, the method had been frequently used in asset pricing process. However there are several assumptions of the theory. As based on investment opportunity, human impatience and market exchange, the assumptions underlying the general Fisherian theory are as follows: 1) The individual investor is assumed to be free to choose the investment assets which will produce the maximum present value with risk taken into account; 2) The actual growth of income might be different with the expected one due to the widely discrepant risk over the time.

Years later, Fisherian Theory had been developed into Discounted Cash-Flow (DCF) Model to evaluate the price of asset within certain holding period. The proposition of discounting all the income within the holding period into the price of asset is the key idea of the DCF model. After being first formally expressed in Fisher (1930b) and Williams (1938)'s work, the concept of discounted cash flow had been applied in host of finance and economic researches. By employing the time value of money into the model, the discounted cash flow formula is derived from the future value equation for calculating the time value of money as follows:

$$FV = DPV \times (1+i)^n \tag{3.1}$$

Where *FV* refers to the future value of money, while *DPV* refers to the discounted cash flow during the period of *n, i* represents the cost of capital, which is assumed to be constant during the whole holding period of the asset.

Therefore the discounted present value (for one cash flow in one future period) can be expressed as follows:

$$DPV = \frac{FV}{(1+i)^n} \tag{3.2}$$

It is clearly shown by the equation (3.2) that the value of certain asset at time *n* (the end of the holding period) would be determined by the aggregation of cash flow and interest rate till time *n* shown as follows:

$$P_t = \sum_{t=0}^{n} \frac{D_t}{(1+i)^t} \tag{3.3}$$

Where *P* refers to the asset's value or price at time *t*, *D* and *i* represent the cash flow (income) and the interest rate at ending period time *t*. Through DCF method, certain asset's value can be estimated based on its time-varying cash flow. For its reasonability of considering the time-varying nature of the money, DCF method is popularly adopted in the asset appraisal area, especially real estate asset and stocks.

However the assumptions of DCF model are the obstacle for it to be closer to the real world. There are two assumptions in DCF model for asset pricing:

(1) the cash-flow is assumed to be constant during the holding period;

(2) the cost of capital (interest rate) is assumed to be constant during the holding period.

Obviously, neither of the two factors is constant in our real world. After formulating by Fisher, the DCF method had been widely adopted when the investment of asset or company was appraised. However the one of the most important things for the application of DCF method is the judgment on selection of the discount rate. Thus the shortcomings of the method are substantially exhibited: 1) The discount rate assumption relies on the market for competing investments at the time of the analysis, which would likely change, perhaps dramatically, over time, and 2) straight line assumptions about income increasing over ten years are generally based upon historic increases in market rent but never factors in the cyclical nature of many real estate markets. Most loans are made during boom real estate markets and these markets usually last less than ten years. Using DCF to analyze commercial real estate during any but the early years of a boom market will lead to overvaluation of the asset.

As time passing by, two variant models of DCF became more and more popular in the application of asset valuation: Gordon Growth Model and Campbell-Shiller model. The former relaxed the first assumption of Fisherian theory while the latter relaxed both of them. The two variant models are regarded as the innovation of DCF method by making it closer to the reality. As mentioned in above section, the Gordon Growth Model and Campbell-Shiller Model are two of the most popular adopted models nowadays. Yet, this does not mean that the shortcomings of the models are to be ignored. In fact, with appropriate adjustments of the models, the new model can be a very good method that utilizes much more information from the market.

To improve DCF method, in 1950s, Gordon (1959) relaxed the first assumption to allow the cash-flow of asset change over time with constant growth during the period. Comparing with DCF model, Gordon Growth Model came closer to the real world for adding the constant growth rate to the income of the asset, which is usually called expected cash-flow growth.

Still with the constant cost of capital, the standard version of the present-value model turned into the formula as follows:

$$P_t = \sum_{t=0}^{n} \frac{D_0(1+g)^{t-1}}{(1+i)^t} \qquad (3.4)$$

where g represents the expected growth of the asset's income. There are two important assumptions for the construction of Gordon Growth Model: (1) it assumes that the asset has income with current value of D_0 and the income is expected to change at a constant rate g; (2) it also assumes that the cost of capital still remains constant at i. Though in formula (3.4), the model involves in summing the infinite series, in practice, it usually use the next value of income $D_1 = D_0(1+g)$. In this way, the model can be stated as:

$$P_0 = \frac{D_1}{i-g} \qquad (3.5)$$

The advantages of Gordon Growth model are obvious:

(1) The main strength of the Gordon growth model is that the valuation calculation is easily performed using readily available or easily estimated inputs.

(2) The model is particularly useful among companies or industries where cash flows are typically strong and relatively stable, and where leverage patterns are also generally consistent.

(3) The model is widely used to provide guideline fair values in mature industries such as financial services and in large-scale real estate ventures. The model can be particularly appropriate in the valuation of real estate investment trusts, given the high proportion of income paid out in dividends and the trusts' strictly defined investment policies.

Among Gordon Growth model which is widely accepted and applied in appraisal practice or valuation research, there are several shortcomings for their applications in real estate market:

(1) their assumptions make the implicit risk premium to be embedded in the cost of capital Chau (1997);

(2) the effect of depreciation over time has not been taken into account in the model Yiu and Hui (2006);

(3) the model requires the growth rate to be less than the cost of capital ($g < i$), and the results of the model are sensitive if the cost of capital is closed to the growth rate. The

similar problem exists in the Term Structure Expected Growth Model in this study. The improvement on this aspect will definitely refine the model further.

(4) When the cost of capital is closed to the perpetual growth rate (g), the results of the GGM will become sensitive.

Till 1980s, Campbell and Shiller (1988a) solved the problem by incorporating the dynamic discount factor to relax both assumptions of DCF model in their research of dividend-price ratio model. The Campbell-Shiller model is log-linearized for the possible non-linear relationships among the asset price, dividend (cash-flow) and returns as expressed in equation (1.15). Small letter variables represent the natural logarithms of the corresponding variables in capital letters, unless otherwise specified:

$$\begin{aligned} p_t &= \log(P_t) \\ d_t &= \log(D_t) \\ r_t &= \log(R_t) \end{aligned} \tag{3.6}$$

Then the logarithm of return r_t is estimated by:

$$\begin{aligned} r_t &= \log(P_{t+1} + D_t) - \log(P_t) \\ &= \log(1 + \mathrm{D_t} / P_{t+1}) + \log(P_{t+1}) - \log(P_t) \\ &= \log(1 + e^{d_t - p_t + 1}) + \log(P_{t+1}) - \log(P_t) \end{aligned} \tag{3.7}$$

By justifying the equation (3.7) in a first-order Taylor expansion, it yields an expression for the average log dividend- price ratio, $\overline{d-p}$:

$$\log\left(\frac{\eta}{1-\eta}\right) = \overline{d-p} \tag{3.8}$$ [7]

Substituting Equation (3.8) into Equation (3.7) results in an approximation for the continuously compounded return:

$$\begin{aligned} r_{t+1} &= (d_{t+1} - p_t) - \eta(d_t - p_{t+1}) + (d_t - d_{t-1}) + \theta \\ &= (d_{t+1} - p_t) - \eta(d_t - p_{t+1}) + \Delta d_t + \theta \end{aligned} \tag{3.9}$$

Where θ is an inessential constant arising from linearization. Then the log dividend-to-price ratio can be obtained by taking expectations and imposing the no-bubbles terminal condition.

$$d_{t-1} - p_t = \frac{\theta}{1+\eta} + E_t \sum_{j=0}^{\infty} \eta^j (r_{t+1+j} - \Delta d_{t+j}) \tag{3.10}$$

[7] note: the detailed expansion process has been established well in Yiu and Hui (2006)'s work

In Campbell-Shiller's model, they assumes that ex post return rate is equal to the sum of ex post discount rate and ex ante return rate:

$$E_t r_t = E_t i_t + \alpha \tag{3.11}$$

Then Campbell-Shiller's dividend ratio model can be expressed as:

$$(\frac{D}{P})_t = d_{t-1} - p_t = \frac{\alpha - \theta}{1-\eta} + E_t \sum_{j=0}^{\infty} \eta^j (i_{t+1+j} - \Delta d_{t+j}) \tag{3.12}$$

Large quantity of research has adopted this model to estimate the asset's future return and cash-flow. By incorporating the dynamic growth of the cost of capital and cash-flow, the Campbell-Shiller's dividend ratio model is the one closest to the real world. However the estimation of the expected cash-flow growth under their model is technically difficult because of the infinite sum equation. Therefore the model is usually used to explain the long-run relationship or predict the long-term dividend-price ratio with the econometric approach, such as VAR method.

The limitations of the two models are obvious: 1) there are restrictive assumptions in both Fisher and Gordon's works, which would push the theory far away from the reality; 2) though Campbell-Shiller's model relieved the assumptions and allowed the expected income growth and the cost of capital to change which is most closed to the real world, the model is hardly able to capture the expected income growth of the asset with market data because of its infinite equation. In this way, an approach with both assumptions closed to the reality and the adoptability with the market data set is in urgent need for research. So far, there is no model allowing both future cash-flow and cost of capital to be dynamic over time while with capability to be estimated with updated market dataset. The problem will be solved in this chapter by deducing a novel model based on Gordon Growth Model to illustrate the present value relationship better.

3.2MODELING THE ASSET'S EXPECTED INCOME GROWTH WITH TERM STRUCTURE

This section aims to solve the two problems in Gordon Growth Model and Campbell-Shiller Model. It is a conventional belief in the past models that when the expected rental income growth goes up/down, the real estate asset's price shall increase/decrease together according to the basic concept of Discounted Cash Flow evaluation method. In this section, we further postulate that the cost of capital would change with constant degree as well as the expected rental income during the investigation period. As mentioned before, neither of their changes should be ignored. Or else, the model will produce biased coefficients and hence an erroneous asset price. Unlike the past models (Gordon Growth Model and Campbell-Shiller Model), the new model will make some adjustments in the assumptions. Therefore the new model will be closed to reality as well as easy to be adopted in future research.

3.2.1 Theoretical Framework

When estimating the price or value of a certain asset with concerns of the time value of money, a practitioner may encounter a problem about how to identify the time value. In DCF[8] (Discounted Cash Flow) model and GGM[9] (Gordon Growth Model), the time value of money is proxied by the discount rate, which is also known as the cost of capital for the asset. Looking from the angle of the investor, the cost of capital for the asset is equal to the return they require (or say expect) from the asset. It should at least be the return of risk-free investment, which is usually equal to the government bond yield rate. Therefore the time value of the money in those models is also named as the required return rate, which is determined by the risk-free return rate.

As mentioned before in this study, we can barely find a model taking the growth of required return rate into account when estimating the price of certain asset. Comparing the assumptions of constant or inconstant growth rate of asset's income, the change of required return rate has been ignored for long time. However the time value of money, or say the cost of capital for certain asset, changes over time. As the required return rate is based on the risk-free return rate, it would change with it then. In this way, the growth of required return rate should be concerned as well when evaluating certain asset.

Before further derivation of the model, the theory of the term structure of interest rate is introduced here first. So that, the assumptions of the new model would be clear and supported by the facts. It is well known that, the bonds' interest rates differ with their terms to maturity. The term structure of interest rate refers to the relationship between the interest rates of different terms to maturity. From the real world, we can easily observe two term structure facts:

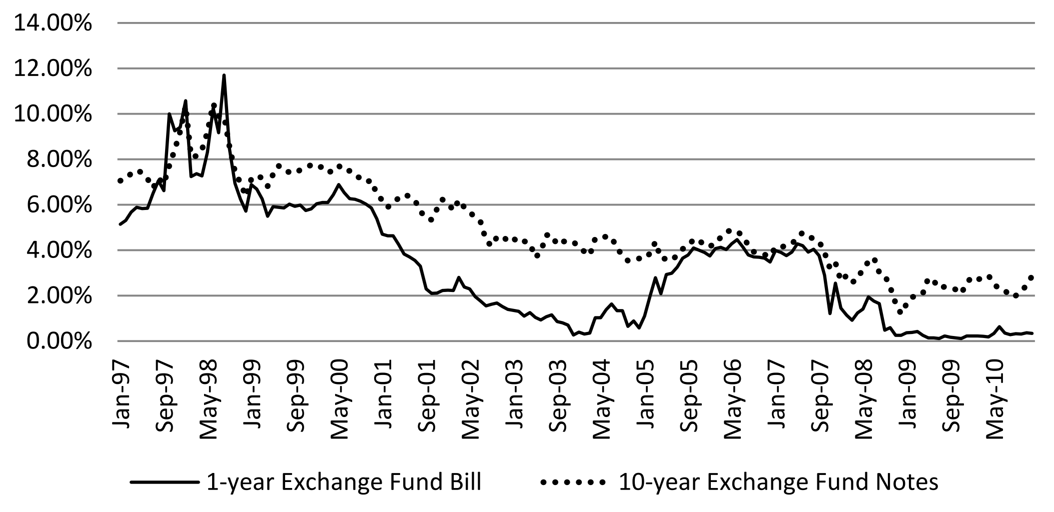
[8] DCF is short for the Discounted Cash Flow in this study;
[9] GGM is short for the Gordon Growth Model in this study.

(1) Interest rates of different maturity terms tend to move together over time;

(2) Yields on short-term bond more volatile than yields on long-term bonds.

Figure 3.1 shows the facts about the term structure of interest rate (discount rate) with Hong Kong Exchange Fund Notes Yields.

Figure 3.1 Term Structure of Exchange Fund Notes



Remarks:

The yields of 1-year exchange fund notes and 10-year exchange fund notes (rate per annum) are issued by Hong Kong SAR government, at:

http://www.info.gov.hk/hkma/eng/statistics/index_efdhk.htm

Sources: Hong Kong Monetary Authority

The expectation theory, which is one of the most common economic theories of term structure, can explain the facts. It contends that the long-term interest rate is geometric mean of the intervening short-term interest rate. The key assumption of the theory is that the investors of bonds do not prefer bond of one maturity over another. Thus the investors will not hold any quantity of a bond if its expected yield is less than that of another. This is called perfect substitutes[10] and the theory can be expressed as:

$$Y(t,T) = \frac{1}{T-t}\int_t^T E_t(y(s))ds \qquad (3.13)$$

[10] What makes long-term bonds different from the short-term bonds are the inflation and interest rate risks. Therefore the expectation theory essentially assumes away inflation and interest rate risks.

where Y represents the yield of long-term bond, $E_t(y(s))$ refers to the expected yield of short-term bond, T represents the term of maturity.

The example might help the theory to be understood. Consider the following two investment strategies:

(1) Buy \$1 of one-year bond (the short bond) and when it matures buy another one-year bond.

(2) Buy \$1 of two-year bond (the long bond) and hold it.

According to the expectations theory, they are perfect substitutes and their expected returns must be equal.

From Investment Strategy 1, the expected return:

$$\begin{aligned} E_1[Y] &= (1+y_t)+(1+y_t)E(y_{t+1})-1 \\ &= y_t + E(y_{t+1}) + y_t E(y_{t+1}) \\ &\approx y_t + E(y_{t+1}) \end{aligned} \tag{3.14}$$

$$\text{because } y_t E(y_{t+1}) \approx 0 \textit{(the product is negligibly small)}$$

From Investment Strategy 2, the expected return:

$$\begin{aligned} E_2[Y] &= (1+y_{2t})+(1+y_{2t})y_{2t}-1 \\ &= 2y_{2t} + (y_{2t})^2 \\ &\approx 2y_{2t} \end{aligned} \tag{3.15}$$

$$\text{because } (y_{2t})^2 \approx 0 \textit{(the product is negligibly small)}$$

According to the expectation theory, $E_1[Y] = E_2[Y]$ then,

$$y_t + E(y_{t+1}) = 2y_{2t} \tag{3.16}$$

Thus,

$$y_{2t} = \frac{y_t + E(y_{t+1})}{2} \tag{3.17}$$

where $E_1[Y] and E_2[Y]$ refer to the expected return of strategy 1 and 2 respectively, $y_t, E(y_{t+1}), y_{2t}$ represent the yield on 1-year bond at t, expectation at t about the yield on 1-year bond at period (t+1), and yield on 2-year bond (at *t*).

That means interest rate on the long bond is the average of the interests on short bonds expected over the life of the long bond. More generally, for n-period bonds,

$$y_{nt} = \frac{y_t + E(y_{t+1}) + E(y_{t+2}) + \cdots + E(y_{t+(n-1)})}{n} \qquad (3.18)$$

According to the expectations theory, long-term rates are all averages of expected future short-term rate. If y_t changes so will y_{nt} for n = 2,3,4,... , etc. Thus, interest rates of different maturities will move together (Fact 1). Also, an average smoothens out large volatilities. Therefore, if the current short-term bond yield changes (say, the expected short-term bond yield of just the next year), it will have very little impact on a long-term bond yield (say, the 10-year bond yield). Thus, short term bonds yields are more volatile (Fact 2). Also the expectation theory suggests a linear rate of change of the term structure over time (see formula (3.18)).

In line with the expectation theory of term structure, we assume linear[11] rate of change of the term structure over time in this study. To be more specific, the first assumption is same with GGM on the constant expected growth of asset's income; while the second assumption is that the required return rate of asset is expected to grow with a constant rate. Therefore based on GGM, the price of certain asset can be calculated with the formula as follows:

$$P = \frac{D}{(1+i)} + \frac{D\times(1+g)}{(1+i+G)^2} + \frac{D\times(1+g)^2}{(1+i+2\times G)^3} + \cdots + \frac{D\times(1+g)^{t-1}}{(1+i+(t-1)\times G)^t} \qquad (3.19)$$

where g[12] and G represent the expected growth of asset's income and the cost of capital respectively. The required rate of return (i) is assumed to grow linearly, however its growth (G) could be either positive or negative, which means the required rate of return can be expected either to increase or decrease. It all depends on the pattern of the yield curve (spread). As referred by Figure 3.2, the spread had been larger than zero during the sample period, which means within the period, the long-term required rate of return had been always larger than the short-term one. Thus the required rate of return had been increased within the sample period in practice. According to the pattern shown in Figure 3.2, the expected growth of the required rate of return (G) has been always positive. If the yield curve turns reverse, or the required return rate is decreasing, there will not be any effects on the Term Structure Expected Growth Model. The Model would still be capable to illustrate the relationship between the expected income growth and asset's price.

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[11] The assumption of linearity changes of interest rate is one of the limitations of the thesis. We also hope to capture the dynamic growth of the interest rate over time. However we could not make it possible now. The assumption is closed to the reality according to the pattern of the government exchange fund note's yields. As the market only provides some terms, the best assumption is a linear interpolation, we cannot see any rationale to identify the non-linearity between the terms.

[12] Thanks for the examiner's comment, it should be pointed out that the g is rather time varying monthly than constant over time. The assumption here is that the g is a constant at any one particular time t.

The equation (3.19) includes both the expected income growth and the required return of the asset. Based on this new model, with the known data series of asset's price, cash-flow, cost of capital and its growth, the expected growth of asset's cash-flow can be calculated in a time-series format.

The selection of required return rate is fundamental to this model. In most valuation model, it would be the discount rate. Though the discount rate of each country can be gained from the public statistics information from the government, it is not applicable for the valuations of all assets, especially those long-lived ones. Actually, in Wong et al. (2008)'s study, the discount rate for long-live asset is derived by examining the mix of lease tenure of land property and their transactions. Wong et al. (2008)'s approach also implies that there is a spread of land property, which reflects the investors' expectations, existing in rents differences of the varied lease tenures. However because of the limitation of the data availability, the method is not applicable in this thesis.

In this way, the required return rate, also the discount rate (***i***) in the model would be proxied by the sum of the risk-free rate in the market, which is usually the US treasury security market[13], and the risk premium[14] of certain asset. Though the variable *G* (the growth of the required return rate) is not directly collectable from the market, it can be calculated from the available Treasury security market data. To be more specific, from the market, we can get the spread of the Treasury bill yield between t-year and 1-year, *S*. With the assumption of constant growth of the rate, the spread and the growth are defined as follows:

$$\boldsymbol{G = \frac{S}{t-1} = \frac{i_t - i}{t-1}} \qquad (3.20)$$

Put the G in formula (3.20) into the formula (3.19), we can get:

$$P = \frac{D}{(1+i)} + \frac{D\times(1+g)}{(1+i+\frac{i_t-i}{t-1})^2} + \frac{D\times(1+g)^2}{(1+i+2\times\frac{i_t-i}{t-1})^3} + \cdots + \frac{D\times(1+g)^{t-1}}{(1+i+(t-1)\times\frac{i_t-i}{t-1})^t} \qquad (3.21)$$

Where *P*, *D* and *g* refer to the price, cash-flow and expected cash-flow growth of the asset while *i* and i_t represent cost of capital with t *1-year* and *t-year* holding period respectively. Comparing with equation (3.4), the term structure $(i_t - i)$ is now incorporated in the Model.

[13] Risk-free assets usually refer to short-dated government bonds. For USD investments, usually US Treasury bills are used; while a common choice for EUR investments are German government bills or Euribor rates. In Hong Kong, the exchange fund notes are chosen as the risk-free assets. Different assets may have different required rate of return. In this study, the required rate of return for real estate asset is proxied by the yield rate of exchange fund notes in Hong Kong.

[14] thanks for the comments from the examiners, the risk premium of certain asset will be considered in this term structure model as a part of the required rate of return, together with the risk free rate in version B of Term Structure Expected Growth Model.

3.2.2 Derived Expected Rental Income Growth of Real Estate Asset in Hong Kong

The empirical investigations of the hypotheses in this study will be conducted in Hong Kong. Thus here in this section, we calculate the expected rental income growth of the real estate assets in Hong Kong. The observable facts will illustrate our argument clearly.

All real estate sectors, including office, retail, industrial and residential (all class), are studied in this paper. And the investors' expectation on each real estate sector had been captured under the Term Structure Expected Growth Model. Therefore the expected rent growth of property in Hong Kong can be captured in the model as follows:

$$P = \frac{D}{(1+i)} + \frac{D \times (1+g)}{(1+i+\frac{i_t - i}{t-1})^2} + \frac{D \times (1+g)^2}{(1+i+2\times\frac{i_t - i}{t-1})^3} + \cdots + \frac{D \times (1+g)^{t-1}}{(1+i+(t-1)\times\frac{i_t - i}{t-1})^t} \qquad (3.22)$$

In this model, the required return rate i and i_t are fundamentals need to access from Hong Kong market. There are two major difficulties in the empirical investigations:

One is the proxy of the long-term bond yield. The available maximum term of maturity market rate is only up to the yield rate of 10-year exchange fund notes[15] while usually the income depreciation period of a property would be 50 years[16]. To deal with this problem, we extrapolate the yield rate to 50-year based on constant growth in this study.

The other is the proxy of the risk premium of the private real estate asset. Looking backward to the previous studies about the real estate risk factor, there has not been a convincing conclusion yet. The methods are various (i.e. the consumption-based CAPM), but the empirical results were quite far from the reality. In this study, we employed the standard deviation of historical averages to proxy the risk premium of private real estate in Hong Kong, if necessary. However we have to admit that this proxy of real estate risk premium would be one of the limitations of this study.

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15 The bond yield is essentially the percentage of return that an investor can anticipate to receive from a bond issue within a specified period of time. Normally the bond issuer will identify the rate, payment, and period when they are issuing a bond security. Here in this study, we take the exchange fund bills & notes issued by HKMA for example. *"Interest Rate: each issue of Notes and Bills will bear a fixed interest rate announced in advance of each tender. Interest Payment: Interest will be paid semi-annually in arrears according to the actual number of days in an interest period and on the basis of a 365-day year. Interest Period: The first interest period shall be the period from and including the issue date to but excluding the first interest payment date." (Source*: http://www.hkma.gov.hk/eng/key-functions/international-financial-centre/debt-market-development/exchange-fund-bills-notes.shtml)
Thereafter interest periods will run from and including each interest payment date to but excluding the next interest payment date. It is same as the bond yield in Term Structure of Interest Rate. We follow the previous studies' practice to take the long-term bond yield proxy.

16 Refer to the European standard for concrete structure that the design life span is 50 years. The European standard for structural safety EN 1990 prescribes 50 years for buildings and 100 years for Monumental building structures, bridges and other civil engineering structures.

Therefore the model for capturing the expected rent growth of property can be interpreted as equation (3.23) without risk premium and as equation (3.24) with risk premium as follows:

$$P=\frac{D}{(1+i)}+\frac{D\times(1+g)}{(1+i+\frac{i_{50}-i}{49})^2}+\frac{D\times(1+g)^2}{(1+i+2\times\frac{i_{50}-i}{49})^3}+\cdots+\frac{D\times(1+g)^{49}}{(1+i+49\times\frac{i_{50}-i}{49})^{50}} \qquad (3.23)$$

and

$$P=\frac{D}{(1+i+rp)}+\frac{D\times(1+g)}{(1+i+rp+\frac{i_{50}-i}{49})^2}+\frac{D\times(1+g)^2}{(1+i+rp+2\times\frac{i_{50}-i}{49})^3}+\cdots+\frac{D\times(1+g)^{49}}{(1+i+rp+49\times\frac{i_{50}-i}{49})^{50}} \qquad (3.24)$$

By moving D to the left hand of the equation and following the assumption of the extrapolation, the model would be:

$$\begin{aligned}\frac{1}{Y}&=\frac{P}{D}\\&=\frac{1}{(1+i)}+\frac{1+g}{(1+i+\frac{i_{50}-i}{49})^2}+\frac{(1+g)^2}{(1+i+2\times\frac{i_{50}-i}{49})^3}+\cdots+\frac{(1+g)^{49}}{(1+i+49\times\frac{i_{50}-i}{49})^{50}}\end{aligned} \qquad (3.25)$$

and

$$\begin{aligned}\frac{1}{Y}&=\frac{P}{D}\\&=\frac{1}{(1+i+rp)}+\frac{1+g}{(1+i+rp+\frac{i_{50}-i}{49})^2}+\frac{(1+g)^2}{(1+i+rp+2\times\frac{i_{50}-i}{49})^3}+\cdots+\frac{(1+g)^{49}}{(1+i+rp+49\times\frac{i_{50}-i}{49})^{50}}\end{aligned} \qquad (3.26)$$

where Y[17] and g refer to the return rate and expected rent growth of the property respectively while, rp refers to the risk premium of private real estate asset in Hong Kong, i and i_{50} represent the yield of *1-year* and *50-year* exchange fund notes issued by the Hong Kong SAR government.

[17] The return rate from RVD is the occupied property's return rate. Thus in derivation, the vacancy rate is assumed to be constant.

3.3 *EMPIRICAL SPECIFICATIONS*

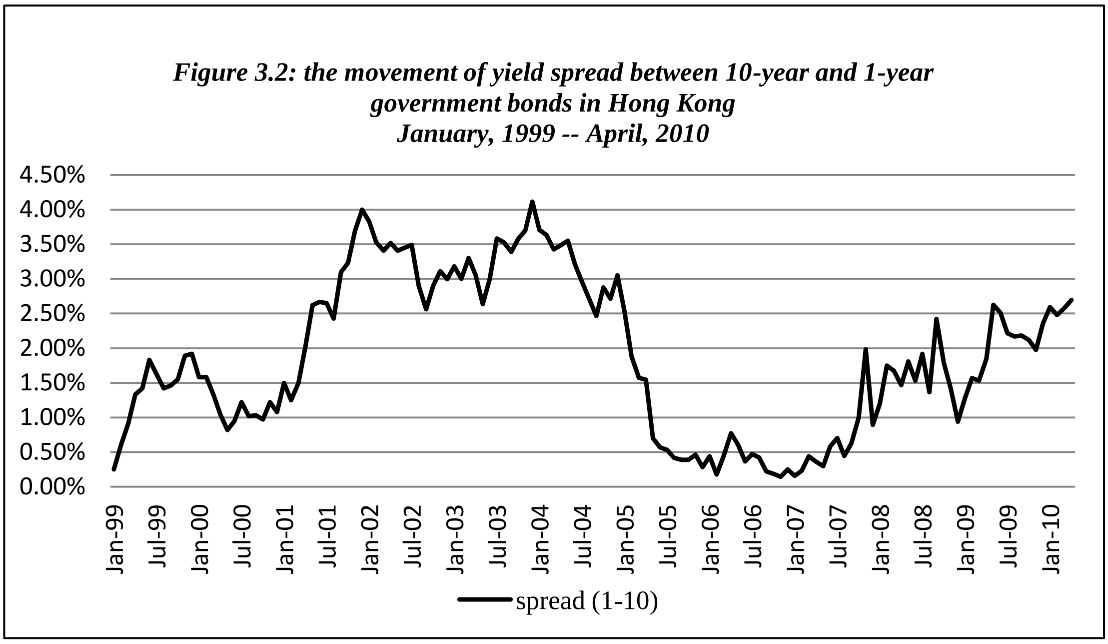
Under the model expressed in equation A (3.25) and B (3.26) with the available data on Hong Kong real estate and capital markets, we can get the investor's expected rent growth of real estate asset in each property sector.

The data used in this section is focused on the Hong Kong real estate market during the period of January 1999 to April 2010. The measures of real estate asset price is the monthly property price and rent indices released by the Rating and Valuation Department, Hong Kong S.A.R. Government (RVD, 2010). The estimations of expected rent growth are based on two models, Term Structure Expected Growth Model and Gordon Growth Model respectively. For the estimation based on the former model, the P/D ratio is the reciprocal of the monthly yield rate of property accessed from the Rating and Valuation Department, Hong Kong S.A.R. Government (RVD, 2010), the spread[18] is defined as the difference between the yields of 1-year and 10-year exchange fund notes issued by the Government of Hong Kong SAR, the discount rate is proxied by the yield of 1-year exchange fund note obtained from the Hong Kong Monetary Authority (HKMA, 2010)[19]. For the estimation based on the latter, the D/P ratio with the monthly yield rate of property obtained from the Rating and Valuation Department, Hong Kong S.A.R. Government (RVD, 2010) is adopted in this section. The data sample covers the period from January 1999 to April 2010.

The term structure of Exchange Fund Notes has been shown in Figure 3.1. Here Figure 3.2 tells the spread movements of the Exchange Fund Notes, based on which the growth of cost of capital is calculated, in Hong Kong.

[18] Thanks for the examiner's comments, the details of this assumption are explained as follows. Observe that the spread between N-year and 1-year bond yield ($i_t^N - i_t^1$) is proportional to the difference between the forward rate calculated from the 10-year and 1-year bond yields, *ft*, and i_t^1. The forward rate is defined as in Shiller et al. (1983): $f_t \equiv (D_N i_t^N - D_1 i_t^1)/(D_N - D_1)$, where D_N is the duration of the long-term bond and D_s is the duration of the 1-year bond. The difference $f_t - i_t^1$ is the correct measure of the slope of the yield curve, but it is proportional to $i_t^N - i_t^1 : f_t - i_t^1 = [D_N/(D_N - D_1)](i_t^N - i_t^1)$.

[19] As neither TED nor LIBOR-OIS spread is applicable in Hong Kong, we employed the spread between long- and short-term government bond yields to illustrate the risk which the investors would like to take on capital market.

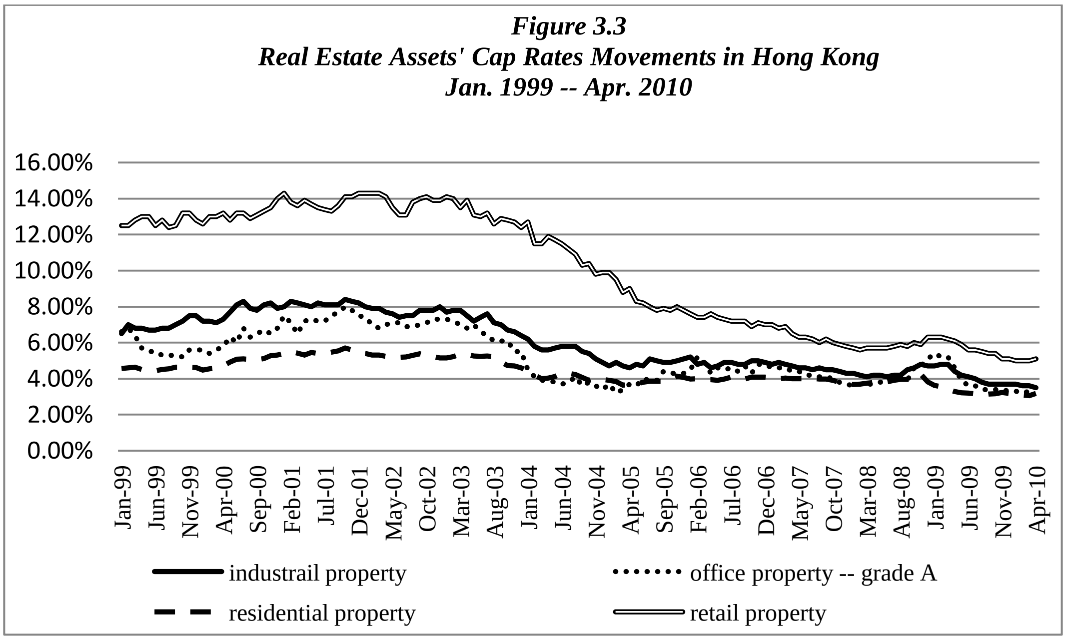


Remarks:

The yield spread of exchange fund notes = 10-year exchange fund note yield – 1-year exchange fund note yield, at http://www.info.gov.hk/hkma/chi/statistics/index_efdhk.htm

Source: Hong Kong Monetary Authority

Figure 3.3 shows the D/P ratio (capitalization rate) with the monthly yield rate of property obtained from the Rating and Valuation Department, Hong Kong S.A.R. Government (RVD, 2010).



Remarks:

The yield of property is from the Rating and Valuation Department, Hong Kong SAR at:

http://www.rvd.gov.hk/sc/publications/pro-review.htm

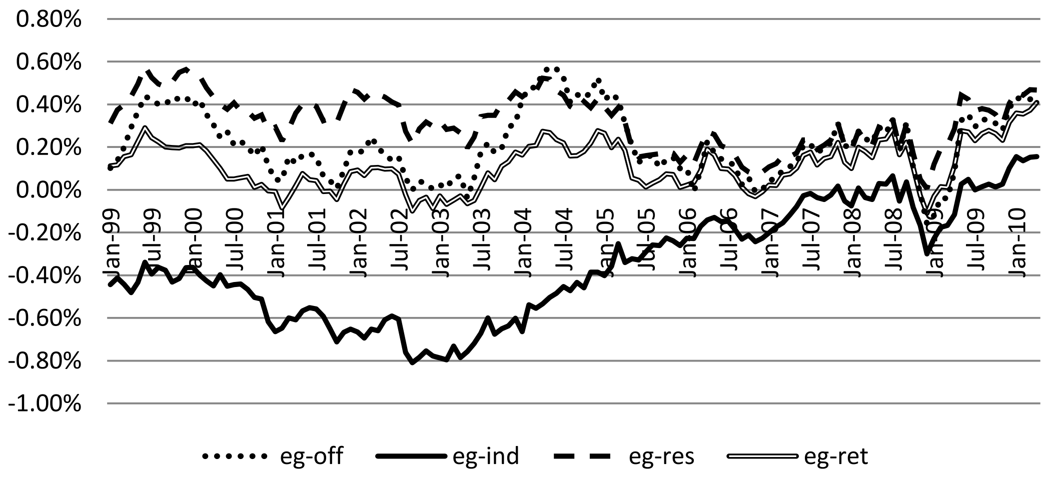
Sources: Rating and Valuation Department, Hong Kong SAR & Hong Kong Monetary Authority

3.3.1 Empirical Specifications with model A (without risk premium in required return rate)

Based on equation (3.25), we can get the expected rental income growth of private real estate assets in Hong Kong, assuming that the investors have no risk premium on them.

Figure 3.4 shows the movements of the expected rental income growth of real estate assets in Hong Kong.

Figure 3.4 the Movements of Expected Rental Income Growth of Real Estate Asset in Hong Kong (without risk premium) January 1999 -- April 2010 Note: eg refers to the expected rental growth of the real estate asset



Remarks:

The spread is from the yield of 1-year exchange fund bill and 10-year exchange fund notes issued by Hong Kong SAR government, at: http://www.rvd.gov.hk/en/publications/pro-review.htm

The yield of property is from the Rating and Valuation Department, Hong Kong SAR at:

http://www.info.gov.hk/hkma/chi/statistics/index_efdhk.htm

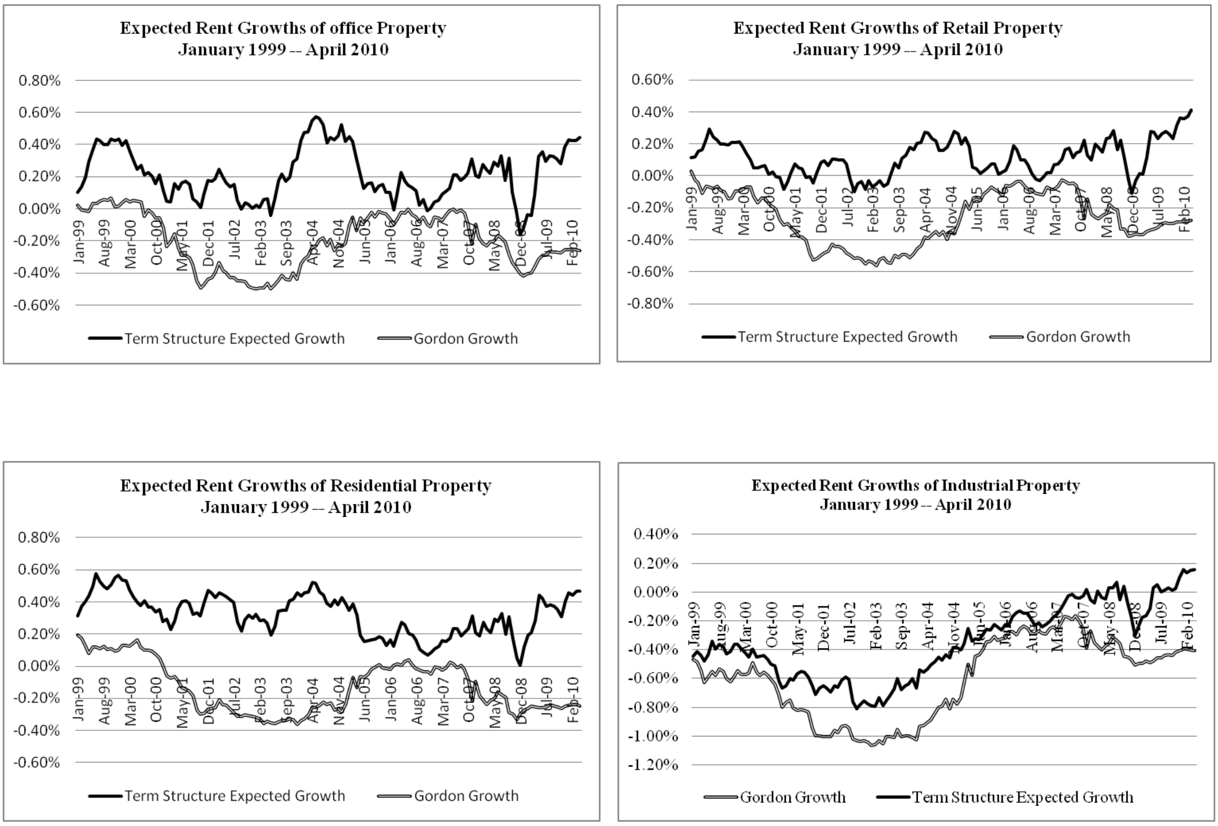
Sources: Rating and Valuation Department, Hong Kong SAR & Hong Kong Monetary Authority

In Figure 3.4, we exhibit the monthly expected rental income growth of the private real estate asset in Hong Kong in content of four sectors. For most of the time during the investigation period, the expected rental income growth of industrial property is negative. That's a special case for Hong Kong. The industrial property in Hong Kong had been developed since 1954 as the exchanging properties for the family factories, which were located in the places where the Hong Kong government required for the re-developments. However some industrial properties had been redeveloped and converted to other usage since 1990s. Thus the purchasers may not expect for the rental incomes but for the capital return after the redevelopments and conversions of the properties. In this way, they would not expect the rental income could grow in the future and the expected rental income growth of industrial property had been exhibited negative during almost 10 years.

Besides, the derived expected rental income growth series in this section is a novel try, which can be regarded as an improved version of the Gordon Growth Model. Thus we would also like to show the comparison of the expected rent growths calculated based on each of the two models. There is one thing need attention that the expected rent growth captured by the new model is the monthly growth rate while the growth based on Gordon Growth Model is annual rate. Thus in this section the Gordon Growth series are transferred into monthly rate series to be compared with the term structure expected rent growth on an equal frequency basis.

Figure 3.5 exhibits the patterns of expected rent growths series derived with Term Structure Expected Growth Model and Gordon Growth Model respectively.

Figure 3.5 the Comparison of Expected Rent Growths Derived from Two Models
Four Real Estate Asset Sectors in Hong Kong
(without risk premium)
January 1999 to April 2010



As suggested by Figure 3.5, the two series of expected rental income growths share similar pattern over the time of more than 10 years, except the residential sector. That can be explained by the investing feature of residential property. The purchasers buy the residential property maybe for their own-usage, so that the future rental income would not affect their decision on the asset's price. Neither Gordon Growth Model nor Term Structure Expected Growth Model can illustrate the relationship between the price and future rent expectation of residential property.

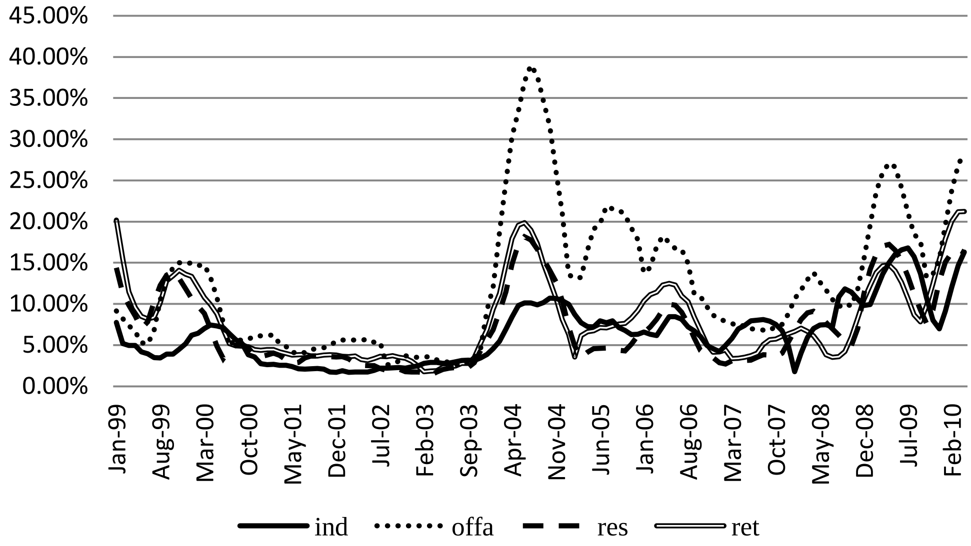
We can also find that the growths derived from Gordon Growth Model are mostly lower than the ones derived from Term Structure Expected Growth Model, which indicates the importance of considering the dynamic discount factor (term structure) in the model. On the basis of Gordon Growth Model, the market expectation on future rental income is under-estimated; which means the appraising price of real estate asset based on Gordon Growth Model is over-estimated. By considering the term structure in the model, the difference between the new expected rental income growth and Gordon's growth differs among different sectors. This indicates the sensitivity of real estate asset's price on the term structure varies among different sectors.

3.3.2 Empirical Specifications with model B (with risk premium in required return rate)

Similar with last section, here we would like to present the expected rental income growth based on equation (3.26), by assuming that the investors would regard the historic average volatility as the risk premium of their real estate investments.

First, Figure 3.6 presents the risk premiums of real estate asset in Hong Kong.

Figure 3.6 risk premium of private real estate assets
Four Real Estate Asset Sectors in Hong Kong
January 1999 to April 2010



Remarks:

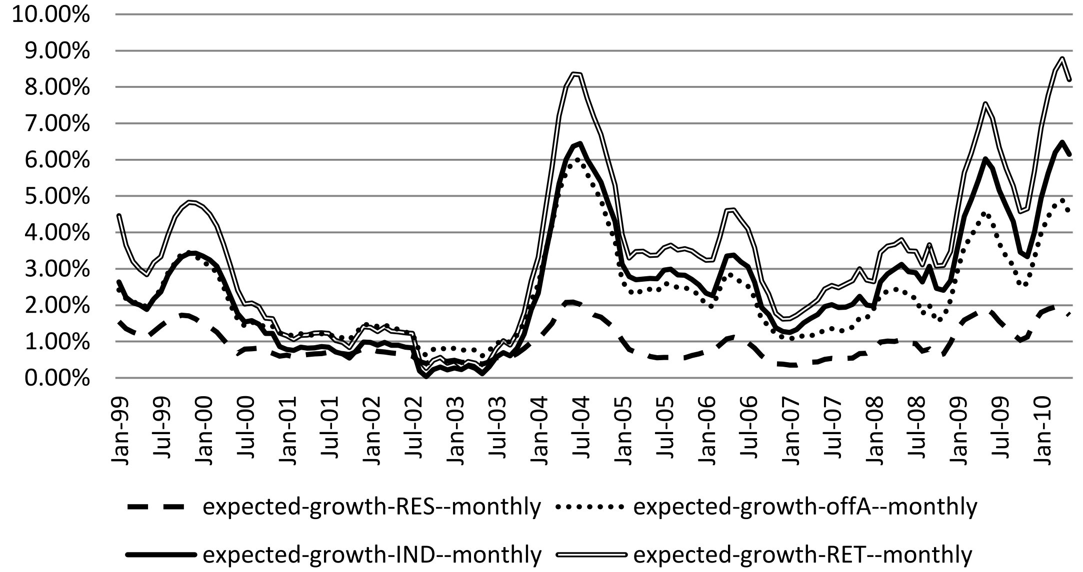
The risk premium of property is calculated by the standard deviation of the historic average property price index for each sector. The property price index is gained from the Rating and Valuation Department, Hong Kong SAR at:

http://www.info.gov.hk/hkma/chi/statistics/index_efdhk.htm

Sources: Rating and Valuation Department, Hong Kong SAR

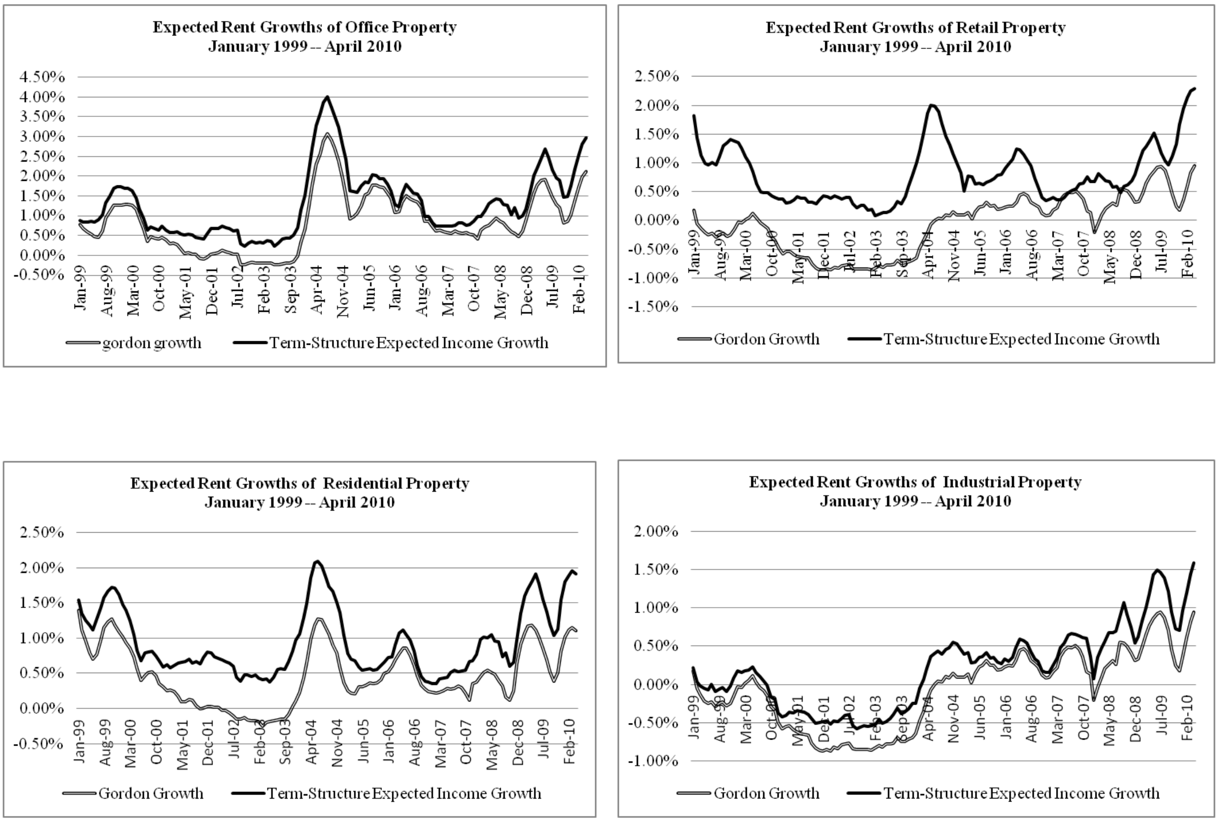
Then we can have Figure 3.7 shows the movements of the expected rental income growth of real estate assets in Hong Kong; while Figure 3.8 exhibits the patterns of expected rent growths series derived with Term Structure Expected Growth Model and Gordon Growth Model[20] respectively.

Figure 3.7 the Movements of Expected Rental Income Growth of Real Estate Asset in Hong Kong (with risk premium) January 1999 -- April 2010



[20] Here in this section, the discount rate in Gordon Growth Model will also be the sum of risk-free rate and the risk premium we calculated based on historical data.

Figure 3.8 the Comparison of Expected Rent Growths Derived from Two Models
Four Real Estate Asset Sectors in Hong Kong
(with risk premium)
January 1999 to April 2010



Besides the grounded visual comparisons between the Term Structure expected rental income growth and other series are presented in this section, we also find that the Term Structure Expected Growth has better correlation with the price growth, comparing to the Gordon Growth in each property sector. Table 3.1a shows the correlation summary of price growth versus Term Structure Expected Growth (A) and Gordon Growth (A); while Table 3.1b shows the correlation summary of price growth versus Term Structure Expected Growth (B) and Gordon Growth (B).

Table 3.1a Correlation Analysis of Price Growth versus Term Structure Growth (A) and Gordon Growth (A)

Property Sector	Correlation	price change	Term Structure Growth	Gordon Growth
Retail Property	price change	1		
	Term Structure Growth	0.4097	1	
	Gordon Growth	0.3789	0.0675	1
Residential Property	price change	1		
	Term Structure Growth	0.3152	1	
	Gordon Growth	0.2265	-0.1089	1
Grade-A Office Property	price change	1		
	Term Structure Growth	0.6307	1	
	Gordon Growth	0.5533	0.3458	1
Industrial Property	price change	1		
	Term Structure Growth	0.4253	1	
	Gordon Growth	0.3437	0.4651	1

Table 3.1b Correlation Analysis of Price Growth versus Term Structure Growth (B) and Gordon Growth (B)

Property Sector	Correlation	price change	Term Structure Growth	Gordon Growth
Retail Property	price change	1		
	Term Structure Growth	0.2426	1	
	Gordon Growth	0.0849	0.9214	1
Residential Property	price change	1		
	Term Structure Growth	0.2648	1	
	Gordon Growth	0.1756	0.8833	1
Grade-A Office Property	price change	1		
	Term Structure Growth	0.3675	1	
	Gordon Growth	0.2909	0.9644	1
Industrial Property	price change	1		
	Term Structure Growth	0.4404	1	
	Gordon Growth	0.3780	0.9624	1

According to Table 3.1 a & b, we found that the correlation coefficient between price change and Term Structure Growth is always larger then it between price change and Gordon Growth, which may suggest a general improvement in correlation between price growth and expected rent growth by incorporating the term structure in rental expectation model. Motivated by this fact, we further test the relationship between price growth and the changes of expected rent growths respectively based on Term Structure Expected Growth model and Gordon Growth Model in Chapter 5 and 6 through the investigation of Hypothesis 2[21]. The comparison of the empirical results comes to the consistent conclusion of the improvement. This hypothesis is derived from equation (3.21) by taking first difference of natural logarithm of both sides of the equation, then we can get:

$$d\log(P) = f(d\log(D), d\log(1+g), d\log(i), d\log(i_t - i)) \quad (3.27)^{22}$$

From equation (3.27), we can find that the capital return of property (dlog(P)) should have correlation with the rent growth (dlog(D)), the change of discount rate(dlog(i)) and spread change (dlog(i_t-i)). More importantly, it tells that the capital return of property (dlog(P)) should relate to the change of expected rental income growth plus 1 (dlog(1+g)). In practice, we investigate the relationship between price change and movement of the expected rental income growth instead for the ease of interpretation.

In this chapter, a detailed review of the present value model and the expectation on the future cash-flow is provided. The novel model to improve the previous models has been constructed, and a preliminary observation on the expected rental income growth of real estate asset in Hong Kong is presented. The rigorous empirical investigations will be carried out in the next two chapters to illustrate the implications and contributions of the model. The review shows the development of the present value relationship dated from 1930s, and also points the problem of capturing the investor's expectation under those models. The novel try of this study derives the Asset's Term Structure Expected Growth Model to capture the investor's expectation on the asset's future income. The empirical observation that focuses on the real estate market in Hong Kong and illustrates the relationship between the expected rental income growth derived by the Term Structure Expected Growth Model and the actual rent growth of the real estate asset will be presented in Chapter 7. Apparently further investigations on the relationship between expected rental income growth and the return of real estate asset on either public or private market is warranted by this chapter. Chapter 5 and 6 will present the answers to our research questions in this study by testing the three hypotheses we stated in Chapter 1.

[21] Thanks for the examiner's comment on the problem of circularity, the hypothesis 2 would rather be an application of the Term Structure Expected Growth Model on private real estate market. It compares the functions of the two models (Term Structure Expected Growth Model and Gordon Growth Model) in practice.

[22] we derive the hypothesis 2 here based on equation (3.21)

CHAPTER 4 MARKET BACKGROUND

This chapter provides a brief overview of the real estate investment market in Hong Kong by distinguishing between private and public real estate from a transaction platform and identifying the price discovery process and the linkage between them.

The real estate market in Hong Kong plays a vital role in the political, social and economic life of this vibrant area. The investment in real estate market can be broadly divided into two types: (1) private real estate investment, which involves the direct ownership of physical real estate assets. The investors can engage into the private real estate investment by purchasing or leasing. In Hong Kong, there are four major private real estate sectors (residential, office, retail and industrial). (2) public real estate investment, for which the investors own the physical real estate assets indirectly through an independent legal entity. Usually, the listed real estate development companies and real estate investment trusts (REITs) are the common forms of these legal entities. However as the return performance of listed real estate development company is less comparable to ***real estate*** than REITs, in this study, the public real estate investment market is specifically to be the REITs market.

There are two main benefits to invest in public real estate market: divisibility and liquidity. If you invest in private real estate market by purchasing a property, the transaction amount is usually very large. But if you invest in public real estate market, the ownership of the property is easy to be split up without physically alienating the assets. To share the transaction amount helps the investor to lower the initial capital requirement for the investment. Moreover, the investor can enjoy more liquidity by investing in public real estate market. As the public real estate assets are listed stock exchange, which is centralized market for the trading of shares, both buyer and seller can have the price information and can reduce the search and negotiation costs significantly. Also the trading cost of private real estate asset investment is comparably high than the public one. Table 4.1 summarized the major trading costs of private and public real estate investment in Hong Kong. Each figure is expressed as the percentage of trading value, which evidenced that the trading cost of private real estate investment is higher than public investment.

Table 4.1: Trading Costs of Private and Public Real Estate Investments

	Private Real Estate Investment % of trading value[23]	**Public Real Estate Investment** % of trading value
Brokerage commission[24]	1	0.25
Stamp duty[25]	1.5 – 3.75	0.1
Legal cost[26]	0.45 – 1.175	n.a.
Land registration fee[27]	0.007 – 0.066	n.a.
Transaction Levy	n.a.	0.007
Trading fee	n.a.	0.005
Total	3.001 – 5.304	0.362

The REITs market in Hong Kong has started to flourish in recent years. The code on REITs was firstly issued in July 2003 in Hong Kong. Then by the end of 2005, the first HK-REITs – LINK REIT was launched in Hong Kong. As regulated by Hong Kong Securities and Futures Commission (SFC), the income tax rate of REITs company is 17.5%; the trust itself is taxable while the unit holders are tax exempted.

As regulated in most countries, the 90% of the yield from the portfolio of REIT should be distributed as dividends to the shareholders of that REIT. In addition, the portfolio of REIT could only be real estate assets so that the shareholders of REIT need not to share the risk of other type of investments made by that REIT's manager. These are the two major differences between REIT and real estate listed company besides the tax benefits. According to the previous research, i.e. Ang and Bekaert (2007), Fama (1990a), Kothari and Shanken (1992), Schwert (1990), Shilling and Sing (2007), Sing et al. (2007), the expected dividend growth would explain the return of certain stock well. Therefore,

[23] It is assumed that the trading value ranges from HK$1,080,000 to HK$20,000,000.

[24] It is usually 1% of the property value for the commission of property agent. And the Hong Kong Exchanges and Clearing Limited set the minimum at 0.25% before 1st April 2003, but the minimum commission rule was abolished thereafter.

[25] for the stamp duty of private real estate transaction, please see the homepage of the Inland Revenue Department <http://www.info.gov.hk/ird> for the latest tax rates; for the stamp duty of public real estate transaction, there are other miscellaneous costs such as the transfer deed stamp duty, transfer fee and trading tariff, but their amounts are negligible. Further cost information can be obtained from the homepage of the Hong Kong Exchanges and Clearing Limited <http://www.hkex.com.hk>.

[26] The legal cost charged by solicitors is governed by the Solicitors (General) Costs Rules of the Hong Kong Solicitors' Guide to Professional Conduct issued by the Law Society of Hong Kong.

[27] See the homepage of the Land Registry <http://www.info.gov.hk/landreg> for the latest fee schedules.

we'd like to presume that the return of REIT would also be explained by its expected dividend growth. Because of the two regulations of REITs mentioned above, the expected dividend growth of REIT should rely on the expected rental income growth of corresponding real estate assets in its portfolio. Based on this logic, we can come to the hypothesis that the expected rental income growth of corresponding real estate assets of REIT could explain its return. In other word, our proposition is that the higher the expected rent income growth of certain real estate market is, the higher the return of corresponding REIT would be.

The measures of private real estate asset price and rent are the monthly property price and rent indices released by the Rating and Valuation Department, Hong Kong S.A.R. Government (RVD, 2010). Figure 4.1 and 4.2 show the indices of the private real estate assets' prices and rents in Hong Kong during from January 1999 to April 2010 respectively. We can find significant drops in both price and rent during the periods of economy recessions. Within the investigation period of this study, there are several financial changes (i.e. the global financial crises in 2008), which had influenced the real estate market. The figures can tell us how the investor's expectation worked.

Figure 4.1
Private Real Estate Assets' Prices Indices Movements in Hong Kong
Jan. 1999 -- Apr. 2010

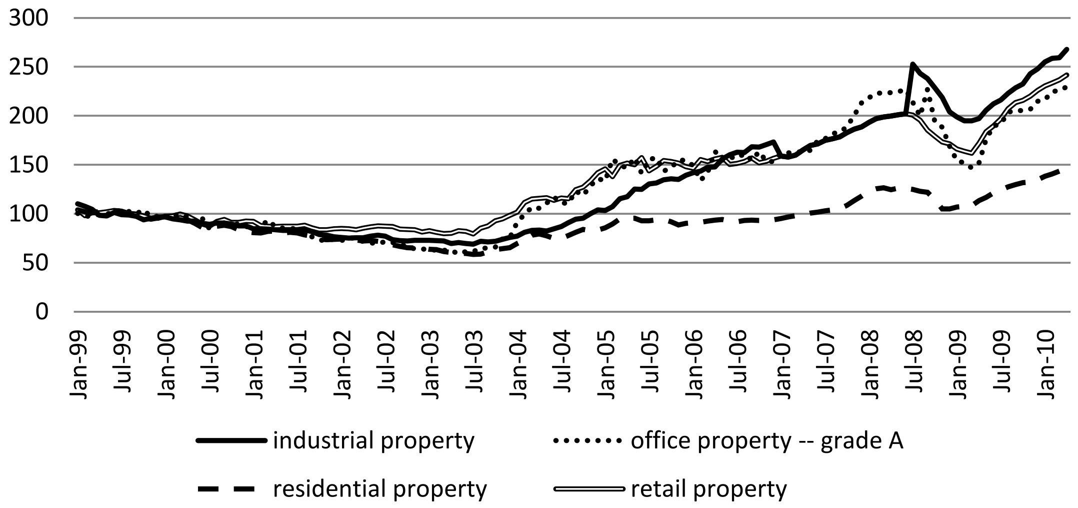
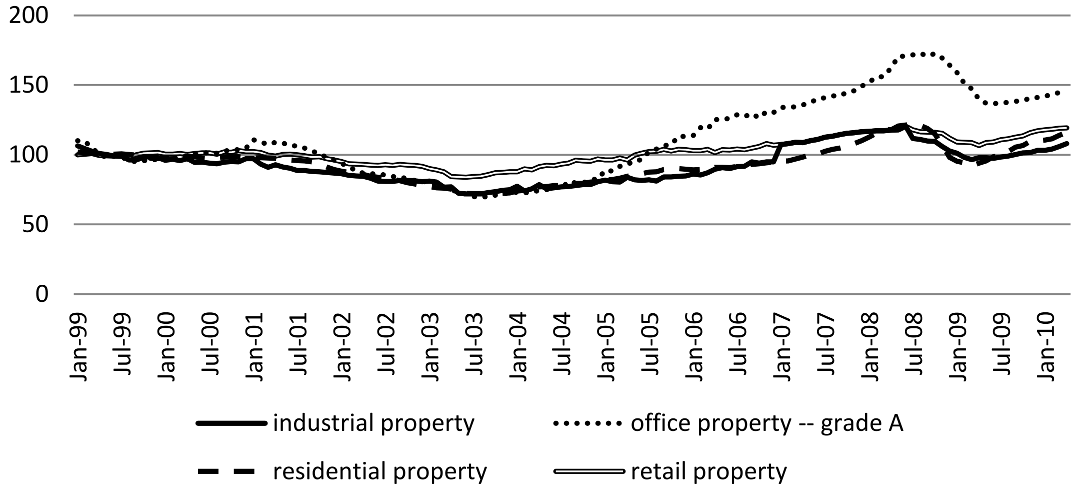
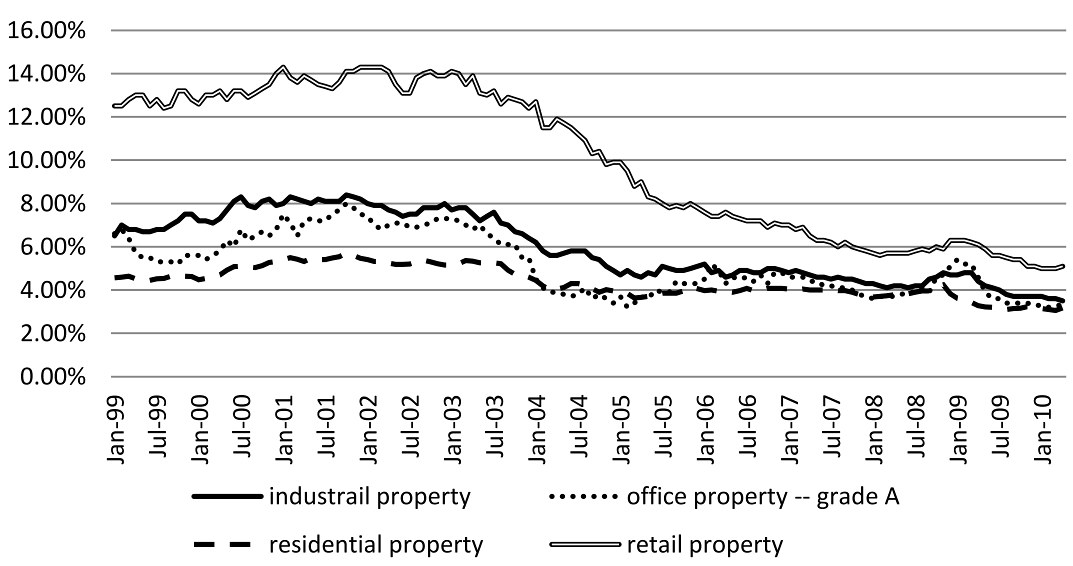


Figure 4.2
Private Real Estate Assets' Rents Indices Movements in Hong Kong
Jan. 1999 -- Apr. 2010



The capitalization rate is a good jumping-off point to quickly compare many investment opportunities, but it should not be the sole factor in any real estate investment decision. Many more factors need to be looked at such as the growth or decline of the potential income, the increase in value of the property, and any alternative investments available. As the capitalization rate is also an important indicator of the market condition, we observe its movements and present them in Figure 4.3 as well. It shows that all four sectors of the real estate market in Hong Kong were in downturn during the global financial crises in 2008. However, comparing to the price or rent, the cap rate went down earlier. The involvement of capital cost and investor's expectation can explain this through the Term Structure Expected Growth Model, which is derived in Chapter 3.

Figure 4.3
Private Real Estate Assets' Cap Rates Movements in Hong Kong
Jan. 1999 -- Apr. 2010



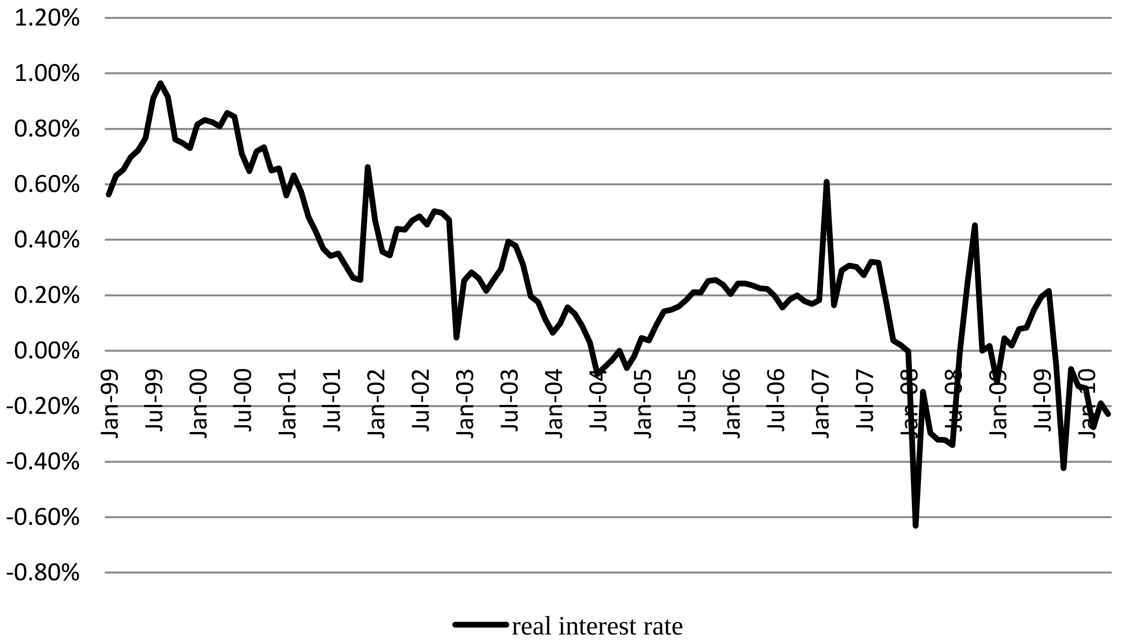
Meanwhile, also the economic situation should be considered when the real estate market is talking about. The real interest rate is the growth rate of purchasing power derived from an investment. By adjusting the nominal interest rate to compensate for inflation, the purchasing power of a given level of capital is kept constant over time. The real interest rate of an investment is calculated as the amount by which the nominal interest rate is higher than the inflation rate, as follows:

$$RINT_t = hibor_t - INF_t \qquad (4.1)$$

where *RINT* refers to real interest rate, *hibor*[28] is the proxy of nominal interest rate and *INF* represents the inflation rate[29] at time *t*.

Here in this study, we used 3-month Hong Kong Inter-Bank Offered Rate as nominal interest rate. Then the real interest rate represents the growth rate of purchasing power derived from the cash. Figure 4.4 presents the monthly real interest rate in Hong Kong during the investigation period.

Figure 4.4
Real Interest Rate (rate per month) Movements in Hong Kong
Jan. 1999 -- Apr. 2010



Also the bond yield spread is another important indicator for the economy and the investor's expectation on future market condition. The difference between yields on differing bonds is the bond yield spread, which is calculated by deducting the yield of one bond from another. The higher

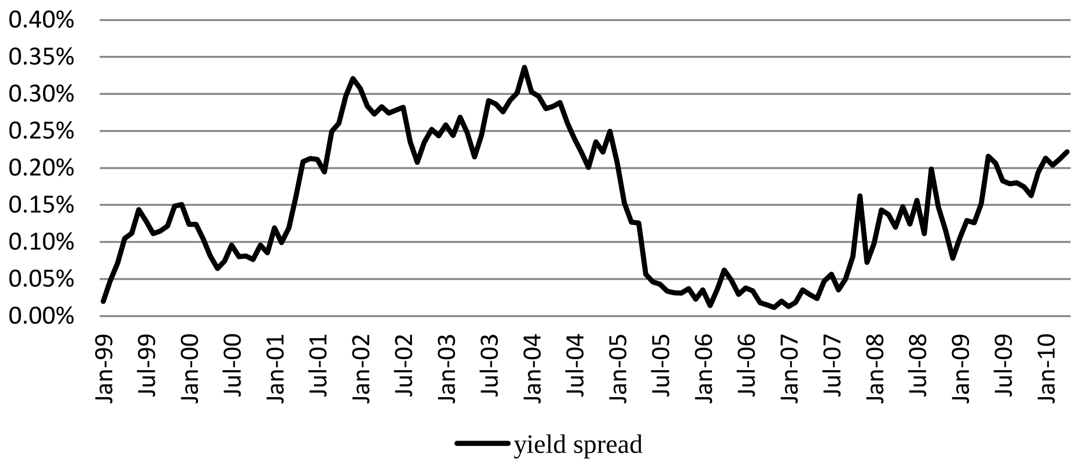
[28] Here in this study, we used the percent rate per month based on the percent rate per annum from HKMA (http://www.info.gov.hk/hkma/eng/statistics/msb/index.htm), the calculation is simple:

$$rate \text{ per month}_t = \frac{rate \text{ per annum}_t}{12}$$

[29] In economics, the inflation rate is a measure of inflation, the rate of increase of a consumer price index. The calculation is: $\text{inflation rate}_t = \frac{P_t - P_{t-1}}{P_{t-1}} \times 100\%$, $\boldsymbol{P_t}$ and $\boldsymbol{P_{t-1}}$ represents the current average price level and the price level one year ago respectively. In this study, we used *Consumer Price Index (CPI) – Series A for non-luxury commodities* Index from the Census and Statistics Department, HKSAR (http://www.censtatd.gov.hk/). We then transfer the inflation rate per annum into rate per month by dividing it with 12 in this study.

the yield spread, the greater the difference between the yields offered by each bond. Looking at the yield spread, often with historical spreads, can give investors ideas for potential investment opportunities. For example, if the five-year Treasury bond is at 6% and the 30-year Treasury bond is at 7%, the yield spread between the two debt instruments is 1% (=7% - 6%). If the yield spread has historically been closer to 6%, the investor is much more likely to invest in the five-year bond compared to the 30-year bond (as it should be trading around 1% instead of 7%). In other words, if the 30-year bond is trading at 7%, then based on the historical yield spread, the five-year should be trading at around 1%, making it very attractive at its current yield of 6%. Figure 4.5 shows the government bond yield spread on Hong Kong market during the investigation period.

Figure 4.5
Government Bonds' Yields Spread Movements in Hong Kong
Jan. 1999 -- Apr. 2010



Remarks:

The long-term and short-term government bond yield rates are proxied by the annual yield rates of 10-year Exchange Fund Notes and 364-day Exchange Fund Bills respectively. Both series are gained from the website of the Hong Kong Monetary Authority *http://www.info.gov.hk/hkma/* *. As the calculation for the expected rental income growth is on monthly basis, the yield spread is also calculated based on monthly yield rates of the two bonds.*

In this chapter, the real estate investment market in Hong Kong has been briefly overviewed in the content of private and public real estate market. This will be helpful to understand the investigations in the following chapters very much.

CHAPTER 5 DATA AND METHODOLOGY

5.1 DATA

This section will discuss the data that will be employed in this study. As the data employed in this study are all time-series data, we need to test whether they are stationary before using them. It is important to mention that the data since 1999 is used for the empirical tests on direct real estate market in Hong Kong. Though the property market data can be dated from 1987 while the HKMA data can be dated from 1999, still we prefer to start our sample period from 1999. Because Hong Kong SAR has been formally established since July 1997, there should be several uncertainties about the government on Hong Kong market. Therefore we start our sample period 18 months afterward to clear the uncertain political influences.

If a time-series of data's mean and auto-covariance do not depend on time, it is said to be stationary while when either of the two conditions is violated, the series is said to be non-stationary. For example, by assuming a time series follows a first order auto-regressive, AR(1), and processing

$$Y_t = \alpha Y_{t-1} + \beta X + \varepsilon_t \qquad (5.1)$$

Where Y_{t-1} refers to the lagged Y_t and α is autocorrelation coefficient. X is a set of other independent variables with β as a vector of corresponding coefficients. ε t is the residual, which means the error with identical independent normal distribution. If $|\alpha| < 1$, the process $Y_t - Y_{t-1}$ is covariance stationary; if $|\alpha| \geq 1$, the process is non-stationary. Especially, if $|\alpha| = 1$, the process is called a unit root process. In this way, the hypothesis of the existence of unit root can be formulated by examining whether $|\alpha| < 1$ or not.

As required by the Granger Causality test and regression test of time-series data, the time-series data need to be stationary. However many economic and finance series exhibit non-stationarity in the mean, i.e. property price and rent indices in this chapter. Thus prior to the analysis, it should determine the most appropriate (stationary) form of the trend in the data.

There are two common trend removal procedures: first differencing and time-trend regression. The Unit Root Test can help to determine if the non-stationary series should be first differenced or regressed on deterministic functions of time to make it stationary. Several alternative methods can be used to test unit root. In this study, the most popular one, Augmented Dickey and Fuller (1981) (ADF)Unit Root Test, is employed to find out whether the time-varied series is stationary or not. Unlike the AR(1) process discussed before, the ADF test extends the assumption to a more general one, say, AR(m) process of *Yt*. That is

$$Y_t = \sum_{i=1}^{m} \alpha_i Y_{t-1} + \beta X + \varepsilon_t \qquad (5.2)$$

Subtracting Y_{t-1} from both sides of equation (5.2), we can get

$$Y_t = \lambda Y_{t-1} + \sum_{i=1}^{m} \omega_i \Delta Y_{t-i} + \beta X + \varepsilon_t \tag{5.3}$$

Where $\lambda = \alpha - 1$. The null and alternative hypotheses of unit root are

H0: $\lambda = 0$ (5.4.1) and H1: $\lambda < 0$ (5.4.2)

The hypotheses are evaluated by t-statistics, which is

$$t(\lambda) = \frac{\hat{\lambda}}{se(\hat{\lambda})} \tag{5.5}$$

Where $\hat{\lambda}$ and $se(\hat{\lambda})$ are the estimation of λ and its standard error respectively. The statistic in equation (5.5) does not follow the distribution of student-t. In this study, we employ the critical values of MacKinnon (1996). The number of lags to be included is determined by AIC or SIC in practice. Eviews[@] can automatically help to choose the optimal lag number based on the criteria mentioned above.

Thus for each Model, we present both the descriptions and stationarity of the dataset.

Thanks for the examiners' comments on the risk premium of direct real estate asset, we employed the expected rental income growths (both with and without risk premium) in the investigations. Thus we would have two sub-models for each hypothesis testing: A and B. For example, for testing of hypothesis 1, we have Model I-A and Model I-B to exhibit the effects of expected rental income growth with and without risk premium being considered. Similarly, there will be Model II-A and Model II-B; Model III-A and Model III-B.

5.1.1 Data for Model I (Expected Growth's Leading Effects)

There are three Granger Causality tests in Model I:

1. lead-lag relationship between price and rent changes of real estate asset;
2. lead-lag relationship between price and the expected rental income growths based on Gordon Growth Model;
3. lead-lag relationship between price and the expected rental income growths based on Term Structure Expected Growth Model.

Model I-A and Model I-B will investigate Hypothesis 1 with different discount rate proxy in the Expected Growth Models. Table 5.1 (a &b) describe the data, Table 5.2 (a&b) summarize the data and Table 5.3(a&b) show the stationarity of the data used in Model I.

5.1.1.1 Model I-A

The investigation of Model I-A is made up of three Granger Causality Tests: one examines the lead-lag relationship between price and rent changes of real estate asset while the other two examine the lead-lag relationship between price and the expected rental income growths based on Gordon Growth Model and Term Structure Expected Growth Model respectively.

5.1.1.1.1 Data Descriptions of Model I-A

As mentioned in Chapter 1, there had been some inconsistent evidence with the relationship between the property price and rent concluded in the simple but naive implication of Fisher's model. Here in this study, we re-examine ***the lead-lag relationship between the property price and rent changes*** in Hong Kong so that the motivation of this study will be illustrated clear with empirical facts.

Also introduced in Chapter 1, we estimate the expected rental growth of real estate asset with market data by employing Gordon Growth Model, which is also developed on the basis of Fisher(1930a)'s work for the preliminary observation to answer the first question of this study. Then the lead-lag relationship between the estimated rent growth and the price growth of real estate asset would be examined. The test is simple and the empirical results are inspiring.

Gordon (1959) derived a discounted cash flow (DCF) model, nowadays commonly known as the Gordon Growth Model (GGM), which incorporates expected rental income growth in the DCF model by assuming a constant expected rental income growth rate.

Mathematically, with an initial rental income, D_0, and a constant expected rental growth rate, g, and a constant discount rate i, the standard version of the GGM is as follows:

$$P = \sum_{t=1}^{n} \frac{D_0 (1+g)^{t-1}}{(1+i)^t} \qquad (5.6)$$

Summing the geometric series, it yields:

$$P = \frac{D_1}{i - g} \qquad (5.7)$$

From Equation (5.7), the expected rental growth g can be expressed as:

$$g = i - \frac{D}{P} \qquad (5.8)$$

In this chapter, we proxy the discount rate i with 1-year exchange fund bill yield rate from HKMA (2010) and the D/P by the annual yield rate of property obtained from the Rating and Valuation Department, Hong Kong S.A.R. Government (RVD, 2010). The data sample covers the period from January 1999 to April 2010. With these data, we first estimate the expected rental income growths of all real estate sectors in Hong Kong based on Gordon Growth Model. Then ***the lead-lag relationships between prices and Gordon Growths*** are examined.

Furthermore, as we had already constructed a Term Structure Expected Growth Model to capture the investor's expected rental income growth of real estate assets in this study, we also examine ***the lead-lag relationships between prices and Term Structure Expected Growths.*** The measures of real estate asset price and rent are the monthly property price and rent indices released by the Rating and Valuation Department, Hong Kong S.A.R. Government (RVD, 2010). The discount rate is measured by the annual yield rate of 1-year Exchange Fund Bill from HKMA (2010), thus the spread is measured by the difference between the annual yield rates of 1-year Exchange Fund Bill and 10-year Exchange Fund Note from HKMA (2010). To estimate the expected real estate cash-flow (rent) growth, the d/p ratio[30] with the annual yield rate (cap rate) of real estate asset obtained from the Rating and Valuation Department, Hong Kong S.A.R. Government (RVD, 2010) is adopted in this chapter. The data sample covers the period from January 1999 to April 2010. With these data, we first estimate the expected rental income growths of all real estate sectors based on the Term Structure Expected Growth Model. Then the lead-lag relationships between prices and both rents and expected rent growths are examined. Table 5.5a describes the variables used in three tests of Model I-A and exhibits the detailed data specification.

[30] D/P ratio in this study refers to the rent to price ratio, which is needed in the calculation of the expected rental income growth of real estate asset.

Table 5.1a Descriptions of the Variables in Model I-A
(All Real Estate Sectors)

Categories	Unit of measure	Descriptions	Symbols
Price index	index	*price index accessed from Rating and Valuation Department (RVD), Hong Kong SAR, http://www.rvd.gov.hk*	*P*
Rent index	index	*rent index are accessed from Rating and Valuation Department (RVD), Hong Kong SAR, http://www.rvd.gov.hk*	*r*
office property price growth	percentage	the first differenced values of the natural log of office property price index	*Pg_off*
office property rent growth	percentage	the first differenced values of the natural log of office property rent index	*Rg_off*
retail property price growth	percentage	the first differenced values of the natural log of retail property price index	*Pg_ret*
retail property rent growth	percentage	the first differenced values of the natural log of retail property rent index	*Rg_ret*
industrial property price growth	percentage	the first differenced values of the natural log of industrial property price index	*Pg_ind*
industrial property rent growth	percentage	the first differenced values of the natural log of industrial property rent index	*Rg_ind*
housing price growth	percentage	the first differenced values of the natural log of housing price index	*Pg_res*
housing rent growth	percentage	the first differenced values of the natural log of housing rent index	*Rg_res*
Expected rental income growth based on Gordon Growth Model	percentage	*Calculated based on Gordon Growth Model*	*EGg*
change of expected office property rent growth	percentage	the first differenced values of the expected office property rent growth	*⊿EGg_off*
change of expected retail property rent growth	percentage	the first differenced values of the expected retail property rent growth	*⊿EGg_ret*
change of expected industrial property rent growth	percentage	the first differenced values of the expected industrial property rent growth	*⊿EGg_ind*
change of expected housing rent growth	percentage	the first differenced values of the expected housing rent growth	*⊿EGg_res*

Expected rental income growth based on Term Structure Expected Growth Model	percentage	*Calculated based on Term Structure Expected Growth Model*	*Erg*
change of expected office property rental income growth	percentage	the first differenced values of the expected office property rent growth	*△Erg_off*
change of expected retail property rental income growth	percentage	the first differenced values of the expected retail property rent growth	*△Erg_ret*
change of expected industrial property rental income growth	percentage	the first differenced values of the expected industrial property rent growth	*△Erg_ind*
change of expected housing rental income growth	percentage	the first differenced values of the expected housing rent growth	*△Erg_res*

Remarks:

the price (or rent) growths are calculated by first-differencing the natural log[31] of price (or rent) index from time t to time t+1, the price and rent indices are accessed from Rating and Valuation Department (RVD), Hong Kong SAR, http://www.rvd.gov.hk;

Due to the focus here is the movement of property price, rent and the investor's expectation, the data used in this section are all the growths of them. Thus the summary statistics of the whole dataset are shown in Table 5.2a in terms of their growths.

[31] First difference of LOG = percentage change: When used in conjunction with differencing, logging converts absolute differences into relative (i.e., percentage) differences. Thus, the series DIFF(LOG(Y)) represents the percentage change in Y from period to period. Strictly speaking, the percentage change in Y at period t is defined as (Y(t)-Y(t-1))/Y(t-1), which is only approximately equal to LOG(Y(t)) - LOG(Y(t-1)), but the approximation is almost exact if the percentage change is small. In Stat graphics terms, this means that DIFF(Y)/LAG(Y,1) is virtually identical to DIFF(LOG(Y)) or DLOG(Y).

Table 5.2a Summary Statistics for Model I-A

all Real Estate Sectors in Hong Kong

Sample Period: January 1999 – April 2010

	Pg_ind	***Pg_off***	***Pg_res***	***Pg_ret***
Mean	0.0066	0.0061	0.0025	0.0062
Median	0.0065	0.0036	0.0032	0.0081
Maximum	0.2252	0.1902	0.0648	0.0912
Minimum	-0.0873	-0.1567	-0.0858	-0.0897
Std. Dev.	0.0319	0.0551	0.0242	0.0298
Sum	0.8894	0.8273	0.3439	0.8433
Sum Sq. Dev.	0.1363	0.4072	0.0785	0.1186
Observations	135	135	135	135
	Rg_ind	***Rg_off***	***Rg_res***	***Rg_ret***
Mean	0.0001	0.0021	0.001	0.0013
Median	0.001	0.0012	0.002	0.0012
Maximum	0.1227	0.0784	0.0308	0.0357
Minimum	-0.0758	-0.053	-0.084	-0.0406
Std. Dev.	0.0208	0.023	0.016	0.0115
Sum	0.014	0.2815	0.1286	0.1775
Sum Sq. Dev.	0.0581	0.0711	0.0344	0.0178
Observations	135	135	135	135
	EGg_ind	***EGg_off***	***EGg_res***	***EGg_ret***
Mean	-0.0060	-0.0020	-0.0013	-0.0027
Median	-0.0055	-0.0021	-0.0018	-0.0028
Maximum	-0.0016	0.0007	0.0019	0.0003
Minimum	-0.0106	-0.0050	-0.0036	-0.0056
Std. Dev.	0.0027	0.0017	0.0016	0.0017
Sum	-0.8173	-0.2727	-0.1811	-0.3607
Sum Sq. Dev.	0.0010	0.0004	0.0003	0.0004
Observations	136	136	136	136
	Erg_ind	***Erg_off***	***Erg_res***	***Erg_ret***
Mean	-0.0035	0.0022	0.0032	0.0011
Median	-0.0038	0.002	0.0033	0.001
Maximum	0.0016	0.0057	0.0058	0.0041
Minimum	-0.0081	-0.0016	0.0001	-0.0011
Std. Dev.	0.0026	0.0016	0.0013	0.0011
Sum	-0.4765	0.294	0.4368	0.1553

Sum Sq. Dev.	0.0009	0.0003	0.0002	0.0002
Observations	136	136	136	136

The preliminary observations on the relationships among real estate asset's price, rent and expected rental income growth (based on Gordon Growth Model) have been illustrated and motivated us to explore further on the expected rental income growth of real estate asset. As stated in Chapter 1, the original motivation of this study lies in the inconsistent evidence found from the empirical observations in the lead-lag relationship of the price, rent and expected rent in real estate market. Therefore the Granger Causality Tests will be employed here again to find out whether the expected rental income growths captured by the new model would lead the price change of real estate assets as well. In the third test, we are planning to conduct the Granger Causality Test again to investigate the relationships among real estate asset's price, rent and expected rental income growth based on our new model. The empirical results will enunciate whether the investor's expectation has effects on the real estate's return.

5.1.1.1.2 Stationarity Test for Model I-A

As stated before, the Unit Root Test of the time-series of data is required before the Granger Causality Tests. The theory and process are reviewed detailed above, so here the results of the Stationarity Tests are shown in Table 5.3a.

As the data series for Granger Causality Test are requested to be stationary, we employ the ADF test. The results of the ADF tests for all data used in Model I-A are exhibited in Table 5.3a, which indicate that property price, rent and the expected rental income growth (through all 4 property sectors) are non-stationary in level terms while stationary at their first-differences. In this case, the first-differenced time series are exploited to carry out the Granger causality test in this section.

Table 5.3a: Augmented Dickey-Fuller unit root test for Model I-A

	Augmented Dickey-Fuller test statistic	
time series variables	**level**	**1st differences**
P_off	-0.89	-4.36^{*}
P_ret	-0.25	-9.67^{*}
P_ind	-0.23	-10.23^{*}

P_res	0.59	-5.96*
R_off	-1.25	-3.36*
R_ret	-0.30	-5.69*
R_ind	-0.83	-10.96*
R_res	-1.32	-4.43*
EGg_off	-1.66	-12.00*
EGg_ret	-1.89	-12.04*
EGg_ind	-0.84	-11.88*
EGg_res	-1.97	-11.60*
Erg_off	-2.33	-10.69*
Erg_ret	-1.94	-10.17*
Erg_ind	-0.26	-12.10*
Erg_res	-2.28	-10.71*

Remarks:

1. ** indicates that the null hypothesis can be rejected at the 1% level;*
2. *off, ret, res and ind refers to the office, retail, residential and industrial property sectors, based on usage type, see RVD(2010)*
3. *P and R represent the price and rent index for each type of property respectively*
4. *Erg and EGg represent the Expected rental income growths derived by Term Structure Expected Growth Model and Gordon Growth Model respectively*

Based on the ADF test results, the expected rental income growth will be its first differenced value in the following Granger Causality Test. Moreover, as the price and rent growths are both the first differenced values of the natural log of the respective index, the proxy variables will not be further modified in the following test.

5.1.1.2 Model I-B

The investigation of Model I-B is made up of three Granger Causality Tests: one examines the lead-lag relationship between price and rent changes of real estate asset while the other two examine the lead-lag relationship between price and the expected rental income growths based on Gordon Growth Model and Term Structure Expected Growth Model respectively.

5.1.1.2.1 Data Descriptions of Model I-B

1. Granger Causality Test between price and rent

The data for the Granger Causality Test between price and rent in Model I-B are reported in Model I-A above.

2. Granger Causality Test between price and expected rental income growth based on Gordon Growth Model

The derivation of Gordon Growth in Model I-B is similar with Model I-A, except the risk premium. The discount rate in equation (5.8) will be proxied by the sum of risk-free rate (1-year exchange fund note yield) and risk premium of the corresponding property. The data sample covers the period from January 1999 to April 2010.

With these data, we first estimate the expected rental income growths of all real estate sectors in Hong Kong based on Gordon Growth Model. Then the lead-lag relationships between prices and expected rent growths are examined.

3. Granger Causality Test between price and expected rental income growth based on Term Structure Expected Growth Model

The derivation of Term Structure Expected Growth in Model I-B is similar with Model I-A, except the risk premium. The discount rate in equation (3.26) will be proxied by the sum of risk-free rate (1-year exchange fund note yield) and risk premium of the corresponding property. The data sample covers the period from January 1999 to April 2010. With these data, we first estimate the expected rental income growths of all real estate sectors based on the Term Structure Expected Growth Model. Then the lead-lag relationships between prices and both rents and expected rent growths are examined. Table 5.1b describes the variables used in three tests of Model I-B and exhibits the detailed data specification.

Table 5.1b Descriptions of the Variables in Model I-B

(All Real Estate Sectors)

Categories	Unit of measure	Descriptions	Symbols
Expected rental income growth based on Gordon Growth Model	percentage	*Calculated based on Gordon Growth Model*	*EGg'*
change of expected office property rent growth	percentage	the first differenced values of the expected office property rent growth	*⊿EGg'_off*
change of expected retail property rent growth	percentage	the first differenced values of the expected retail property rent growth	*⊿EGg'_ret*
change of expected industrial property rent growth	percentage	the first differenced values of the expected industrial property rent growth	*⊿EGg'_ind*
change of expected housing rent growth	percentage	the first differenced values of the expected housing rent growth	*⊿EGg'_res*
Expected rental income growth based on Term Structure Expected Growth Model	percentage	*Calculated based on Term Structure Expected Growth Model*	*Erg'*
change of expected office property rental income growth	percentage	the first differenced values of the expected office property rent growth	*△Erg'_off*
change of expected retail property rental income growth	percentage	the first differenced values of the expected retail property rent growth	*△Erg'_ret*
change of expected industrial property rental income growth	percentage	the first differenced values of the expected industrial property rent growth	*△Erg'_ind*

change of expected housing rental income growth	percentage	the first differenced values of the expected housing rent growth	*△Erg'_res*

Due to the focus here is the movement of property price, rent and expected future rental income; the data used in this section are all the growths of them. Thus the summary statistics of the whole dataset are shown in Table 5.2b in the context of their growths.

Table 5.2b Summary Statistics for all Real Estate Sectors in Hong Kong

Model I-B

Sample Period: January 1999 – April 2010

	EGg'_ind	***EGg'_off***	***EGg'_res***	***EGg'_ret***
Mean	-0.0007	0.0084	0.0046	0.0040
Median	0.0005	0.0071	0.0038	0.0034
Maximum	0.0095	0.0307	0.0139	0.0171
Minimum	-0.0086	-0.0024	-0.0025	-0.0040
Std. Dev.	0.0050	0.0075	0.0042	0.0048
Sum	-0.0893	1.1394	0.6274	0.5476
Sum Sq. Dev.	0.0034	0.0077	0.0024	0.0031
Observations	136	136	136	136
	Erg'_ind	*Erg'_off*	*Erg'_res*	*Erg'_ret*
Mean	0.0021	0.0130	0.0095	0.0081
Median	0.0024	0.0107	0.0078	0.0068
Maximum	0.0159	0.0399	0.0209	0.0230
Minimum	-0.0058	0.0023	0.0035	0.0009
Std. Dev.	0.0053	0.0084	0.0047	0.0050
Sum	0.2886	1.7744	1.2928	1.1022
Sum Sq. Dev.	0.0038	0.0096	0.0030	0.0034
Observations	136	136	136	136

5.1.1.2.2 Stationarity Test for Model I-B

Similar with Model I-A, the Unit Root Test is employed to show the stationarity of the time-series of data in Model I-B. The results are shown in Table 5.3b (without repeating the data of price and rent growths).

Table 5.3b: Augmented Dickey-Fuller unit root test for Model I-B

	Augmented Dickey-Fuller test statistic	
time series variables	**level**	**1st differences**
EGg'_off	-3.11**	11.39***
EGg'_ret	-2.73*	6.56***
EGg'_ind	-1.00	5.88***
EGg'_res	-3.70***	13.35***
Erg'_off	-2.68	9.68***
Erg'_ret	-2.19	10.30***
Erg'_ind	-0.94	6.65***
Erg'_res	-3.36	11.35***

Remarks:

1. ** indicates that the null hypothesis can be rejected at the 1% level;*
2. *off, ret, res and ind refers to the office, retail, residential and industrial property sectors, based on usage type, see RVD(2010)*
3. *Erg' and EGg' represent the Expected rental income growths derived by Term Structure Expected Growth Model and Gordon Growth Model respectively*

Based on the ADF test results, the expected rental income growth will be its first differenced value in the following Granger Causality Test. Moreover, as the price and rent growths are both the first differenced values of the natural log of the respective index, the proxy variables will not be further modified in the following tests.

5.1.2 Data for Model II (Expected Growth's Effects on Private Real Estate Market)

This section discusses the data used in Model II. In this section, the primary data source is the Rating and Valuation Department (RVD) and Hong Kong Monetary Authority (HKMA) in Hong Kong. Monthly data of both real estate and financial market can be gained from their statistics report, quarterly data of GDP and unemployment rate can be gained from the report of Census and Statistics Department, Hong Kong S.A.R. *(http://www.censtatd.gov.hk/home/index.jsp)*. Similar with Model I, there are two datasets for Model II: Model II-A without considering risk premium and Model II-B with risk premium in discount rate.

5.1.2.1 Data Descriptions for Model II-A

In this study, the expected rental income growth of property is derived based on Term Structure Expected Growth Model we constructed in Chapter 3. And the capitalization rate and the spot return rate of property is accessed from the RVD monthly statistics. And the risk free return rate is the 10-year exchange fund note yield, gained from HKMA statistics. The investigation period is from January 1999 to March 2009. Table 5.4 describe the dependent and independent variables in this study. And Table 5.5a.1 show the summary of the statistics of the variables used in Model II-A, and Table 5.5a.2 show the summary of the statistics of the variables used in the estimation of the real rent growth.

Table 5.4 Descriptions of the Variables in Model II

Note: the sample period is from 1st Quarter 1999 to 1st Quarter 2010

Categories	**Unit of measure**	**Descriptions**	**Symbols**
		Dependent Variable:	
office property capital return	percentage	the first differenced values of the natural log of office property price index	*Pg_off*
retail property price growth	percentage	the first differenced values of the natural log of retail property price index	*Pg_ret*
industrial property price growth	percentage	the first differenced values of the natural log of industrial property price index	*Pg_ind*
housing price growth	percentage	the first differenced values of the natural log of housing price index	*Pg_res*
		Independent Variables:	
expected rental income growth of office property	percentage	derived from the Term Structure Expected Growth Model constructed in Chapter 3; (on monthly basis)	*Erg_off*
expected rental income growth of retail property	percentage	derived from the Term Structure Expected Growth Model constructed in Chapter 3; (on monthly basis)	*Erg_ret*
expected rental income growth of industrial property	percentage	derived from the Term Structure Expected Growth Model constructed in Chapter 3; (on monthly basis)	*Erg_ind*
expected rental income growth of residential property	percentage	derived from the Term Structure Expected Growth Model constructed in Chapter 3; (on monthly basis)	*Erg_res*
expected Gordon growth of office property	percentage	derived from the Gordon Growth Model; (on monthly basis)	*EGg_off*

expected Gordon growth of retail property	percentage	derived from the Gordon Growth Model; (on monthly basis)	*EGg_ret*
expected Gordon growth of industrial property	percentage	derived from the Gordon Growth Model; (on monthly basis)	*EGg_ind*
expected Gordon growth of residential property	percentage	derived from the Gordon Growth Model; (on monthly basis)	*EGg_res*
estimated office property rental changes	percentage	estimated based on equation (5.13) in chapter 5	$\hat{R}g_{offt}$
estimated retail property rental changes	percentage	estimated based on equation (5.13) in chapter 5	$\hat{R}g_{rett}$
estimated industrial property rental changes	percentage	estimated based on equation (5.13) in chapter 5	$\hat{R}g_{indt}$
estimated residential property rental changes	percentage	estimated based on equation (5.13) in chapter 5	$\hat{R}g_{rest}$
cost of capital for one year	percentage	the annual yield rate of 364-day Exchange Fund Bills issued by Hong Kong Monetary Authority,(http://www.info.gov.hk/hkma/)	*i*
spread between long-term and short-term costs of capital	percentage	the difference between the annual yield rates of 10-year Exchange Fund Notes and 364-day Exchange Fund Bills	*S*

Variables for Estimation of property rental change:

office property rent growth	percentage	the first differenced values of the natural log of office property rent index	*Rg_off*
retail property rent growth	percentage	the first differenced values of the natural log of retail property rent index	*Rg_ret*

industrial property rent growth	percentage	the first differenced values of the natural log of industrial property rent index	*Rg_ind*
residential property rent growth	percentage	the first differenced values of the natural log of housing rent index	*Rg_res*
seasonal adjusted GDP growth	percentage	gained from the Census and Statistics Department, Hong Kong S.A.R. (http://www.censtatd.gov.hk/home/index.jsp)	*GDP_g*
unemployment rate	percentage	gained from the Census and Statistics Department, Hong Kong S.A.R. (http://www.censtatd.gov.hk/home/index.jsp)	*UNE*
real interest rate	percentage	difference between the 1-year HIBOR rate and inflation rate	*RINT*

***Remarks**:*

1. The return of property refers to the capital return of the asset, which is usually calculated by the natural logarithm of the prices ratio between current- and last-period. In this study, the return of property is calculated by the process $ln\_p_t=ln(P_t/P_{t-1})$, where Pt refers to the price index value of the property market at quarter t. The price index of property can be gained from Rating and Valuation Department, Hong Kong S.A.R. (http://www.rvd.gov.hk)

2. The annual expected rental growth of the property is derived from the Term Structure Expected Growth Model (both A and B) discussed in Chapter 3. In this section of test, the annual expected rental growth of the property is transferred into monthly series because of the need for data frequency consistency.

3. because of the multi-co-linearity problem, the rental changes in this section is estimated based on the equation (5.9) as introduced in this Chapter

4. The i represents the cost of capital on holding the property for one year (364 days), and is proxied by the yield rate of the Exchange Fund Bills, which is regarded as the government bond yield rate in Hong Kong. The data series is gained from the website of the Hong Kong Monetary Authority http://www.info.gov.hk/hkma/.

5. The S is equal to the difference between the long-term and short-term government bond yield rate. In this study, they are proxied by the annual yield rates of 10-year Exchange Fund Notes and 364-day Exchange Fund Bills respectively. Both series are gained from the website of the Hong Kong Monetary Authority http://www.info.gov.hk/hkma/.

6. The seasonal adjusted GDP growth is used for estimation of the rental change of property. The time series can be gained from the Census and Statistics Department, Hong Kong S.A.R. (http://www.censtatd.gov.hk/home/index.jsp) on quarterly basis.

7. The unemployment is also confirmed to be an explanatory variable in determining the rental change of property. Thus we get it from the Census and Statistics Department, Hong Kong S.A.R. (http://www.censtatd.gov.hk/home/index.jsp) on monthly basis. The quarterly series of unemployment rate is the average rate during period of one quarter.

8. The real interest rate is the determinant for rental changes of property as well. In this study, the nominal interest rate is proxied by the 1-year interbank offered rate in Hong Kong while the inflation rate is calculated based on the annual change of the Consumer Price Index (CPI) – Series A for non-luxury commodities. Both of them are annual rate on monthly basis and we transferred them into monthly rate on quarter basis. The monthly rates are assumed to be equal to the 1/12 of annual rate while the quarter series are average rates of monthly series during period of one quarter.

Table 5.5a.1 Summary Statistics of the Quarterly Series of Variables in the Regression Test of Model II-A

2nd Quarter 1999 to 1st Quarter 2010

Note: **off, ind, ret** and **res** refer to the four section of Hong Kong real estate market, namely office (Grade A), industrial, retail and residential (all classes) respectively; ***Pg*** and ***E(Rg)*** denote the capital return of the property and the estimated rental change of the property respectively, while ***Erg*** denotes the expected rental growth of the property; ***EGg*** refers to the Gordon Growth of the property ***S*** refers to the spread between long- and short-term government bond yields; ***i*** represents the short-term government bond yield (cost of capital).

	Pg_off	$\hat{R}g_{offt}$	*S*	*Erg_off*	*EGg_off*	*i*
Mean	0.31%	0.24%	0.15%	0.20%	-0.20%	0.25%
Median	-0.14%	0.45%	0.12%	0.18%	-0.20%	0.22%
Maximum	11.51%	2.28%	0.31%	0.56%	0.05%	0.55%
Minimum	-9.82%	-3.04%	0.02%	-0.07%	-0.49%	0.03%
Std. Dev.	3.29%	1.25%	0.09%	0.15%	0.17%	0.16%
Sum	0.1259	0.0969	0.0605	0.0833	-0.0900	0.1039
Sum Sq. Dev.	0.0434	0.0062	0.0000	0.0001	0.0001	0.0001
	Pg_ind	$\hat{R}g_{indt}$	*S*	*Erg_ind*	*EGg_ind*	*i*
Mean	0.47%	-0.01%	0.15%	-0.39%	-0.60%	0.25%
Median	0.53%	0.05%	0.12%	-0.41%	-0.55%	0.22%
Maximum	5.47%	1.28%	0.31%	0.02%	-0.19%	0.55%
Minimum	-5.14%	-1.88%	0.02%	-0.77%	-1.05%	0.03%
Std. Dev.	2.10%	0.74%	0.09%	0.24%	0.28%	0.16%
Sum	0.1918	-0.0035	0.0605	-0.1613	-0.2710	0.1039

Sum Sq. Dev.	0.0177	0.0022	0.0000	0.0002	0.0003	0.0001
	Pg_ret	$\hat{R}g_{rett}$	*S*	*Erg_ret*	*EGg_ret*	*i*
Mean	0.37%	0.10%	0.15%	0.10%	-0.27%	0.25%
Median	0.00%	0.20%	0.12%	0.09%	-0.25%	0.22%
Maximum	5.29%	0.95%	0.31%	0.26%	-0.01%	0.55%
Minimum	-3.63%	-1.41%	0.02%	-0.06%	-0.54%	0.03%
Std. Dev.	1.94%	0.56%	0.09%	0.09%	0.17%	0.16%
Sum	0.1515	0.0421	0.0605	0.0393	-0.1193	0.1039
Sum Sq. Dev.	0.0150	0.0013	0.0000	0.0000	0.0001	0.0001
	Pg_res	$\hat{R}g_{rest}$	*S*	*Erg_res*	*EGg_res*	*i*
Mean	0.03%	0.05%	0.15%	0.31%	-0.13%	0.25%
Median	-0.13%	0.17%	0.12%	0.30%	-0.19%	0.22%
Maximum	5.92%	1.33%	0.31%	0.54%	0.17%	0.55%
Minimum	-5.04%	-2.62%	0.02%	0.08%	-0.35%	0.03%
Std. Dev.	2.03%	1.02%	0.09%	0.13%	0.16%	0.16%
Sum	0.0110	0.0221	0.0605	0.1284	-0.0595	0.1039
Sum Sq. Dev.	0.0166	0.0042	0.0000	0.0001	0.0001	0.0001

**Remarks: 1. The descriptive statistics in Table 5.7.1 are about the variables used in the Hypothesis we test.*

2. The long- and short-term government bond yield rates are proxied by the annual yield rates of 10-year Exchange Fund Notes and 364-day Exchange Fund Bills respectively. Both series are gained from the website of the Hong Kong Monetary Authority http://www.info.gov.hk/hkma/*. In this section of* *study, all return and changing rates are quarterly rates, thus we transferred the annual rates of government bond yield into quarterly rates, which the statistics are based on.*

3. Total 41 observations of each series for each property sector are included in this study after adjustment

Table 5.5a.2* Descriptive Statistics of the Quarterly Series of Variables for Estimation of Natural Logarithm Change of Property Rents

2nd Quarter 1999 to 1st Quarter 2010

Note: **off, ind, ret** and **res** refer to the four sections of Hong Kong real estate market, namely office (Grade A), industrial, retail and residential (all classes) respectively; ***GDP_g, UNE and RINT*** denote the seasonal adjusted GDP growth, unemployment rate and real interest rate.

	Rg_off	*Rg_ind*	*Rg_ret*	*Rg_res*	*GDP_g*	*UNE*	*RINT*
Mean	0.17%	-0.03%	0.10%	0.09%	1.12%	5.58%	0.29%
Median	0.47%	0.27%	0.24%	0.24%	1.50%	5.33%	0.22%
Maximum	3.65%	4.55%	1.42%	2.42%	6.30%	8.33%	1.04%
Minimum	-3.64%	-3.10%	-1.55%	-6.35%	-3.20%	3.30%	-0.28%
Std. Dev.	1.70%	1.36%	0.79%	1.48%	1.67%	1.34%	0.32%
Sum	0.0782	-0.0142	0.0443	0.0401	0.5030	2.5093	0.1322
Sum Sq. Dev.	0.0128	0.0081	0.0027	0.0096	0.0122	0.0079	0.0005

**Remarks:*

1. The descriptive statistics in Table 5.7.2 are about the variables used in the process of estimation for natural logarithm change of property rents.

2. The seasonal adjusted GDP growth is used for estimation of the rental change of property. The time series can be gained from the Census and Statistics Department, Hong Kong S.A.R. (http://www.censtatd.gov.hk/home/index.jsp) on quarterly basis.

3. The unemployment is also confirmed to be an explanatory variable in determining the rental change of property. Thus we get it from the Census and Statistics Department, Hong Kong S.A.R. (http://www.censtatd.gov.hk/home/index.jsp) on monthly basis. The quarterly series of unemployment rate is the average rate during period of one quarter.

4. The real interest rate is the determinant for rental changes of property as well. In this study, the nominal interest rate is proxied by the 3-month interbank offered rate in Hong Kong while the inflation rate is calculated based on the annual change of the Consumer Price Index (CPI) – Series A for *non-luxury commodities. Both of them are annual rate on monthly basis and we transferred them into monthly rate on quarter basis. The monthly rates are assumed to be equal to the 1/12 of annual rate while the quarter series are average rates of monthly series during period of one quarter.*

5. Total 45 observations of each series for each property sector are included in this study after adjustment.

5.1.2.2 Stationarity Test for Model II-A

According to Table 5.6.1 and Table 5.6.2, some series (i.e. *S* (spread), *i* (government bond yield) and *Erg* (expected rental income growth)) are not stationary on level data while stationary under 1st differenced condition. Therefore, the test for Application of the Hypothesis (H2) will be carried out with the data of 1st differenced series of these variables.

Table 5.6.1: Augmented Dickey-Fuller unit root test on Quarterly GDP growth, Unemployment Rate and Real Interest Rate

2nd Quarter 1999 – 1st Quarter 2010		
Note: ***GDP_g, UNE*** and ***RINT*** denotes to the seasonal adjusted GDP growth, unemployment rate and real interest rate.		
time series variables	**Augmented Dickey-Fuller test statistic**	
	level	**1st differences**
GDP_g	-5.53*	-11.72*
UNE	-2.14	-3.52**
RINT	-1.29	-5.79*

Remarks:

** indicates that the null hypothesis can be rejected at the 1% level; ** indicates that the null hypothesis can be rejected at the 5% level*

Table 5.6.2: Augmented Dickey-Fuller unit root test for Model II

2nd Quarter 1999 – 1st Quarter 2010

Note: ***off, ind, ret*** and ***res*** refer to the four section of Hong Kong real estate market, namely office (Grade A), industrial, retail and residential (all classes) respectively.

Pg and ***E(Rg)*** denote the natural logarithm changes of property price and rent respectively; ***Erg*** denotes the derived expected rental growth of the property; ***S*** refers to the spread between long- and short-term government bond yields; ***i*** represents the short-term government bond yield. All series are on quarterly basis.

time series variables	**Augmented Dickey-Fuller test statistic**	
	level	**1st differences**
Pg_off	-4.76*	-7.84*
Pg_ind	-5.05*	-8.19*
Pg_ret	-4.64*	-9.49*
Pg_res	-5.05*	-11.16*
$\hat{R}g_{offt}$	-3.04**	-4.97*
$\hat{R}g_{indt}$	-3.75*	-8.48*
$\hat{R}g_{rett}$	-3.51*	-7.83*
$\hat{R}g_{rest}$	-3.48**	-8.08*
Erg_off	-2.33	-10.69*
Erg_ind	-0.26	-12.10*
Erg_ret	-1.94	-10.17*
Erg_res	-2.28	-10.71*
EGg_off	-1.97	-4.54*
EGg_ind	-1.56	-3.91*
EGg_ret	-2.00	-4.45*
EGg_res	-2.43	-4.54*
S	-1.6	-5.13
i	-1.29*	-5.79*

Remarks:

***** *indicates that the null hypothesis can be rejected at the 1% level;* ** *indicates that the null hypothesis can be rejected at the 5% level*

5.1.2.3 Data Descriptions for Model II-B

In this section, the expected rental income growth of property is derived based on Term Structure Expected Growth Model, which included the risk premium into the discount rate. The dependent and independent variables in this section are exactly the same with Model II-A, except the expected rental income growth. In Model II-B, the expected rental income growth for each property sector is derived based on the Term Structure Expected Growth Model with risk premium included in the discount rate. Same discount rate is also employed in Gordon Growth Model to derive the Gordon Growth in this section for the comparison.

Table 5.5b shows the summary of the statistics of the expected rental income growths and Gordon Growths for all four property sectors.

Table 5.5b Summary Statistics of the Quarterly Series of the Expected Rental Income Growth in the Regression Test of Model II-B

2nd Quarter 1999 to 1st Quarter 2010

Note: **off, ind, ret** and **res** refer to the four section of Hong Kong real estate market, namely office (Grade A), industrial, retail and residential (all classes) respectively; ***Erg*** denotes the expected rental growth of the property; ***EGg*** refers to the Gordon Growth of the property.

	Erg_off	*EGg_off*	*Erg_ind*	*EGg_ind*	*Erg_ret*	*EGg_ret*	*Erg_res*	*EGg_res*
Mean	1.29%	0.83%	0.20%	-0.07%	0.80%	0.39%	0.94%	0.46%
Median	1.16%	0.73%	0.25%	0.06%	0.70%	0.33%	0.80%	0.38%
Maximum	3.75%	2.89%	1.37%	0.85%	2.11%	1.36%	2.01%	1.18%
Minimum	0.29%	-0.22%	-0.54%	-0.85%	0.13%	-0.37%	0.37%	-0.20%
Std. Dev.	0.82%	0.74%	0.52%	0.50%	0.48%	0.46%	0.46%	0.42%
Sum	58.16%	37.28%	9.09%	-3.29%	35.97%	17.76%	42.45%	20.55%
Sum Sq. Dev.	0.30%	0.24%	0.12%	0.11%	0.10%	0.09%	0.09%	0.08%

**Remarks: 1. The descriptive statistics in Table 5.7.1 are about the variables used in the Hypothesis we test.*

2. The long- and short-term government bond yield rates are proxied by the annual yield rates of 10-year Exchange Fund Notes and 364-day Exchange Fund Bills respectively. Both series are gained from the website of the Hong Kong Monetary Authority http://www.info.gov.hk/hkma/. In this section of study, all return and changing rates are quarterly rates, thus we transferred the annual rates of government bond yield into quarterly rates, which the statistics are based on.

3. Total 41 observations of each series for each property sector are included in this study after adjustment

5.1.2.4 Stationarity Test for Model II-B

Table 5.6b exhibits the stationarity of the expected rental growths and Gordon Growths, which will be investigated in Model II-B.

Table 5.6b: Augmented Dickey-Fuller unit root test for Model II-B

2nd Quarter 1999 – 1st Quarter 2010

Note: ***off, ind, ret*** and ***res*** refer to the four section of Hong Kong real estate market, namely office (Grade A), industrial, retail and residential (all classes) respectively.

Pg and ***E(Rg)*** denote the natural logarithm changes of property price and rent respectively; ***Erg*** denotes the derived expected rental growth of the property; ***S*** refers to the spread between long- and short-term government bond yields; ***i*** represents the short-term government bond yield. All series are on quarterly basis.

time series variables	**Augmented Dickey-Fuller test statistic**	
	level	**1st differences**
Erg_off	-1.96	-6.33***
Erg_ind	-0.17	-2.82*
Erg_ret	-1.44	-5.20***
Erg_res	-1.85	-5.77***
EGg_off	-1.86	-7.01***
EGg_ind	-6.01	-2.99**
EGg_ret	-1.89	-5.89***
EGg_res	-1.77	-6.32***

Remarks:

***** *indicates that the null hypothesis can be rejected at the 1% level;* ** *indicates that the null hypothesis can be rejected at the 5% level*

5.1.2.5 Estimation of rent changes

As for the multicollinearity between movements of property rent and other variables, the empirical study in this chapter will be conducted through several steps. First we follow the previous studies to model the office property's rent movements:

$$\Delta \ln R_{0t} = \beta_0 + \beta_1 \times \Delta(RINT_t) + \beta_2 \times GDP\_g_t + \beta_3 \times \Delta UNE_t + \phi_t \qquad (5.9)$$

$\Delta \ln R_{0t}$ represents the real rent growth, $RINT_t$ refers to the real interest rate, GDP_g_t and UNE_t represent the GDP growth and unemployment rate at time t.

According to the results in Table 5.10.1, we can find that the series of GDP, unemployment rate and real interest rate is not stationary on level data. Thus we need to employ the differenced series of data. In this study, we follow the previous findings and estimate the coefficient of each explanatory variable with the Ordinary Least Square Regression Process

$$\hat{R}g_{it} = c + \alpha_{i1} GDP\_g_t + \alpha_{i2} d(UNE_t) + \alpha_{i3} d(RINT_t) + \varepsilon_t \qquad (5.10)$$

Where $\hat{R}g_{it}$ represents the natural logarithm change of property rent in sector i at quarter t; GDP_g_t, $d(UNE_t)$ and $d(RINT_t)$ refer to the seasonal adjusted GDP growth and differenced series of unemployment rate and real interest rate (which is equal to the difference between the 1-year HIBOR rate and inflation rate in Hong Kong) at quarter t. Table 5.7 reports the empirical results for Regression Process.

Table 5.7 Estimation of Co-efficient for Property Rent Changes

2nd Quarter 1999 – 1st Quarter 2010

Note: ***off, ind, ret*** and ***res*** refer to the four sectors of Hong Kong real estate market, namely office (Grade A), industrial, retail and residential (all classes) respectively.

GDP_G, UNE and ***RINT*** denotes to the seasonal adjusted GDP growth, unemployment rate and the real interest rate.

sector	*c*	*GDP_g*	*d(UNE)*	*d(RINT)*
off	0.0024	-0.1081	-3.1652***	0.2155
ind	-0.0036	0.2932**	-0.7149	-1.1620
ret	-0.0015	0.2042***	-0.6524***	-1.0321
res	-0.0035	0.3048**	-1.4044***	-2.1152

****,**,** *significance at respective 1%, 5% and 10% level*

Based on the results of the regression process above, we can formulate the estimation equation for natural logarithm change of property rent in each sector as follows:

$$ERg_{offt} = 0.0024 - 0.1081 \times GDP\_g_t - 3.1652 \times d(UNE_t) + 0.2155 \times d(RINT_t) + \varepsilon_t \quad (5.11.1)$$

$$ERg_{indt} = -0.0036 + 0.2932 \times GDP\_g_t - 0.7149 \times d(UNE_t) - 1.1620 \times d(RINT_t) + \varepsilon_t \quad (5.11.2)$$

$$ERg_{rett} = -0.0015 + 0.2042 \times GDP\_g_t - 0.6524 \times d(UNE_t) - 1.0321 \times d(RINT_t) + \varepsilon_t \quad (5.11.3)$$

$$ERg_{rest} = -0.0035 + 0.3048 \times GDP\_g_t - 1.4044 \times d(UNE_t) - 2.1152 \times d(RINT_t) + \varepsilon_t \quad (5.11.4)$$

where $\hat{R}g_{offt}$, $\hat{R}g_{indt}$, $\hat{R}g_{rett}$ and $\hat{R}g_{rest}$ represent the natural logarithm change of rental change of office – Grade A, industrial, retail and residential properties at quarter *t* respectively; ***GDP_g, UNE*** and ***RINT*** denotes to the seasonal adjusted GDP growth, unemployment rate and real interest rate.

With the estimated co-efficient values, we further estimate the property rental changes ($\hat{R}g_{0t}$) without error term in the equation. Thus the multicollinearity between rent and other variables' movements can be eliminated and the newly estimated rent changes series are used in the empirical test for the relationship between property return and macroeconomic factors. The estimated natural logarithm change of rental change of the real estate asset in each sector will be employed in the regression test with other empirical data.

5.1.3 Data for Model III (Expected Growth's Effects on Public Real Estate Market)

This section discusses the data used in Model III. The purpose of the investigation of Model III is to explore whether the returns of public real estate assets (REITs) can be affected by the expected rental growth of property as hypothesized in the Term Structure Expected Growth Model with empirical data. To this end, we use total return index of REITs in Hong Kong market to proxy the returns of indirect real estate assets. There are four REITs in Hong Kong selected to be included in the empirical test sample. Among all seven REITs in Hong Kong market, we choose these four ones because they (1) contain property asset in Hong Kong in their portfolios; (2) have been launched for a relatively longer time. As their portfolios are made up with different type of properties, the investors' expectations may differ among them. Thus in this study, we construct the empirical test model based on panel data sample. Besides, the panel data would help to eliminate the shortage caused by the small quantity of the observations. As stated in Chapter 1, the last hypothesis in this study covers the explanatory variables of stock market movements which is proxied by the return of Hang Seng Index, the risk premium proxied by the REITs market BETA, the real interest rate and the expected rental growth of property derived by the Term Structure Expected Growth Model. Our sample consists of monthly series with average data during the period from November 2005 to April 2010 due to the data availability. The four REITs are LINK REIT, CHAMPION REIT, PROSPETIRY RET and SUNLIGHT REIT. The detailed information of the companies, including their market capitalizations, percentage contributions to the stock market, gearing ratios, and the property portfolio compositions, are given in Table 5.8. The data of property portfolio compositions are gained from the annual report of each REIT, while other company data are collected from DataStream®. The following sub-sections will describe the empirical data, the methodology and the results in detail, together with the analysis.

Table 5.8 Portfolio Characteristics of the Four Selected REIT Companies by the End of 2009[32]

		Property Company	LINK	CHAMPION	PROSPERITY	SUNLIGHT
Market Capitalization		**(HK$ m)**	48783.81	18923.12	2101.27	3378.33
Market-to-Book Ratio			1.14	0.58	0.58	0.55
Dividend Paid per Share		**(HK$)**	0.97	0.26	0.11	0.25
Property Portfolio Composition	**office**	**(%)**	0	100	80.95	33.63
	industrial	**(%)**	0	0	19.05	66.37
	retail	**(%)**	100	0	0	0
	residential	**(%)**	0	0	0	0
	others	**(%)**	0	0	0	0

**: The category "Other" includes China infrastructure, China property development and container terminal.*

5.1.3.1 Data Descriptions for Model III-A

The purpose of this section is to exhibit the data used in this study for the empirical tests of Hypothesis III. Table 5.9 describes all variables in the test while Table 5.10a reports the descriptive statistics of the movements of REITs' and other investment assets (i.e. stock market and cash) returns together with the changes of risk premium and the investor's expected rental growth of the property.

Both HSI and returns index of each REITs are obtained from the DataStream ®. The price and rental indices of the direct real estate market are gained from the Department of Rating and Valuation Department, Hong Kong S.A.R. (http://www.rvd.gov.hk). The short-term interest rate is proxied by the monthly rate of 1-year Hong Kong Inter Bank Offered Rate while costs of capital for long-term and short-term are proxied by the monthly yield rates of 364-day Exchange Fund Notes and 10-year Exchange Fund Bills respectively. These sets of data are all obtained from the Hong Kong Monetary Authority (http://www.info.gov.hk/hkma/). The inflation rate is calculated as the monthly rate of annual change of the Consumer Price Index (CPI) – Series A for non-luxury commodities. The CPI together with GDP, Seasonal adjusted GDP growth and unemployment rate are gained from the Census and Statistics Department, Hong Kong S.A.R. (http:// www.censtatd.gov.hk/home/index.jsp).

[32] There are several changes of the characteristics in each year; we only list their conditions here in this study by the end of 2009.

Table 5.9 Descriptions of the Variables in the Empirical Model III

Categories	Unit of measure	Descriptions
Dependent Variable:		
Total return of REIT, ln_R	percentage	Total return of REIT = $\ln(RI_t/RI_{t-1})$[1]
Independent Variables:		
Assets Attributes		
Average return of stock market, ln_HSI	percentage	Average return of stock market = $\ln(HSI_t/HSI_{t-1})$
Real interest rate, RINT,	percentage	Real interest rate = 1-year hibor – inflation rate
Risk premium (BETA)[2]	number	BETA=(REIT's return – 10-year exchange fund note's yield)/(stock return – 10-year exchange fund note's yield)
Property Attribute		
Expected rental income growth of REIT's portfolio Eg_{it}[3]	percentage	The derived expected rental income growth[4] of the portfolio of each REIT at time t

***Remarks:**

1. *The return of REIT is calculated as the compounded return of stock with the equation:*

   $\ln\_R = \ln(V_f) - \ln(V_i)$ *, where R denotes to the return of REIT, V_f and V_i refer to the final and initial values of the investment (REIT) during the period (one month).*

   RI denotes to the total return index of REIT gainded from DATASTREAM.

2. *the risk premium for each REIT (BETA) is calculated based on the CAPM model with the equation as :*

$$BETA_{it} = \frac{R_{at} - EFN_t}{R_{hsit} - EFN_t}$$

where $\mathbf{R_{at}}$ *and* $\mathbf{R_{hsit}}$ *denote to the average return of the selected REITs and the general stock market respectively while the* $\mathbf{EFN_t}$ *refers to the yield of 10-year exchange fund note (government bond) at month* ***t****.*

3. *The expected rental growth of the portfolio for the ith REIT at month t is calculated followed the process that:*

$$Eg_{it} = \omega_{off} \times Erg_{offt} + \omega_{ind} \times Erg_{indt} + \omega_{ret} \times Erg_{rett} + \omega_{res} \times Erg_{rest} \quad (5.12)$$

where ω_{off} , ω_{ind} , ω_{ret} *and* ω_{res} *denote to the weighting of each kind of property in the portfolio of the ith REIT and* Erg_{offt}, Erg_{indt}, Erg_{rett} *and* Erg_{rest} *denote to the expected rental income growth of each property sector. The* Eg_{it} *refers to expected rental growth of the portfolio for the* i^{th} *REIT at month t.*

4. *The expected rental income growth here is the monthly growth rate.*

Table 5.10a Descriptive Statistics of the Monthly Series of Variables in Test for Model III-A (Panel Data, full sample)

November 2005 to April 2010

Note: ***RI*** and ***HSI*** refer to the total return index of REITs and price index stock market in HONG KONG respectively.

BETA, RINT and ***Eg*** denote the risk premium, the real interest rate and the expected rental growth of REIT's portfolio respectively.

	RI	*HSI*	*BETA*	*RINT*	*Eg*
Mean	102.44	20105.57	-3.29	0.02%	0.13%
Median	94.71	20484.12	0.32	0.02%	0.13%
Maximum	194.60	29078.79	28.96	0.28%	0.46%
Minimum	39.10	12794.95	-237.69	-0.32%	-0.25%

Std. Dev.	38.14	3959.93	32.86	0.00	0.00
Sum	19668.13	3860270.00	-696.46	0.05	0.26
Sum Sq. Dev.	277838.90	3000000000.00	227806.1	0.00	0.00
Observations	192	192	192	192	192

And the correlations among all factors are provided in Table 5.11a

Table 5.11a Coefficients of Correlation among the Factors in Model III-A

	RI	HSI	BETA	RINT	Eg
RI	1				
HSI	0.2428	1			
BETA	-0.0119	0.0540	1		
RINT	-0.0529	-0.2010	-0.0394	1	
Eg	0.2739	0.47844	0.04920	-0.3303	1

5.1.3.2 Stationarity Test for Model III-A

In this section, the unit root test is carried out for panel data to investigate whether the series of each factor are stationary. The stationarity of each series is exhibited in Table 5.12a.

Table 5.12a the Stationarity of the Variables Employed in Test for Model III-A

level data	*ln_ R*	*ln_H S I*	*Eg*	*RINT*	*BETA*
Null: Unit root (assumes common unit root process)					
Levin, Lin & Chu t*	-6.93387	-8.2399	1.2747	0.9915	28.2800

Null: Unit root (assumes individual unit root process)					
Im, Pesaran and Shin W-stat	-7.0920	-5.9857	-0.1101	2.2779	-38.5200
ADF - Fisher Chi-square	62.1909	50.5409	5.7319	1.0315	92.9300
PP - Fisher Chi-square	69.6112	63.0260	5.7784	0.8551	73.6800
1st differenced data	*ln(_R*	*ln_H S I*	*Eg*	*RINT*	*BETA*
Null: Unit root (assumes common unit root process)					
Levin, Lin & Chu t*	-13.7741	-16.1606	-8.3386	-9.3603	-5.5700
Null: Unit root (assumes individual unit root process)					
Im, Pesaran and Shin W-stat	-14.7968	-14.9272	-7.4287	-7.2832	-50.2700
ADF - Fisher Chi-square	144.1960	150.0610	66.4535	64.7461	73.6800
PP - Fisher Chi-square	152.7830	73.6827	127.0540	115.6250	73.6800

***,**,* significance at respective 1%, 5% and 10%

5.1.3.3 Data Descriptions for Model III-B

As the empirical test is similar with Model III-A, the descriptions of variables will not be repeated here. Table 5.10b reports the descriptive statistics of the movements of REITs' and other investment assets (i.e. stock market and cash) returns together with the changes of risk premium and the investor's expected rental growth of REITs.

Table 5.10b Descriptive Statistics of the Monthly Series of Variables in Test for Model III-B (Panel Data, full sample)

November 2005 to April 2010

Note: ***RI*** and ***HSI*** refer to the total return index of REITs and price index stock market in HONG KONG respectively.

BETA, RINT and ***Eg*** denote the risk premium, the real interest rate and the expected rental growth of REIT's portfolio respectively.

	RI	***HSI***	***BETA***	***RINT***	***Eg***
Mean	102.35	20056.19	-1.50	2.59%	1.17%
Median	94.76	20475.51	0.36	2.50%	1.02%
Maximum	194.60	29078.79	28.96	4.67%	2.97%
Minimum	39.10	12794.95	-237.69	0.23%	0.34%
Std. Dev.	37.85	3954.65	24.33	0.02	0.01
Sum	19957.78	3910957	-293.2734	5.055595	2.2737
Sum Sq. Dev.	277969	3.03E+09	114883.4	0.04496	0.006352
Observations	195	195	195	195	195

And the correlations among all factors are provided in Table 5.11b

Table 5.11b Coefficients of Correlation among the Factors in Model III-B

	RI	HSI	BETA	RINT	Eg
RI	1				
HSI	0.2420	1			
BETA	-0.0127	0.1376	1		
RINT	-0.0275	-0.0844	-0.1147	1	

Eg	-0.2184	-0.1934	0.0026	-0.6272	1

5.1.3.4 Stationarity Test for Model III-B

In this section, the unit root test is carried out for panel data to investigate whether the series of each factor are stationary. The stationarity of each series is exhibited in Table 5.12b.

Table 5.12b the Stationarity of the Variables Employed in Test for Model III-B

level data	*ln_ R*	*ln_H S I*	*E(g)*	*RINT*	*BETA*
Null: Unit root (assumes common unit root process)					
Levin, Lin & Chu t*	-6.93387	-8.2399	1.5412	0.9915	28.2800
Null: Unit root (assumes individual unit root process)					
Im, Pesaran and Shin W-stat	-7.0920	-5.9857	0.4877	2.2779	-38.5200
ADF - Fisher Chi-square	62.1909	50.5409	3.916	1.0315	92.9300
PP - Fisher Chi-square	69.6112	63.0260	0.2823	0.8551	73.6800
1st differenced data	*ln_R*	*ln_H S I*	*E(g)*	*RINT*	*BETA*
Null: Unit root (assumes common unit root process)					
Levin, Lin & Chu t*	-13.7741	-16.1606	-4.1803	-9.3603	-5.5700
Null: Unit root (assumes individual unit root process)					
Im, Pesaran and Shin W-stat	-14.7968	-14.9272	-4.6910	-7.2832	-50.2700
ADF - Fisher Chi-square	144.1960	150.0610	37.9337	64.7461	73.6800
PP - Fisher Chi-square	152.7830	73.6827	42.3878	115.6250	73.6800

***,**,* significance at respective 1%, 5% and 10%

5.2 METHODOLOGY AND RESEARCH DESIGN

Different methods are opted in this study to testify the three hypotheses stated in Chapter 1. First of all, we use Granger Causality Test to show the motivation of this study and meanwhile to test our first hypothesis that *the expected rental income growth of the real estate asset leads the changes of real estate asset price* (Model I). The testing results answer our research question: whether the investor's expected rental income growth has effects on real estate returns. Secondly, a two-step OLS regression model is adopted in Model II to investigate our Application of the Hypothesis (H2) that *the expected rental income growth has a positive effect on the corresponding real estate price movement, ceteris paribus*. The testing results give answer to our second research question: why the investor's expected rental income growth has effects on real estate returns. The investigation of Model II provides empirical evidence from Hong Kong to support our theoretical model. Besides, in Model II, we also do the same empirical investigation with Gordon Growth. The comparisons of the results are provided in Chapter 6. The empirical investigation of Model II is extended to be a critical test to show the advantages of Term Structure Expected Growth Model. The detailed empirical exploration of the critical test is presented in Chapter 7. Lastly, a panel regression model is applied in Model III to explore our third hypothesis *The expected rental income growth of the underlying real estate asset has positive effect on the fluctuation of REIT's return, ceteris paribus.* The testing results answer to our last research question: how the investor's expected rental income growth has effects on real estate returns. The exploration under Model III tests the application of our theoretical model. The design of this study presents a theory that can handle variability of the market and remain effective.

5.2.1 Methodology of Model I (Expected Growth's Leading Effects)

The objective of this section is to illustrate how we design the research to determine the importance of expected rental income growth in real estate asset pricing, which is also the motivation of the whole study. With the help of Model I, our first hypothesis *the change of expected rental income growth of the real estate asset leads the changes of real estate asset price* will be tested.

It is the empirical observation on real estate market which motivates me to carry out this study to further explore the investor's expectation. Previous theories, including the DiPasquale-Wheaton (DW) Model, assumes housing price as a discounted sum of net future rent, and Lai and van Order (2010)modeled that property rent should lead its price. However, a large number of contrary evidence has been found in many different parts of the world, such that housing price leads rent. This study contends that the those models ignore the investors' expectations of rental income growths, and therefore it is hypothesized that the expected future rental income growth is determined, among others, by the discount rate, which is one of the key determinants of real estate asset price. One of the testable implications of this hypothesis is that the expected rental income growth should lead the real estate asset price growth. The empirical results of Model I suggest that investors' expectations on the future rent Granger caused the real estate asset price growth in several sectors of Hong Kong real estate market from Jan. 1999 to Apr. 2010.

This Model derives the theoretical contention by employing Gordon (1959)'s Growth Model, which allows expectation of rent growth to be incorporated in the pricing model. It is interesting to note that, the Gordon Growth Model is frequently mentioned in the previous research of real estate market though (such as, Gallin (2008), Clayton et al. (2009), Plazzi et al. (2010) and Lai and Van Order (2010)), the investor's expectation on the future cash-flow (rent) growth had been assumed to be equal to the real rent growth or a function of it (the detailed theoretical justifications are presented in Section 1 of Chapter 1). In other words, the effects of expected rental income growth on price growth have been ignored without an opportunity to be tested. In the light of this gap, this section aims to study the lead-lag relationship between real estate asset price growth and both expected and real rent growth of the real estate asset. The Granger Causality Test is employed to study the relationships.

<u>Granger Causality Test</u>

To test whether the property price growth *Pg*, leads its rent growth, *Rg*, the Granger causality test is running under the null hypotheses of no causality (i.e., β_{0i}=0 and β_{1i}=0) in the following bi-variate regressions:

$$P_t^c = \sum_{i=1}^{n} \alpha_{0i}^c P_{t-i}^c + \sum_{i=1}^{n} \beta_{0i}^c R_{t-i}^c + u_t^c \tag{5.13}$$

$$R_t^c = \sum_{i=1}^{n} \alpha_{1i}^c R_{t-i}^c + \sum_{i=1}^{n} \beta_{1i}^c P_{t-i}^c + v_t^c$$

$$P_t^c = \sum_{i=1}^{n} \alpha_{0i}^c P_{t-i}^c + \sum_{i=1}^{n} \beta_{0i}^c R_{t-i}^c + u_t^c \tag{5.14}$$

$$E[R]_t^c = \sum_{i=1}^{n} \alpha_{1i}^c E[R_{t-i}^c] + \sum_{i=1}^{n} \beta_{1i}^c P_{t-i}^c + v_t^c$$

where *n* represents to the optimal lag length, which is determined by an extensive search of the lag space as shown in section 7.4.

As the expected rental income growths derived under the model newly-built in Chapter 3 is the focus of this study, the investigations of the lead-lag relationship real estate asset price and rent growths are designed to be the Granger Causality tests:

Lead-lag relationship between real estate asset price growth and the movement of expected rental income growth derived under Term Structure Expected Growth Model in this study.

As demonstrated in Chapter 1 with our casual observation, the real estate asset price changes are expected to lead the movements of its actual rent. Further the expected rental income growths are expected to lead the changes of the real estate asset price. The casual observations in Chapter 1 partially reveal our motivation to develop this study while the expecting empirical results of Tests in Model I help illustrate the motivations clearly and completely. Meanwhile, our first hypothesis will be confirmed by the supportive empirical evidence from the expecting results of Model I. Our research question whether the investor's expected rental income growth would affect the real estate return will be answered with the investigation results and the importance to explore the relationship between the investor's expectation and real estate asset's price will be presented.

5.2.2Methodology of Model II

This section aims at illustrating how the research is designed to test the Application of the Hypothesis (H2) *the change of expected rental income growth has a positive correlation with the corresponding real estate price movement, ceteris paribus* in this study.

There is a great deal of research focusing on the links between real estate market returns and macroeconomic factors such as interest rates, inflation rates, and gross domestic production. However there are heterogeneous real estate asset trades on the private market, which is illiquid and highly segmented. Besides, the private real estate asset is not easy to be short-sold, which prohibits the smart investors to enter the market and eliminate the mis-pricing of the asset. All these characteristics seem to lead the private real estate asset's return to be explained by the investor (trader)'s expectation. Based on the Term Structure Expected Growth Model derived in Chapter 3, Model II re-examines the interest rate spread's effects on the real estate return. Moreover and more important, Model II will apply the Term Structure Expected Growth Model and Gordon Growth model in the same asset market (private real estate market in Hong Kong), and compare their empirical results to show the importance of the term structure of cost of capital.

The real estate market is an important part of both the nation's economy and the investors' portfolios. And there is a great deal of work focusing on the relationship between real estate market and macroeconomic events, such as the fluctuations in interest rates, inflation rates, and industrial production. Among those macroeconomic factors, the interest rate is the most volatile one and thus is regarded as a vital source of risk for the asset investments. However, there's surprisingly little research being performed on the impact of interest rate effects on the real estate asset pricing. Most of the existing ones are focused on the interest rate sensitivity of the securitized real estate return while few are investigating the co-movements of real estate asset price and the interest rate. Several pieces of work has been talking about the real estate return and interest rate, however most of them were focused on the interest rate sensitivity of real estate by considering interest rate as one of the risk factors in the multi-factor pricing models. Among them, few of empirical studies concerning the term structure of interest rate, except Ling and Naranjo (1997) and Sing (2004)'s work. However they had not explained why the interest rate spread had effect on the price movements of real estate asset yet.

The existing asset pricing theories in finance area, i.e. CAPM and APT, are mainly for valuing the equity which is frequently traded. The common point of both theories is the concerns of risk factors and beta. As the transaction needs to be frequent enough for estimating the beta while the selection of risk factors is not easy, neither theories is capable for the long-term holding asset, such as the property. Contrary to CAPM and APT, the DCF model, which discounts the future income into the present value of the asset, is more capable for pricing the long-term holding asset with transaction cost (i.e. the real estate asset). As the asset is held based on its income-producing feature, the future income and the cost for holding it become the key factor to explain the asset's value. For real estate asset, the future income refers to the future rent while the cost of capital should be market driven, expected rate of return that the market requires to commit capital to the property. Through the cost of capital, the property price is connected with the expected rate of return, which is usually equal to the government bond yield (interest rate).

The DCF model has been improved and re-constructed into Term Structure Expected Growth Model in Chapter 3. The model indicates that both the spread of interest rate and expected rental income growth would explain the movement of real estate return. Thus in this chapter, their effects on the real estate return will be demonstrated and empirically confirmed.

Notwithstanding its simplicity, the Term Structure Expected Growth Model makes it possible to explain the relationship between real estate and capital markets in a mathematically logical method that provided a first view of the issues involved. Besides, one of the implications of the Term Structure Expected Growth Model is to incorporate the expected rental income growth to explain the real estate return, which will be helpful for the valuation of real estate asset on private market.

The price of the real estate asset is expressed by the present rent income and interest rate, the expected growth of future rents and interest rate spread in the Term Structure Expected Growth Model. Following the logic of the model, this chapter provides the empirical investigation of its implication on the private real estate market. It extends the existed findings of the relationship between the term structure of interest rate and the return of real estate asset by investigating the investors' expectations on both future interest rate and rent of the real estate asset.

The empirical investigation is designed to be carried out with the data of Hong Kong private real estate market. The empirical model is expressed as:

$$Pg_t = \alpha_1 + \alpha_2 \times \hat{R}g_t + \alpha_3 \times d(Erg_t) + \alpha_4 \times d(i_t) + \alpha_5 \times d(S_t) + \varepsilon \qquad (5.15)$$

Where $\boldsymbol{Pg_t}$ refers to the capital return of property, $\hat{R}g_t$ and $\boldsymbol{d\,(Erg_t)}$ represent the estimated natural logarithm change of current rental income and the first differenced value of derived expected rental income growth of the property, $\boldsymbol{d\,(i_t)}$ and $\boldsymbol{d\,(S_t)}$ denote to differenced values of the cost of capital and the spread between long- and short-term costs of capital at quarter $\boldsymbol{t}$.

The price and rent changes of the real estate asset are calculated based on the price and rent indices, thus the multi-collinearity problem exits. To resolve the problem, the regression tests are conducted through two steps:

(1) the rent changes will be estimated based on real estate asset[33] rent dynamics model from previous studies;

$$\ln R_{0t} = \beta_0 + \beta_1 \times \Delta(RINT_t) + \beta_2 \times \Delta GDP_t + \beta_3 \times \Delta UNE_t + \phi_t \qquad (5.16)$$

[33] The research on office property rent dynamics is numerous, comparing to retail and industrial property. As the income of these three kinds of properties is all based on the rental, we postulate the the rent dynamics are the same among them. As for residential property rent changes, Blank and Winnick (1953) modeled the residential rent changes as a function of vacancy rate , which is not easy to trace with empirical data. Therefore in this study, we also assume the residential property rent shares the same dynamics with commercial properties.

It’s been at the heart of the real estate literature to explore the rent dynamics ever since 1950s when Blank and Winnick (1953) modeled the residential rent changes as a function of vacancy rate. Shilling et al. (1987) applied this model to explain the office rent changes in the United States. Also both Wheaton (1987) and Wheaton and Torto (1988) estimated the model for the aggregate office property market in US. For the research in European market, Hendershott et al. (2002) and Brounen and Jennen (2009) modeled the office rents and examined an international panel of cities with economic data.

In the previous theoretical research on rent dynamics, the influences are mainly divided into demand and supply aspects. Usually the supply side is proxied by the stock and vacancy rate while the demand side is usually proxied by several economic factors, including GDP or industrial production, employment rate, interest rate and inflation rate. Thus the research has become two streams with different focus dynamics. Considering the economic drivers (demand side) only, the previous findings acknowledged that the macroeconomic factors, such as GDP, inflation rate, interest rate and employment rate could influence the real estate rent changes (see Giussani et al. (1992)). In line with the previous study on rent dynamics from demand side, this study also estimates the rent changes with the acknowledged macroeconomic variables.

(2) the estimated movement of rent will be put into the private real estate return empirical model as one of the fundamental factors.

Therefore the rental factor in the empirical model (5.15) will be proxied by the estimated rental factor (from equation 5.16).

Model II will be tested with both Gordon Growth and Term Structure Expected Growth respectively. The comparisons between the results will reveal whether the Term Structure Expected Growth Model can predict the real estate return better with more information.

The regression tests will be carried out with the empirical data of each property sector one by one for robustness of the investigation. For each sector, the spot rent and expected rental income growth are expecting to positively affect the real estate return (price changes) while the real interest rate and interest rate spread are expected to be negative related to the return. The effects of three conventional factors (spot rent changes, real interest movements, and interest rate spread changes) had been confirmed in previous studies with empirical evidence from other countries. With the theoretical framework in this study, they are expected to be consistently supported with empirical data in Hong Kong. For the new factor in our model, the expected rental income growth, we expect it to have positive effect on the real estate returns (price changes). If so, our Application of the Hypothesis (H2) will be confirmed while the second research question why the expected rental income will affect the real estate return will be answered with both theoretical justification and empirical investigation.

5.2.3Methodology of Model III

The investigation of Model III tests the robustness of the theory in this study. The empirical examination of this section will answer our research question: how the investor's expected rental income growth affect the real estate return by testing our third hypothesis *the change of expected Rental Income growth of underlying real estate asset has positive correlation with the fluctuation of REIT's return, ceteris paribus* with empirical data from Hong Kong. The results can tell whether the REIT's return can be explained by the expected rental income growth of the corresponding private real estate assets, which suggests that public and private real estate are becoming closer substitute for each other. The theoretical model of this study had already explained why the investor's expectation on future rental income could affect the real estate asset's return. As the future rental income of the private real estate assets in REIT's portfolio is the major income of REIT's dividend, plus the dividend income had been confirmed to explain the equity's return, our theoretical model may imply that the investor's expectation on future rental income can also explain the related REIT's return. By testing this implication, our theory in this study will be empirically investigated again and the findings may indicate that the public and private real estate markets are linked by the investors' expectations, which implies that the information between public and private real estate markets is shared well.

This investigation presents a novel attempt on the exploration of the relationship between public and private real estate market by examining the dependence of REIT's return on the expected growth of yield on private real estate assets. To be more specific, this study argues that due to the dividend and investment portfolio regulations on REIT, its dividend, which is regulated to be 90% of the yield of the underlying property portfolio, would depend on the yield of the assets. In addition, by investing in a REIT, the investors would concern more on its dividend in the long term, so that, concern more on the future (expected) yield the REIT will gain from the real estate assets in its portfolio. Then the price of REIT will also change with the movement of the expected rental income on direct real estate market. Following this logic the return of REITs should be explained by the expected rental income growth of its property portfolio rather than capital or rental return of that.

The purpose of this investigation is to explore whether the returns of public real estate assets (REITs) can be affected by the expected rental income growth of property as hypothesized in the Term Structure Expected Growth Model with empirical data. To this end, we use total return index of REITs in Hong Kong market to proxy the returns of public real estate assets. As introduced in the fourth section of Chapter 1, there are seven REITs in Hong Kong market now. There are four REITs in Hong Kong selected to be included in the empirical test sample. Among all seven REITs in Hong Kong market, we choose these four ones because they (1) contain property asset in Hong Kong in their portfolios; (2) have been launched for relatively long time. As their portfolios are made up with different type of properties, the investors' expectations may differ among them. Thus in this study, we construct the empirical test model based on panel data sample. Besides, the panel data would help to resolve the problem caused by the small quantity of the observations. The following sub-sections will describe the empirical data and the methodology in detail, together with the analysis.

To build the empirical model, we borrowed the logic from Sharpe (1992)'s factor model and apply it here in this study.

1. Factor Model

Sharpe (1984) used the factor model, which describes the return generating process, to explain the equity returns. It assumes that the returns on equities are determinant by some economic factors, and the process is usually expressed as:

$$R_{it} = \sum_{n=1}^{n} b_{in} F_{nt} + \varepsilon_{it} \tag{5.17}$$

Where $\boldsymbol{R_{it}}$ refers to the $\boldsymbol{i^{th}}$ equity return at time t (i=1,2,……,I; t-1,2,……T), $\boldsymbol{F_{nt}}$ denote to the value of the nth factor at time t (n=1,2,……N), $\boldsymbol{b_{in}}$ represents the sensitivity or factor loading of the $\boldsymbol{i^{th}}$ equity to the nth factor, and $\boldsymbol{\varepsilon_{it}}$ is the random error term equal to zero expectedly.

Besides the error term ($\boldsymbol{\varepsilon_{it}}$) and the factors ($\boldsymbol{F_{nt}}$) are assumed to be uncorrelated and error terms ($\boldsymbol{\varepsilon_{it}}$) of two equities $\boldsymbol{h}$ and $\boldsymbol{i}$ are not correlated. Under these assumptions, the error term can be taken as the specific return of the equity which is not related to any factors.

1) Asset Class Factor Model

When specifying the factor model to the application on equities return analysis, the selection of factors on equity market cannot be neglected. The identification of the relevant factors that significantly influence the returns of equities is presented in this section.

As far as the portfolio management to be concerned, the manager would include both passive and active strategy when the decisions to be made. The passive strategy refers to the asset allocation policy that build the normal portfolio based on the common estimations of risk and return while the active strategy is presented by active asset allocation and equity selection with divergences from the common estimations of the normal asset and equity weights respectively. According to the assertion of style analysis, the asset policy is considered to be the major economic factors that affect the returns of portfolio. Therefore it will identify the asset classes, which is very important for asset allocation (i.e. stock, risk, and cash), as the only relevant factors. In this way, the factor model reviewed in above section (5.17) can explain the return of REITs, if $\boldsymbol{F_{nt}}$ denote to the value of the $\boldsymbol{n^{th}}$ asset class factor at time $\boldsymbol{t}$, $\boldsymbol{b_{in}}$ represents the sensitivity or factor loading of the $\boldsymbol{i^{th}}$ equity to the $\boldsymbol{n^{th}}$ asset class, and $\boldsymbol{\varepsilon_{it}}$ is the random error term equal to zero expectedly.

2. Factor Models for REITs

A general framework for the factor model has been established in above section. And it will be specifically applied to REITs, which has not been investigated in the previous studies. Thus the special characteristics of REITs will be accommodated in the style model of this study. We adopted the style model to analyze the REITs' return by taking advantage of the model that includes all factors without missing ones. The REITs Company is regulated to engage mainly on investment, which refers to a buy-and-hold strategy in which properties are purchased for long-term holding. Thus the rental income is the major source of REITs' income. The REITs property style model is constructed in this study to analyze the companies.

On the basis of equation 5.17, an implied REITs factor portfolio can be constructed to test whether the return of REITs companies can be closely replicated by the asset investment together with the real estate attribute as one of the factors. Chau et al. (2003) used to adopt this approach to explore the existence of pure property components. Based on their findings, we skip the ***non-property style model*** in this study but employ the REITs factor model which is similar with the ***property style model*** in their research. This approach is also in line with most previous studies in style analysis on real estate funds returns (see Myer and Webb (1996), Gallo et al. (2000) and Kallberg et al. (2000)). Also quantities of studies concluded that the property type has larger effect on property returns than geographical diversification (i.e. Lee and Byrne (1998) Lee (2001) and Glascock and Kelly (2007)), especially in Hong Kong (Brown et al. (2000)). Thus in this study, we divide the properties into four types: office, industrial, retail and residential property sectors; which is consistent with the categorization of the Department of Rating and Valuation in Hong Kong.

As the investment portfolio of REITs is regulated to be pure property investment, the asset class in the model for REITs analysis is much simpler. We constructed the REITs Style Model to analyze the $\boldsymbol{i^{th}}$ REIT's return at month $\boldsymbol{t}$ mathematically by:

$$R_{it} = b_{i1} \times HSI_t + b_{i2} \times BETA_t + b_{i3} \times RINT_t + b_{i4} \times Eg_{it} + \varepsilon_{it} \tag{5.18}$$

where $\boldsymbol{HSI_t}$ represents the return on Hang Seng Index, $\boldsymbol{BETA_t}$ and $\boldsymbol{RINT_t}$ refers to the risk premiums and the real interest rate, $\boldsymbol{Eg_{it}}$ denotes to the expected rental growth of the underlying property portfolio of the $\boldsymbol{i^{th}}$ REIT at month $\boldsymbol{t}$ (referring the calculation of equation (5.12)).

In this model, we employ the expected rental growth of property to proxy the property attribute for REIT's return instead of property price or rental indices because of the special feature of REITs' dividend distribution policy. The REIT's management policy requires the REITs to distribute to the unit holders as dividends an amount higher than 90% of the distributable income for each financial year. Thus we adopt the investor's expectation on rental growth of the property as the linkage between REITs and property market.

As the investigation in this section is aiming to explore whether the investor's expectation would affect the REIT's return, the REITs Factor Model here would relax the constraints on the factor loadings discussed in above section. The REITs Factor Model is employed to ensure that there will not be missing variable to determine the REIT's return, thus the constraints are not necessary in this study.

3. Empirical Model

Based on the REITs Factor Model (5.18), we construct the empirical model as:

$$\ln R_{i,t} = \alpha + \beta_{i1} \times \ln HSI_{i,t} + \beta_{i1} \times BETA_{i,t} + \beta_{i3} \times d(RINT_{i,t}) + \beta_{i4} \times d(Eg_{i,t}) + \varepsilon_{it} \quad (5.19)$$

where $\boldsymbol{R_{i,t}}$ denotes to the total return index of the $\boldsymbol{i^{th}}$ REIT at month $\boldsymbol{t}$; $\boldsymbol{HSI_{,t}}$, $\boldsymbol{RINT_{i,t}}$ and $\boldsymbol{BETA_{i,t}}$ refer to the return from general stock market, cash deposit and the risk premium at month $\boldsymbol{t}$; $\boldsymbol{Eg_{it}}$ represents the expected rental income growth the $\boldsymbol{i^{th}}$ REIT's portfolio at month $\boldsymbol{t}$ (referring the calculation of equation (5.12)).

As introduced above that the REITs market in Hong Kong, which was launched by the end of 2005, is still very young. Besides the number of selected REITs in our sample is only four, which is quite small. Thus we employ the panel regression model in this study rather than running regression model with time-series data for each REIT one by one. In statistics and econometrics, the term panel data refers to multi-dimensional data. Panel data contains observations on multiple phenomena observed over multiple time periods for the same firms or individuals. Time series and cross-sectional data are special cases of panel data that are in one-dimension only. Panel data analysis is employed in the tests because:

(1) The sample size in this investigation is very small. With the help of the repeated observations of each cross-sectional variable group in panel analysis, the dynamic changes of each variable will be better observed.

(2) With the combining observations of the different cross-sectional and time-series data, the multi-colinearity among the explanatory variables will be cut down, and therefore the testing results will be more reliable.

In the panel regression test, we will apply the fixed-effects specification on cross-sectional series, which means the specific features of each REIT will be considered.

CHAPTER 6 EMPIRICAL FINDINGS

This Chapter discusses the test results of the three hypotheses formulated in Chapter 1. The basic econometric tools, such as Granger Causality Test, Ordinary Least Square Regression Test with time-series and Panel data are adopted in this study. As they are considerably quantitative and complicated, Chapter 5 has already introduced them generally first and discuss their specific applications in testing the hypotheses subsequently. Thus in this chapter, the empirical results will be reported and interpreted following the sequence of the three hypotheses. Each section below presents the empirical models and results for hypothesis I, II and III respectively with descriptive statistics tables and graphics.

6.1 EMPIRICAL FINDINGS OF MODEL I

6.1.1 Empirical Results of Model I

6.1.1.1 Empirical Results of Model I-A

As introduced in Chapter 5, there are three Granger Causality Tests in Model I-A. we selected the lag-length of 2 and 4 in the tests.[34]

1. Granger Causality Test between price and rent

The empirical investigation results of the Granger Causality Test in Hong Kong real estate market and found that the price changes lead rent changes, which is inconsistent with the naive understanding of DW model, are exhibited in Table 6.1.

[34] According to Thornton and Batten (1985)'s research, there are two alternatives to a complete search of the lag space: (1) to identify the "appropriate" lag-length based on some statistical criterion or (2) to specify a few alternative lag structures (the most common are 4-4 and 8-8). In real estate research area, the most commonly used lags are 2-2 and 4-4. Thus we specified the lag structure as 2 and 4 here in our study. We empirically tested the lead-lag relationship in Model I with lag 1 to 8, which is provided in section 7.4 of Chapter 7 in detail. The direction of causality for each property sector is consistent.

Table 6.1: Granger Causality Tests on

the movements of price and rent indices

Sample objectives: four sectors of real estate market in Hong Kong

sample period: Jan. 1999 to Apr. 2010

Null Hypothesis:	F-Statistic at 2 lags	F-Statistic at 4 lags
OFFICE		
rent growth does not Granger Cause price growth	1.31	1.79
price growth does not Granger Cause rent growth	3.98**	3.43**
RETAIL		
rent growth does not Granger Cause price growth	0.59	2.55 **
price growth does not Granger Cause rent growth	7.51 ***	3.93 ***
INDUSTRIAL		
rent growth does not Granger Cause price growth	8.55 ***	4.41 ***
price growth does not Granger Cause rent growth	4.61 **	2.09*
RESIDENTIAL		
rent growth does not Granger Cause price growth	0.26	0.23
price growth does not Granger Cause rent growth	21.42***	13.01***

Notes:

**The null hypothesis can be rejected at the 10% level.*

***The null hypothesis can be rejected at the 5% level.*

****The null hypothesis can be rejected at the 1% level.*

The empirical results are listed in Table 6.1 with the monthly data sample during period of January 1999 through April 2010. They provide some inconsistent evidence with the argument indicated in 1st quadrant of DW model. The real estate price change leads the rent change in every property sector while the rent change leads the price change in the industrial property sector. We wonder why the real estate asset's price change is not caused by its rent change.

2. Granger Causality Test between price and expected rental income growth based on Gordon Growth Model

Following the theoretical derivation in Lai and Van Order (2010)'s work, the inconsistence shown in Table 6.2 motivates us to explore further the lead-lag relationship between real estate asset price and rent in the context of expectation. Same as the granger causality test on property price and rent growths, the lead-lag analysis between property prices and expected rent growths is carried out through similar process. The results are provided in Table 6.2a.

Table 6.2a: Granger Causality Tests on

the movements of price and expected rental income growth based on Gordon Growth Model

Sample objectives: four sectors of real estate market in Hong Kong

sample period: Jan. 1999 to Apr. 2010

	F-Statistic	
OFFICE		
Null Hypothesis:	at 2 lags	at 4 lags
expected rental income growth change does not Granger Cause price growth	0.19	0.05
price growth does not Granger Cause expected rental income growth change	0.15	0.61
RETAIL		
Null Hypothesis:	at 2 lags	at 4 lags
expected rental income growth change does not Granger Cause price growth	1.16	0.60
price growth does not Granger Cause expected rental income growth change	3.37**	1.27
INDUSTRIAL		
Null Hypothesis:	at 2 lags	at 4 lags
expected rental income growth change does not Granger Cause price growth	2.67*	1.83
price growth does not Granger Cause expected rental income growth change	0.19	0.56
RESIDENTIAL[35]		
Null Hypothesis:	at 2 lags	at 4 lags
expected rental income growth change does not Granger Cause price growth	0.02	0.29
price growth does not Granger Cause expected rental income growth change	1.43	0.90

[35] We also examined the lead-lag relationship between housing price and expected rental income growth based on Gordon Growth Model with five sub-classes for experiment. The results indicate that in subclass A, B, C the lead-lag relationship cannot be evidenced while in subclass D and E, the expected rental income growth leads the price changes.

Notes:

**The null hypothesis can be rejected at the 10% level.*

***The null hypothesis can be rejected at the 5% level.*

****The null hypothesis can be rejected at the 1% level.*

Based on Gordon Growth Model, the empirical findings cannot completely support the theory in Lai and Van Order (2010)'s work. Only the movements of expected rental income growth of industrial property lead its price changes. Meanwhile, in retail sector, the lead-lag relationship even seems to conflict with the theory. But the empirical findings cannot reject Lai and Van Order (2010)'s theory on the relationship between the expectation and property price. Thus we further improve Gordon Growth Model with an aim of deriving the expected rental income growth on a more accurate basis with market information.

3. Granger Causality Test between price and expected rental income growth based on Term Structure Expected Growth Model

As we had improved the Gordon Growth Model by considering the term structure of interest in the model. Thus here in this section, we will test our first hypothesis through the Granger Causality Test again with the expected rental income growth calculated based on our new model. Table 6.3a exhibits the empirical results of our test.

Table 6.3a: Granger Causality Tests on

the movements of prices and the expected rental income growths based on Term Structure Expected Growth Model

Sample objectives: four sectors of real estate market in Hong Kong

Sample period: January. 1999 to April. 2010

OFFICE

Null Hypothesis:	F-Statistic	
	at 2 lags	at 4 lags
expected rent growth does not Granger Cause price growth	**2.55***	**2.41***
price growth does not Granger Cause expected rent growth	3.11**	2.07*

RETAIL

Null Hypothesis:	F-Statistic	
	at 2 lags	at 4 lags
expected rent growth does not Granger Cause price growth	1.34	1.07
price growth does not Granger Cause expected rent growth	0.51	0.71

INDUSTRIAL

Null Hypothesis:	F-Statistic	
	at 2 lags	at 4 lags
expected rent growth does not Granger Cause price growth	**3.23****	**2.64****
price growth does not Granger Cause expected rent growth	1.38	1.85

RESIDENTIAL[36]

Null Hypothesis:	F-Statistic	
	at 2 lags	at 4 lags
expected rent growth does not Granger Cause price growth	0.74	1.28
price growth does not Granger Cause expected rent growth	4.56**	1.39*

Notes:

**The null hypothesis can be rejected at the 10% level.*

***The null hypothesis can be rejected at the 5% level.*

****The null hypothesis can be rejected at the 1% level.*

36 We also examine the lead-lag relationship between housing price and expected rental income growth based on Term Structure Expected Growth Model with five sub-classes for experiment. The results indicate that in subclass A,B,C the lead-lag relationship cannot be evidenced while in subclass D and E, the expected rental income growth leads the price changes.

6.1.1.2 Interpretations of the Empirical Results of Model I-A

With the help of tests in Model I, the first hypothesis of this study has been partially confirmed and the motivation of this study has been illustrated clearly with the empirical data in Hong Kong market. Both in office (Grade A) and industrial property sectors, the expected rental income growths' changes had been empirically evidenced to lead the movements of their prices. This would empirically confirm our first hypothesis that *the expected rental income growth of the real estate asset leads the changes of real estate asset price.* The results are consistent with Lai and Van Order (2010)'s theoretical work on the expectations. As stated in the chapter 1 and presented in chapter 5, the price changes empirically lead the rent changes in office property sector while the lead-lag relationship between price and rent changes is mutual in industrial property sector.

However the price changes empirically lead the movements of expected rental income growth in residential property sector while their lead-lag relationship is not evidenced to exist in retail property sector. The conflicting empirical result in residential property sector could be explained by the unique feature of residential property. As the residential property is not only an investment instrument but also one of the living requisite, its price changes might be different with other properties'. Besides there are also several substitutions for it in Hong Kong, such as the public housing for both purchasing and renting. These particular characteristics may cause the converse lead-lag relationship between the residential property price changes and its expected rental income growth movements. The unclear relationship in retail property sector may due to its special rental income scheme (percentage rent). In this way, the rental income of the retail property depends on not only the basic rents which the lender and tenants agreed, but also the percentage rent which the tenants produced.

As the Term Structure Expected Growth Model is the improved model of Gordon Growth Model, we compare the two here in the context of the lead-lag relationship with price growth. Table 6.4 exhibits the results.

Table 6.4 comparison between newly-derived expected rental income growth and Gordon growth

		Newly-derived expected growth	Gordon Growth
Whether the movements of expected rental income growth lead the real estate price changes	Office property (Grade A)	Yes	No
	Industrial property	Yes	Yes
	Retail property	No	No
	Residential property	No	No

Judging from the results exhibited in Table 6.4, the two sets of the expected rental income growths of the real estate assets have similar causal effects on the real estate price changes. Particularly, there is more empirical evidence confirming our first hypothesis in the investigation with the newly-derived growth than the Gordon Growth. The evidence indicates that two sets of the expected rent growths behave in similar style in office property sectors. In industrial property sector, the newly-derived expected rental income growth is empirically evidenced to lead the price changes while the Gordon Growth does not. In retail property sector, still the two sets of the expected rent growths behave similarly to each other that neither series has significant lead-lag relationship with price changes, which can be explained by the special rental scheme of retail property. In the residential property sector, the two series have different effects on price changes. The expected housing rent growth derived based on Gordon Growth Model is confirmed to Granger cause the housing price changes while the housing price changes is confirmed to Granger cause the expected housing rent growth movement derived by Term Structure Expected Growth Model. The situation of housing market is kind of complicated, especially in Hong Kong. First, there are five sub-classes of housing property on the market but only the average value of the 5 sub-classes are used in this section for the simplicity. Secondly, unlike the other three sectors, the housing property is usually purchased by the individual investors for either leasing or self-usage. The self-using individual investors may not be sensitive with the risk or rent changes because they shall not expect any income from the property they had purchased. In this sense, the housing property might not be an investment asset but consumption. Thus, the housing price change might not be Granger caused by the movement of the market expectations. Our experimental results of the Granger Causality Tests on 5 sub-classes housing property provide empirical evidence for this statement.

6.1.1.3 Empirical Results of Model I-B

As introduced in Chapter 5, there are three Granger Causality Tests in Model I-B.

1. Granger Causality Test between price and rent

The empirical investigation results of the Granger Causality Test in Hong Kong real estate market and found that the price changes lead rent changes, which is inconsistent with the simple understanding of DW model, are exhibited in Table 6.1. This will not be repeated in this section.

2. Granger Causality Test between price and expected rental income growth based on Gordon Growth Model

Similar with the corresponding part in Model I-A, the lead-lag analysis between property prices and expected rent growths based on Gordon Growth Model with risk premium is carried out here. The results are provided in Table 6.2b.

Table 6.2b: Granger Causality Tests on
the movements of price and expected rental income growth based on Gordon Growth Model with risk premium
Sample objectives: four sectors of real estate market in Hong Kong
sample period: Jan. 1999 to Apr. 2010

OFFICE		
Null Hypothesis:	F-Statistic	
	at 2 lags	at 4 lags
expected rental income growth change does not Granger Cause price growth	0.69	0.25
price growth does not Granger Cause expected rental income growth change	2.67^{*}	4.30^{***}
RETAIL		
Null Hypothesis:	F-Statistic	
	at 2 lags	at 4 lags
expected rental income growth change does not Granger Cause price growth	0.40	1.41
price growth does not Granger Cause expected rental income growth change	4.24^{**}	2.12^{*}
INDUSTRIAL		
Null Hypothesis:	F-Statistic	
	at 2 lags	at 4 lags
expected rental income growth change does not Granger Cause price growth	1.67	0.97
price growth does not Granger Cause expected rental income growth change	3.35^{**}	1.85

RESIDENTIAL[37]

Null Hypothesis:	F-Statistic	
	at 2 lags	at 4 lags
expected rental income growth change does not Granger Cause price growth	0.56	0.98
price growth does not Granger Cause expected rental income growth change	0.31	0.46

Notes:

**The null hypothesis can be rejected at the 10% level.*

***The null hypothesis can be rejected at the 5% level.*

****The null hypothesis can be rejected at the 1% level.*

Based on Gordon Growth Model, the empirical findings cannot support the theory in Lai and Van Order (2010)'s work. Meanwhile, the empirical findings cannot reject Lai and Van Order (2010)'s theory on the relationship between the expectation and property price. Thus we further improve Gordon Growth Model with an aim of deriving the expected rental income growth on a more accurate basis with market information.

[37] We also examined the lead-lag relationship between housing price and expected rental income growth based on Gordon Growth Model with five sub-classes for experiment. The results indicate that in subclass A, B, C the lead-lag relationship cannot be evidenced while in subclass D and E, the expected rental income growth leads the price changes.

3. Granger Causality Test between price and expected rental income growth based on Term Structure Expected Growth Model

As we had improved the Gordon Growth Model by considering the term structure of interest in the model. Thus here in this section, we will test our first hypothesis through the Granger Causality Test again with the expected rental income growth calculated based on our new model with risk premium. Table 6.3b exhibits the empirical results of our test.

Table 6.3b: Granger Causality Tests on
the movements of prices and the expected rental income growths based on Term Structure Expected Growth Model with risk premium

Sample objectives: four sectors of real estate market in Hong Kong

Sample period: January. 1999 to April. 2010

OFFICE

Null Hypothesis:	F-Statistic	
	at 2 lags	at 4 lags
expected rent growth does not Granger Cause price growth	**0.35**	**0.24**
price growth does not Granger Cause expected rent growth	5.48***	5.21***

RETAIL

Null Hypothesis:	F-Statistic	
	at 2 lags	at 4 lags
expected rent growth does not Granger Cause price growth	0.04	1.02
price growth does not Granger Cause expected rent growth	1.91	0.94

INDUSTRIAL

Null Hypothesis:	F-Statistic	
	at 2 lags	at 4 lags
expected rent growth does not Granger Cause price growth	**1.60**	**0.76**
price growth does not Granger Cause expected rent growth	0.07	0.98

RESIDENTIAL[38]

Null Hypothesis:	F-Statistic	
	at 2 lags	at 4 lags
expected rent growth does not Granger Cause price growth	0.11	0.80
price growth does not Granger Cause expected rent growth	0.23	0.13

Notes:

**The null hypothesis can be rejected at the 10% level.*

***The null hypothesis can be rejected at the 5% level.*

****The null hypothesis can be rejected at the 1% level.*

[38] We also examine the lead-lag relationship between housing price and expected rental income growth based on Term Structure Expected Growth Model with five sub-classes for experiment. The results indicate that in subclass A,B,C the lead-lag relationship cannot be evidenced while in subclass D and E, the expected rental income growth leads the price changes.

6.1.1.4 Interpretations of the Empirical Results of Model I-B

According to the empirical results of Model I-B, our first hypothesis cannot be either confirmed or rejected. As stated in Chapter 3, the risk premium of private real estate asset could be regarded as a limitation of this study. Although we employ the standard deviation of historical averages as its proxy, the measurement is not good enough. Thus the investigation of our first hypothesis cannot be clearly illustrated with the expected rental income growth based on the model with risk premium being considered.

6.2 EMPIRICAL FINDINGS OF MODEL II

6.2.1Empirical Results of Model II-A

1. Model II based on Term Structure Expected Growth Model

In this section, the investigation of Application of the Hypothesis (H2) is to construct the regression model and carry out the test with empirical data. On the basis of Term Structure Expected Growth Model constructed in this study (equation 6.1) , the property should be priced by the rental income and its expected growth, together with the cost of capital and its growth (term structure).

$$P=\frac{R}{(1+i)}+\frac{R\times(1+g)}{(1+i+\frac{S}{49})^{2}}+\frac{R\times(1+g)^{2}}{(1+i+2\times\frac{S}{49})^{3}}+\cdots+\frac{R\times(1+g)^{t-2}}{(1+i+(t-2)\times\frac{S}{49})^{t-1}}+\frac{R\times(1+g)^{49}}{(1+i+49\times\frac{S}{49})^{50}} \qquad (6.1)$$

Where ***P*** refers to the property price, ***R*** and ***g*** represent the current rental income and its expected future growth, ***i*** and ***S*** denote to the cost of capital and the spread between long- and short-term costs of capital.

In this study, the capital return series is found to be stationary and be the research objective; the expression above can be transferred to a growth function by getting the first difference of natural logarithm to both sides of equation (3.21):

$$d\log P=f(d\log R, d\log(1+g), d\log(i), d\log(S)) \qquad (6.2)$$

Based on this function, the empirical model process is constructed:

$$Pg_t=\alpha_1+\alpha_2\times\hat{R}g_t+\alpha_3\times d(Erg_t)+\alpha_4\times d(i_t)+\alpha_5\times d(S_t)+\varepsilon \qquad (6.3)$$

Where $\boldsymbol{Pg_t}$ refers to the capital return of property, $\hat{R}g_t$ and d (Erg_t) represent the estimated natural logarithm change of current rental income and the first differenced value of derived expected rental income growth of the property, $\boldsymbol{d\ (i_t)}$ and $\boldsymbol{d\ (S_t)}$ denote to differenced values of the cost of capital and the spread between long- and short-term costs of capital at quarter ***t***.

We run separate regressions for the quarterly data in four property sectors by applying OLS (Ordinary Least Square) model. The dependent variable in the model is the natural logarithm change of property price index, which is proxy of the capital return of property. Table 6.5a gives summary of the results of the OLS model with empirical data in Hong Kong real estate market.

Table 6.5a: Empirical Results of the Tests of Model II-A with Term Structure Expected Growth (A)

Dependent Variable: Pg_t

	Office -- Grade A		***Industrial***		***Retail***		***Residential***	
Explanatory Variable	*coeff. Value*	*t-value*	*coeff. Value*	*t-value*	*coeff. Value*	*t-value*	*coeff. Value*	*t-value*
$\hat{R}g_t$	0.8758	3.9238^{***}	0.4650	1.2497	1.1525	3.0954^{***}	0.7169	2.9959^{***}
$d(S_t)$	-64.1547	-4.3617^{***}	-26.7325	-2.4337^{**}	-67.4957	-5.2603^{***}	-94.4553	-4.9089^{***}
$d(Erg_t)$	36.4713	9.3005^{***}	26.1924	4.4377^{***}	33.0735	6.7988^{***}	43.0895	6.1089^{***}
$d(i_t)$	-2.1550	-3.0540^{***}	-1.4568	-1.9255^{*}	-3.0840	-4.9804^{***}	-3.4466	-4.3843^{***}
Adjusted R-squared	0.7434		0.4440		0.5989		0.5304	
Prob (F-statistics)	0.0000		0.0000		0.0000		0.0000	
Durbin-Watson stat	1.8462		1.9676		2.3619		2.0960	

***,**,* *significance at respective 1%, 5% and 10% level*

As presented in the Table 6.5a, the regression results are consistent with the simulations carried out in chapter 7 and confirm the Application of the Hypothesis (H2) that the investor's expectation on the property rent growth would affect the capital return of the property market. The signs of the coefficients for estimated dlog(Rent) and d (Expected rental growth) are positive and significant as expected while the coefficients for d(cost of capital) and d(spread) are negative and significant as hypothesized as well. The findings are consistent with the common sense on the real estate asset investment that the rising rent will be priced in the transaction of the property in a positive way.

2. Model II based on Gordon Growth Model

Accordingly, based on Gordon Growth Model, the property price growth can be expressed as a function by taking the first difference of natural logarithm of both sides of Gordon Growth Model:

$$d\log P = f(d\log R, d\log(1+g), d\log(i)) \quad (6.4)^{39}$$

Based on this function, the empirical model process is constructed:

$$Pg_t = \alpha_1 + \alpha_2 \times \hat{R}g_t + \alpha_3 \times d(Erg_t) + \alpha_4 \times d(i_t) + \varepsilon \quad (6.5)$$

Where $\boldsymbol{Pg_t}$ refers to the capital return of property, $\hat{R}g_t$ and $\boldsymbol{d\ (Erg_t)}$ represent the estimated natural logarithm change of current rental income and the first differenced value of derived expected rental income growth of the property, $\boldsymbol{d\ (i_t)}$ denotes to differenced values of the cost of capital at quarter ***t***.

We run separate regressions for the quarterly data in four property sectors by applying OLS (Ordinary Least Square) model. The dependent variable in the model is the natural logarithm change of property price index, which is proxy of the capital return of property. Table 6.6a gives summary of the results of the OLS model with empirical data in Hong Kong real estate market.

[39] Similar with the equation (3.27), the variable dlog(1+g) will be tested as dlog(g) for the ease of interpretation. Further as the g (expected rental income growth) is a percentage, we employ d(g) instead of dlog(g) to avoid the existence of the extreme small values of the variable.

Table 6.6a: Empirical Results of the Tests of Model II-A with Gordon Growth (A)

Dependent Variable: ***Pg_t***

	Office -- Grade A		***Industrial***		***Retail***		***Residential***	
Explanatory Variable	*coeff. Value*	*t-value*	*coeff. Value*	*t-value*	*coeff. Value*	*t-value*	*coeff. Value*	*t-value*
$\hat{R}g_t$	0.9148	4.0135***	0.6993	1.8129*	1.2987	3.9337***	0.8175	3.3379**
d(Erg_t)	68.9027	9.7087***	31.1979	3.4480***	62.9975	8.1867***	88.4381	6.0034***
d (i_t)	-5.5123	-7.2385***	-2.2873	-2.3195**	-5.5827	-7.8261***	-7.4656	-5.8418***
Adjusted R-squared	0.7177		0.3640		0.6773		0.5062	
Prob (F-statistics)	0.0000		0.0000		0.0000		0.0000	
Durbin-Watson stat	1.9287		2.0970		2.3871		2.2852	

***,**,* *significance at respective 1%, 5% and 10% level*

As presented in the Table 6.6a, the regression results are similar with the findings based on Term Structure Expected Growth Model and confirmed the Application of the Hypothesis (H2) that the investor's expectation on the property rent growth would affect the capital return of the property market. The signs of the coefficients for estimated dlog(Rent) and d (Expected rental growth) are positive and significant as expected while the coefficients for d(cost of capital) is negative and significant as hypothesized as well.

6.2.2 Empirical Results of Model II-B

1. Model II-B based on Term Structure Expected Growth Model (B)

The investigation in this section is similar with the corresponded part of Model II-A. We used separate regressions with the quarterly data in four property sectors by applying OLS (Ordinary Least Square) model. The dependent variable in the model is the natural logarithm change of property price index, which is proxy of the capital return of property. Table 6.5b gives summary of the results of the OLS model with empirical data in Hong Kong real estate market.

Table 6.5b: Empirical Results of the Tests of Model II-B with Term Structure Expected Growth (B)

Dependent Variable: Pg_t

	Office -- Grade A		***Industrial***		***Retail***		***Residential***	
Explanatory Variable	*coeff. Value*	*t-value*	*coeff. Value*	*t-value*	*coeff. Value*	*t-value*	*coeff. Value*	*t-value*
$\hat{R}g_t$	0.8537	3.5831***	0.5707	1.4480	1.1107	2.9342***	0.6695	2.6987**
$d(S_t)$	-75.0571	-5.3084***	-36.2402	-3.3986***	-66.0025	-5.2789***	-95.8117	-4.7742***
$d(Erg_t)$	33.8548	8.7686***	26.0433	4.1155***	30.8727	6.5032***	39.6616	5.5778***
$d(i_t)$	-2.9631	-8.3706***	-2.1881	-3.7314***	-2.7555	-6.5823***	-3.5410	-5.4570***
Adjusted R-squared	0.7125		0.4040		0.5846		0.4890	
Prob (F-statistics)	0		0		0		0	
Durbin-Watson stat	1.7673		1.9945		2.3231		2.0815	

***, **, * *significance at respective 1%, 5% and 10% level*

As an application of the Term Structure Expected Model, the empirical results presented in Table 6.5b are consistent with the pattern of the simulations carried out in Chapter 7. They are consistent with the common sense on the real estate asset investment that the rising rent will be priced in the transaction of the property in a positive way.

2. Model II-B based on Gordon Growth Model (B)

Accordingly, the investigation of this section is similar with the second part of Model II-A. We run separate regressions with the quarterly data in four property sectors by applying OLS (Ordinary Least Square) model. The dependent variable in the model is the natural logarithm change of property price index, which is proxy of the capital return of property. Table 6.6b gives summary of the results of the OLS model with empirical data in Hong Kong real estate market.

Table 6.6b: Empirical Results of the Tests of Model II-B with Gordon Growth (B)

Dependent Variable: Pg_t

	Office -- Grade A		***Industrial***		***Retail***		***Residential***	
Explanatory Variable	*coeff. Value*	*t-value*	*coeff. Value*	*t-value*	*coeff. Value*	*t-value*	*coeff. Value*	*t-value*
$\hat{R}g_t$	0.9213	4.1028***	0.7713	1.9727*	1.2970	3.8288 ***	0.7592	3.2428 ***
d(Erg$_t$)	68.1468	9.4683***	31.2756	3.5857***	61.7487	7.6966***	94.6896	6.2435***
d (i$_t$)	-5.6666	-9.2698 ***	-2.5024	-3.3029 ***	-5.2146	-7.7739***	-7.9783	-6.1880***
Adjusted R-squared	0.7156		0.3682		0.6536		0.5277	
Prob (F-statistics)	0		0		0		0	
Durbin-Watson stat	1.8767		2.1133		2.4859		2.2144	

***, **, * *significance at respective 1%, 5% and 10% level*

As presented in the Table 6.6B, the regression results are similar with the findings based on Term Structure Expected Growth Model (B).

The following section will interpret the empirical findings with details.

6.2.3Interpretations of the Empirical Results of Model II

1. ***Interpretations of the Empirical Results of Model II based on Term Structure Expected Growth Model (A &B)***

The explanatory variable “spread” shows the strong negative effects on the movement of property prices. According to the empirical results, a one-percentage increase in spread will cause a decrease of transaction price ranging from 26.73% to 94.46%. The effects reveal that when the difference between long- and short-term costs of capital (government bond yield) rises by 1%, the property transaction price will fall 26.73% to 94.46%. On one hand, from angle of economics in the relationship between demand and supply, the rise of spread means the cost of capital for longer period will increase or the cost for shorter period will decrease. Under this condition, the owner of the property would prefer to sell the property rather than holding it. In this way, the transaction price of property will decrease. On the other hand, the previous studies on the term structure of interest concluded that the spread of interest can forecast the anticipated future inflation. According to the expectation hypothesis of term structure, the long-term interest rates reflect expectations of future short-term interest rates and can be expressed simply as:

$$Y_2 = \frac{1}{2}(Y_1 + E(Y_1)) \qquad (6.6)$$

Where Y_2 denote the interest rate (yield to maturity) on a two-year bond; Y_1 denotes the interest rate on a one-year bond; $E(Y_1)$ denotes the expected interest rate next year on a one-year bond (the interest rate one year from now on a bond maturing two years from now).

Then we can have:

$$Spread = Y_2 - Y_1 = E(Y_1) - Y_2 \qquad (6.7)$$

If the spread increases, either the expected short-term bond yield increases or the long-term bond yield decreases. If short-term interest rates are in turn driven by inflation and the output gap, as in the Taylor rule, then the term structure of interest rates ought to reflect expectations of future inflation and the output gap. Thus the increased spread, which predicts the decreased future inflation, will logically lead to the fall of the property transaction price.

The effect of interest rate (short-term government bond yield) indicates that the negative relationship between the property transaction price and the short-term cost of capital. As suggested in the empirical results, a one-percent increase of interest rate will lead the property price decrease ranging from 1.46% to 3.45%. Though the relationship is weakly significant in industrial and residential property sectors, the income-oriented property sectors (office and retail properties) still provide empirical evidence to confirm that the interest rate (cost to hold the property) is priced in the transaction of property in a negative way. It reveals that when the cost of capital, which is the minimum cost to hold the property, raises by one percent, the property owner prefers to sell the property rather than holding it. Therefore the property price will tend to decrease.

The effects of the expectation variable are the most important and interesting findings of this study. Besides the estimated rent growth of the ($\hat{R}g_t$), the expected rental income growth of the property also affects the property price changes. The empirical results on the relationship between property price and expected rental growth are positively significant as expected. It concludes that a one-percent of increase in the expected rental growth of property will cause 26.04% to 43.09% increase of the property price. This indicates that the higher the investor expects the property rent will grow, the higher he/she will price the property.

Collectively speaking, the test results based on the empirical data presented in this section imply that:

- The change of property rent has positive correlation with the property price;
- The adjustments of either long-term or short-term government bond yields will cause the relative change of property price in a negative way;
- The expected rental income growth of property works on the property price change just like in a magnifier. A slight movement of expected rental growth will lead to large fluctuation of the property price.

Overall, the Term Structure Expected Growth Model provides a solid theoretical basis to explore the determinants of the capital returns of property market. As an application of Term Structure Expected Growth Model, Model II provides empirical results to support the Application of the Hypothesis (H2).

For the influence from varying property rents on the capital return of property, we examine it in a novel style with the estimations of the property rental change. The method we adopted in this study not only waives the interference from the multi-collinearity between the property rent and other variables but also makes the other macro-economic factors (i.e. GDP growth, unemployment rate, real interest rate) to be involved into the whole examination. Last but not least, the investor's expectation on the future rental growth of the property has been considered in the determining process of the property's capital returns for the first time.

As reviewed in Chapter 2, though the investor expectations or analyst prediction had been analyzed as one of the explanatory variables of the real estate returns, the expected rental growth of property derived based on theoretical model had not been explored before. This study not only constructs the model to derive the expected rental growth, but also empirically apply the expected growth to investigate how it affects the capital return of property. The regression model acts like a magnifier, which enlarges the property price's sensitivity on the change of expected rental growth of property. As suggested by the results, the capital return of property is very sensitive to the growth (either positive or non-positive) of the expected rental growth of property, which provides empirical evidence to support the Application of the Hypothesis (H2) implied from the model.

2. ***Interpretations of the Empirical Results of Model II based on Gordon Growth Model (A & B)***

The effect of interest rate (short-term government bond yield) indicates that the negative relationship between the property transaction price and the short-term cost of capital. As suggested in the empirical results, a one-percent increase of interest rate will lead the property price decrease ranging from 2.29% to 7.47%. Though the relationship is weakly significant in industrial and residential property sectors, the income-oriented property sectors (office and retail properties) still provide empirical evidence to confirm that the interest rate (cost to hold the property) is priced in the transaction of property in a negative way. It reveals that when the cost of capital, which is the minimum cost to hold the property, raises by one percent, the property owner prefers to sell the property rather than holding it. Therefore the property price will tend to decrease.

The effects of the expectation variable are the most important and interesting findings of this study. Besides the real growth of the property rent, the expected rental income growth of the property also affects the property price changes. The empirical results on the relationship between property price and expected rental growth are positively significant as expected. It concludes that a one-percent of increase in the expected rental growth of property will cause 31.20% to 94.69% increase of the property price. This indicates that the higher the investor expects the property rent will grow, the higher he/she will price the property.

Collectively speaking, the test results based on the empirical data presented in this section imply that:

- The change of property rent can affect the property price in a positive way;
- The adjustments of short-term government bond yields will cause the relative change of property price in a negative way;
- The expected rental income growth of property works on the property price change just like in a magnifier. A slight movement of expected rental growth will lead to large fluctuation of the property price.

3. Comparison between the results of two models

As the Term Structure Expected Growth Model is the improved model of Gordon Growth Model, we compare the two here in Table 6.7.

Table 6.7 comparison between Term Structure expected rental income growth and Gordon growth

		Term Structure expected growth	Gordon Growth
Magnitudes of the expectation's impact on property price growth	Office property (Grade A)	36.47% (A) 33.85%(B)	68.90%(A) 68.15%(B)
	Industrial property	26.19%(A) 26.04%(B)	31.20%(A) 31.28%(B)
	Retail property	33.07%(A) 30.87%(B)	63.00%(A) 61.75%(B)
	Residential property	43.09%(A) 39.66%(B)	88.44%(A) 94.69%(B)

According to Table 6.7, we can find that without considering the impact of term structure, the effect of expected rental income growth would be almost 2 times larger on the property price growth. Although Gordon Growth is supported to have impact on the property price growth, the predicting accuracy is doubtable.

To show the advantage of Term Structure Expected Growth, we further conduct a critical test in Chapter 7. The empirical results of the critical test indicate that with when the term structure changes, the bias of ignoring it will be found from the expected rental income growth's effect on real estate asset's capital return (price growth).

6.3 EMPIRICAL FINDINGS OF MODEL III

6.3.1 Empirical Results of Model III-A

(1) Factor Model for REITs

A general framework for the factor model has been established in Chapter 5. And it will be specifically applied to REITs, which has not been investigated in the previous studies. Thus the special characteristics of REITs will be accommodated in the factor model of this study. We adopted the factor model to analyze the REITs' return by taking advantage of the model that includes all factors without missing ones. The REITs Company is regulated to engage mainly on investment, which refers to a buy-and-hold strategy in which properties are purchased for long-term holding. Thus the rental income is the major source of REITs' income. The REITs property style model is constructed in this study to analyze the companies.

An implied REITs style portfolio can be constructed to test whether the return of REITs companies can be closely replicated by the asset investment together with the real estate attribute as one of the factors. Chau et al. (2003) used to adopt this approach to explore the existence of pure property components. Based on their findings, we skip the ***non-property style model*** in this study but employ the REITs factor model which is similar with the ***property style model*** in their research. This approach is also in line with most previous studies in style analysis on real estate funds returns (see Myer and Webb (1996), Gallo et al. (2000) and Kallberg et al. (2000)). Also quantities of studies concluded that the property type has larger affect on property returns than geographical diversification (i.e. Lee and Byrne (1998); Lee (2001) and Glascock and Kelly (2007)), especially in Hong Kong (Brown et al. (2000)). Thus in this study, we divide the properties into four types: office, industrial, retail and residential; which is consistent with the categorization of the Department of Rating and Valuation in Hong Kong.

As the investment portfolio of REITs is regulated to be pure property investment, the asset class in the model for REITs analysis is much simpler. We constructed the REITs Factor Model to analyze the $\boldsymbol{i^{th}}$ REIT's return at month $\boldsymbol{t}$ mathematically by:

$$R_{it} = b_{i1} \times HSI_t + b_{i2} \times BETA_t + b_{i3} \times RINT_t + b_{i4} \times Eg_{it} + \varepsilon_{it} \qquad (6.8)$$

where $\boldsymbol{HSI_t}$ represents the return on Hang Seng Index, $\boldsymbol{BETA_t}$ and $\boldsymbol{RINT_t}$ refers to the market risk premiums and the real interest rate, $\boldsymbol{Eg_t}$ denotes to the expected rental growth of the underlying property portfolio of the $\boldsymbol{i^{th}}$ REIT at month $\boldsymbol{t}$ (referring the calculation of equation (5.12)).

In this model, we employ the expected rental growth of property to proxy the property attribute for REIT's return instead of property price or rental indices because of the special feature of REITs' dividend distribution policy. The REIT's management policy requires the REITs to distribute to the unit holders as dividends an amount higher than 90% of the distributable income for each financial year. Thus we adopt the investor's expectation on rental growth of the property as the linkage between REITs and property market.

As the investigation in this section is aiming to explore whether the investor's expectation would affect the REIT's return, the REITs factor model here would relax the constraints on the factor loadings discussed in above section. The REITs Factor Model is employed to ensure that there will not be missing variable to determine the REIT's return, thus the constraints are not necessary in this study.

(2) Empirical Model

Based on the REITs Factor Model (6.8), we construct the empirical model as:

$$\ln R_{i,t} = \alpha + \beta_{i1} \times \ln HSI_{i,t} + \beta_{i1} \times BETA_{i,t} + \beta_{i3} \times d(RINT_{i,t}) + \beta_{i4} \times d(Eg_{i,t}) + \varepsilon_{it} \quad (6.9)$$

where $\boldsymbol{R_{i,t}}$ denotes to the total return index of the $\boldsymbol{i^{th}}$ REIT at month $\boldsymbol{t}$; $\boldsymbol{HSI_{i,t}}$, $\boldsymbol{RINT_{i,t}}$ and $\boldsymbol{BETA_{i,t}}$ refer to the return from general stock market, cash deposit and the risk premium at month $\boldsymbol{t}$; $\boldsymbol{Eg_{i,t}}$ represents the expected rental income growth the $\boldsymbol{i^{th}}$ REIT's portfolio at month $\boldsymbol{t}$.

As introduced in Chapter 1 that the REITs market in Hong Kong, which was launched by the end of 2005, is still very young. Besides the number of selected REITs in our sample is only four, which is quite small. Thus we employ the panel regression model in this study rather than running regression model with time-series data for each REIT one by one.

(3) Empirical Results

The regression is run with the monthly data of four REITs applying panel model. The dependent variable in the model is the natural logarithm change of property total return index, which is a proxy of the total return of REIT. Table 6.8a gives summary of the results of the Panel regression model with empirical data in Hong Kong public real estate market.

Table 6.8a: Empirical Results of Panel Regression Test of Model III-A

Dependent Variable: $\boldsymbol{ln\_R_{i,t}}$

Variables	**coeff. Value**	**t-value**
$\boldsymbol{ln\_HSI_{i,t}}$	0.5871	9.9402***
$\boldsymbol{BETA_{i,t}}$	-0.0006	-2.7157**

d(INT$_{i,t}$)	-3.6393	-3.0997***
d(Eg$_{i,t}$)	17.3351	2.8342***
Adjusted R-squared	0.4443	
Prob(F-statistics)	0.0000	
Durbin-Watson stat	1.5636	

***,**,* *significance at respective 1%, 5% and 10%*

6.3.2 Empirical Results of Model III-B

As same as Model III-A, the regression of Model III-B is run with the monthly data of four REITs applying panel model. The dependent variable in the model is the natural logarithm change of property total return index, which is a proxy of the total return of REIT. The expected rental growth of each REIT's portfolio is calculated based on Term Structure Expected Growth Model with risk premium being considered. Table 6.8b gives summary of the results of the Panel regression model with empirical data in Hong Kong public real estate market.

Table 6.8b: Empirical Results of Panel Regression Test of Model III-B

Dependent Variable: ln_R$_{i,t}$

Variables	**coeff. Value**	**t-value**
ln_HSI$_{i,t}$	0.4921	10.4713***
BETA$_{i,t}$	-0.0007	-10.1033***
d(INT$_{i,t}$)	-3.7086	-4.0723***
d(Eg$_{i,t}$)	3.1306	1.9384*

Adjusted R-squared	0.5253
Prob(F-statistics)	0.0000
Durbin-Watson stat	1.4496

***,**,* significance at respective 1%, 5% and 10%

6.3.3 Interpretations of the Empirical Results of Model III

As presented in the Table 6.6, the regression results provide empirical evidence to confirm our hypothesis that the investor's expectation on the property rental growth can affect the REITs return. The signs of the coefficients for estimated ***ln_HSI*** and ***⊿ (Expected rental income growth)*** are positive and significant as expected while the coefficients for ***BETA*** are negative and significant as hypothesized as well. The results show that the factor of ***⊿ (RINT)***, which denotes to the asset class of cash, is negatively significantly related to the REITs return. The regression results can be expressed in the following equation for REITs returns:

$$\ln\_R_{i,t} = -0.0038 + 0.5871 \times \ln\_HSI_{i,t} - 0.0006 \times BETA_{i,t} - 3.6393 \times \Delta(RINT_{i,t}) + 17.3351 \times \Delta E(g)_{i,t} + \varepsilon \quad (6.10)$$

Or

$$\ln\_R_{i,t} = -0.0036 + 0.4921 \times \ln\_HSI_{i,t} - 0.0007 \times BETA_{i,t} - 3.7086 \times \Delta(RINT_{i,t}) + 3.1306 \times \Delta E(g)_{i,t} + \varepsilon \quad (6.11)$$ [40]

According to the result of Model III-A, the effects of a one-percentage increase in Hang Seng Index will lead to a 0.59% increase of total return of REIT. Although the explanatory variable "risk premium" shows the negative effects on the movement of REIT return, a one-percentage increase in spread will barely cause the change of REIT return. The effect of interest rate (asset class of cash) indicates that the relationship between the REIT return and the interest rate cannot be confirmed. The effects of the expectation variable are the most important findings of this study. Besides all other factors among the asset classes, the expected rental growth of property show strong positive influence on the change of REIT return. According to the empirical results, a one-percent increase in the investor's expectation on the income growth of REIT portfolio (underlying properties) will lead to 17.34% increase of the total return of REIT. The linkage between REITs and direct real estate markets has been confirmed to be the expected rental income growth of the underlying real estate assets. And the gearing effects of the investor's expectation on the rental income growth are confirmed by the empirical evidence as well.

According to the result of Model III-B, the effects of a one-percentage increase in Hang Seng Index

[40] Equation 6.11 exhibits the empirical implication of Model III-B while Equation 6.10 exhibits the empirical implication of Model III-A.

will lead to a 0.49% increase of total return of REIT. Although the explanatory variable “risk premium” shows the negative effects on the movement of REIT return, a one-percentage increase in spread will barely cause the change of REIT return. The effect of interest rate (asset class of cash) is supported to be negative on REIT’s return. The effects of the expectation variable are the most important findings of this study. Besides all other factors among the asset classes, the expected rental growth of property show strong positive influence on the change of REIT return. According to the empirical results, a one-percent increase in the investor’s expectation on the income growth of REIT portfolio (underlying properties) will lead to 3.13% increase of the total return of REIT. The linkage between REITs and direct real estate markets has been confirmed to be the expected rental income growth of the underlying real estate assets.

Collectively speaking, the test results based on the empirical panel data in this section imply that:

- As a type of public traded securities on the stock exchange board, REITs’ returns move together with the general stock market movements;
- In the context of the risk premium for each REIT, the relationship between the risk premium and the return is confirmed to be significant;
- The real interest rate, which is the proxy of cash as one of the asset classes, is evidenced to be related to the REITs’ returns;
- The expected rental income growth of REIT’s portfolio is empirically confirmed to affect the REIT’s return strongly.

Overall, the linkage between indirect (REITs) and direct real estate markets is confirmed to be the expected rental income growth of REIT’s portfolio. The empirical results support the Hypothesis III about the price discovery process between the two markets. The REITs’ returns would change with the investors’ expectations on the income growth of the underlying portfolios.

6.4 CONCLUDING REMARKS

With the empirical data from Hong Kong real estate market, the research designed in Chapter 5 has been conducted in this chapter. The empirical findings of the three methods provide plenty of evidence to confirm our hypotheses presented in Chapter 1. Table 6.9 presents the brief framework of our empirical investigations of the three hypotheses.

Table 6.9 Brief Framework of Empirical Investigations of the Hypotheses

	Reason	Method	Data	Results
H1: ***The change of expected rental income growth of the real estate asset leads the changes of real estate asset price***	◆ The motivation of this study; ◆ Theoretically derived from Lai and Van Order (2010)'s work	Granger Causality Tests on all property sectors	◆ Monthly data from Jan 1999 to Apr 2010 ◆ Growths of price index, rent index and expected rental income growth based on both Gordon Growth Model and Term Structure Expected Growth Model	Hypothesis has been partially confirmed
APPLICATION OF THE HYPOTHESIS (H2): ***The change of expected rental income growth has a positive correlation with the corresponding real estate price movement, ceteris paribus***	an application of term structure expected growth model on private real estate market	Regression Tests on all property sectors	◆ Quarterly data from 2nd quarter of 1999 to 1st quarter of 2010 ◆ Growths of price index and expected rental income growth based on Term Structure Expected Growth Model; estimated rent growth, GDP growth, unemployment rate, real interest rate, government bond spread, short-term bond yield rate	Hypothesis has been confirmed
H3: ***The change of expected rental income growth of the underlying real estate asset has positive correlation with the fluctuation***	empirical test of term structure expected growth model on public real estate market without the	Panel Regression Tests of 4	◆ Monthly data from Nov 2005 to Apr 2010 ◆ Four selected REITs as the cross-sectional sample	Hypothesis has been confirmed

of REIT's return, ceteris paribus	limitations from private market	selected REITs	◆ REIT's total return, beta, general stock market return, real interest rate, expected REIT's portfolio income growth

Based on the price and rent indices and the calculated expected rental income growth of real estate asset in Hong Kong, lead-lag relationships between price and rent are explored. The findings indicate that it is the expected rent growth but not the actual rent lead the movement of real estate asset price. The hypothesis that the fundamental value of real estate asset increases based on the investor's expectation on future rent has been confirmed. The supplement of expected rent growth could refine the understanding of the DW model to be more closed to the real world. Therefore, the importance of the investigation of investor's expectation on future rent growth of real estate asset has been presented with detailed empirical observations by Model I. Meanwhile, with the help of the comparison and further granger causality test, the newly-derived expected rent growth of real estate asset is evidenced to be the most proper indicator to present the investor's expectation.

Model II illustrates the application of the Term Structure Expected Growth Model in practice and compares it with the practical application of Gordon Growth Model. It is implied that the investors' expectations are not only the econometric forecasts or the survey reports but also can be captured by combining the asset and capital markets. As the Term Structure Expected Rental Growth has better correlation than Gordon Growth with the property price growth, the practical applications of both models aimed at elaborating the relationships in detail.

The implication of the Term Structure Expected Growth Model on the effect of interest rate spread on the real estate return has also been examined and supported. The findings are consistent with previous work on the relationship between real estate return and interest rate spread. However, this study investigates and confirms the hypothesis based on a more solid theoretical background.

Model III examines the third hypothesis based on the implication of Term Structure Expected Growth Model in this study. The investigation examines the robustness of our theory about the Term Structure Expected Growth Model. The empirical results show that the linkage between REITs and private real estate market lies not in the actual appreciations or rent growths of the properties but in their expected rental income growths. This can be explained by the unique feature of constitute of REITs portfolio and the dividends distribution regulation mentioned above in the paper. The findings in this chapter not only reveal the price discovery process between public and private real estate market, but also present a new fundamental to explain the fluctuations of the public real estate market.

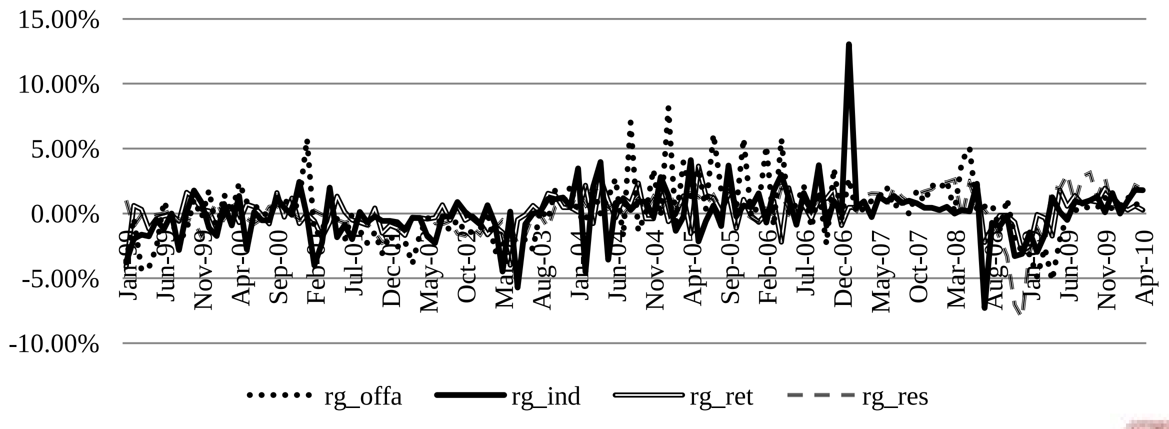
CHAPTER 7 SUPPLEMENTARY TESTS

7.1 RELATIONSHIP TESTS BETWEEN EXPECTED AND REAL RENTAL INCOME GROWTHS

Considering the term structure of interest into the Expectation Model is a novel try. And it is difficult for now to test whether the derived expectation is the market expectation. So here in this section, we compare the derived expected rental income growth with the real rent growth to investigate the relationship between them.

Comparing to the expected rental income growths (Figure 4.6), the movements of real rental growths of real estate assets are more volatile. Figure 7.1 exhibits their movements based on the rental index of each property sector in Hong Kong.

Figure 7.1 the Movements of Real Rent Growth of Real Estate Asset in Hong Kong, January,1999 -- April,2010
Note: rg refers to the actual rent growth of the real estate asset; offa, ind, ret and res represent the office-Grade A, industrial, retail and resid



Remarks: the rent index is available from the Rating and Valuation Department, Hong Kong SAR at http://www.rvd.gov.hk/en/publications/pro-review.htm

Sources: the Rating and Valuation Department, Hong Kong SAR

The derived expected rent growth of properties in each sector are derived in this chapter and reproduced here together with the actual rental growth of them for comparison (Figure 4.6 & Figure 7.1). Although the variances of the derived expected rent growth series are smoother than the actual ones, the changing directions of them are almost the same. The graphs (Figure 4.6 & Figure 7.1) show the general picture of the relationship between the actual and derived expected rental income growth of property in each sector respectively. However the magnitude of the difference between the two series is high (almost 10 times), which makes their relationship confusing. Luckily some other observations with statistical angle are helpful for deeper understanding on that.

First of all, Table 7.1 describes the summary statistics of the data used in this section.

Table 7.1 Descriptive Statistics of the Monthly Growth of HONG KONG Direct Real Estate Market, 1999 January – 2010 April

Note: ***OFF, IND, RET*** *and* ***RES*** *refer to the four sectors of Hong Kong real estate market, namely office (Grade A), industrial, retail and residential (all classes) respectively.*

Erg *denotes derived expected rental growth of the property while* ***RG*** *denotes the actual rental growth of the property. Both series are monthly rate.*

	Erg_OFF	***Erg_IND***	***Erg_RET***	***Erg_RES***
Mean	0.22%	-0.35%	0.11%	0.32%
Median	0.20%	-0.38%	0.10%	0.33%
Maximum	0.57%	0.16%	0.41%	0.58%
Minimum	-0.16%	-0.81%	-0.11%	0.01%
Std. Dev.	0.16%	0.26%	0.11%	0.13%
Sum	0.2940	-0.4765	0.1553	0.4368
Sum Sq. Dev.	0.0003	0.0009	0.0002	0.0002
Observations	136	136	136	136
	RG_OFF	***RG_IND***	***RG_RET***	***RG_RES***
Mean	0.21%	0.00%	0.11%	0.11%
Median	0.06%	0.10%	0.12%	0.20%

Maximum	8.15%	13.05%	3.64%	3.13%
Minimum	-5.16%	-7.30%	-4.13%	-8.05%
Std. Dev.	2.34%	2.12%	1.20%	1.58%
Sum	0.2808	0.0053	0.1452	0.1556
Sum Sq. Dev.	0.0739	0.0608	0.0196	0.0336
Observations	136	136	136	136

Remarks:

The expected rental income growth for each property sector is captured based on the Term Structure Expected Growth Model derived in this study;

The actual rent growth for each property sector is calculated based on the rent index of each sector, which can be accessed from Rating and Valuation Department, Hong Kong SAR government.

In this section, the relationship between actual and derived expected rental income growth of property is analyzed in five steps as follows:

<u>Step 1 Stationarity Test</u>

Usually many economic time series exhibit non-stationary properties, which can be verified by unit root test. If a time-series of data's mean and auto-covariance do not depend on time, it is said to be stationary while when either of the two conditions is violated, the series is said to be non-stationary.

Both series of actual and derived expected rental growth of property in each sector are tested in this section and the results are exhibited in Table 7.2.

Table7.2 The Results of Unit Root Tests on Real and Derived Expected Rental Growth of Property

(level and 1st differenced) (sample period: January 1999 –April 2010)

***Note: OFF, IND, RET** and **RES** refer to the four section of Hong Kong real estate market, namely office (Grade A), industrial, retail and residential (average of all classes) respectively.*

***Erg** denotes derived expected rental growth of the property while **RG** denotes the actual rental growth of the property. Both series are monthly rate.*

	level	1st differenced
Erg_off	-2.33	-10.69*
Erg_ret	-1.94	-10.17*
Erg_ind	-0.26	-12.10*
Erg_res	-2.28	-10.71*
RG _off	-3.15**	-15.31*
RG _ret	-5.93*	-10.99*
RG _ind	-11.21*	-12.87*
RG _res	-4.64*	-15.48*

***Remarks**:*

1. *Including 135 observations for period from January, 1999 to April, 2010.*
2. ** indicates that the null hypothesis can be rejected at the 1% level;*
3. *** indicates that the null hypothesis can be rejected at the 5% level*

According to Table 7.2, the four time-varied series of derived expected rental growth of property are not stationary on level while stationary after first-differenced. For the actual rental growth of property, they are all stationary on level data. Thus all series are stationary data on first differenced basis, and the next step of Johansen Cointegration Test can be induced on the series.

Step 2 Johansen Cointegration Test

As the series of derived expected rental growth are not stationary at level data, we need to test the cointegration relationship between the real and derived expected rental growth of property to explore their relations. In statistics, the cointegration tests indicate the presence of the stable long-term relationships. In general, linear combinations of non-stationary time series would be still non-stationary. However, by bounding together with some long-run equilibrium forces, some linear combinations of those variables could be stationary, which has already predicted by economic theories. Thus when the economic theory is valid, the variables among the combination would not wander too far away from each other. In this study, the actual and derived expected rental income growths of property are linked together and the expected series are nonstationary according to the unit root test results in last section. However, as they share the same underlying market fundamentals together in theory, they could be combined together by the common fundamentals.

Johansen (1988)'s Cointegration Test is one of the existing methods with several desirable properties, such as the fact that all variables in the test are treated as endogenous variables[41]. The detailed results of cointegration test on each pair of expected rental income growth and price change of property are reported in Table 7.3.

Table 7.3 Unrestricted Cointegration Rank Test (Trace)

On each pair of real and expected rental income growth of property

Note: OFF, IND, RET and RES refer to the four section of Hong Kong real estate market, namely office (Grade A), industrial, retail and residential property sector respectively.

Erg denotes derived expected rental growth of the property while RG denotes the real rental growth of the property. Both series are monthly rate.

	hypothesized # of C.E.'s	***Erg****_off vs. RG_off*	***Erg****_ind vs. RG_ind*	***Erg****_ret vs. RG_ret*	***Erg****_res vs. RG_res*
trace statistic	*none*	30.5157	49.0416	45.7484	19.8213
	at most 1	7.3116	0.0521	5.9082	4.3098
0.05 critical value	*none*	15.4947	15.4947	15.4947	15.4947
	at most 1	3.8415	3.8415	3.8415	3.8415
prob.	*none*	0.0001	0.0000	0.0000	0.0104
	at most 1	0.0068	0.8194	0.0151	0.0379

**Remarks: including 134 observations for period from 1999 January to 2010 April.*

The cointegration test results indicate that at 0.05 critical values, there is cointegration relationship existing between real and derived expected rental growth of property. Thus the

41 *Note: for further discussion of Johansen's (1988) cointegration test and its advantages, please see Gonzalo (1994).*

long-term equilibrium relationship between real and expected rental income growth is empirically confirmed to be existed.

<u>Step 3 Granger Causality Tests</u>

The Granger Causality Test is carried out in this section in order to assess whether there is any potential predictability power of derived expected rental income growth to actual one. The tests results are provided in Table 7.4 with analysis.

Table 7.4 Granger Causality Test between real and derived expected rent growth of property

*Note: **OFF, IND, RET** and **RES** refer to the four section of Hong Kong real estate market, namely office (Grade A), industrial, retail and residential (all classes) respectively.*

***Erg** denotes derived expected rental growth of the property while **RG** denotes the actual rental growth of the property. Both series are monthly rate.*

Null hypothesis	***RG** does not Granger Cause **Erg***		***Erg** does not Granger Cause **RG***	
	F-statistics	prob.	F-statistics	prob.
off	0.4888	0.6145	5.8193	0.0038
ind	3.4075	0.0361	4.6772	0.0109
ret	0.1249	0.8827	4.2102	0.0169
res	1.5724	0.2115	6.5497	0.0020

**Remarks: including 134 observations for period from January 1999 to April 2010.*

According to the results of the Granger Causality Tests, the predicting power of expected rental growth on actual one can be confirmed in four sectors of real estate market while that of actual growth on expected one cannot be confirmed. This is consistent with finding of previous studies on equity research in finance area that the expected dividend growth has effect on equity return. Also the results are evidence supporting the logic of this study that the investors' expectations on future earnings growth can move the investment market.

Step 4 Test for Equality

The tests for equality (t-test) are employed to observe the equality of mean, median and variance between the series of actual and derived expected rental growth of real estate asset.

A t-test is a type of statistical hypothetical test. In a t test, if the null hypothesis is supported, the test statistics would follow the Student's t distribution. It was introduced in 1908 by Gosset (1908), who devised the t-test as a way to monitor the quality of stout.

The explicit expressions that can be used to carry out t-tests are given below. In this section, only the t-test between two sample with equal sample sizes and variances is demonstrated. This is the most suitable one used in this study.

The test is only used when both samples have

(1) equal sample size (that is the number of the observations, *n*);

(2) it can be assumed that the two distributions have the same variance.

The t statistic to test whether the means are different can be calculated as follows:

$$t = \frac{\overline{X}_1 - \overline{X}_2}{S_{x_1 x_2} \times \sqrt{\frac{2}{n}}} \qquad (7.1)$$

where, $$S_{x_1 x_2} = \sqrt{\frac{1}{2} \times (S^2{}_{x_1} + S^2{}_{x_2})} \qquad (7.2)$$

and $S_{x_1 x_2}$ is the grand standard deviation, *1* refers to series *1* while *2* refers to series *2*. The denominator of *t* is the standard error of the difference between two means. For significance testing, the degrees of freedom for t-test is *2n-2*, where *n* is the number of observations in each series.

Once a *t* value is determined, a *p*-value can be found using a table of values from Student's *t*-distribution. If the calculated *p*-value is below the threshold chosen for statistical significance (usually the 10%, the 5%, or 1% level), then the null hypothesis is rejected in favor of the alternative hypothesis.

The tests for equality are employed in this section to observe the equality of mean, median and variance between the series of actual and derived expected rental growth of property. The results listed in Table 7.5, 7.6 and 7.7 provide the statistics relationship between the two series of data.

Table 7.5 Test for Equality of Means between Real and Derived Expected Rental Growth

Sector/method	*t-test*	*Satterthwaite-Welch t-test*	*Anova F-test*	*Welch F-test*
industrial	0.0544	0.0544	0.0544	0.0544
office-A	0.9616	0.9616	0.9616	0.9616
residential	0.1289	0.1300	0.1289	0.1300
retail	0.9433	0.9433	0.9433	0.9433

**Remarks: including 136 observations for period from 1999 January to 2010 April.*

Table 7.6: Test for Equality of Medians between Real and Derived Expected Rental Growth

sector	*Wilcoxon/Mann-Whitney*	*Wilcoxon/Mann-Whitney (tie-adj.)*	*Med. Chi-square*	*Adj. Med. Chi-square*	*Kruskal-Wallis*	*Kruskal-Wallis (tie-adj.)*	*van der Waerden*
industrial	0.0006	0.0006	0.0003	0.0004	0.0006	0.0006	0.0041
office	0.4523	0.4523	0.4669	0.5443	0.4519	0.4519	0.5424
residential	0.3122	0.3122	0.4669	0.5443	0.3119	0.3119	0.4091
retail	0.8672	0.8672	0.8084	0.9035	0.8666	0.8666	0.8940

**Remarks: including 136 observations for period from January 1999 to April 2010.*

Table 7.7 Test for Equality of Variance between Actual and Derived Expected Rental Growth

sector	*F-test*	*Siegel-Tukey*	*Bartlett*	*Levene*	*Brown-Forsythe*

industrial	0.0000	0.0000	0.0000	0.0000	0.0000
office	0.0000	0.0000	0.0000	0.0000	0.0000
residential	0.0000	0.0000	0.0000	0.0000	0.0000
retail	0.0000	0.0000	0.0000	0.0000	0.0000

***Remarks: including 136 observations for period from 1999 January to 2010 April.**

Though the results above provide few evidence to support the equality of mean and median between actual and derived expected rental growth of property in each sector, there are strong evidence showing that the variance of the two series are similar.

Step 5 the Effect of Expected Rental Income Growth on Real Rent Growth[42]

Furthermore, this test examines the effect of the expected rental income growth on actual rent growth. It is helpful for understanding the implications of deriving the investor's expectation on the future rent of the real estate asset. In this test, the Ordinary Least Square regression method is adopted to the time-series of the date set. The OLS (Ordinary Least Squares) method is one of the commonly adopted to estimate the unknown parameters in a linear regression model. The sum of squared vertical distances between the observed responses in the data series is minimized under this method and the responses would then be predicted by the linear approximation. The resulting estimator can be expressed by a simple formula as stated in this section. The OLS estimator is consistent when the independent variables in the regression model are exogenous and there is no multi-collinearity. The optimal situation in the class of linear unbiased estimators exists when the errors are homoscedastic and uncorrelated to each other in series. OLS can be derived as a maximum likelihood estimator under the assumption that the errors are normally distributed. As stated before, the stationarity of the series are required in OLS test. Thus in this test, the Unit Root Test is employed as well.

To examine the predicting power of expected rental income growth, the empirical model is constructed based on previous findings on property rent determinants. The macro-economic variables are included into the model together with the expected rental income growth as expressed as

[42] Thanks for the examiner's comment on this part, we would investigate whether the expected long-run rental growth would be realized in future. With the supporting evidence, we could find another piece of confirming evidence that the expectation has been measured successfully with the Term Structure Expected Growth Model.

$$\overline{R(g)_{i,t}} = c + c_1 \times GDP_t + c_2 \times UNE_t + c_3 \times (RINT_t) + c_4 \times Erg_{i,t} + \theta_t \quad (7.3)$$

Where $\overline{R(g)_{i,t}}$, GDP, UNE, RINT, Erg represent the average actual rent growth of property over 3-month period ex ante time t, the gross domestic production growth, the unemployment rate growth, the real interest rate changes and the expected rental income growth[43] of the property respectively. *i* and *t* in the model represents the i^{th} property sector and time *t*. The OLS method has been adopted for the four sectors one by one.

Table 7.8 shows the detailed data specification in this test.

Table 7.8 Descriptions of the Variables in the Predictive Power Test

Four Real Estate Sectors in Hong Kong

Sample Period: January 1999 to April 2010

Categories	**Unit of measure**	**Descriptions**	**Symbols**
Gross Domestic Production Growth	percentage	the first differenced values of the GDP	*GDP_g*
real interest rate	percentage	the real interest rate, refers to remarks No. 7	*RINT*
unemployment rate growth	percentage	the first differenced values of the unemployment rate	*UNE*
office property rent growth	percentage	3-month average of the first differenced values of the natural log of office property rent index	$\overline{R(g)_{off}}$
change of expected office property rent growth without risk premium	percentage	the first differenced values of the expected office property rent growth without risk premium	*Erg_off (A)*
change of expected office property rent growth with	percentage	the first differenced values of the expected office property rent	*Erg_off (B)*

[43] Both the expected rental income growth (A) (without risk premium) and (B) (with risk premium) will be investigated.

risk premium		growth with risk premium	
retail property rent growth	percentage	3-month average of the first differenced values of the natural log of retail property rent index	$\overline{R(g)_{ret}}$
change of expected retail property rent growth without risk premium	percentage	the first differenced values of the expected retail property rent growth without risk premium	*Erg_ret(A)*
change of expected retail property rent growth with risk premium	percentage	the first differenced values of the expected retail property rent growth with risk premium	*Erg_ret(B)*
industrial property rent growth	percentage	3-month average of the first differenced values of the natural log of industrial property rent index	$\overline{R(g)_{ind}}$
change of expected industrial property rent growth without risk premium	percentage	the first differenced values of the expected industrial property rent growth without risk premium	*Erg_ind(A)*
change of expected industrial property rent growth with risk premium	percentage	the first differenced values of the expected industrial property rent growth with risk premium	*Erg_ind(B)*
residential property rent growth	percentage	3-month average of the first differenced values of the natural log of residential property rent index (average)	$\overline{R(g)_{res}}$
change of expected residential rent growth without risk premium	percentage	the first differenced values of the expected residential property rent growth (average) without risk premium	*Erg_res(A)*
change of expected residential rent growth with risk premium	percentage	the first differenced values of the expected residential property rent growth (average) with risk premium	*Erg_res(B)*

***Remarks**:*

1. *the expected rental income growth of property is derived based on Term Structure Expected Growth Model;*

2. *the price (or rent) growths are calculated by first-differencing the price (or rent) index from time t to time t+1, the price and rent indices are accessed from Rating and Valuation Department (RVD), Hong Kong SAR, http://www.rvd.gov.hk;*

3. *the D/P ratio used in Gordon Growth Model is proxied by the yield rate accessed from the RVD monthly statistics;*

4. *the discount rate used in Gordon Growth Model is proxied by the 1-year inter-bank-offer-rate, accessed from HKMA statistics (2010) http://www.info.gov.hk/hkma/;*

5. *The seasonal adjusted GDP growth is used for estimation of the rental change of property. The time series can be gained from the Census and Statistics Department, Hong Kong S.A.R. (http://www.censtatd.gov.hk/home/index.jsp) on quarterly basis;*

6. *The unemployment is also confirmed to be an explanatory variable in determining the rental change of property. Thus we get it from the Census and Statistics Department, Hong Kong S.A.R. (http://www.censtatd.gov.hk/home/index.jsp) on monthly basis. The quarterly series of unemployment rate is the average rate during period of one quarter*

7. *The real interest rate is the determinant for rental changes of property as well. In this study, the nominal interest rate is proxied by the 3-month interbank offered rate in Hong Kong while the inflation rate is calculated based on the annual change of the Consumer Price Index (CPI) – Series A for non-luxury commodities. Both of them are annual rate on monthly basis and we transferred them into monthly rate on quarter basis. The monthly rates are assumed to be equal to the 1/12 of annual rate while the quarter series are average rates of monthly series during period of one quarter*

As required by the OLS regression method, the Unit Root Tests need to be carried out here. The results of the stationarity of each variable used in the following tests are shown in Table 7.9.

Table 7.9: Augmented Dickey-Fuller unit root test of Variables

in the Predictive Power Test of Expected Rental Income Growth on Real Rent Growth

time series variables	Augmented Dickey-Fuller test statistic

	level	1st differences
$\overline{R(g)_{off}}$	-3.13**	-7.11*
$\overline{R(g)_{ret}}$	-3.79*	-6.33*
$\overline{R(g)_{ind}}$	-4.74*	-10.87*
$\overline{R(g)_{res}}$	-4.38**	-5.99*
Erg_off(A)	-4.05	-5.52*
Erg_ret(A)	-2.06	-5.65*
Erg_ind(A)	0.31	-3.44*
Erg_res(A)	-2.11	-6.38*
Erg_off(B)	-1.96	-6.33***
Erg_ret(B)	-1.44	-5.20***
Erg_ind(B)	-0.17	-2.82*
Erg_res(B)	-1.85	-5.77**
GDP_g	-2.28	-21.32*
UNE	-2.14	-3.52*
RINT	-1.1	-3.05*

Remarks:

** indicates that the null hypothesis can be rejected at the 1%level; ** indicates that the null hypothesis can be rejected at the 5%level; off, ret and ind refers to the office, retail and industrial property sectors, based on usage type, see RVD(2010);rg and Erg represent the actual and expected rental income growt for each type of property respectively.*

As shown in Table 7.10, except the real rent growth series, other series cannot show their stationarity until transferred to 1st differenced level.

The summary statistics of the variables are presented in Table 7.10.

Table 7.10 Descriptive Statistics of the Quarterly Series of Variables in Test of Property Rent Changes

2nd Quarter 1999 to 1st Quarter 2010

Note: OFF, IND, RET and RES refer to the four sectors of Hong Kong real estate market, namely office (Grade A), industrial, retail and residential property sector respectively

	Mean	Median	Maximum	Minimum	Std. Dev.	Sum	Sum Sq. Dev.	Observations
Erg_IND(A)	-0.0035	-0.0040	0.0015	-0.0077	0.0026	-0.1594	0.0003	45
Erg_OFF(A)	0.0021	0.0019	0.0056	-0.0007	0.0015	0.0965	0.0001	45
Erg_RES(A)	0.0032	0.0035	0.0054	0.0008	0.0012	0.1440	0.0001	45
Erg_RET(A)	0.0011	0.0010	0.0036	-0.0006	0.0010	0.0504	0.0000	45
Erg_IND(B)	0.00202	0.0025	0.013733	-0.00543	0.00517	0.0909	0.001176	45
Erg_OFF(B)	0.012924	0.011633	0.037467	0.002933	0.008247	0.581567	0.002992	45
Erg_RES(B)	0.009434	0.007967	0.020067	0.003733	0.004623	0.424533	0.00094	45
Erg_RET(B)	0.007994	0.006967	0.0211	0.0013	0.004812	0.359733	0.001019	45
GDP_g	0.0112	0.0150	0.0630	-0.0320	0.0167	0.5030	0.0122	45
$\overline{R(g)}_{ind}$	-0.0001	0.0028	0.0482	-0.0300	0.0137	-0.0042	0.0082	45
$\overline{R(g)}_{off}$	0.0020	0.0047	0.0378	-0.0357	0.0171	0.0904	0.0128	45
$\overline{R(g)}_{res}$	0.0010	0.0024	0.0245	-0.0613	0.0146	0.0457	0.0094	45
$\overline{R(g)}_{ret}$	0.0011	0.0024	0.0143	-0.0152	0.0078	0.0476	0.0027	45
RINT	0.0031	0.0026	0.0101	-0.0027	0.0031	0.1397	0.0004	45
UNE	0.0558	0.0533	0.0833	0.0330	0.0134	2.5093	0.0079	45

***Remarks:**

1. The seasonal adjusted GDP growth is used for estimation of the rental change of property. The time series ca be gained from the Census and Statistics

2. The unemployment is also confirmed to be an explanatory variable in determining the rental change of propert Thus we get it from the Census and Statistics

3. The real interest rate is the determinant for rental changes of property as well. In this study, the nominal interest rate is proxied by the 1-year interbank offered rate in Hong Kong while the inflation rate is calculated based on the annual change of the Consumer Price Index (CPI) – Series A for non-luxury commodities. Both of them are annual rate on monthly basis and we transferred them into monthly rate on quarter basis. The monthly rates are assumed to be equal to the 1/12 of annual rate while the quarter series are average rates of monthly series during period of one quarter.

Table 7.11(a): Effects of Expected Rental Income Growth (A) on Real Rent Growth of Property Regression (OLS)

Dependent Variable: $\Delta\ (\overline{R(g)})$

Explanatory Variable	Office -- Grade A		Industrial		Retail		Residential (average)	
	coeff. Value	t-statistics	coeff. Value	t-statistics	coeff. Value	t-statistics	coeff. Value	t-statistics
△(GDP_g)	0.1565	2.4319**	0.1152	1.7475*	0.1023	2.2619**	0.0666	0.8478
△UNE	-0.5565	-1.7532*	0.3402	1.0298	0.2301	1.0033	0.4437	1.1143
△RINT	-0.3737	-0.3629	-0.7697	-0.7424	0.2083	0.2798	-2.7254	-2.1191**
△Erg(A)	4.5484	3.5962***	3.3159	1.4992	2.1121	1.7108*	6.3258	3.0014***
Adjusted R-squared	0.3804		0.1224		0.1883		0.2527	
Prob (F-statistics)	0.0001		0.0581		0.0156		0.0037	
Durbin-Watson stat	1.9391		2.4178		2.3163		1.7389	

****, **, * significance at respective 1%, 5% and 10%*

Table 7.11(b): Effects of Expected Rental Income Growth (B) on Real Rent Growth of Property Regression (OLS)

Dependent Variable: $\Delta\ (\overline{R(g)})$

Explanatory	Office -- Grade A	Industrial	Retail	Residential

Variable							(average)	
	coeff. Value	t-statistics	coeff. Value	t-statistics	coeff. Value	t-statistics	coeff. Value	t-statistics
∆(GDP_g)	0.2350	3.3751***	0.1540	2.3493**	0.1219	2.6768**	0.1210	1.4963
∆UNE	-0.6170	-1.6839	0.2054	0.5987	0.2238	0.9373	0.4190	0.9644
∆RINT	-0.2836	-0.2377	-0.7380	-0.6784	0.2598	0.3303	-2.3900	-1.6908*
∆Erg(B)	0.1375	0.4586	0.2427	0.3986	0.0785	0.2356	1.0026	1.6897*
Adjusted R-squared	0.1794		0.0746		0.1287		0.1429	
Prob (F-statistics)	0.0189		0.1358		0.0517		0.0394	
Durbin-Watson stat	1.7779		2.3931		2.2458		1.7717	

****,**,* significance at respective 1%, 5% and 10%*

The results provided by Table 7.11 (a&b) illustrate how the expected rent growth would be realized in real rent growth within 3-month period. Our Term Structure Expected Growth Model captured the long-run expected rent growth in this study. With the help of the empirical evidence above, we found that the short-run realized rent growth can be explained by the captured long-run expected rent growth. It confirms that the expected rent growth derived by the Term Structure Expected Growth Model has been measured successfully.

Concluding with the results in all five steps of tests in this section, the expected rental income growth is evidenced to affect the real rent growth of the property in future. Anyway, the expected rental income growth cannot be exactly same with the real one. These preliminary observations reveal the long-term equilibrium relationship between them.

7.2 SIMULATIONS OF TERM STRUCTURE EXPECTED GROWTH MODEL ON PRIVATE REAL ESTATE MARKET

Before the empirical investigation, some experiments of the model are carried out to illustrate the relationship between real estate returns and the explanatory factors in Term Structure Expected Growth Model first. In each experiment, we set one chosen variable in the model to be changing randomly while the other variables to keep constant. Each experiment will be run for 6 times in Microsoft Excel. The correlations between real estate return (price changes) and the movements of the chosen variable will be shown with graphs to demonstrate the theoretical relationship between real estate return and each variable.

The simulations are carried out to illustrate the relationship between real estate returns and the explanatory factors in Term Structure Expected Growth Model:

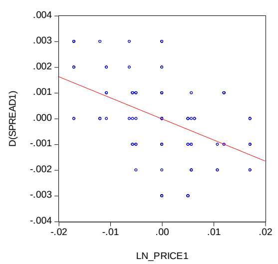
$$\frac{P}{D}=\frac{1}{(1+i)}+\frac{1+g}{(1+i+\frac{i_{50}-i}{49})^2}+\frac{(1+g)^2}{(1+i+2\times\frac{i_{50}-i}{49})^3}+\cdots+\frac{(1+g)^{49}}{(1+i+49\times\frac{i_{50}-i}{49})^{50}} \qquad (7.4)$$

(1) <u>Real estate returns vs. term structure of interest (spread)</u>

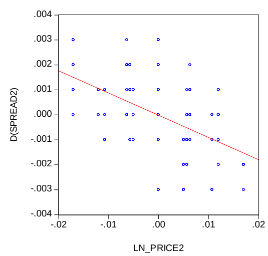
Six times of the simulation has been run with constant values of other variables and the changing value of interest rate spread. The correlations between real estate return and differenced interest rate spread are shown as follows with scattered plot graph respectively:

Simulation	1st	2nd	3rd	4th	5th	6th
Correlation	-0.4614	-0.5074	-0.4191	-0.5292	-0.4470	-0.4739

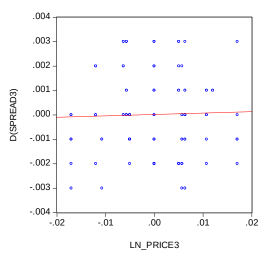
Graph 1: 1st simulation



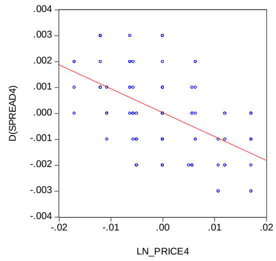
Graph 2: 2nd simulation



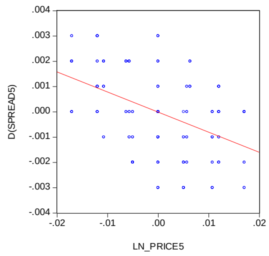
Graph 3: 3rd simulation



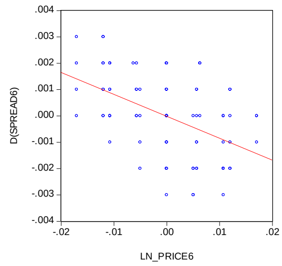
Graph 4: 4th simulation



Graph 5: 5th simulation



Graph 6: 6th simulation

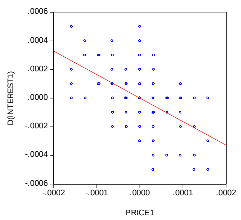


(2) ***Real estate returns vs. interest rate***

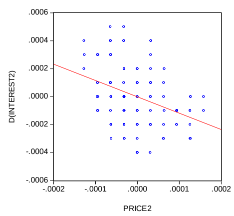
Six times of the simulation has been run with constant values of other variables and the changing value of interest rate. The correlations between real estate return and differenced interest rate are shown as follows with scattered plot graph respectively:

Simulation	1^{st}	2^{nd}	3^{rd}	4^{th}	5^{th}	6^{th}
Correlation	-0.5205	-0.3650	-0.4321	-0.5603	-0.5650	-0.4887

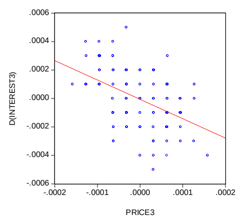
Graph 1: 1^{st} simulation



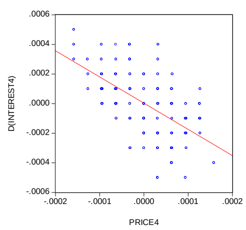
Graph 2: 2^{nd} simulation



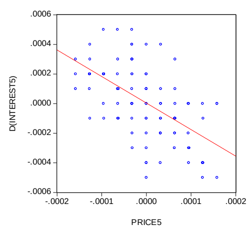
Graph 3: 3^{rd} simulation



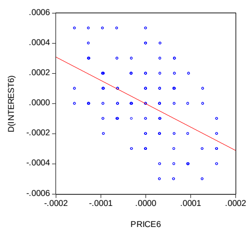
Graph 4: 4^{th} simulation

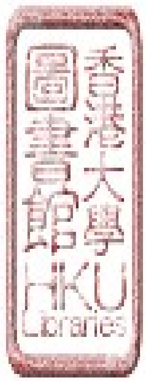


Graph 5: 5^{th} simulation



Graph 6: 6^{th} simulation



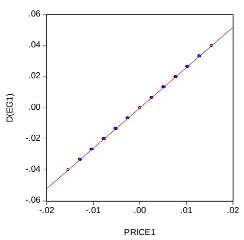


(3) <u>Real estate returns vs. expected rental income growth of real estate asset</u>

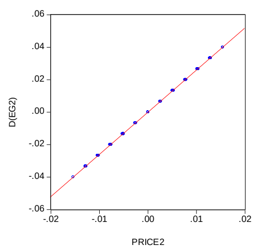
Six times of the simulation has been run with constant values of other variables and the changing value of expected rental income growth of real estate asset. The correlations between real estate return and differenced expected rental income growth are shown as follows with scattered plot graph respectively:

Simulation	1st	2nd	3rd	4th	5th	6th
Correlation	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999

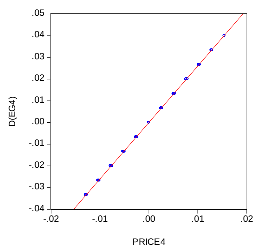
Graph 1: 1st simulation



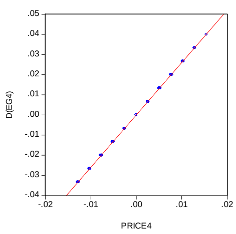
Graph 2: 2nd simulation



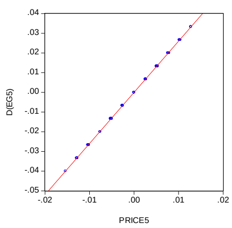
Graph 3: 3rd simulation



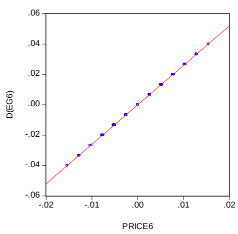
Graph 4: 4th simulation



Graph 5: 5th simulation



Graph 6: 6th simulation

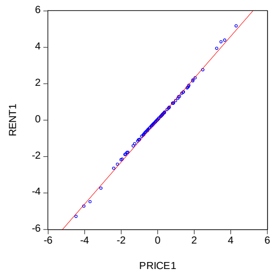


(4) <u>Real estate returns vs. its spot rental income</u>

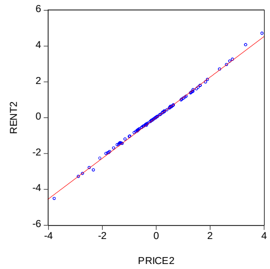
Six times of the simulation has been run with constant values of other variables and the changing value of spot rental income of real estate asset. The correlations between real estate return and spot rent growth are shown as follows with scattered plot graph respectively:

Simulation	1st	2nd	3rd	4th	5th	6th
Correlation	0.9987	0.9987	0.9995	0.9985	0.9987	0.9989

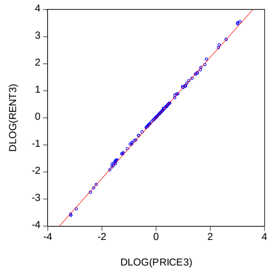
Graph 1: 1st simulation



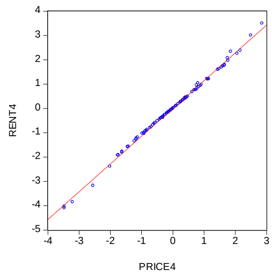
Graph 2: 2nd simulation



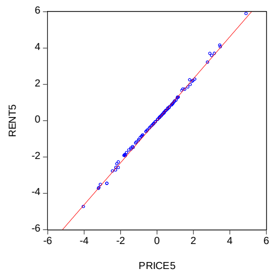
Graph 3: 3rd simulation



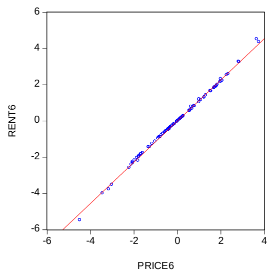
Graph 4: 4th simulation



Graph 5: 5th simulation



Graph 6: 6th simulation



According to the simulation results, we find that the real estate asset's price growth (capital return) would be:

(1) Positively related to the changes of spot rent and expected rental income growth ;

(2) Negatively related to the movements of interest rate and the term structure of interest.

In Chapter 6, the empirical investigations of Model II examine whether these results can be supported by the empirical evidence.

7.3 CRITICAL TEST OF TERM STRUCTURE EXPECTED GROWTH MODEL

As introduced in Chapter 6, we set a critical test of our model here to examine the different results of the Gordon Growth and Term Structure Expected Growth when the term structure changes.

The difference between Term Structure Expected Growth Model and Gordon Growth Model lies how to handle the growth of cost of capital, which is the term structure of the cost of capital. By ignoring the term structure's effect, the Gordon Growth may lose its impact on the property price growth. During the whole empirical investigation period, the term structure had never been observed to be negative. Therefore, we hypothesize that:

When the term structure goes up, the expected rental income growth based on Gordon Growth Model will lose its impact on the property price growth while the Term Structure Expected Growth will keep its predictive power;

When the term structure goes down, the two expected rental income growths will both have their impacts on the property price growth.

According to the pattern of the term structure movement in Figure 4.5, we divide our investigation into 2 panels: Panel 1 (term structure increases during the periods from 1st quarter, 1999 to 4th quarter, 2001 and from 1st quarter, 2007 to 1st quarter, 2010) and Panel 2 (term structure decreases during the period from 1st quarter 2002 to 4th quarter 2006).

The empirical models and datasets are the same as in Model II. And the empirical results are shown here in Table 7.12.

Table 7.12: Empirical Results of Critical Test

Panel 1: Term Structure Goes Up (Q1 1999 -- Q4 2001 & Q1 2007 -- Q1 2010)								
Gordon Growth								
Dependent Variable: ln_P_t								
	office -- Grade A		**Industrial**		**Retail**		**Residential**	
Variables	**coeff. Value**	**t-value**	**coeff. Value**	**t-value**	**coeff. Value**	**t-value**	**coeff. Value**	**t-value**
$\hat{R}g_t$	0.7482	1.6026	1.0745	1.8474*	1.5034	2.3770**	0.8616	2.3383**
$d(Erg_t)$	34.4033	3.2994***	-4.3254	-0.9215	14.2729	1.8714*	44.9048	3.2099***
$d(I_t)$	-4.1522	-2.5782**	0.6516	0.5753	-1.8977	-1.6231	-4.9089	-3.1090***

Adjusted R-squared	0.3260	0.0470	0.2222	0.3196
Prob(F-statistics)	0.0121	0.2783	0.0459	0.0132
Durbin-Watson stat	2.0592	1.7032	1.6602	1.6683

Term Structure Expected Growth

Dependent Variable: ln_P_t

	office -- Grade A		**Industrial**		**Retail**		**Residential**	
Variables	**coeff. Value**	**t-value**	**coeff. Value**	**t-value**	**coeff. Value**	**t-value**	**coeff. Value**	**t-value**
$\hat{R}g_t$	0.8758	3.9238***	-0.2966	-0.8446	1.1525	3.0954***	0.7169	2.9959***
$d(S_t)$	-64.1547	-4.3617***	-22.0383	-2.7446**	-67.4957	-5.2603***	-94.4553	-4.9089***
$d(Erg_t)$	36.4713	9.3005***	21.0422	4.3538***	33.0735	6.7988***	43.0895	6.1089***
$d(I_t)$	-2.1550	-3.0540***	-0.8510	-1.8704*	-3.0840	-4.9804***	-3.4466	-4.3843***
Adjusted R-squared	0.7434		0.4893		0.5989		0.5304	
Prob(F-statistics)	0.0000		0.0018		0.0000		0.0000	
Durbin-Watson stat	1.8462		1.8086		2.3619		2.0960	

Panel 2: Term Structure Goes Down (Q1 2002 -- Q4 2006)

Gordon Growth

Dependent Variable: ln_P_t

	office -- Grade A		**Industrial**		**Retail**		**Residential**	
Variables	**coeff. Value**	**t-value**	**coeff. Value**	**t-value**	**coeff. Value**	**t-value**	**coeff. Value**	**t-value**
$\hat{R}g_t$	1.4382	4.0131***	0.9974	1.9398*	1.6815	2.3535**	0.0437	0.0660
$d(Erg_t)$	72.5687	8.2981***	34.2023	3.3779***	64.0378	4.7727***	119.5761	3.5072***
$d(I_t)$	-6.0345	-7.2655***	-2.2447	-2.0749*	-5.6086	-5.3140***	-8.4093	-3.3582***

Adjusted R-squared	0.8682	0.5655	0.6726	0.4931
Prob(F-statistics)	0.0000	0.0043	0.0008	0.0105
Durbin-Watson stat	1.7577	2.0027	2.6195	3.0641

Term Structure Expected Growth

Dependent Variable: ln_P_t

	office -- Grade A		**Industrial**		**Retail**		**Residential**	
Variables	**coeff. Value**	**t-value**	**coeff. Value**	**t-value**	**coeff. Value**	**t-value**	**coeff. Value**	**t-value**
$\hat{R}g_t$	1.4132	3.7148***	1.0409	1.8501*	2.1286	2.6417**	0.5417	0.8876
$d(S_t)$	-74.5361	-4.2211***	-32.6413	-2.3936**	-80.3334	-3.9227***	-140.9819	-3.7336***
$d(Erg_t)$	38.1803	7.7065***	26.0441	3.0663**	33.5215	4.0170***	57.9878	3.7086***
$d(I_t)$	-2.6001	-2.9321**	-1.3238	-1.3973	-3.6619	-4.0046***	-3.8152	-2.8507**
Adjusted R-squared	0.8528		0.5215		0.6030		0.5167	
Prob(F-statistics)	0.0000		0.0144		0.0055		0.0152	
Durbin-Watson stat	1.8449		1.9563		2.1400		2.6536	

***,**,* significance at respective 1%, 5% and 10%

Judging from the empirical results above, we can find that: on one hand, when the term structure goes up, the effect of Gordon growth would decrease and even lose its impact in the industrial property sector while the effect of Term Structure Expected growth kept still. On the other hand, when the term structure goes down, which means the difference between the two growths became smaller; both of them would keep their impacts on the property price growths. We believe by giving longer sample period, the results could be clearer.

The empirical results of this critical test suggest that the ignorance of term structure's effect in expected growth model could lead to the elimination of the expectation's impact on asset's price changes. Therefore our Term Structure Expected Growth Model is evidenced to be better than Gordon Growth Model in asset pricing procedure.

7.4 THE SELECTION OF LAG-LENGTH IN GRANGER CAUSALITY TESTS OF MODEL I

As suggested by Thornton and Batten (1985)'s research on the selection of lag-length in Granger Causality Tests, there are several criteria and methods, to select the lag-length in Granger Causality Test[44]. Here in this section, we will present the results of Model I with one to eight lags first and then explain how the lag-lengths are chosen in this study.

1. Lead-lag relationship between price and rent changes

Table 7.13 reports the results of Granger Causality Tests on the movements of price and rent indices with 1 to 8 lags.

Table 7.13: Granger Causality Tests on the movements of price and rent indices with 1 to 8 lags
Sample objectives: four sectors of real estate market in Hong Kong
sample period: Jan. 1999 to Apr. 2010

	Pairwise Granger Causality Tests	**Industrial Sector**		
	Null Hypothesis:	**Obs**	**F-Statistic**	**Prob.**
lag 1	rent changes does not Granger Cause price changes	134	16.64	0.00
	price changes does not Granger Cause rent changes		8.23	0.00
lag 2	rent changes does not Granger Cause price changes	133	8.55	0.00
	price changes does not Granger Cause rent changes		4.61	0.01
lag 3	rent changes does not Granger Cause price changes	132	5.59	0.00
	price changes does not Granger Cause rent changes		2.32	0.08
lag 4	rent changes does not Granger Cause price changes	131	4.41	0.00
	price changes does not Granger Cause rent changes		2.09	0.09

[44] The detailed summary of the previous methods can be found in Thornton and Batten (1985)'s paper.

	Null Hypothesis:	Obs	F-Statistic	Prob.
lag 5				
	rent changes does not Granger Cause price changes	131	3.72	0.00
	price changes does not Granger Cause rent changes		1.82	0.11
lag 6				
	rent changes does not Granger Cause price changes	129	2.97	0.01
	price changes does not Granger Cause rent changes		1.54	0.17
lag 7				
	rent changes does not Granger Cause price changes	128	2.51	0.02
	price changes does not Granger Cause rent changes		1.29	0.26
lag 8				
	rent changes does not Granger Cause price changes	127	2.47	0.02
	price changes does not Granger Cause rent changes		1.38	0.21

	Pairwise Granger Causality Tests	**Grade A Office Sector**		
	Null Hypothesis:	**Obs**	**F-Statistic**	**Prob.**
lag 1				
	rent changes does not Granger Cause price changes	134	3.77	0.05
	price changes does not Granger Cause rent changes		4.17	0.04
lag 2				
	rent changes does not Granger Cause price changes	133	1.31	0.27
	price changes does not Granger Cause rent changes		3.98	0.02
lag 3				
	rent changes does not Granger Cause price changes	132	2.32	0.08
	price changes does not Granger Cause rent changes		3.42	0.02
lag 4				
	rent changes does not Granger Cause price changes	131	1.79	0.14
	price changes does not Granger Cause rent changes		3.43	0.01
lag 5				
	rent changes does not Granger Cause price changes	130	1.77	0.12
	price changes does not Granger Cause rent changes		3.19	0.01
lag 6				
	rent changes does not Granger Cause price changes	129	1.54	0.17
	price changes does not Granger Cause rent changes		2.25	0.04
lag 7				
	rent changes does not Granger Cause price changes	128	1.47	0.18
	price changes does not Granger Cause rent changes		1.86	0.08
lag 8				
	rent changes does not Granger Cause price changes	127	1.30	0.25
	price changes does not Granger Cause rent changes		1.60	0.13

Pairwise Granger Causality Tests		Residential Sector		
	Null Hypothesis:	**Obs**	**F-Statistic**	**Prob.**
lag 1	rent change does not Granger Cause price change	134	0.43	0.51
	price change does not Granger Cause rent change		35.83	0.00
lag 2	rent change does not Granger Cause price change	133	0.26	0.77
	price change does not Granger Cause rent change		21.42	0.00
lag 3	rent change does not Granger Cause price change	132	0.12	0.95
	price change does not Granger Cause rent change		14.23	0.00
lag 4	rent change does not Granger Cause price change	131	0.23	0.92
	price change does not Granger Cause rent change		13.02	0.00
lag 5	rent change does not Granger Cause price change	130	0.89	0.49
	price change does not Granger Cause rent change		10.18	0.00
lag 6	rent change does not Granger Cause price change	129	1.42	0.21
	price changs does not Granger Cause rent change		8.19	0.00
lag 7	rent change does not Granger Cause price change	128	1.20	0.31
	price change does not Granger Cause rent change		6.70	0.00
lag 8	rent change does not Granger Cause price change	127	1.02	0.43
	price change does not Granger Cause rent change		5.81	0.00

Pairwise Granger Causality Tests		Retail Sector		
	Null Hypothesis:	**Obs**	**F-Statistic**	**Prob.**
lag 1	rent change does not Granger Cause price change	134	1.42	0.24
	price change does not Granger Cause rent change		4.67	0.03
lag 2	rent change does not Granger Cause price change	133	0.59	0.55
	price change does not Granger Cause rent change		7.51	0.00
lag 3	rent change does not Granger Cause price change	132	2.02	0.12
	price change does not Granger Cause rent change		5.59	0.00

lag 4				
	rent change does not Granger Cause price change	131	2.55	0.04
	price change does not Granger Cause rent change		3.93	0.00
lag 5				
	rent change does not Granger Cause price change	130	2.42	0.04
	price change does not Granger Cause rent change		3.41	0.01
lag 6				
	rent change does not Granger Cause price change	129	2.19	0.05
	price change does not Granger Cause rent change		4.04	0.00
lag 7				
	rent change does not Granger Cause price change	128	1.91	0.07
	price change does not Granger Cause rent change		3.20	0.00
lag 8				
	rent change does not Granger Cause price change	127	1.71	0.11
	price change does not Granger Cause rent change		2.74	0.01

Based on the results shown in Table 7.13, we found that for each property sector, the lead-lag relationship between price and rent changes are consistent. To be more specific, among three property sectors (Grade-A office, residential and retail) the price changes are found to Granger Cause the rent changes while only one property sector showed opposite evidence. Thus for each property sector, the directions of causality with different lag structures are consistent. Table 7.14 summarizes the directions of causality with different lag structures, it is denoted by (L) if the p-value of null hypothesis *rent change does not Granger Cause price change* is larger than the p-value of null hypothesis *price change does not Granger Cause rent change*; it is denoted by (S) otherwise .

Table 7.14 Summary of Causality Directions with Various Lag Structures

price change vs. rent change

Lag structure	**Industrial Sector**	**Grade-A Office Sector**	**Residential Sector**	**Retail Sector**
1	S	L	L	L
2	S	L	L	L
3	S	L	L	L
4	S	L	L	L
5	S	L	L	L
6	S	L	L	L
7	S	L	L	L
8	S	L	L	L

2. Lead-lag relationship between price changes and the changes of Term Structure Expected Growth

Table 7.15 (a and b) report the results of Granger Causality Tests on the movements of price and expected rental income growth based on the Tern Structure Expected Growth Model with 1 to 8 lags.

Table 7.15a: Granger Causality Tests on the movements of price and Term Structure Expected Growth (A) with 1 to 8 lags

Sample objectives: four sectors of real estate market in Hong Kong

sample period: Jan. 1999 to Apr. 2010

	Pairwise Granger Causality Tests	**Industrial Sector**		
	Null Hypothesis:	**Obs**	**F-Statistic**	**Prob**
lag 1	the change of Term Structure Expected Growth does not Granger Cause price change	134	0.39	0.54
	price change does not Granger Cause the change of Term Structure Expected Growth		1.08	0.30
lag 2	the change of Term Structure Expected Growth does not Granger Cause price change	133	3.23	0.04
	price change does not Granger Cause the change of Term Structure Expected Growth		1.38	0.26
lag 3	the change of Term Structure Expected Growth does not Granger Cause price change	132	2.88	0.04
	price change does not Granger Cause the change of Term Structure Expected Growth		1.24	0.30
lag 4	the change of Term Structure Expected Growth does not Granger Cause price change	131	2.64	0.04
	price change does not Granger Cause the change of Term Structure Expected Growth		1.85	0.12
lag 5	the change of Term Structure Expected Growth does not Granger Cause price change	130	2.58	0.03
	price change does not Granger Cause the change of Term Structure Expected Growth		1.45	0.21
lag 6	the change of Term Structure Expected Growth does not Granger Cause price change	129	3.31	0.00
	price change does not Granger Cause the change of Term Structure Expected Growth		2.14	0.05
lag 7	the change of Term Structure Expected Growth does not	128	3.04	0.01

	Granger Cause price change			
	price change does not Granger Cause the change of Term Structure Expected Growth		1.99	0.06
lag 8	the change of Term Structure Expected Growth does not Granger Cause price change	127	2.84	0.01
	price change does not Granger Cause the change of Term Structure Expected Growth		1.67	0.11

	Pairwise Granger Causality Tests	Grade A Office Sector		
	Null Hypothesis:	**Obs**	**F-Statistic**	**Prob.**
lag 1	the change of Term Structure Expected Growth does not Granger Cause price change	134	0.35	0.55
	price change does not Granger Cause the change of Term Structure Expected Growth		2.83	0.09
lag 2	the change of Term Structure Expected Growth does not Granger Cause price change	133	2.55	0.08
	price change does not Granger Cause the change of Term Structure Expected Growth		3.11	0.05
lag 3	the change of Term Structure Expected Growth does not Granger Cause price change	132	2.47	0.07
	price change does not Granger Cause the change of Term Structure Expected Growth		2.05	0.11
lag 4	the change of Term Structure Expected Growth does not Granger Cause price change	131	2.41	0.05
	price change does not Granger Cause the change of Term Structure Expected Growth		2.07	0.09
lag 5	the change of Term Structure Expected Growth does not Granger Cause price change	130	2.41	0.04
	price change does not Granger Cause the change of Term Structure Expected Growth		2.04	0.08
lag 6	the change of Term Structure Expected Growth does not Granger Cause price change	129	3.27	0.01
	price change does not Granger Cause the change of Term Structure Expected Growth		1.34	0.25
lag 7	the change of Term Structure Expected Growth does not Granger Cause price change	128	3.70	0.00
	price change does not Granger Cause the change of Term Structure Expected Growth		2.10	0.05

lag 8	the change of Term Structure Expected Growth does not Granger Cause price change	127	3.07	0.00
	price change does not Granger Cause the change of Term Structure Expected Growth		1.73	0.10

	Pairwise Granger Causality Tests	**Residential Sector**		
	Null Hypothesis:	**Obs**	**F-Statistic**	**Prob**
lag 1	the change of Term Structure Expected Growth does not Granger Cause price change	134	0.22	0.64
	price change does not Granger Cause the change of Term Structure Expected Growth		3.57	0.06
lag 2	the change of Term Structure Expected Growth does not Granger Cause price change	133	0.74	0.48
	price change does not Granger Cause the change of Term Structure Expected Growth		4.56	0.01
lag 3	the change of Term Structure Expected Growth does not Granger Cause price change	132	1.10	0.35
	price change does not Granger Cause the change of Term Structure Expected Growth		3.33	0.02
lag 4	the change of Term Structure Expected Growth does not Granger Cause price change	131	1.28	0.28
	price change does not Granger Cause the change of Term Structure Expected Growth		2.39	0.05
lag 5	the change of Term Structure Expected Growth does not Granger Cause price change	130	1.35	0.25
	price change does not Granger Cause the change of Term Structure Expected Growth		2.68	0.02
lag 6	the change of Term Structure Expected Growth does not Granger Cause price change	129	1.17	0.32
	price change does not Granger Cause the change of Term Structure Expected Growth		2.07	0.06
lag 7	the change of Term Structure Expected Growth does not Granger Cause price change	128	1.15	0.34
	price change does not Granger Cause the change of Term Structure Expected Growth		1.90	0.08
lag 8	the change of Term Structure Expected Growth does not Granger Cause price change	127	0.99	0.45
	price change does not Granger Cause the change of Term Structure Expected Growth		1.87	0.07

	Pairwise Granger Causality Tests	Retail Sector		
	Null Hypothesis:	Obs	F-Statistic	Prob
lag 1	the change of Term Structure Expected Growth does not Granger Cause price change	134	2.76	0.10
	price change does not Granger Cause the change of Term Structure Expected Growth		0.01	0.94
lag 2	the change of Term Structure Expected Growth does not Granger Cause price change	133	1.34	0.27
	price change does not Granger Cause the change of Term Structure Expected Growth		0.52	0.60
lag 3	the change of Term Structure Expected Growth does not Granger Cause price change	132	1.46	0.23
	price change does not Granger Cause the change of Term Structure Expected Growth		0.39	0.76
lag 4	the change of Term Structure Expected Growth does not Granger Cause price change	131	1.07	0.38
	price change does not Granger Cause the change of Term Structure Expected Growth		0.71	0.59
lag 5	the change of Term Structure Expected Growth does not Granger Cause price change	130	1.09	0.37
	price change does not Granger Cause the change of Term Structure Expected Growth		0.73	0.60
lag 6	the change of Term Structure Expected Growth does not Granger Cause price change	129	1.04	0.40
	price change does not Granger Cause the change of Term Structure Expected Growth		0.63	0.71
lag 7	the change of Term Structure Expected Growth does not Granger Cause price change	128	1.12	0.36
	price change does not Granger Cause the change of Term Structure Expected Growth		0.54	0.81
lag 8	the change of Term Structure Expected Growth does not Granger Cause price change	127	0.99	0.45
	price change does not Granger Cause the change of Term Structure Expected Growth		0.62	0.76

Table 7.15b: Granger Causality Tests on the movements of price and Term Structure Expected Growth (B) with 1 to 8 lags

Sample objectives: four sectors of real estate market in Hong Kong

sample period: Jan. 1999 to Apr. 2010

	Pairwise Granger Causality Tests	**Industrial Sector**		
	Null Hypothesis:	**Obs**	**F-Statistic**	**Prob**
lag 1	the change of Term Structure Expected Growth does not Granger Cause price change	134	0.21	0.65
	price change does not Granger Cause the change of Term Structure Expected Growth		0.14	0.71
lag 2	the change of Term Structure Expected Growth does not Granger Cause price change	133	1.60	0.21
	price change does not Granger Cause the change of Term Structure Expected Growth		0.07	0.93
lag 3	the change of Term Structure Expected Growth does not Granger Cause price change	132	0.72	0.54
	price change does not Granger Cause the change of Term Structure Expected Growth		0.96	0.41
lag 4	the change of Term Structure Expected Growth does not Granger Cause price change	131	0.76	0.55
	price change does not Granger Cause the change of Term Structure Expected Growth		0.98	0.42
lag 5	the change of Term Structure Expected Growth does not Granger Cause price change	130	1.30	0.27
	price change does not Granger Cause the change of Term Structure Expected Growth		1.14	0.35
lag 6	the change of Term Structure Expected Growth does not Granger Cause price change	129	3.26	0.01
	price change does not Granger Cause the change of Term Structure Expected Growth		2.15	0.05
lag 7	the change of Term Structure Expected Growth does not Granger Cause price change	128	2.97	0.01
	price change does not Granger Cause the change of Term Structure Expected Growth		1.92	0.0[illegible]
lag 8	the change of Term Structure Expected Growth does not Granger Cause price change	127	2.90	0.0[illegible]
	price change does not Granger Cause the change of Term Structure Expected Growth		1.60	0.1[illegible]

	Pairwise Granger Causality Tests	Grade A Office Sector		
	Null Hypothesis:	**Obs**	**F-Statistic**	**Prob**
lag 1	the change of Term Structure Expected Growth does not Granger Cause price change	134	0.21	0.64
	price change does not Granger Cause the change of Term Structure Expected Growth		12.44	0.00
lag 2	the change of Term Structure Expected Growth does not Granger Cause price change	133	0.35	0.70
	price change does not Granger Cause the change of Term Structure Expected Growth		5.48	0.01
lag 3	the change of Term Structure Expected Growth does not Granger Cause price change	132	0.30	0.83
	price change does not Granger Cause the change of Term Structure Expected Growth		7.34	0.00
lag 4	the change of Term Structure Expected Growth does not Granger Cause price change	131	0.24	0.92
	price change does not Granger Cause the change of Term Structure Expected Growth		5.21	0.00
lag 5	the change of Term Structure Expected Growth does not Granger Cause price change	130	0.32	0.90
	price change does not Granger Cause the change of Term Structure Expected Growth		4.38	0.00
lag 6	the change of Term Structure Expected Growth does not Granger Cause price change	129	0.31	0.93
	price change does not Granger Cause the change of Term Structure Expected Growth		3.30	0.00
lag 7	the change of Term Structure Expected Growth does not Granger Cause price change	128	0.59	0.76
	price change does not Granger Cause the change of Term Structure Expected Growth		2.99	0.01
lag 8	the change of Term Structure Expected Growth does not Granger Cause price change	127	0.52	0.84
	price change does not Granger Cause the change of Term Structure Expected Growth		2.49	0.0

	Pairwise Granger Causality Tests	Residential Sector		
	Null Hypothesis:	**Obs**	**F-Statistic**	**Prob**
lag 1	the change of Term Structure Expected Growth does not Granger Cause price change	134	0.05	0.8
	price change does not Granger Cause the change of Term		0.33	0.5

	Structure Expected Growth			
lag 2	the change of Term Structure Expected Growth does not Granger Cause price change	133	0.11	0.90
	price change does not Granger Cause the change of Term Structure Expected Growth		0.23	0.79
lag 3	the change of Term Structure Expected Growth does not Granger Cause price change	132	0.99	0.40
	price change does not Granger Cause the change of Term Structure Expected Growth		0.17	0.92
lag 4	the change of Term Structure Expected Growth does not Granger Cause price change	131	0.80	0.52
	price change does not Granger Cause the change of Term Structure Expected Growth		0.13	0.97
lag 5	the change of Term Structure Expected Growth does not Granger Cause price change	130	0.65	0.66
	price change does not Granger Cause the change of Term Structure Expected Growth		0.15	0.98
lag 6	the change of Term Structure Expected Growth does not Granger Cause price change	129	0.61	0.72
	price change does not Granger Cause the change of Term Structure Expected Growth		0.89	0.50
lag 7	the change of Term Structure Expected Growth does not Granger Cause price change	128	0.58	0.77
	price change does not Granger Cause the change of Term Structure Expected Growth		0.77	0.61
lag 8	the change of Term Structure Expected Growth does not Granger Cause price change	127	0.53	0.84
	price change does not Granger Cause the change of Term Structure Expected Growth		0.66	0.72

	Pairwise Granger Causality Tests		**Retail Sector**	
	Null Hypothesis:	**Obs**	**F-Statistic**	**Prob**
lag 1	the change of Term Structure Expected Growth does not Granger Cause price change	134	0.23	0.6
	price change does not Granger Cause the change of Term Structure Expected Growth		3.04	0.0
lag 2	the change of Term Structure Expected Growth does not Granger Cause price change	133	0.04	0.9
	price change does not Granger Cause the change of Term		1.91	0.1

	Structure Expected Growth			
lag 3	the change of Term Structure Expected Growth does not Granger Cause price change	132	1.22	0.30
	price change does not Granger Cause the change of Term Structure Expected Growth		1.73	0.16
lag 4	the change of Term Structure Expected Growth does not Granger Cause price change	131	1.02	0.40
	price change does not Granger Cause the change of Term Structure Expected Growth		0.94	0.44
lag 5	the change of Term Structure Expected Growth does not Granger Cause price change	130	2.03	0.08
	price change does not Granger Cause the change of Term Structure Expected Growth		1.10	0.36
lag 6	the change of Term Structure Expected Growth does not Granger Cause price change	129	1.66	0.14
	price change does not Granger Cause the change of Term Structure Expected Growth		0.98	0.45
lag 7	the change of Term Structure Expected Growth does not Granger Cause price change	128	1.55	0.16
	price change does not Granger Cause the change of Term Structure Expected Growth		0.93	0.48
lag 8	the change of Term Structure Expected Growth does not Granger Cause price change	127	1.33	0.23
	price change does not Granger Cause the change of Term Structure Expected Growth		0.76	0.64

Based on the results shown in Table 7.15, we found that for each property sector, the lead-lag relationship between price and Term Structure Expected Growth changes are not consistent. Table 7.16 summarizes the directions of causality with different lag structures, it is denoted by (L) if the p-value of null hypothesis *Term Structure Expected Growth change does not Granger Cause price change* is larger than the p-value of null hypothesis *price change does not Granger Cause Term Structure Expected Growth change*; it is denoted by (S) otherwise .

Table 7.16 Summary of Causality Directions with Various Lag Structures

Price change vs. Term Structure Expected Growth (A) change					**Price change vs. Term Structure Expected Growth (B) change**				
Lag structure	**Industrial Sector**	**Grade-A Office Sector**	**Residential Sector**	**Retail Sector**	**Lag structure**	**Industrial Sector**	**Grade-A Office Sector**	**Residential Sector**	**Retail Sector**
1	L	L	L	S	**1**	S	L	L	L
2	S	L	L	S	**2**	S	L	L	L
3	S	S	L	S	**3**	L	L	S	L
4	S	S	L	S	**4**	L	L	S	L
5	S	S	L	S	**5**	S	L	S	S
6	S	S	L	S	**6**	S	L	L	S
7	S	S	L	S	**7**	S	L	L	S
8	S	S	L	S	**8**	S	L	L	S

Based on the results shown in Table 7.16, the causality directions differed with different lag structures. However we select the commonly used lag structures (2 and 4), because for most of the time, they are capable to present the results of all lag structures.

3. Lead-lag relationship between price changes and the changes of Gordon Growth

Table 7.17 (a and b) report the results of Granger Causality Tests on the movements of price and expected rental income growth based on Gordon Growth Model with 1 to 8 lags.

Table 7.17a: Granger Causality Tests on the movements of price and Gordon Growth (A) with 1 to 8 lags

Sample objectives: four sectors of real estate market in Hong Kong

sample period: Jan. 1999 to Apr. 2010

	Pairwise Granger Causality Tests	**Industrial Sector**		
	Null Hypothesis:	**Obs**	**F-Statistic**	**Prob.**
lag 1	the change of Gordon Growth does not Granger Cause price change	134	3.66	0.06
	price change does not Granger Cause the change of Gordon Growth		0.65	0.42
lag 2	the change of Gordon Growth does not Granger Cause price change	133	2.67	0.07
	price change does not Granger Cause the change of Gordon Growth		0.19	0.83
lag 3	the change of Gordon Growth does not Granger Cause price change	132	2.20	0.09
	price change does not Granger Cause the change of Gordon Growth		0.42	0.74
lag 4	the change of Gordon Growth does not Granger Cause price change	131	1.83	0.13
	price change does not Granger Cause the change of Gordon Growth		0.56	0.69
lag 5	the change of Gordon Growth does not Granger Cause price change	130	1.54	0.18
	price change does not Granger Cause the change of Gordon Growth		0.63	0.68
lag 6	the change of Gordon Growth does not Granger Cause price change	129	1.23	0.30
	price change does not Granger Cause the change of Gordon Growth		1.02	0.41
lag 7	the change of Gordon Growth does not Granger Cause price change	128	1.84	0.09
	price change does not Granger Cause the change of Gordon		0.98	0.45

	Growth			
lag 8	the change of Gordon Growth does not Granger Cause price change	127	2.38	0.02
	price change does not Granger Cause the change of Gordon Growth		0.93	0.50

	Pairwise Granger Causality Tests	**Grade A Office Sector**		
	Null Hypothesis:	**Obs**	**F-Statistic**	**Prob.**
lag 1	the change of Gordon Growth does not Granger Cause price change	134	0.20	0.66
	price change does not Granger Cause the change of Gordon Growth		0.29	0.59
lag 2	the change of Gordon Growth does not Granger Cause price change	133	0.19	0.83
	price change does not Granger Cause the change of Gordon Growth		0.15	0.86
lag 3	the change of Gordon Growth does not Granger Cause price change	132	0.05	0.99
	price change does not Granger Cause the change of Gordon Growth		0.46	0.71
lag 4	the change of Gordon Growth does not Granger Cause price change	131	0.05	1.00
	price change does not Granger Cause the change of Gordon Growth		0.61	0.65
lag 5	the change of Gordon Growth does not Granger Cause price change	130	0.48	0.79
	price change does not Granger Cause the change of Gordon Growth		0.56	0.73
lag 6	the change of Gordon Growth does not Granger Cause price change	129	0.39	0.88
	price change does not Granger Cause the change of Gordon Growth		0.76	0.61
lag 7	the change of Gordon Growth does not Granger Cause price change	128	0.28	0.96
	price change does not Granger Cause the change of Gordon Growth		0.85	0.55
lag 8	the change of Gordon Growth does not Granger Cause price change	127	0.28	0.97
	price change does not Granger Cause the change of Gordon		0.61	0.77

Growth

	Pairwise Granger Causality Tests	Residential Sector		
	Null Hypothesis:	Obs	F-Statistic	Prob.
lag 1	the change of Gordon Growth does not Granger Cause price change	134	0.04	0.85
	price change does not Granger Cause the change of Gordon Growth		2.85	0.09
lag 2	the change of Gordon Growth does not Granger Cause price change	133	0.02	0.98
	price change does not Granger Cause the change of Gordon Growth		1.43	0.24
lag 3	the change of Gordon Growth does not Granger Cause price change	132	0.16	0.92
	price change does not Granger Cause the change of Gordon Growth		1.06	0.37
lag 4	the change of Gordon Growth does not Granger Cause price change	131	0.29	0.89
	price change does not Granger Cause the change of Gordon Growth		0.90	0.47
lag 5	the change of Gordon Growth does not Granger Cause price change	130	0.39	0.86
	price change does not Granger Cause the change of Gordon Growth		1.55	0.18
lag 6	the change of Gordon Growth does not Granger Cause price change	129	0.44	0.85
	price change does not Granger Cause the change of Gordon Growth		1.38	0.23
lag 7	the change of Gordon Growth does not Granger Cause price change	128	0.36	0.92
	price change does not Granger Cause the change of Gordon Growth		1.09	0.38
lag 8	the change of Gordon Growth does not Granger Cause price change	127	0.18	0.99
	price change does not Granger Cause the change of Gordon Growth		1.29	0.26

	Pairwise Granger Causality Tests	Retail Sector		
	Null Hypothesis:	Obs	F-Statistic	Prob.

lag 1	the change of Gordon Growth does not Granger Cause price change	134	0.77	0.38
	price change does not Granger Cause the change of Gordon Growth		0.18	0.67
lag 2	the change of Gordon Growth does not Granger Cause price change	133	1.16	0.32
	price change does not Granger Cause the change of Gordon Growth		3.37	0.04
lag 3	the change of Gordon Growth does not Granger Cause price change	132	0.52	0.67
	price change does not Granger Cause the change of Gordon Growth		1.76	0.16
lag 4	the change of Gordon Growth does not Granger Cause price change	131	0.60	0.67
	price change does not Granger Cause the change of Gordon Growth		1.27	0.29
lag 5	the change of Gordon Growth does not Granger Cause price change	130	0.47	0.80
	price change does not Granger Cause the change of Gordon Growth		1.32	0.26
lag 6	the change of Gordon Growth does not Granger Cause price change	129	0.48	0.82
	price change does not Granger Cause the change of Gordon Growth		1.11	0.36
lag 7	the change of Gordon Growth does not Granger Cause price change	128	0.65	0.72
	price change does not Granger Cause the change of Gordon Growth		1.03	0.41
lag 8	the change of Gordon Growth does not Granger Cause price change	127	0.57	0.80
	price change does not Granger Cause the change of Gordon Growth		0.97	0.47

Table 7.17b: Granger Causality Tests on the movements of price and Gordon Growth (B) with 1 to 8 lags

Sample objectives: four sectors of real estate market in Hong Kong

sample period: Jan. 1999 to Apr. 2010

	Pairwise Granger Causality Tests	**Industrial Sector**		
	Null Hypothesis:	**Obs**	**F-Statistic**	**Prob.**
lag 1	the change of Gordon Growth does not Granger Cause price change	134	1.10	0.30
	price change does not Granger Cause the change of Gordon Growth		3.79	0.05
lag 2	the change of Gordon Growth does not Granger Cause price change	133	0.60	0.55
	price change does not Granger Cause the change of Gordon Growth		3.10	0.05
lag 3	the change of Gordon Growth does not Granger Cause price change	132	0.43	0.73
	price change does not Granger Cause the change of Gordon Growth		2.41	0.07
lag 4	the change of Gordon Growth does not Granger Cause price change	131	0.43	0.79
	price change does not Granger Cause the change of Gordon Growth		1.96	0.10
lag 5	the change of Gordon Growth does not Granger Cause price change	130	0.74	0.60
	price change does not Granger Cause the change of Gordon Growth		1.61	0.16
lag 6	the change of Gordon Growth does not Granger Cause price change	129	2.56	0.02
	price change does not Granger Cause the change of Gordon Growth		1.87	0.09
lag 7	the change of Gordon Growth does not Granger Cause price change	128	2.85	0.01
	price change does not Granger Cause the change of Gordon Growth		1.19	0.31
lag 8	the change of Gordon Growth does not Granger Cause price change	127	2.45	0.02
	price change does not Granger Cause the change of Gordon Growth		1.44	0.19

	Pairwise Granger Causality Tests	Grade A Office Sector		
	Null Hypothesis:	Obs	F-Statistic	Prob.
lag 1	the change of Gordon Growth does not Granger Cause price change	134	0.05	0.82
	price change does not Granger Cause the change of Gordon Growth		6.20	0.01
lag 2	the change of Gordon Growth does not Granger Cause price change	133	0.04	0.96
	price change does not Granger Cause the change of Gordon Growth		2.93	0.06
lag 3	the change of Gordon Growth does not Granger Cause price change	132	0.19	0.90
	price change does not Granger Cause the change of Gordon Growth		5.42	0.00
lag 4	the change of Gordon Growth does not Granger Cause price change	131	0.18	0.95
	price change does not Granger Cause the change of Gordon Growth		3.30	0.01
lag 5	the change of Gordon Growth does not Granger Cause price change	130	0.86	0.51
	price change does not Granger Cause the change of Gordon Growth		2.62	0.03
lag 6	the change of Gordon Growth does not Granger Cause price change	129	0.71	0.64
	price change does not Granger Cause the change of Gordon Growth		2.05	0.06
lag 7	the change of Gordon Growth does not Granger Cause price change	128	0.51	0.83
	price change does not Granger Cause the change of Gordon Growth		1.88	0.08
lag 8	the change of Gordon Growth does not Granger Cause price change	127	0.43	0.90
	price change does not Granger Cause the change of Gordon Growth		1.75	0.09

	Pairwise Granger Causality Tests	Residential Sector		
	Null Hypothesis:	Obs	F-Statistic	Prob.
lag	the change of Gordon Growth does not Granger Cause price	134	0.28	0.60

1	change			
	price change does not Granger Cause the change of Gordon Growth		0.45	0.50
lag 2	the change of Gordon Growth does not Granger Cause price change	133	0.38	0.69
	price change does not Granger Cause the change of Gordon Growth		0.50	0.61
lag 3	the change of Gordon Growth does not Granger Cause price change	132	1.04	0.38
	price change does not Granger Cause the change of Gordon Growth		0.43	0.73
lag 4	the change of Gordon Growth does not Granger Cause price change	131	1.59	0.18
	price change does not Granger Cause the change of Gordon Growth		0.45	0.77
lag 5	the change of Gordon Growth does not Granger Cause price change	130	1.39	0.23
	price change does not Granger Cause the change of Gordon Growth		0.68	0.64
lag 6	the change of Gordon Growth does not Granger Cause price change	129	1.24	0.29
	price change does not Granger Cause the change of Gordon Growth		0.62	0.72
lag 7	the change of Gordon Growth does not Granger Cause price change	128	1.06	0.39
	price change does not Granger Cause the change of Gordon Growth		0.72	0.66
lag 8	the change of Gordon Growth does not Granger Cause price change	127	1.57	0.14
	price change does not Granger Cause the change of Gordon Growth		0.84	0.57

	Pairwise Granger Causality Tests	**Retail Sector**		
	Null Hypothesis:	**Obs**	**F-Statistic**	**Prob.**
lag 1	the change of Gordon Growth does not Granger Cause price change	134	1.03	0.31
	price change does not Granger Cause the change of Gordon Growth		3.07	0.08
lag	the change of Gordon Growth does not Granger Cause price	133	0.28	0.76

2	change			
	price change does not Granger Cause the change of Gordon Growth		3.48	0.03
lag 3	the change of Gordon Growth does not Granger Cause price change	132	1.50	0.22
	price change does not Granger Cause the change of Gordon Growth		2.57	0.06
lag 4	the change of Gordon Growth does not Granger Cause price change	131	1.15	0.34
	price change does not Granger Cause the change of Gordon Growth		1.72	0.15
lag 5	the change of Gordon Growth does not Granger Cause price change	130	1.66	0.15
	price change does not Granger Cause the change of Gordon Growth		2.08	0.07
lag 6	the change of Gordon Growth does not Granger Cause price change	129	1.48	0.19
	price change does not Granger Cause the change of Gordon Growth		1.74	0.12
lag 7	the change of Gordon Growth does not Granger Cause price change	128	1.17	0.32
	price change does not Granger Cause the change of Gordon Growth		1.79	0.10
lag 8	the change of Gordon Growth does not Granger Cause price change	127	0.97	0.46
	price change does not Granger Cause the change of Gordon Growth		1.36	0.22

Based on the results shown in Table 7.17, we found that for each property sector, the lead-lag relationship between price and Gordon Growth changes are not consistent. Table 7.18 summarizes the directions of causality with different lag structures, it is denoted by (L) if the p-value of null hypothesis *Gordon Growth change does not Granger Cause price change* is larger than the p-value of null hypothesis *price change does not Granger Cause Gordon Growth change*; it is denoted by (S) otherwise .

Table 7.18 Summary of Causality Directions with Various Lag Structures

Price change vs. Gordon Growth (A) change					Price change vs. Gordon Growth (B) change				
Lag structure	**Industrial Sector**	**Grade-A Office Sector**	**Residential Sector**	**Retail Sector**	**Lag structure**	**Industrial Sector**	**Grade-A Office Sector**	**Residential Sector**	**Retail Sector**
1	S	L	L	S	**1**	L	L	L	L
2	S	S	L	L	**2**	L	L	L	L
3	S	L	L	L	**3**	L	L	S	L
4	S	L	L	L	**4**	L	L	S	L
5	S	L	L	L	**5**	L	L	S	L
6	S	L	L	L	**6**	S	L	S	L
7	S	L	L	L	**7**	S	L	S	L
8	S	L	L	L	**8**	S	L	S	L

Based on the results shown in Table 7.18, the causality directions differed with different lag structures. However we select the commonly used lag structures (2 and 4), because for most of the time, they are capable to present the results of all lag structures.

CHAPTER 8 CONCLUSIONS AND LIMITATIONS

This Chapter reviews the content of the thesis, summarizes the findings, the contributions and the implications made in previous chapters, points out the limitations of the study, and suggests the further research directions.

8.1 REVIEW OF THE THESIS

It is well-known that the investor's expectation is one of the market's most important factors. The analysis on the investor's expectation has attracted quantity of research in both economic and finance areas. The current commonly-used approaches to find out the investor's expectation are mainly two streams: the behavioral research method (i.e. survey) and the econometric estimation method (i.e. VAR). However the applicable method to estimate the present value with dynamic investor's expectation is still absent in existed studies and actually in urgent need for both practical and academic applications. This thesis proposes an important improvement of the Present Value relationship of the asset price, term structure and expectations on future income. It involves the deduction of the theory, empirical test of the theory together with the empirical investigations on the implications suggested by the theory. The thesis is motivated by the casual observations of the lead-lag relationship between expected rental income growth and price changes on the real estate market illustrated in Chapter 1 and the theoretical framework is examined empirically on Hong Kong real estate market in Chapter 5 & 6.

The previous research concerning the investor's expectation has been critically reviewed in Chapter 2. On one hand, the historical development of the measurement and application of investor's expectation were reviewed. On the other hand, the empirical investigations of the investor's expectation in private and public real estate investment market are also presented. All in all, the expected income growth has been studied as a vital variable in asset pricing and return predicting research. Though the two main methods (both estimating and forecasting) for computing this variable are widely-used in previous studies, there are some inevitable shortcomings in the models. In this way, a novel mathematical model for improving them would be contributable for future research in this area.

The aim of the thesis is to derive theoretical model for dynamic present value relationship of asset value, expected income and term structure of interest rate in real estate asset pricing analysis. Therefore it allows the estimation of the effect of the expected rental income growth on both private and public real estate returns.

There are three major objectives to be achieved in this study: (1) to develop a theoretical model to illustrate the investor's expected rental income growth's influences on real estate returns

(Chapter 3); (2) to test the theory with empirical data from Hong Kong (Chapter 5 & 6); (3) to test the theory further by testing its applications on Hong Kong REITs market (Chapter 5 & 6).

The first objective has been achieved by deriving the Term Structure Expected Growth Model mathematically, the present value relationship of asset value, expected future income and term structure of interest rate is illustrated meanwhile the expected income growth can be captured with updated market data.

The second objective shows the importance of the expected rental income growth in real estate asset pricing. The theoretical model has been applied in practice with the empirical data from Hong Kong private real estate market.

The last objective addresses the implications of the theory introduced in this study. By testing its implications on REITs market, the theory can be examined critically further with empirical data. In this way, the induction of the theory will be completed.

The investigations in the thesis are motivated by our research questions: (1) whether the real estate expected rental income growth leads its price change? (2) why the expected rental income growth affects private real estate price change (capital return)? (3) how the expected rental income growth affects public real estate return?

To make our objectives more tractable and answer our research questions, three related hypotheses are developed progressively based on previous research findings and gaps:

Hypothesis 1 (H1):

The change of expected rental income growth of the real estate asset leads the changes of real estate asset price.

Our first hypothesis relates to the inconsistence evidence of the lead-lag relationship between rent and price changes of the real estate assets to the simple understanding of DW model. With the Lai and Van Order (2010)'s theoretical work and our preliminary observations on the lead-lad relationship among the movements of property rent, price and expected rental income growth based on Gordon Growth Model, we further explore the lead-lag relationship between the real estate asset expected rental income growth and its price changes by testing our first hypothesis. The empirical result of this hypothesis provides the evidence to partially support Lai and Van Order's theory about the investor's expectation's impact on real estate asset's price. Thus after this investigation, we should be able to answer our first research question: *Whether the real estate expected rental income growth leads its price change?* However the lead-lag relationship only shows the changes of the investor's expectation are earlier than the property price changes, still we are not able to answer why the expected rental income growth could affect the real estate asset's price. The Term Structure Expected Growth Model explains why and what impacts the expected rental income growth has on the real estate asset's price. And the investigation of our Application of the Hypothesis (H2):

Application of the Hypothesis 2 (H2):

The change of expected rental income growth has a positive correlation with the *corresponding real estate price movement, ceteris paribus.*

shall answer the second research question with the empirical results. The empirical results of hypothesis 2 provide empirical evidence to support our theoretical model constructed in Chapter 3. Besides, the critical test of our Application of the Hypothesis (H2) is helpful to understand the importance of the Term Structure Expected Growth Model.

Hypothesis 3 (H3):

The change of expected rental income growth of the underlying real estate asset has positive correlation with the fluctuation of REIT's return, ceteris paribus.

The third hypothesis aims to examine the impact of expected rental income growth on public real estate asset's return. This relates to the long lasting debates of whether the public real estate's return is related to the private real estate assets (previous studies concerning this topic had been reviewed in Chapter 2). The relationship between the two market exists in some studies while doesn't exist in some others. If our hypothesis cannot be rejected, then we could not reject the existence of a link between the two markets. The testing of this hypothesis could test our theory of this thesis without limitations on the private real estate market.

The main empirical results of the hypotheses are provided in Chapter 6, which is organized into three major parts corresponding to the three hypotheses developed in Chapter 1. First, the lead-lag relationship of the movements of property price, rent and expected rental income growth is examined. Following that, the empirical study focuses on the impact of expected rental income growth on private real estate asset's return (price change) to test our theoretical model empirically. Finally the implication of our theory is tested with the aim of testing our theoretical model critically by exploring the impact of expected rental income growth on public real estate's return. The findings, contributions and implications are summarized in the following section.

8.2 FINDINGS, CONTRIBUTIONS AND IMPLICATIONS

Contrary to the simple implication of the famous DW model, our empirical observations show that it is not the rent but the expectation on future rental income growth leads the property price changes. With partially confirming of our first hypothesis on Hong Kong real estate market, this study suggests that the investor's expected rental income growth have certain impacts on the real estate asset's price changes. Therefore the expected rental income growth becomes the research focus of this study.

By improving Gordon Growth Model, we constructed our Term Structure Expected Growth Model to illustrate the dynamic present value relationship among the asset's price, expected future income and the term structure of interest rate on real estate market. The practical application of this theoretical model is provided by Model II, and the comparison between Term Structure Expected Growth Model and Gordon Growth Model is presented as well. The results are consistent with the previous findings that the real rent growth has positive impact on property price changes; while the interest rate and its term structure have negative impacts on property price changes. Our model offers a theoretical basis for the previous applications in this sense.

Our third hypothesis is also confirmed by the empirical investigation of the implication of the Term Structure Expected Growth Model on the public real estate market in the context of the effect of the investor's expectation in the REIT's returns. The price discovery process between public and private real estate market in Hong Kong is further explored in Chapter 5 and 6 with the help of the expected rental income growth captured by the Term Structure Expected Growth Model. The empirical findings provide supportive evidence for the implication of our theory that the expected rental income growth of underlying real estate asset has positive impact on the fluctuation of REIT's return, ceteris paribus. Therefore our theory has been tested critically and the investor's expectation has been found to be the linkage between the two markets for the first time.

A set of implications can be drawn from the thesis. As we have illustrated that the investor's expectation is a very important factor for the asset pricing and return analysis with appropriate modeling, it is hoped that the Term Structure Expected Growth Model constructed in this thesis can provide a helpful framework for the investors, banks and governments in their future information analysis of the asset investment and health-check of financial market. In particular, we hope that the analysis on expected future income growth could be generalized and shed light on the future research in other asset types as well as in other countries.

In summary, this thesis makes vital contributions to existing knowledge of the investor's expectation, especially in the context of real estate market. On one hand, the construction of the Term Structure Expected Growth Model is a significant improvement of Gordon Growth Model. Without this new model, the expected rental income growth would be under-estimated so that the property price would be over-estimated according to the empirical specifications in Chapter 3. It reveals the importance of considering the term structure of interest rate into the pricing process. On the other hand, comparing to those dynamic present value model (i.e. Campbell-Shiller's model), our Term Structure Expected Growth Model is easier to applied in real world with the available market data. Thus the expected rental income growth derived based on our model would be the market expectation, which had been firstly captured from the real world.

The significance of this thesis is manifold. It is the first study considering the term structure of interest rate when modeling the expected income growth, the first study that examines the impact of the expected rental income growth on real estate price changes, and the first study that investigates the linkage of the information share between public and private real estate markets.

8.3 LIMITATIONS AND FURTHER AREAS OF RESEARCH

The major limitation of this thesis lies in the proxy of the interest rate spread. As there is no appropriate long-term government bond being issued in Hong Kong, we have to assume the constant growth of each unit-term yield of the government bond. To be more specific, the available market rate is only up to the yield rate of 10-year exchange fund notes while usually the income depreciation period of a property would be 50 year. In this study, we linearly extrapolate the yield rate to 50-year based on constant growth in this thesis. The linearly extrapolated long-term interest rate indicates that the dynamic characteristic of the cost of capital has not been completely captured in the model, which might prevent the thorough understanding of the investor's expectation.

There are also some minor limitations in this thesis. First, the yield (return rate) of the real estate asset is calculated by the Rating and Valuation Department, Hong Kong SAR based on the average rated rent and price levels, which might include some appraisal bias. Second, as widely-known the rents of office and retail properties are usually on two or three year basis with some business confidential terms. These special features of the commercial real estate assets may have slight influences on the analysis of the investor's expectation. The exact transaction rent is needed to fill the gap. Thirdly, the Term Structure Expected Growth Model is derived based on the previous present value model (Gordon Growth Model), which contains no risk factor. So in our model, the risk premium is assumed to be constant. Although the risk premium on public real estate market has been employed into the empirical model, we have to admit that the expected rental income growth derived based on our model does not contain any information of risk. Fourthly, it is difficult to find the appropriate proxy for the discount rate of the Term Structure Expected Growth Model. In this study, we used risk-free rate as the discount rate in Term Structure Expected Growth Model (A) and employed the sum of risk premium and risk-free rate as the discount rate in Term Structure Expected Growth (B). However, the risk premium for private real estate asset is hard to define. There has not been a widely-accepted method to derive it. We here in this study employ a usual but not very proper method to calculate it. It is reasonable to believe that, by giving more appropriate proxy for discount rate, the Term Structure Expected Growth Model would exhibit more improvements. Lastly, the REITs market in Hong Kong is still young and small, in which the empirical results are pilot but not totally convincing enough to make our statements. The only way to make it up is to wait till the Hong Kong REITs market to grow and be enlarged. The more frequent transaction data will benefit the research by that time.

One of the key areas for further research is obviously the direct empirical test to examine whether the derived expected rental income growth is truly the market investors' expectations. Though the empirical investigation of our Application of the Hypothesis (H2) provides the supportive empirical evidence for our theory, the direct empirical test approach would be better. It is difficult but worthy of further research.

Another key area for further research concerns the explanation of the public real estate returns. There are several variables that may have been omitted because our empirical REIT's return model is based on the Chau et.al. (2003)'s factor model of the list property company's return. The management structure and company specific factors have not been examined in this study. The management structure of Hong Kong REIT is single, so its effect is neglected in our study though it had been examined in previous research. The company-specific factors are usually unobservable. We only specify each REIT's portfolio which is accessible in this study. To control those unobservable factors, our panel regression needs more cross-sectional series to balance. This means that the current data set is expected to be extended along with the development of Hong Kong REITs market.

There is also an important area for further research on the term structure of interest rate. As mentioned, the growth of the interest rate is assumed to be constant in this study, which may make its term structure different with the real one. Also we linearly extrapolate long-term interest rate may lead that the dynamic characteristic of the cost of capital has not been completely captured in the model. It is expected that further development of mathematical approaches can be made, so that the term structure of interest rate employed in the model would be perfect for the real world.

Last but not least, it should be emphasized that the Term Structure Expected Growth Model is a general framework for asset's pricing and is not restricted to the applications in the real estate market. Once data in other markets (i.e. expensive metal and petroleum markets) becomes available, the Term Structure Expected Growth Model should be set in place to capture the market investor's expectation on their investment future income growths as well.

GLOSSARY

expectation [*] **:**	the average observable degree of how much the cash-flow of asset or cost of capital will grow in long-term, which is not observable
cash-flow [**] **:**	the movement of cash into or out of an asset. It is usually measured during a specified and finite period of time with regular frequency, i.e. monthly, quarterly or annually
cost of capital [**] **:**	the cost of an asset's funds or the investor's required return on this asset
expected cash-flow growth [*] **:**	the measure of the degree, to which the asset's income stream will change during the specific holding period
expected growth of the cost of capital [*] **:**	the measure of the degree, to which the cost of the investment of asset will change during the specific holding period
private real estate investment [*] **:**	the investment that involves the direct ownership of physical real estate assets. The investors can engage into the private real estate investment by purchasing or leasing. In Hong Kong, there are four major private real estate sectors (residential, office, retail and industrial).
Public real estate investment [*] **:**	the investment of which the investors own the physical real estate assets indirectly through an independent legal entity. Usually, the listed real estate development companies and real estate investment trusts (REITs) are the common forms of these legal entities. However as the listed real estate development company is comparable less real estate than REITs, in this study, the public real estate investment market is specifically to be the REITs market.
*****	The item is defined by the author.
******	The item is defined based on public knowledge from inter http://en.wikipedia.org/wiki

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