**Examination of the Rationality of Real Estate Market Pricing:**

**Focusing on the US Office Property Market**

by

**Jinbae Jeong**

M.S., Architectural Engineering

Yonsei University, 2001

Submitted to the Center for Real Estate in Partial Fulfillment of the Requirements
for the Degree of Master of Science in Real Estate Development

at the

Massachusetts Institute of Technology

September, 2009



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## Abstract

This study examines whether or not investors behave rationally when they price the U.S. office properties. After reviewing several previous studies on the market efficiency, this paper makes three new attempts: first, we employs the actual information on transactions and rents at the property level to resolve the substitution problems; second, we introduce another pricing method which use gross yields and typical cap rate method; lastly, Shiller Test with those actual data is conducted to determine whether future rental growth can be predicted by both or either of those two pricing methods.

The major empirical results can be summarized into the two findings: 1) in the pricing models, the gross yield reflects a property's future rental growth, whereas the cap rate is mostly correlated to the relatively short-term rental growth in the past, 2) in Shiller Test, the future rental growth of a property can be forecasted by the gross yield, not by the cap rate.

These findings suggest that although not perfect, investors of the US office properties, at least partially, forecast the future income of the investments, and reflect them into the pricings by means of gross yields rather than cap rates.

Thesis Supervisor William C. Wheaton
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# Chapter 1 Introduction

## 1.1 Background

Market efficiency of real estate investment, that market price reflects all available information about the value, is not a new research topic any more considering numerous studies published over the past years. However, it is still one of most disputable or even hottest subject given the fact that previous studies brought conclusions that contradict one another. For examples, a study by Hendershott and MacGregor concludes that UK office and retail property investors behave rationally (2005b), but they also find in another study that Australian and US office property investors do not (2005a). Why do they have those opposite outcomes? Would it really be true that Australian and US investors' behaviors are not rational, while UK investors behave rationally? Before making a hasty conclusion to the questions, it will be worth conducting more studies with diverse methods. In the light of this conflict, this study examines the market efficiency through different data and methodology focusing on the US office market.

Existing studies on the rational pricing of real estate assets have left two factors to be improved. One is the accuracy of data for the analyses: due to data constraints of actual transactions or market rents at property level, the previous researches tend to substitute appraisal value for price, several indexes for capitalization rate, and market-wide average rent for the rent of transacted properties. However, several authors raise issues that these substitutes for actual data may cause an 'appraisal smoothing' problem[1]. By contrast, Wheaton and Nechayev (2005) testify to the space market efficiency using actual transaction data for the multi-family housing properties in the Atlanta market. It will be worth applying the analysis method of

[1] Geltner (1991), Hendershott and Kane (1995), and Jud and Winkler (1995)

Wheaton and Nechayev (2005) from the residential property to the commercial property. That is what this study aims to archive: examine the commercial market efficiency with real transaction data.

The other factor to be improved from previous studies is the proxy of real estate pricing. While most existing studies use capitalization rate as a proxy for real estate pricing, several studies suspect that capitalization rates might not be an accurate proxy for the pricing, because they do not necessarily reflect a true picture of fair market rent (Conner and Liang, 2005). Thus this study employs not only the capitalization rate method but also the gross yield method as an alternative for pricing.

Regarding methodology, this study employs the Shiller Test[2] as well as existing methods of pricing models in order to examine the efficiency of the US office property market. Most previous studies examined the market efficiency by constructing models with capitalization rate as the dependent variable and several independent variables including past rental growth and future rental growth as follows:

$$Cap\ rate = F[\Delta past\ rent]\ or\ F[\Delta future\ rent] \qquad (1\text{-}1)$$

As the existing studies which employ the model of (1-1) do not use the actual data, it is necessary to re-examine this model with actual data in this study. Applying the method of (1-1) with actual data, this study, as mentioned previously, also tests the gross yield as another proxy for pricing.

[2] A test to determine whether or not market pricing is correlated to subsequent income behavior, Campbell and Shiller, "Cointegration and tests of Present Value Models," 1986

*Gross yield = F [Δpast rent] or F [Δfuture rent]* *(1-2)*

Meanwhile, Shiller and Campbell (1986) say in their study that efficient markets can at least partially anticipate the future. They also claim that since the information on the past income or rent growth are mechanically connected with pricing, using the previous information is not appropriate to examine the market efficiency, but that the only way to examine the efficiency is to reveal whether or not information on the subsequent income or rent growth is correlated with pricing. Hence, in addition to the above models of (1-1) and (1-2), this study will conduct Shiller Test with future rental growth as dependent variable and pricing methods as independent variables.

*Δfuture rent = F [Cap rate] or F [Gross yield]* *(1-3)*

As a result, this study will demonstrate whether or not the US office property market is efficient, and reveal which proxy is better for pricing between the capitalization rate and the gross yield.

## 1.2 Objectives

Considering the above background or motivation, the primary objectives of this thesis are as follows:

- To investigate determinants of pricing for the office property.
- To examine whether pricing reflects market information such as rent growth and level of rent.
- To compare the pricing methods to see if capitalization rate is a more appropriate way to price real estate properties than gross yield.

## Chapter 2 Literature Review

Researches to date on real estate market efficiency can be classified into the following three categories: 1) study of chronological variation of pricing, 2) study of variation in pricing across different geographical markets, 3) study of variation in pricing across product types. This study, which uses a cross-sectionally dominated panel dataset, falls into category two. However, in order to establish the basis for the study, the categories of (1) and (2) are reviewed in this chapter.

### 2.1 Time series analysis for real estate investment rationality

Jun Chen, Susan Hudson-Wilson, and Hans Nordby (2004) examine the connections between the capital markets and the real estate markets, and the relative investment environment using cap rate spreads[3], or risk premium, between the implied cap rate and the 10-year Treasury bond, or risk-free rate. The study observes the historical real estate performance and pricing and conducts quantitative analysis of the pricing of the four property types: office, apartment, retail, and industrial. The explanatory variables used in the modeling are lagged cap rate spread, change of construction, rent growth year to year, rent cycle, vacancy change year to year, inflation rate, real GDP growth rate, and growth rate of S&P 500 stock index. The findings indicate that even though the primary variables driving cap rate spread in each sector are different, most property types still look reasonably priced against the risks.

Philip Conner and Youguo liang (2005) examine the historical relationship between real estate

[3] Authors derive an equation of capitalization rate spread over T-bond as the relation between risk premium of space market and real estate growth rate;

$CapSpread = Y_{NOI} - r_{(b)} = r_f + RP_{(RE)} - g_{RE} - (r_f + RP_{(b)}) = RP_{(RE)} - RP_{(b)} - g_{RE} = RP_{(space)} - g_{RE}$

property market forces, which drive property earnings, and capital market forces, which largely determine cap rates, to help investors better understand how the two forces have affected property values in the past and how changes in either might affect property values in the future. Through mathematical decomposition of cap rate, the authors demonstrate that property appreciation is composed of the three factors: the income effect, the cap rate effect, and the interaction effect[4]. Further, NCREIF appreciation is decomposed into these three factors during two market downturns, the period between 1991 and 1993, and the more recent downturn of 2002 to 2004. As a result, it is found that capital market forces clearly dominated property market forces during both periods but with very different results. In the early 1990s' downturn, property income fell and cap rates rose as investors liquidated assets at distressed prices. However, during the recent downturn, property income fell sharply, but cap rates declined as capital poured into the asset class.

As demonstrated in the previous two studies, the relation between real estate pricing and capital market factors is important, but the effects should be consistent across all markets in the US at a specific period of time. Since this thesis analyzes the cross-sectionally dominated panel data, it does not focus on the capital market factors, but it employs year dummy variables to control time trends.

Serguei Chervachidze, James Costello and William Wheaton (2009) construct and test three models to explain the determinants of real estate capitalization rates: Standard rents and T-

[4] The percentage change in price is the sum of three components: percentage growth in income, percentage change in cap rate, and the product of the two, as following equation;
$\Delta P/P_1 = \Delta NOI/NOI_1 + \Delta C/C_2 + (\Delta NOI/NOI_1)(\Delta C/C_2)$

bond model, extended model without structural change, and extended model with structural change. The standard model uses 'real rent index,' and 'real T-bond yield' as the determinants of cap rate. In this model, the coefficient of real rent index has a statistically significant negative sign, which testifies to the backward-looking behavior of real estate investors. For extended model without structural change, this study identifies two macroeconomic factors, besides risk free treasury rates, that greatly impact cap rates: 'the general corporate risk premium operating in the economy,' and 'the amount of debt (liquidity) available.' The extended model adding these factors to the standard model is able to explain the rise of cap rates in the early 1990s, the secular fall of cap rates in the last decade and the recent rise during the financial crisis. Furthermore, with the extended model with structural change, the authors provide the findings that gradually-occurring structural change due to long-term hard-to-measure factors such as investor sentiment has an important effect on the dynamics of capitalization rates.

As a time-series analysis, the authors use the variable of 'real rent index'[5] to reveal the investor's backward-looking or forward-looking behavior. This thesis will also examine the behaviors of investors, but with a method that differs from their study. This thesis will examine whether the pricing of a transacted property reflects the past or future growth rates of rents for this property. Further, like capital market effects, the macroeconomic factors should be consistent across all markets, and they are covered by the year dummy variables to control time trends of several years.

[5] Real rent index(RRI) is calculated as a ratio of real rent for a given MSA in a given quarter to the historical average of real rent for this MSA;
$RRI_{j,t\text{-}s} = Real\ Rent_{j,t} / Mean(Real\ Rent_j)$, *i= time, j= MSA*

## 2.2 Cross sectional analysis for real estate investment rationality

William Wheaton and Gleb nechayev (2005) examine whether the theory of space price equilibrium also applies to the submarket levels within a metropolitan area. The analysis is based on the theory of space price equilibrium, i.e. real estate prices reflect systematically different rent growth across locations. The authors focus on the Atlanta apartment market over the period from 1994 through 2004. The analysis finds large differences in the fundamentals, especially in rent levels and long-run rental growth, and also finds indifference in the total return of investment across locations, which considerably indicates correct market pricing. The coefficient of the average local rental growth rate on property yields is in the neighborhood of -0.6, which is quite close to the theory's prediction of -1.0. It means that the yield in areas with a higher risk closely compensates investors and provides a roughly equivalent total return.

This thesis employs the analysis methods that are similar to the work by Wheaton and Nechayev (2005). The differences are that this thesis focuses on the US office property, and that it does examine the impact of property-level growth rate instead of the market-level growth rate.

Doina Chichernea, Norm Miller, Jeff Fisher, Michael Sklarz and Bob White (2007), investigate the relation between the geographical cross-sectional variance of capitalization rates and the influences from housing demand growth, supply constraints, and liquidity risk. Using data from

Real Capital Analytics for multifamily properties, they construct apartment cap rate model[6] which consists of the explanatory variables such as size and height of a property, age at the sale year, and distance to the center of a city. Further, they construct the second model for cross-sectional cap rate variation. As a result, they claim a very robust relation between supply constraints and cap rates. Similarly, this thesis constructs office pricing models using the variables from property information such as area, and age at the time of sale.

In summary, the two main trends of research for real estate market efficiency are 1) studies of chronological variation of pricing, 2) studies of variation in pricing across different geographical markets. The first group of studies concludes that capitalization rate is affected mainly by the capital market and macroeconomic factors. On the other hand, the second group of studies utilizes the data of age, size or number of units for the property-specific information to construct pricing models. Even though this study does not focus on chronological variation of pricing, it needs to control time trends of capital market or macroeconomics since the transaction data extend over several years. Besides, like the previous studies, this study will also use gross floor area (GFA) and age at the time of sale for the property information variables.

[6] $R_i - R_f = a_0 + a_1 SqFt + a_2 AgeatSale + a_3 GardenDummy + a_4 Mid/Highrise + a_5 CondConv + a_6 DistanceToCenter + \Sigma b_j YearDummy + \Sigma c_j MSADummy_i$

## Chapter 3 Real Estate Pricing Methods

In this chapter, pricing methods are explored since this thesis employs not only the capitalization rate but also the gross yield, which is not common in the US. At the last part of this chapter, the pricing methods will be discomposed mathematically to help establish the foundation of the model construction for further research.

### 3.1 DCF Method and Direct Capitalization

Income approach is the most widely used valuation method for commercial properties, and is used as the bases for buy and sell decisions. Income approach is composed of two methods: the discounted cash flow (DCF) method and the direct capitalization method. Unlike the DCF method, which takes explicit account of factors such as trends in cash flows and changes in exit value, the direct capitalization method takes account of only one year's income and sale price and thus is much simpler. While the direct capitalization is a fairly crude method, it is extensively used at the preliminary phase of investment to estimate the probable market value of property. In addition, the initial yield is also quite a useful indicator of trends in property value over time or across region. Before analysis, it is necessary to specify the terms of discount rate, initial yield, and capitalization rate (cap rate) since even some professional papers interchange those terms without clarification.

### 3.2 Discount Rate, Capitalization Rate, and Gross Initial Yield

Discount rate is the interest rate which is applied to future cash flows in the DCF method to derive a present value of a property. It can be also regarded as 'required rate of return (RRR)'

or 'cost of capital' for investment, and is equivalent of internal rate of return (IRR), or total return of investment assuming that a single discount rate is applied to the same cash flow.

Whereas discount rate is used in the DCF method, cap rate and yield are employed in the direct capitalization method. Cap rate is simply a ratio of a property's net operating income (NOI) to its total price or value:

$$R = NOI / V \qquad (3\text{-}1)$$

Although cap rate provides an indication of a property's recurring earnings power, it does not necessarily provide a true picture of what an investor can expect to receive from the property[7], nor match with market information. Specifically, the NOI which is used to calculate a cap rate varies by property type, and in some cases, it also shows a discrepancy by leasing structure even among the same property type. Therefore, the question of whether cap rate is an appropriate proxy of pricing particularly for the examination of market efficiency should be raised.

An alternative to cap rate is 'gross initial yield (GIY),' which is defined as follows:

$$GIY^{8} = \text{gross market rent} / \text{market value} \qquad (3\text{-}2)$$

As shown in the above formula, the gross yield substitutes NOI with gross market rent, which is to eliminate the income variance caused by calculation of NOI or different leasing structure and thus to reduce inaccuracy. In this study, both proxies of cap rate and gross yield are used to

[7] In some cases, the expenses that are excluded from NOI, which in the office, industrial, and retail sectors include leasing commissions and tenant improvements, can have a significant impact on cash flow.
Philip Conner and Youguo liang. "Income and Cap Rate Effects on Property Appreciation," The Journal of Portfolio Management, 2005

[8] It can be also expressed by another way: *GIY = expected income of first year / total property price*
Martine Van Wouwe, Tom M. Berkhout, and Pol R. Tansens, "Risk Premiums in Cap rates of Investment Property," *The Appraisal Journal*, Summer 2008

examine the rationality of investor's behavior and to observe which method is more appropriate.

### 3.3 Structure of Gross Yield and Capitalization Rate

To articulate the formulas of (1-1) and (1-2), we motivate our empirical models with the simple Gordon growth model. If rent, from a long-term perspective, is expected to grow at a constant rate *g*, then the total return (R) of an investment is composed of two factors: initial yield and expected growth in rent.

$$R^i = Y^i + g^i \qquad (3\text{-}3)$$

From the risk perspective, another formula for *R* is the sum of risk free rate and risk premium. Meanwhile, the risk premium of an investment of a property is assumed to consist of factors of the capital market, macroeconomics, and the property itself.[9,10]

$$R^i = r^t_f + RP^{i,t} = r^t_f + RP^t_{capital\ market} + RP^t_{macro} + RP^i_{property} \qquad (3\text{-}4)$$

(i: property, t: time)

Using the formulas of (3-3) and (3-4), the formula for the gross yield or the cap rate can be derived as follows:

$$Y^i = R^i - g^i \qquad (3\text{-}5)$$

$$= r^t_f + RP^t_{capital\ market} + RP^t_{macro} + RP^i_{property} - g^i \qquad (3\text{-}6)$$

As mentioned in the previous chapters, the risk free rate and the risk factors from the capital market and macroeconomics at a certain time can be assumed a time trend. Accordingly, the

[9] Jun Chen, Susan Hudson-Wilson, and Hans Nordby, "Real Estate Pricing: Spreads & Sensibilities: Why Real Estate Pricing is Rational," Journal of Real Estate Portfolio Management, Vol. 10. No. 1, 2004

[10] Serguei Chervachidze, James Costello and William Wheaton, "The Secular and Cyclic Determinants of Capitalization Rates: the Role of Property Fundamentals, Macroeconomic Factors, and Investor Sentiment," 2009

formula of (3-6) can be more simply expressed by three terms as follows:

$$Y^i = Trend^t + RP^i_{property} - g^i \qquad (3\text{-}7)$$

$R^i$ : total return of property *i*

$r^t_f$ : risk free rate at time *t*

$RP^{i,t}$ : risk premium of property *i* at time *t*

$Y^i$ : initial yield of property *i* (gross yield or cap rate)

$g^i$ : constant rental growth rate of property *i*

$Trend^t$ : overall time trends at time *t*

The formula of (3-7) can be referred to the basis of pricing models in this study, which are constructed and explained in detail in the following chapter. This study uses both of past and future growth rates in separated models to explore whether investors' behaviors are backward-looking or forward-looking. For examples, if the analysis concludes that past rental growth is significant, it indicates the backward-looking behavior of investors.

The equation of (3-7) can be converted as follows, deriving the formula for Shiller Test.

$$g^i = Trend^t + RP^i_{property} - Y^i \qquad (3\text{-}8)$$

Both equations of (3-7) and (3-8) indicate that cap rates or gross yields should negatively correlate with rental growth rates. Unlike the pricing models, Shiller Test is to examine only the correlation between subsequent rent growth and pricing, and thus just the future rent growth is used in this model.

In summary, the basic theory of income approach and the difference between cap rates and

gross yields were explored in this chapter. As several studies hint that cap rates might not be an accurate proxy for the pricing, this study will use both pricing methods. Besides, cap rates or gross yields were decomposed into three parts such as time trend, risk premium of property, and income growth.

## Chapter 4 Data Set and Recent Trends in US Office Property

This analysis focuses on the US office market over the period from 2003 through 2008 plus the first quarter of 2009, and uses two data sources: transaction data from Real Analytics Advisors, Inc. (RCA), and market rent data for the transacted property from CBRE Econometric Advisors (CBRE)[11].

### 4.1 US Office Transaction Data: 2003q1 – 2009q1

For the past several years, RCA has been collecting information on actual commercial property sales transactions in many metropolitan statistics areas (MSAs) around the US. Between 2003q1 and 2009q1, the RCA database spans 8,412 transactions records across 62 MSAs, and Table 1 shows the number of sales by MSA and year.

**Table 1: RCA Office Transactions**

| market name | Year sold | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|
| | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | |
| Albany | 0 | 0 | 2 | 2 | 5 | 0 | 0 | 9 |
| Albuquerque | 1 | 2 | 5 | 6 | 6 | 0 | 0 | 20 |
| Atlanta | 29 | 62 | 68 | 68 | 73 | 31 | 0 | 331 |
| Austin | 4 | 11 | 13 | 22 | 31 | 14 | 1 | 96 |
| Baltimore | 9 | 8 | 12 | 16 | 21 | 6 | 0 | 72 |
| Boston | 19 | 46 | 41 | 68 | 88 | 21 | 3 | 286 |
| Charlotte | 7 | 8 | 15 | 13 | 23 | 5 | 0 | 71 |
| Chicago | 47 | 68 | 73 | 101 | 91 | 25 | 3 | 408 |
| Cincinnati | 7 | 13 | 11 | 15 | 4 | 1 | 0 | 51 |
| Cleveland | 4 | 3 | 7 | 5 | 14 | 5 | 0 | 38 |
| Columbia, SC | 1 | 4 | 0 | 6 | 4 | 1 | 0 | 16 |
| Columbus | 2 | 9 | 9 | 8 | 10 | 10 | 2 | 50 |
| Dallas | 33 | 58 | 69 | 93 | 63 | 26 | 3 | 345 |
| Denver | 16 | 35 | 39 | 79 | 69 | 32 | 1 | 271 |
| Detroit | 7 | 13 | 12 | 9 | 20 | 4 | 0 | 65 |
| Edison | 3 | 16 | 17 | 18 | 10 | 9 | 0 | 73 |
| Fort Lauderdale | 11 | 16 | 39 | 28 | 24 | 4 | 0 | 122 |
| Fort Worth | 9 | 8 | 9 | 14 | 13 | 7 | 1 | 61 |
| Fresno | 2 | 2 | 1 | 2 | 5 | 0 | 0 | 12 |
| Honolulu | 6 | 5 | 5 | 3 | 7 | 7 | 0 | 33 |
| Houston | 32 | 48 | 63 | 55 | 79 | 21 | 1 | 299 |
| Indianapolis | 4 | 7 | 7 | 21 | 7 | 2 | 0 | 48 |
| Jacksonville | 2 | 8 | 9 | 11 | 11 | 1 | 0 | 42 |
| Kansas City | 6 | 8 | 13 | 16 | 13 | 9 | 0 | 65 |
| Las Vegas | 11 | 15 | 27 | 18 | 13 | 7 | 0 | 91 |
| Long Island | 11 | 20 | 16 | 13 | 21 | 9 | 2 | 92 |
| Los Angeles | 83 | 102 | 122 | 131 | 139 | 58 | 1 | 636 |
| Louisville | 0 | 2 | 3 | 3 | 13 | 6 | 0 | 27 |
| Memphis | 3 | 2 | 4 | 3 | 4 | 3 | 0 | 19 |
| Miami | 21 | 27 | 39 | 37 | 29 | 15 | 0 | 168 |
| Milwaukee | 1 | 7 | 6 | 7 | 10 | 4 | 0 | 35 |

| market name | Year sold | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|
| | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | |
| Minneapolis | 18 | 14 | 34 | 24 | 23 | 13 | 1 | 127 |
| Nashville | 8 | 4 | 8 | 12 | 17 | 7 | 0 | 56 |
| New York | 41 | 86 | 77 | 93 | 114 | 47 | 3 | 461 |
| Newark | 13 | 14 | 17 | 29 | 27 | 9 | 2 | 111 |
| Oakland | 12 | 18 | 26 | 26 | 33 | 17 | 4 | 136 |
| Oklahoma City | 3 | 1 | 7 | 3 | 3 | 5 | 0 | 22 |
| Orange County | 41 | 43 | 54 | 62 | 102 | 19 | 3 | 324 |
| Orlando | 8 | 20 | 26 | 24 | 27 | 4 | 0 | 109 |
| Philadelphia | 16 | 26 | 34 | 55 | 42 | 12 | 1 | 186 |
| Phoenix | 32 | 35 | 68 | 68 | 60 | 20 | 1 | 284 |
| Pittsburgh | 2 | 3 | 9 | 7 | 9 | 5 | 0 | 35 |
| Portland | 10 | 6 | 16 | 15 | 50 | 12 | 1 | 110 |
| Raleigh | 8 | 6 | 17 | 10 | 23 | 9 | 0 | 73 |
| Riverside | 10 | 9 | 8 | 4 | 8 | 8 | 0 | 47 |
| Sacramento | 22 | 22 | 41 | 37 | 48 | 9 | 1 | 180 |
| Salt Lake City | 5 | 6 | 8 | 21 | 17 | 4 | 0 | 61 |
| San Antonio | 9 | 3 | 10 | 11 | 12 | 7 | 1 | 53 |
| San Diego | 40 | 49 | 39 | 69 | 69 | 22 | 1 | 289 |
| San Francisco | 17 | 27 | 64 | 51 | 93 | 18 | 1 | 271 |
| San Jose | 6 | 11 | 23 | 23 | 42 | 13 | 0 | 118 |
| Seattle | 16 | 27 | 39 | 44 | 107 | 18 | 1 | 252 |
| St. Louis | 11 | 8 | 18 | 14 | 19 | 13 | 2 | 85 |
| Stamford | 4 | 11 | 23 | 9 | 32 | 9 | 0 | 88 |
| Tampa | 10 | 11 | 28 | 17 | 19 | 6 | 1 | 92 |
| Toledo | 1 | 0 | 2 | 0 | 1 | 1 | 0 | 5 |
| Trenton | 2 | 0 | 0 | 3 | 0 | 0 | 0 | 5 |
| Tucson | 2 | 2 | 5 | 1 | 5 | 1 | 0 | 16 |
| Ventura | 1 | 1 | 1 | 7 | 7 | 1 | 0 | 18 |
| Washington, DC | 94 | 114 | 140 | 162 | 172 | 41 | 7 | 730 |
| West Palm Beach | 8 | 13 | 26 | 24 | 18 | 12 | 2 | 103 |
| Wilmington | 4 | 1 | 4 | 1 | 2 | 1 | 0 | 13 |
| Total | 865 | 1224 | 1628 | 1817 | 2121 | 706 | 51 | 8412 |

[11] Formerly Torto Wheaton Research

Table 1 also shows the steady increase of sales from 2004 through 2007 in total, and then a sharp decrease at year 2008 and the first quarter of 2009, caused by the current financial crisis. The MSA which has the biggest number of transactions is Washington D.C. with 730 sales records, followed by Los Angeles with 636, New York with 461, and Chicago with 408. Each record includes information on MSA, address, gross floor area, completion year, closing date, and sale price.

**Table 2: Average Cap Rates of Sample Office Buildings by MSA**

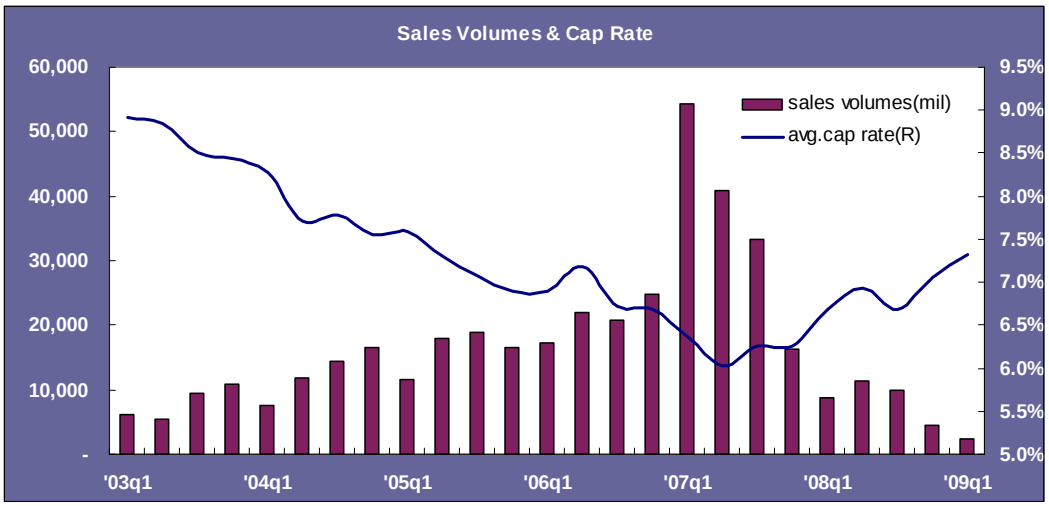
| Market Name | Mean(%) | Std. Dev. | Frequency |
|---|---|---|---|
| Albany | 5.76 | 0.00 | 1 |
| Austin | 6.03 | 2.17 | 21 |
| New York | 6.06 | 1.55 | 169 |
| San Francisco | 6.26 | 1.73 | 99 |
| Ventura | 6.47 | 1.75 | 6 |
| Long Island | 6.53 | 1.24 | 29 |
| San Jose | 6.60 | 1.77 | 35 |
| West Palm Beac | 6.69 | 1.55 | 40 |
| Seattle | 6.75 | 1.72 | 57 |
| Louisville | 6.82 | 1.98 | 4 |
| Los Angeles | 6.84 | 1.49 | 260 |
| Stamford | 6.86 | 1.53 | 24 |
| Washington, DC | 6.87 | 1.35 | 283 |
| Miami | 6.95 | 1.61 | 59 |
| Boston | 6.95 | 1.70 | 79 |
| Newark | 6.96 | 1.41 | 37 |
| Edison | 6.97 | 1.07 | 21 |
| Orange County | 7.00 | 1.46 | 136 |
| San Diego | 7.04 | 1.28 | 129 |
| Portland | 7.05 | 1.75 | 36 |
| Fort Lauderdal | 7.07 | 1.71 | 51 |
| Honolulu | 7.07 | 2.13 | 8 |
| Fresno | 7.17 | 0.53 | 5 |
| Charlotte | 7.19 | 1.04 | 32 |
| Chicago | 7.28 | 1.60 | 139 |
| Tampa | 7.34 | 0.80 | 22 |
| Wilmington | 7.34 | 0.82 | 5 |
| Atlanta | 7.41 | 1.45 | 122 |
| Denver | 7.42 | 1.39 | 78 |
| Oakland | 7.46 | 1.97 | 51 |
| Las Vegas | 7.52 | 1.15 | 45 |

| Market Name | Mean(%) | Std. Dev. | Frequency |
|---|---|---|---|
| Tucson | 7.53 | 0.60 | 5 |
| Phoenix | 7.53 | 1.30 | 96 |
| Orlando | 7.58 | 1.96 | 36 |
| Milwaukee | 7.59 | 0.85 | 13 |
| Columbus | 7.61 | 0.75 | 9 |
| Kansas City | 7.61 | 1.30 | 23 |
| Philadelphia | 7.68 | 1.15 | 82 |
| Raleigh | 7.69 | 1.51 | 26 |
| Dallas | 7.72 | 1.86 | 110 |
| Indianapolis | 7.72 | 1.18 | 18 |
| Salt Lake City | 7.73 | 0.82 | 21 |
| Riverside | 7.79 | 1.46 | 23 |
| Baltimore | 7.79 | 1.50 | 21 |
| Houston | 7.88 | 1.45 | 106 |
| Sacramento | 7.88 | 1.33 | 62 |
| Albuquerque | 7.89 | 1.11 | 9 |
| Minneapolis | 7.90 | 1.19 | 33 |
| St. Louis | 7.92 | 1.65 | 19 |
| San Antonio | 8.08 | 1.40 | 16 |
| Oklahoma City | 8.16 | 1.99 | 8 |
| Nashville | 8.32 | 1.31 | 17 |
| Cincinnati | 8.33 | 1.47 | 17 |
| Cleveland | 8.36 | 1.22 | 13 |
| Jacksonville | 8.42 | 1.83 | 12 |
| Fort Worth | 8.42 | 1.47 | 24 |
| Memphis | 8.46 | 0.96 | 6 |
| Pittsburgh | 8.59 | 1.75 | 11 |
| Toledo | 8.71 | 0.00 | 1 |
| Columbia, SC | 8.85 | 1.48 | 5 |
| Detroit | 9.01 | 0.99 | 15 |
| Trenton | 9.27 | 1.98 | 2 |
| Total | 7.18 | 1.58 | 2942 |

Out of these records, 2,942 have cap rate information. Aggregating across years (2003q1 to 2009q1), the average cap rate by MSA are computed as shown in Table 2. The range in average cap rates across MSA is about 300 basis points from low 6% of Austin and New York to low 9% of Detroit and Trenton. However, Table 2 does not reveal the trend over time. Figure 1 demonstrates the sample's transaction trend over time from 2003q1 through 2009q1. As the capital was concentrated in the commercial properties, the sales volumes increased until

the first quarter of 2007, which made average cap rates keep moving down. After it hit the peak during the first quarter of 2007, the office sales turned around and cap rates also hit the bottom during the next quarter. Since then a decrease in the sales volumes and an increase in the cap rates have occurred, which accelerated during the third quarter of 2008 as the US economy faced the unprecedented financial crisis.

**Figure 1: Sales Volumes & Cap Rates**




## 4.2 Sample Office Buildings' Rents: 1998q1 – 2009q1

While most existing studies use market-wide average rent, this study employs property level rents of sample buildings, owing to CBRE Econometric Advisors (CBRE), which collects information on the commercial properties' rents across the country for every quarter.

These should be treated as market rents of properties rather than actual rents or contract rents since they represent rents offered by landlords or property managers for available space in their market at that time. These quarterly rent data from 1998q1 to 2009q1, provided by CBRE, are matched by address to the each transaction data from RCA. Since it is recoded only when a

property has an available space, a rent record of a property at a certain quarter may not be available.

In addition, two types of rent exist in the US office market, gross rent and net rent, and the CBRE data are divided by those two types. The gross rent accounts for over eighty percentage of the total sample properties. To keep the consistency, only the gross rent is used, while the net rent data is discarded. These missing data of the rents, combined with the missing information on cap rates from RCA, decrease the total number of available data for the analyses. However, it is still large enough for analyses since it ranges from 1,358 to 4,054, varied by the variables used in models.

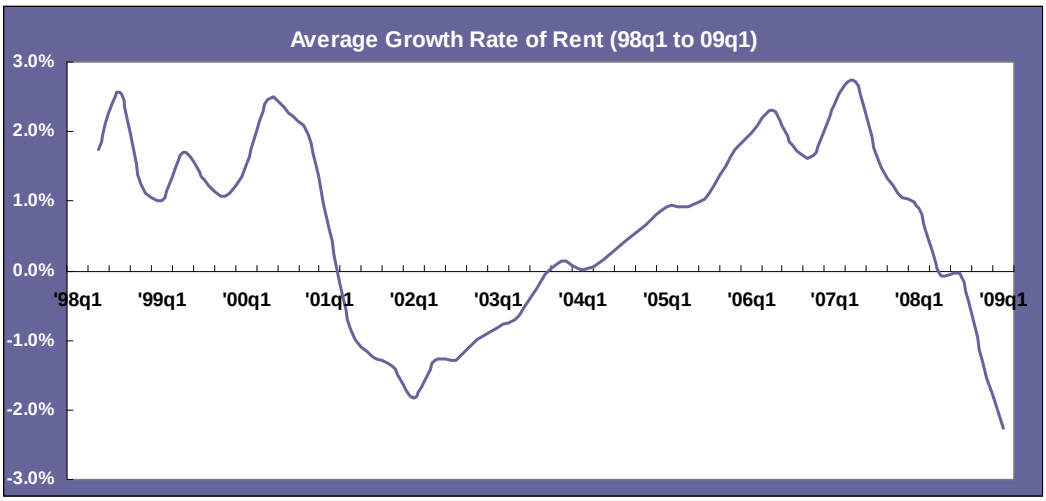
**Table 3: Average Rent at Transaction of Sample Office Buildings**

| Market Name | Mean($/SF) | Std. Dev. | Frequency | Market Name | Mean($/SF) | Std. Dev. | Frequency |
|---|---|---|---|---|---|---|---|
| New York | 38.17 | 17.99 | 275 | Orlando | 20.20 | 2.88 | 82 |
| Honolulu | 30.30 | 4.54 | 6 | Philadelphia | 19.79 | 3.67 | 50 |
| Washington, DC | 29.43 | 7.53 | 511 | Columbia, SC | 19.56 | 0.00 | 1 |
| Stamford | 29.29 | 7.80 | 62 | Tampa | 19.45 | 2.72 | 72 |
| San Diego | 26.46 | 5.75 | 213 | Pittsburgh | 19.42 | 3.63 | 25 |
| Los Angeles | 26.40 | 7.09 | 487 | Detroit | 19.36 | 3.42 | 43 |
| San Jose | 25.81 | 6.43 | 64 | Memphis | 19.19 | 2.59 | 16 |
| Boston | 25.77 | 8.55 | 160 | Charlotte | 19.13 | 3.25 | 54 |
| Trenton | 25.29 | 0.36 | 3 | Atlanta | 19.02 | 3.17 | 218 |
| Ventura | 25.17 | 2.02 | 12 | Cleveland | 18.86 | 4.20 | 25 |
| Miami | 25.17 | 6.13 | 111 | Austin | 18.71 | 2.99 | 45 |
| Orange County | 25.02 | 4.28 | 225 | San Antonio | 18.60 | 2.88 | 25 |
| Long Island | 24.98 | 4.30 | 65 | Raleigh | 18.39 | 2.31 | 46 |
| Oakland | 24.90 | 4.99 | 90 | Kansas City | 18.05 | 2.56 | 48 |
| Newark | 24.70 | 4.43 | 83 | Jacksonville | 18.03 | 2.12 | 26 |
| San Francisco | 24.42 | 6.75 | 159 | Minneapolis | 17.60 | 3.27 | 9 |
| Las Vegas | 23.31 | 4.58 | 51 | Denver | 17.48 | 3.12 | 205 |
| Seattle | 23.04 | 4.34 | 149 | Nashville | 17.47 | 2.99 | 45 |
| Sacramento | 22.86 | 4.52 | 135 | Louisville | 17.20 | 1.57 | 8 |
| Edison | 22.70 | 3.99 | 52 | Houston | 17.13 | 2.80 | 245 |
| Wilmington | 22.13 | 2.83 | 9 | Toledo | 16.86 | 2.57 | 3 |
| Phoenix | 21.80 | 4.25 | 228 | Fort Worth | 16.86 | 2.48 | 28 |
| Riverside | 21.41 | 3.95 | 32 | Salt Lake City | 16.67 | 3.11 | 41 |
| West Palm Beac | 20.99 | 2.60 | 18 | Indianapolis | 16.24 | 2.63 | 43 |
| Chicago | 20.99 | 3.83 | 144 | Dallas | 16.18 | 2.17 | 130 |
| Portland | 20.89 | 3.76 | 100 | Albuquerque | 16.04 | 1.86 | 12 |
| Fresno | 20.70 | 4.67 | 2 | Cincinnati | 15.71 | 3.19 | 21 |
| Fort Lauderdal | 20.46 | 4.59 | 34 | Milwaukee | 15.13 | 3.30 | 3 |
| Tucson | 20.42 | 1.63 | 8 | Columbus | 15.05 | 2.23 | 17 |
| Baltimore | 20.30 | 4.62 | 56 | Oklahoma City | 14.71 | 1.69 | 8 |
| St. Louis | 20.24 | 3.03 | 65 | Total | 23.57 | 8.35 | 5203 |

Aggregating across years (2003q1 to 2009q1), the average gross rents at transaction of sample buildings by MSA are shown in Table 3. New York averages above 38 ($/SF) of the highest rent,

followed by Honolulu, Washington, DC and Stamford with about 29 to 30 ($/SF), and Oklahoma City showing the lowest average, roughly a third of the New York's rent.

**Figure 2: Quarterly Average Rental Growth of Sample Buildings**




To explore the time trend of the sample buildings' rents, the each sample property's growth rates from 1998q1 through 2009q1 are computed and averaged quarterly. As shown in Figure 2, the rental growth rate continued to increase after trough of 2002 until the peak of the year 2007. This pattern is quite similar to that of sales volumes observed from the RAC transaction data (See Figure 3).

This explains the correlation of growth rate with transactions and cap rates: a positive correlation between growth rate and sales volumes, and a negative correlation between growth rate and cap rates (see Figure 4). In other words, an increase in rent attracts investors' capital, lowering the cap rate simultaneously, while a rent decrease depresses investments, raising the cap rate at once. In fact, the rental growth, one of the most important fundamentals in real estate, can be said to have a significant effect on the investment activities.

**Figure 3: Sales Volumes & Rent Growth**

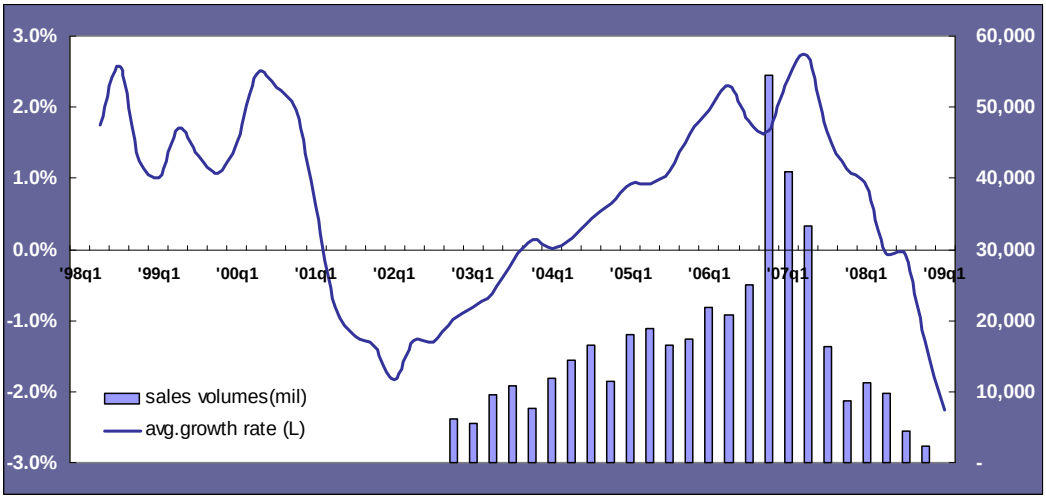
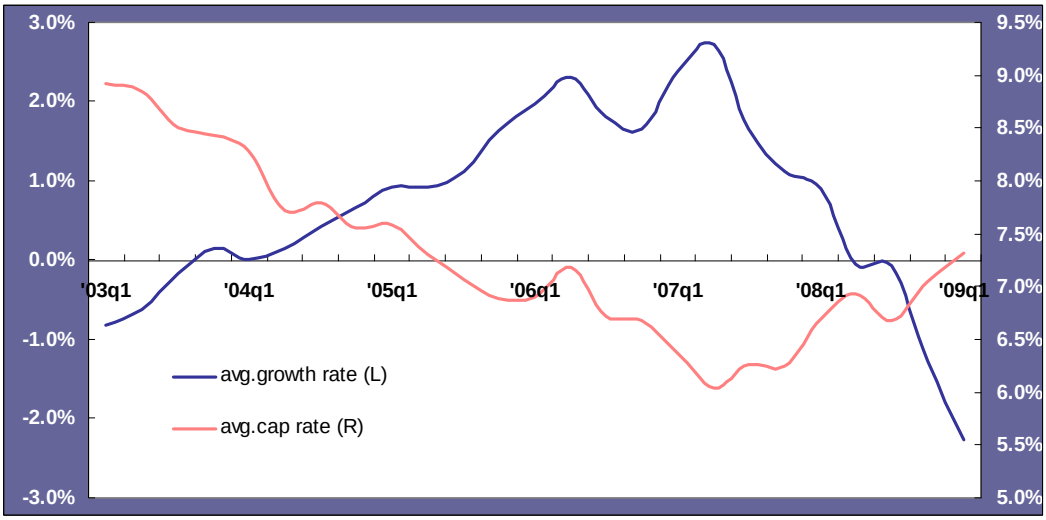
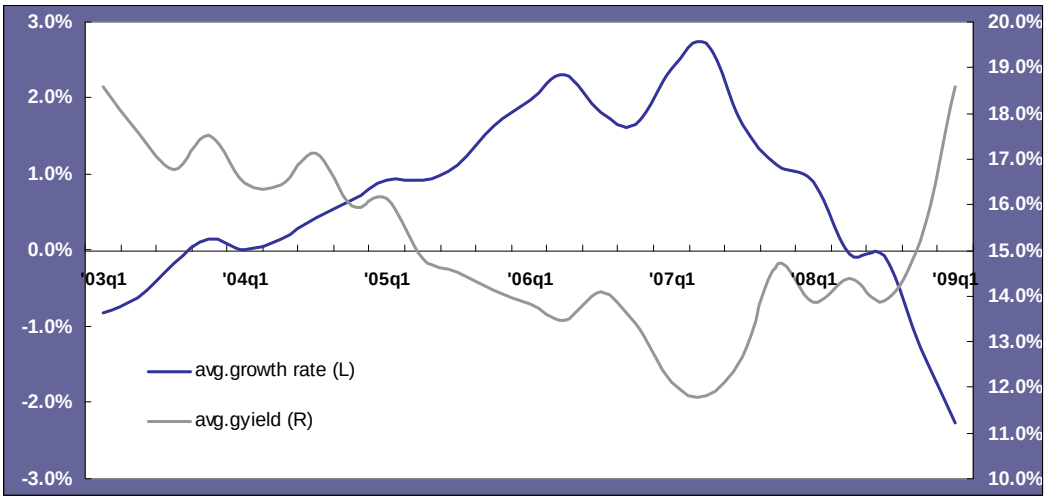



**Figure 4: Cap Rate & Average Rental Growth**




As a mean of comparing the pricing methods, the gross yield for the transacted property is also computed and located in place of the cap rate in the figure for relation between pricing and rent growth (See Figure 5). It seems that the gross yield has a perfect negative correlation to the rent growth compared to the cap rate in Figure 4.

**Figure 5: Gross Yield & Average Rental Growth**




What causes the different patterns between the cap rate and the gross yield? Is this difference significant or not? It is necessary to examine these issues in the further analysis.

In this chapter, observing and combining the actual data from two different sources gave us a chance to glance through the recent trends in the US office market. The trends of the rental growth and the investment over time are strongly correlated enough to arouse our curiosity that investors' behavior, namely pricing of real estate, may be rational at the overall market level. Besides, they also raise the questions whether or not the gross yield reflects market information more appropriately than the cap rate. In the next two chapters, those inquiries or issues will be examined in depth at the property level by constructing numerous models.

## Chapter 5 Methodology

As mentioned previously, this thesis employs the Shiller Test to examine whether or not investors in the market precisely are predicting the future income growth and appropriately reflecting it into pricing. For the research, several multi-variables regression models are constructed to run. Four categories of variables are employed: pricing methods, level of income, rent growth, and property information.

### 5.1 Pricing Methods: Cap Rate vs. Gross Yield

The variables for pricing are the cap rate and the gross yield. The cap rate (CAP_RATE) for a transacted property, besides the closing date and sales price, is provided from RCA. The gross yield (GYIELD) for the same property is computed from the sales price and the gross rent from CBRE. The gross rent is an average of four quarters, which are three preceding quarters and the quarter when the transaction occurred. The gross yield is derived by dividing the gross rent by the sales price.

### 5.2 Level of Income: NOI vs. Gross Rent

Like the growth rate of income, the level of income at the time of transaction is also important information for investors since it reflects the locational condition as well as the grade of the property. As the proxy for income, implied NOI and gross rent (both of them are measured by dollar amount/SF) are employed, and the correlation between the two variables is investigated. The sales price/SF is multiplied by the cap rate to derive NOI/SF (NOI) for each transacted property. The gross rent (GRENT) is estimated by averaging the rents of eight quarters

preceding the quarter of transaction. Assuming a non-leaner relation between the pricing and the income level, this study employs the variable of square of the gross rent (SQR_GRENT).

### 5.3 Income Growth: Past Growth Rate vs. Future Growth Rate

In theory, the pricing should reflect market information precisely, and the future growth rate of income is considered as the most important one because it significantly affects the cash flows generated from the invested property. For this analysis, three different growth rates of rent are examined. The first one is the average future rent growth over the eight consecutive quarters following the transaction (FUTURE2_GROWTH). If the future rent growth is reflected appropriately, investors' behavior must be forward-looking. However, as reviewed in the previous literatures, several studies reveal the backward-looking behavior of investors. Therefore, in this analysis, two past growth rates are also examined: the average growth rates over the previous eight quarters (PAST2_GROWTH) and twenty quarters (PAST5_GROTWH) respectively. If either of those turns out to be more significant than the future growth, then that would explain the backward-looking behavior of investors. In addition, two different time horizons for the past growth will help to specify the characteristics of pricing.

### 5.4 Property Information and Time Trend: Age, Area, Price (PSF), and Time dummy

To identify property characteristics, the regression models add explanatory variables in the form of property-level information on age (AGE), gross floor area (GFA), and price/SF (PRRICE_PSF). Besides, the models include dummy variables of the year sold to control the trends over time in cap rates, gross yields or rents (D_YRSOLD_04, D_YRSOLD_05 ... D_YRSOLD_09, and the year 2003 is default).

**Table 4: List of Variables**

| | | |
|---|---|---|
| Proxy for Pricing | CAP_RATE | (provided by RCA) |
| | GYIELD | avg. gross rent (T-3q , T) / PRICE_PSF |
| Proxy for Bias | SPRD_GR_NOI | GRENT – NOI |
| Property Income | NOI | CAP_RATE x PRICE_PSF |
| Market Rent | GRENT | avg. gross rent (T-7q , T) |
| | SQR_GRENT[12] | Square of GRENT |
| Rental Growth Rate | FUTURE_GROWTH | avg. growth rate of gross rent (T , T+8q) : minimum period → (T) ~ (T+3q) |
| | PAST2_GROWTH | avg. growth rate of gross rent(T-8q , T) : minimum period → (T-6q) ~ (T-2q) |
| | PAST5_GROWTH | avg. growth rate of gross rent(T-20q , T) : minimum period → (T-16q) ~ (T-4q) |
| Property Characteristics | AGE | year sold – year built |
| | GFA | gross floor area (sf x 1,000) |
| | PRICE_PSF | sale price per square footage |
| Year Dummies[13] | D_YRSOLD_04 | = 1 if the year sold is 2004 |
| | D_YRSOLD _05 | = 1 if the year sold is 2005 |
| | D_YRSOLD _06 | = 1 if the year sold is 2006 |
| | D_YRSOLD _07 | = 1 if the year sold is 2007 |
| | D_YRSOLD _08 | = 1 if the year sold is 2008 |
| | D_YRSOLD _09 | = 1 if the year sold is 2009 |

## 5.5 Model Construction

To examine the office asset pricing, several multi-variable regression models are constructed. Before exploring asset pricing directly, the relation between NOI and gross rent is investigated in Chapter 6 since they should be the main reason of the various patterns of the cap rate and the gross yield, observed in the chapter 4. Then the asset pricing models are examined in Chapter

[12] Square of gross rent is used to capture non-linear effect of NOI or gross rent
[13] Year 2003 is the default year.

7. In summary, the next analyses are composed of the four phases: 1) Models for NOI, 2) models for cap rate, 3) models for gross yield, and 4) models for the Shiller test. Each of the first three groups tests three models by replacing the variables for the rent growth (Model1: PAST5_GROWTH, Modle2: PAST2_GROWTH, and Model3: FUTURE2_GROWTH), while maintaining the other proxies for income, property information, and time trends. The last models for the Shiller test examine the relation between the future growth and pricing methods: the cap rate and the gross yield.

# Chapter 6 Examination of NOI and Rent

## 6.1 NOI and Gross Rent

The purpose of NOI regression models is to observe the relation between NOI and gross rent. For this analysis, NOI, specifically the implied NOI for a transacted property, is derived by multiplying its cap rate by sales price as mentioned in the last chapter. To decide which model is the most appropriate among three models tested, it is necessary to observe the test results from both statistical and economical perspectives.

Tables 5, 6 and 7 demonstrate the results for each model. Model 1 (with past 5years' growth) and model 3 (with future 2years' growth) have significant coefficients of rental growths, while model 2 (with past 2years' growth) does not. It also should be noted that PAST5_GROWTH is negatively correlated, whereas FUTURE2_GROWTH is positively correlated. The negative correlation of PAST5_GROWTH can be explained as follows: the implied NOI, which is supposed to have been applied for pricing, would be an average of past several years preceding the transaction. Thus, a property with higher rental growth rate in the past would have a lower average NOI than a property of the same current rent with lower growth rate. For examples, if two properties have the same rent today, but different past growth rates, the property with a faster past growth has a lower average NOI value for the past several years. Consequently the negative correlation of PAST5_GROWTH makes sense economically, but the positive correlation of FUTURE2_GROWTH cannot be explained at this time. Then model 1 among three can be judged to be the most appropriate statistically and economically, and it also has the highest 'Adjusted R square.'

Several results are observed from the model 1. First of all, a property with a higher rent has also a higher NOI, but their relation is not linear considering that SQR_RETNT is significant. As a rent grows higher, the NOI also increases, but the growth of the NOI decreases like diminishing marginal utility. It is shown clearly in the graph of Figure 8, in which the NOI and rent are plotted while the other variables are handled like constants entering average values.

In addition, the property level information also has explanatory powers. Older properties have an effect on lowering NOI, which matches the expectation. However, larger office buildings seem to have lower NOIs, which seem unreasonable. But, this result can be explained by the inherent characteristics of the rent data collected by CBRE advisors. The market rents used here are the rent offered in the market for available space. In general, a large-scale building or high-rise building has a relatively huge spectrum of rent, and tends to have vacant space at the top floors with higher rents, causing discrepancy between the total average rent for the building and the average rent for available space in the building. As a result, this causes a negative relation between NOI and size of a building, and also gives a low ratio of NOI to rent.

The dummy variables for year sold demonstrate the time trend in the past and the recent years, that is, the upward movement till the year of 2007, and then the downward trend, although some of them do not appear to be strong.

**Table 5: NOI Model 1 - Past Rental Growth (5yr)**

| | | | | |
|---|---|---|---|---|
| Number of obs | = | 1524 | R-squared | = 0.6062 |
| F( 11, 1512) | = | 211.57 | Adj R-square | = 0.6033 |
| Prob > F | = | 0 | Root MSE | = 4.2667 |

| NOI | Coef. | Std. Err. | t | P>t | [95% Conf. | Interval] |
|---|---|---|---|---|---|---|
| GRENT | 0.9626083 | 0.0370284 | 26 | 0 | 0.8899759 | 1.035241 |
| SQR_GRENT | -0.0042669 | 0.0004774 | -8.94 | 0 | -0.0052032 | -0.0033305 |
| PAST5_GROWTH | -0.2065665 | 0.0246968 | -8.36 | 0 | -0.2550102 | -0.1581229 |
| AGE | -0.0169518 | 0.0052303 | -3.24 | 0.001 | -0.0272113 | -0.0066924 |
| GFA | -0.0015536 | 0.0004301 | -3.61 | 0 | -0.0023973 | -0.0007099 |
| D_2004 | 0.6505512 | 0.4034787 | 1.61 | 0.107 | -0.140886 | 1.441988 |
| D_2005 | 0.7303896 | 0.3860374 | 1.89 | 0.059 | -0.0268359 | 1.487615 |
| D_2006 | 0.81877 | 0.3831657 | 2.14 | 0.033 | 0.0671773 | 1.570363 |
| D_2007 | 0.7731444 | 0.3813527 | 2.03 | 0.043 | 0.025108 | 1.521181 |
| D_2008 | -0.0988683 | 0.5410151 | -0.18 | 0.855 | -1.160088 | 0.9623514 |
| D_2009 | -4.670907 | 1.653942 | -2.82 | 0.005 | -7.91517 | -1.426644 |
| cons | -5.64505 | 0.6769994 | -8.34 | 0 | -6.973008 | -4.317093 |

**Table 6: NOI Model 2 - Past Rental Growth (2yr)**

| | | | | |
|---|---|---|---|---|
| Number of obs | = | 1582 | R-squared | = 0.5782 |
| F( 11, 1570) | = | 195.65 | Adj R-square | = 0.5752 |
| Prob > F | = | 0 | Root MSE | = 4.4208 |

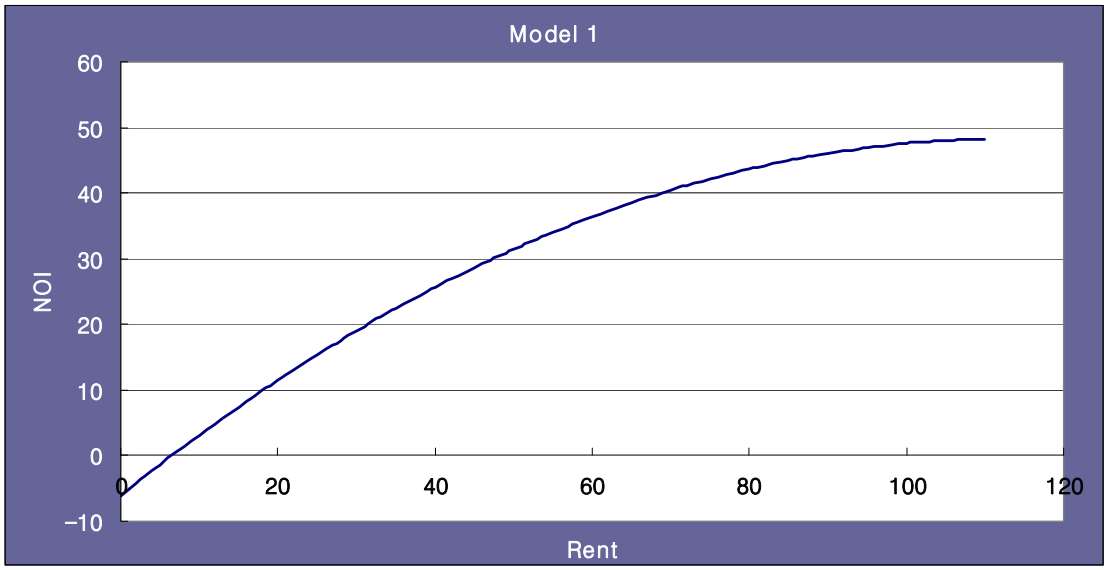
| NOI | Coef. | Std. Err. | t | P>t | [95% Conf. | Interval] |
|---|---|---|---|---|---|---|
| GRENT | 0.8995494 | 0.0394105 | 22.83 | 0 | 0.8222467 | 0.9768521 |
| SQR_GRENT | -0.0038623 | 0.0005369 | -7.19 | 0 | -0.0049155 | -0.0028092 |
| PAST2_GROWTH | -0.0097127 | 0.0141255 | -0.69 | 0.492 | -0.0374195 | 0.0179941 |
| AGE | -0.0208664 | 0.005275 | -3.96 | 0 | -0.0312133 | -0.0105196 |
| GFA | -0.0004402 | 0.0004101 | -1.07 | 0.283 | -0.0012446 | 0.0003643 |
| D_2004 | 0.9546848 | 0.4026992 | 2.37 | 0.018 | 0.1647999 | 1.74457 |
| D_2005 | 1.372244 | 0.387984 | 3.54 | 0 | 0.6112228 | 2.133266 |
| D_2006 | 1.016673 | 0.3930524 | 2.59 | 0.01 | 0.2457106 | 1.787636 |
| D_2007 | 0.5812102 | 0.404581 | 1.44 | 0.151 | -0.2123658 | 1.374786 |
| D_2008 | -0.7002417 | 0.5397416 | -1.3 | 0.195 | -1.758932 | 0.3584486 |
| D_2009 | -3.027382 | 1.612889 | -1.88 | 0.061 | -6.191026 | 0.1362611 |
| cons | -4.851722 | 0.7116963 | -6.82 | 0 | -6.247698 | -3.455747 |

**Table 7: NOI Model 3 - Future Rental Growth (2yr)**

| | | | | | |
|---|---|---|---|---|---|
| Number of obs | = | 1358 | R-squared | = | 0.5774 |
| F( 10, 1347) | = | 184.06 | Adj R-square | = | 0.5743 |
| Prob > F | = | 0 | Root MSE | = | 4.1718 |

| NOI | Coef. | Std. Err. | t | P>t | [95% Conf. | Interval] |
|---|---|---|---|---|---|---|
| GRENT | 0.8143887 | 0.0555764 | 14.65 | 0 | 0.705363 | 0.9234145 |
| SQR_GRENT | -0.0022687 | 0.000897 | -2.53 | 0.012 | -0.0040284 | -0.0005091 |
| FUTURE2_GROWTH | 0.0977915 | 0.0122883 | 7.96 | 0 | 0.0736852 | 0.1218979 |
| AGE | -0.0305615 | 0.0056851 | -5.38 | 0 | -0.0417141 | -0.019409 |
| GFA | -0.0005188 | 0.0004392 | -1.18 | 0.238 | -0.0013803 | 0.0003427 |
| D_2004 | 0.4753424 | 0.3994167 | 1.19 | 0.234 | -0.3082041 | 1.258889 |
| D_2005 | 0.5566181 | 0.3827069 | 1.45 | 0.146 | -0.1941481 | 1.307384 |
| D_2006 | 0.2927729 | 0.3813615 | 0.77 | 0.443 | -0.4553542 | 1.0409 |
| D_2007 | 0.5149952 | 0.3799765 | 1.36 | 0.176 | -0.2304149 | 1.260405 |
| D_2008 | 0.5468245 | 0.6418928 | 0.85 | 0.394 | -0.7123937 | 1.806043 |
| D_2009 | (dropped) | | | | | |
| cons | -3.624021 | 0.8812476 | -4.11 | 0 | -5.352788 | -1.895254 |

**Figure 6: Graph of NOI and Rent (Model 1)**




## 6.2 Spread of Rent over NOI

In order to examine the variations between rents and NOIs from another perspective, the spread of rent over NOI is examined. Tables 8, 9 and 10 are the results of the spread models.

By the same norms of the sign and significance of the growth rate coefficients, the model 1 for spread is determined to be proper.

The spread of gross rent over NOI can be considered as 'level of bias' toward market information since the gross rent reflects market information fairly, while NOI is not likely to. In the meantime, gross rent and NOI are numerators for the gross yield and the cap rate respectively. Thus, if the spread and the gross rent were in a definite proportion, namely, a linear relation, the gross yield and the cap rate would show a similar pattern due to their linear correlation. However, the result of model 1 shows that the spread is not in a definite proportion to the rent. Especially in the case of a high level of rent, the spread rises sharply (See Figure 7). Thus, it is clear that the cap rate and the gross yield do not have a similar movement, and the difference grows bigger as the rent increases.

**Table 8: Spread Model 1 - Past Rental Growth (5yr)**

| | | | | | |
|---|---|---|---|---|---|
| Number of obs | = | 1524 | R-squared | = | 0.4321 |
| F( 11, 1512) | = | 104.61 | Adj R-square | = | 0.428 |
| Prob > F | = | 0 | Root MSE | = | 4.2667 |

| SPRD_GR_NOI | Coef. | Std. Err. | t | P>t | [95% Conf. | Interval] |
|---|---|---|---|---|---|---|
| GRENT | 0.0373917 | 0.0370284 | 1.01 | 0.313 | -0.0352408 | 0.1100241 |
| SQR_GRENT | 0.0042669 | 0.0004774 | 8.94 | 0 | 0.0033305 | 0.0052032 |
| PAST5_GROWTH | 0.2065665 | 0.0246968 | 8.36 | 0 | 0.1581229 | 0.2550102 |
| AGE | 0.0169518 | 0.0052303 | 3.24 | 0.001 | 0.0066924 | 0.0272113 |
| GFA | 0.0015536 | 0.0004301 | 3.61 | 0 | 0.0007099 | 0.0023973 |
| D_2004 | -0.6505512 | 0.4034787 | -1.61 | 0.107 | -1.441988 | 0.140886 |
| D_2005 | -0.7303896 | 0.3860374 | -1.89 | 0.059 | -1.487615 | 0.0268359 |
| D_2006 | -0.81877 | 0.3831657 | -2.14 | 0.033 | -1.570363 | -0.0671773 |
| D_2007 | -0.7731444 | 0.3813527 | -2.03 | 0.043 | -1.521181 | -0.025108 |
| D_2008 | 0.0988682 | 0.5410151 | 0.18 | 0.855 | -0.9623514 | 1.160088 |
| D_2009 | 4.670907 | 1.653942 | 2.82 | 0.005 | 1.426643 | 7.91517 |
| cons | 5.64505 | 0.6769994 | 8.34 | 0 | 4.317092 | 6.973007 |

## Table 9: Spread Model 2 - Past Rental Growth (2yr)

| | | | | |
|---|---|---|---|---|
| Number of obs | = | 1582 | R-squared = | 0.3737 |
| F( 11, 1570) | = | 85.16 | Adj R-square = | 0.3693 |
| Prob > F | = | 0 | Root MSE = | 4.4208 |

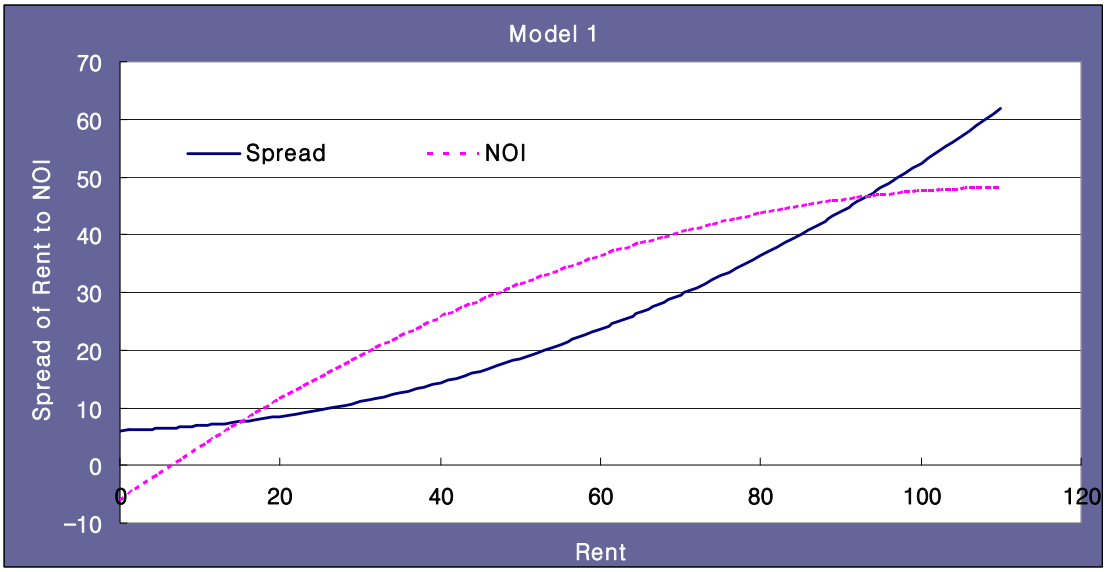
| SPRD_GR_NOI | Coef. | Std. Err. | t | P>t | [95% Conf. | Interval] |
|---|---|---|---|---|---|---|
| GRENT | 0.1004506 | 0.0394105 | 2.55 | 0.011 | 0.023148 | 0.1777533 |
| SQR_GRENT | 0.0038623 | 0.0005369 | 7.19 | 0 | 0.0028092 | 0.0049155 |
| PAST2_GROWTH | 0.0097127 | 0.0141255 | 0.69 | 0.492 | -0.0179941 | 0.0374195 |
| AGE | 0.0208664 | 0.005275 | 3.96 | 0 | 0.0105196 | 0.0312133 |
| GFA | 0.0004402 | 0.0004101 | 1.07 | 0.283 | -0.0003643 | 0.0012446 |
| D_2004 | -0.9546848 | 0.4026992 | -2.37 | 0.018 | -1.74457 | -0.1647999 |
| D_2005 | -1.372244 | 0.387984 | -3.54 | 0 | -2.133266 | -0.6112228 |
| D_2006 | -1.016673 | 0.3930524 | -2.59 | 0.01 | -1.787636 | -0.2457106 |
| D_2007 | -0.5812102 | 0.404581 | -1.44 | 0.151 | -1.374786 | 0.2123658 |
| D_2008 | 0.7002417 | 0.5397416 | 1.3 | 0.195 | -0.3584486 | 1.758932 |
| D_2009 | 3.027382 | 1.612889 | 1.88 | 0.061 | -0.1362612 | 6.191025 |
| cons | 4.851722 | 0.7116963 | 6.82 | 0 | 3.455747 | 6.247697 |

## Table 10: Spread Model 3 - Future Rental Growth (2yr)

| | | | | |
|---|---|---|---|---|
| Number of obs | = | 1358 | R-squared = | 0.2925 |
| F( 10, 1347) | = | 55.68 | Adj R-square = | 0.2872 |
| Prob > F | = | 0 | Root MSE = | 4.1718 |

| SPRD_GR_NOI | Coef. | Std. Err. | t | P>t | [95% Conf. | Interval] |
|---|---|---|---|---|---|---|
| GRENT | 0.1856113 | 0.0555764 | 3.34 | 0.001 | 0.0765855 | 0.294637 |
| SQR_GRENT | 0.0022687 | 0.000897 | 2.53 | 0.012 | 0.0005091 | 0.0040284 |
| FUTURE2_GROWTH | -0.0977915 | 0.0122883 | -7.96 | 0 | -0.1218979 | -0.0736852 |
| AGE | 0.0305615 | 0.0056851 | 5.38 | 0 | 0.019409 | 0.0417141 |
| GFA | 0.0005188 | 0.0004392 | 1.18 | 0.238 | -0.0003427 | 0.0013803 |
| D_2004 | -0.4753423 | 0.3994167 | -1.19 | 0.234 | -1.258889 | 0.3082041 |
| D_2005 | -0.5566181 | 0.3827069 | -1.45 | 0.146 | -1.307384 | 0.1941481 |
| D_2006 | -0.2927729 | 0.3813615 | -0.77 | 0.443 | -1.0409 | 0.4553542 |
| D_2007 | -0.5149952 | 0.3799765 | -1.36 | 0.176 | -1.260405 | 0.2304149 |
| D_2008 | -0.5468245 | 0.6418928 | -0.85 | 0.394 | -1.806043 | 0.7123937 |
| D_2009 | (dropped) | | | | | |
| cons | 3.624021 | 0.8812476 | 4.11 | 0 | 1.895254 | 5.352788 |

**Figure 7: Graph of Spread and Rent (Model 1)**



# Chapter 7 Examination of Office Asset Pricing

## 7.1 Models for Cap Rate

The cap rate models are tested with the same independent variables as in NOI models by the same ways. The results of tests (table 11, 12 and 13) show that the variables for rental growths all have an appropriate sign in each model, although the significance of each varies vastly. The coefficient of PAST2_GROWTH is most significant statistically, however, that of FUTURE2_GROWTH is not significant. In other words, the cap rate models demonstrate that investors pay more attention to the short-term growth in the past or the current growth rather than the future growth or the relatively long-term growth in the past. As a result, 'Model 2' out of three is chosen as the best for the cap rate.

The variables of GRENT and SQR_RENT, like those in the NOI model, have the explanatory power with an appropriate effect. The high level of rent represents preferable location as well as sound physical condition, and accordingly, investors are willing to price up a property with a high level of rent, meaning a low cap rate. The cap rate converges at a certain level instead of decreasing continuously (See Figure 8).

Regarding the property information, investors seem to care more about the size of a property than the age. The dummy variables of the year sold in the models clearly demonstrate that the cap rates have experienced a significant change in the recent years: a strong downward trend continued until 2007, which turned around and rose sharply to make the cap rate level in 2009 even higher than the cap rates of 2005.

**Table 11: Cap Rate Model 1 - Past Rental Growth (5yr)**

| | | | | | |
|---|---|---|---|---|---|
| Number of obs | = | 1524 | R-squared | = | 0.4261 |
| F( 11, 1512) | = | 102.05 | Adj R-square | = | 0.4219 |
| Prob > F | = | 0 | Root MSE | = | 1.1818 |

| CAP_RATE | Coef. | Std. Err. | t | P>t | [95% Conf. | Interval] |
|---|---|---|---|---|---|---|
| GRENT | -0.1372439 | 0.0102566 | -13.38 | 0 | -0.1573626 | -0.1171253 |
| SQR_GRENT | 0.0010108 | 0.0001322 | 7.64 | 0 | 0.0007514 | 0.0012702 |
| PAST5_GROWTH | -0.0138202 | 0.0068408 | -2.02 | 0.044 | -0.0272387 | -0.0004016 |
| AGE | 0.0002185 | 0.0014488 | 0.15 | 0.88 | -0.0026233 | 0.0030603 |
| GFA | -0.0004458 | 0.0001191 | -3.74 | 0 | -0.0006795 | -0.0002121 |
| D_2004 | -0.821978 | 0.1117606 | -7.35 | 0 | -1.0412 | -0.6027558 |
| D_2005 | -1.630068 | 0.1069295 | -15.24 | 0 | -1.839814 | -1.420323 |
| D_2006 | -1.887021 | 0.106134 | -17.78 | 0 | -2.095206 | -1.678835 |
| D_2007 | -2.396279 | 0.1056319 | -22.69 | 0 | -2.60348 | -2.189079 |
| D_2008 | -1.659856 | 0.1498572 | -11.08 | 0 | -1.953806 | -1.365906 |
| D_2009 | -1.502136 | 0.4581295 | -3.28 | 0.001 | -2.400772 | -0.6034988 |
| cons | 11.39104 | 0.1875238 | 60.74 | 0 | 11.0232 | 11.75887 |

**Table 12: Cap Rate Model 2 - Past Rental Growth (2yr)**

| | | | | | |
|---|---|---|---|---|---|
| Number of obs | = | 1582 | R-squared | = | 0.4248 |
| F( 11, 1570) | = | 105.4 | Adj R-square | = | 0.4208 |
| Prob > F | = | 0 | Root MSE | = | 1.1788 |

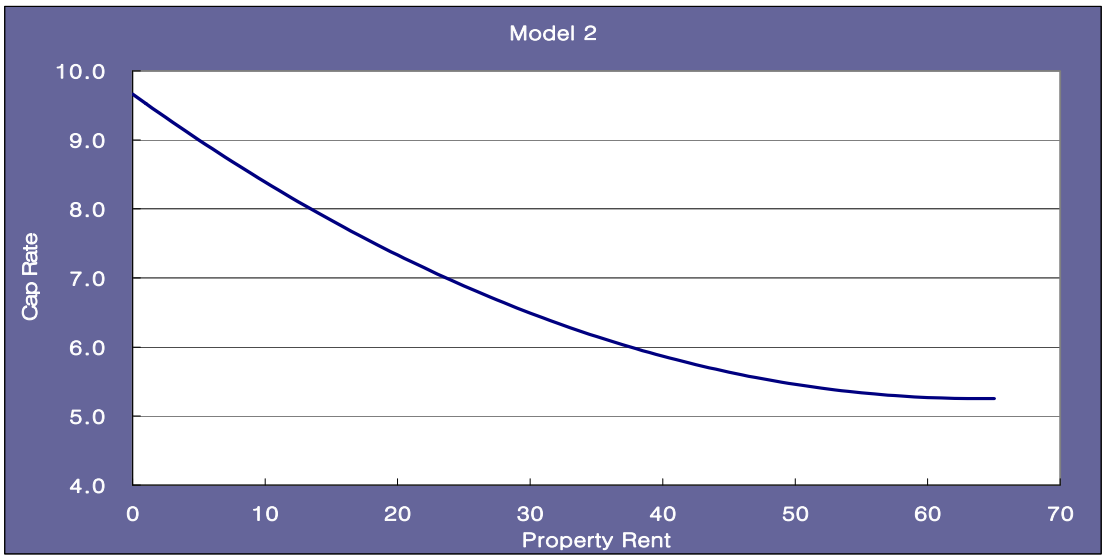
| CAP_RATE | Coef. | Std. Err. | t | P>t | [95% Conf. | Interval] |
|---|---|---|---|---|---|---|
| GRENT | -0.1381142 | 0.0105089 | -13.14 | 0 | -0.1587272 | -0.1175012 |
| SQR_GRENT | 0.0010816 | 0.0001432 | 7.55 | 0 | 0.0008008 | 0.0013625 |
| PAST2_GROWTH | -0.0179908 | 0.0037666 | -4.78 | 0 | -0.0253789 | -0.0106027 |
| AGE | -0.0002217 | 0.0014066 | -0.16 | 0.875 | -0.0029807 | 0.0025374 |
| GFA | -0.0003853 | 0.0001094 | -3.52 | 0 | -0.0005998 | -0.0001708 |
| D_2004 | -0.8019336 | 0.1073812 | -7.47 | 0 | -1.012559 | -0.591308 |
| D_2005 | -1.528767 | 0.1034573 | -14.78 | 0 | -1.731696 | -1.325838 |
| D_2006 | -1.804641 | 0.1048088 | -17.22 | 0 | -2.010221 | -1.599061 |
| D_2007 | -2.284354 | 0.107883 | -21.17 | 0 | -2.495964 | -2.072744 |
| D_2008 | -1.627116 | 0.1439241 | -11.31 | 0 | -1.90942 | -1.344812 |
| D_2009 | -1.273355 | 0.4300827 | -2.96 | 0.003 | -2.116952 | -0.4297579 |
| cons | 11.3307 | 0.1897764 | 59.71 | 0 | 10.95846 | 11.70294 |

## Table 13: Cap Rate Model 3 - Future Rental Growth (2yr)

| | | | | | |
|---|---|---|---|---|---|
| Number of obs | = | 1358 | R-squared | = | 0.4296 |
| F( 10, 1347) | = | 101.45 | Adj R-square | = | 0.4254 |
| Prob > F | = | 0 | Root MSE | = | 1.1677 |

| CAP_RATE | Coef. | Std. Err. | t | P>t | [95% Conf. | Interval] |
|---|---|---|---|---|---|---|
| GRENT | -0.1752879 | 0.0155564 | -11.27 | 0 | -0.2058053 | -0.1447705 |
| SQR_GRENT | 0.0016096 | 0.0002511 | 6.41 | 0 | 0.0011171 | 0.0021022 |
| FUTURE2_GROWTH | -0.0032828 | 0.0034396 | -0.95 | 0.34 | -0.0100304 | 0.0034648 |
| AGE | 0.0010533 | 0.0015913 | 0.66 | 0.508 | -0.0020684 | 0.004175 |
| GFA | -0.0002956 | 0.0001229 | -2.4 | 0.016 | -0.0005367 | -0.0000544 |
| D_2004 | -0.8557231 | 0.1118007 | -7.65 | 0 | -1.075045 | -0.6364007 |
| D_2005 | -1.601361 | 0.1071234 | -14.95 | 0 | -1.811508 | -1.391214 |
| D_2006 | -1.948158 | 0.1067468 | -18.25 | 0 | -2.157567 | -1.73875 |
| D_2007 | -2.413457 | 0.1063592 | -22.69 | 0 | -2.622104 | -2.204809 |
| D_2008 | -1.740023 | 0.1796721 | -9.68 | 0 | -2.09249 | -1.387555 |
| D_2009 | (dropped) | | | | | |
| cons | 11.9114 | 0.2466699 | 48.29 | 0 | 11.4275 | 12.3953 |

## Figure 8: Graph of Cap Rate and Rent (Model 2)




minimum value rent : $63.85 cap rate : 5.25%

## 7.2 Models for Gross Yield

In order to compare the gross yield with the cap rate, three regression models for the gross yield are also run with the same explanatory variables as in the previous cap rate tests. The results shown in table 14, 15 and 16 appear much clearer than the cap rate tests. In terms of the growth rates, the result of this test is quite different from the result of the previous cap rate tests. While the three growth rates are all negative in the cap rate models, only one out of three variables for growth has a right sign with significance in the gross yield models, and it is the FUTURE2_GROWTH. Accordingly, the model 3 is determined to be the best one.

Also in this model, GRENT, SQR_GRENT have the significant explanatory powers, and the trends over time seem to have similar patterns to the cap rate, while the reactions to the property information such as AGE and GFA are varied.

Explicitly, the gross yield of properties with high level of rent and expected fast growth is lower, providing investors with equivalent total return. Besides, Figure 9 clearly shows differences in reactions of two pricing methods to buildings' rents. The gross yield seems to reflect the market rent with much greater sensitivity than the cap rate. It leads to the conclusion that the gross yield reflects the market information rationally, while the cap rate does not.

## Table 14: Gross Yield Model 1 - Past Rental Growth (5yr)

| | | | | | |
|---|---|---|---|---|---|
| Number of obs | = | 4054 | R-squared | = | 0.185 |
| F( 11, 4042) | = | 83.39 | Adj R-square | = | 0.1828 |
| Prob > F | = | 0 | Root MSE | = | 6.4398 |

| GYIELD | Coef. | Std. Err. | t | P>t | [95% Conf. | Interval] |
|---|---|---|---|---|---|---|
| GRENT | -0.6229846 | 0.0327917 | -19 | 0 | -0.6872744 | -0.5586949 |
| SQR_GRENT | 0.0047649 | 0.0004238 | 11.24 | 0 | 0.003934 | 0.0055958 |
| PAST5_GROWTH | 0.2114108 | 0.0231525 | 9.13 | 0 | 0.1660192 | 0.2568025 |
| AGE | 0.0363612 | 0.0048657 | 7.47 | 0 | 0.0268218 | 0.0459005 |
| GFA | 0.0032119 | 0.0004426 | 7.26 | 0 | 0.0023441 | 0.0040797 |
| D_2004 | -1.046183 | 0.4082213 | -2.56 | 0.01 | -1.846521 | -0.2458438 |
| D_2005 | -2.755529 | 0.3939898 | -6.99 | 0 | -3.527966 | -1.983092 |
| D_2006 | -3.816421 | 0.3862989 | -9.88 | 0 | -4.57378 | -3.059062 |
| D_2007 | -4.931017 | 0.3769875 | -13.08 | 0 | -5.67012 | -4.191913 |
| D_2008 | -3.51033 | 0.4859397 | -7.22 | 0 | -4.46304 | -2.55762 |
| D_2009 | 1.049911 | 1.513312 | 0.69 | 0.488 | -1.917016 | 4.016837 |
| cons | 27.40872 | 0.6264718 | 43.75 | 0 | 26.18049 | 28.63695 |

## Table 15: Gross Yield Model 2 - Past Rental Growth (2yr)

| | | | | | |
|---|---|---|---|---|---|
| Number of obs | = | 4341 | R-squared | = | 0.1657 |
| F( 11, 4329) | = | 78.18 | Adj R-square | = | 0.1636 |
| Prob > F | = | 0 | Root MSE | = | 6.554 |

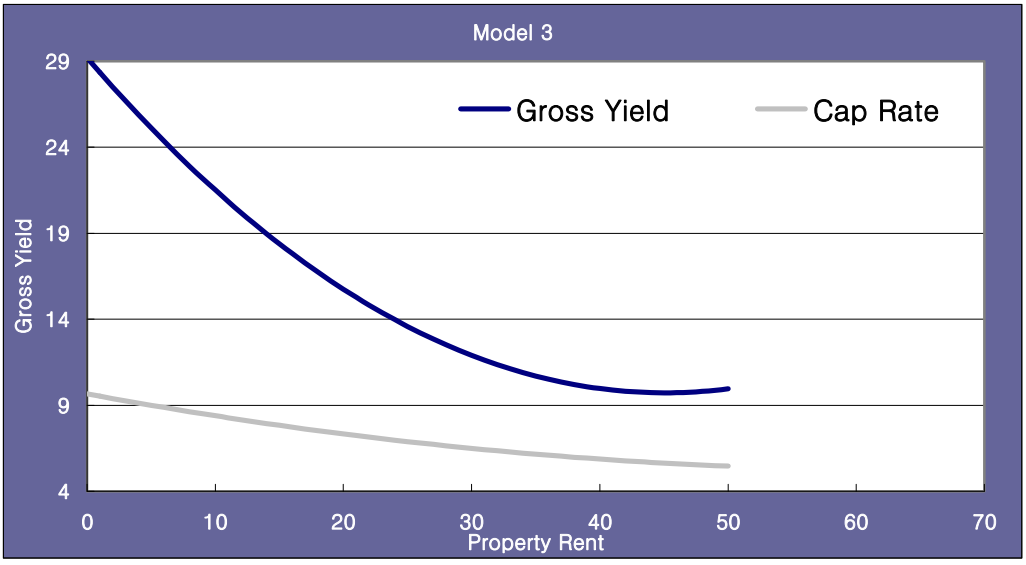
| GYIELD | Coef. | Std. Err. | t | P>t | [95% Conf. | Interval] |
|---|---|---|---|---|---|---|
| GRENT | -0.5886437 | 0.0327501 | -17.97 | 0 | -0.6528507 | -0.5244368 |
| SQR_GRENT | 0.0048197 | 0.0004381 | 11 | 0 | 0.0039608 | 0.0056787 |
| PAST2_GROWTH | 0.0320958 | 0.0126842 | 2.53 | 0.011 | 0.0072283 | 0.0569634 |
| AGE | 0.0387482 | 0.0048415 | 8 | 0 | 0.0292564 | 0.04824 |
| GFA | 0.0024746 | 0.0004253 | 5.82 | 0 | 0.0016408 | 0.0033084 |
| D_2004 | -1.607483 | 0.3965805 | -4.05 | 0 | -2.384984 | -0.8299821 |
| D_2005 | -3.435646 | 0.3844764 | -8.94 | 0 | -4.189416 | -2.681875 |
| D_2006 | -4.360037 | 0.3860888 | -11.29 | 0 | -5.116969 | -3.603105 |
| D_2007 | -5.116235 | 0.3885069 | -13.17 | 0 | -5.877907 | -4.354562 |
| D_2008 | -3.433292 | 0.4808227 | -7.14 | 0 | -4.375951 | -2.490634 |
| D_2009 | 2.109909 | 1.38062 | 1.53 | 0.127 | -0.5968134 | 4.816631 |
| cons | 27.1831 | 0.6284854 | 43.25 | 0 | 25.95095 | 28.41525 |

**Table 16: Gross Yield Model 3 - Future Rental Growth (2yr)**

| | | | | | |
|---|---|---|---|---|---|
| Number of obs | = | 3699 | R-squared | = | 0.2208 |
| F( 10, 3688) | = | 104.53 | Adj R-square | = | 0.2187 |
| Prob > F | = | 0 | Root MSE | = | 6.3113 |

| GYIELD | Coef. | Std. Err. | t | P>t | [95% Conf. | Interval] |
|---|---|---|---|---|---|---|
| GRENT | -0.8641593 | 0.0600301 | -14.4 | 0 | -0.9818547 | -0.7464639 |
| SQR_GRENT | 0.009586 | 0.0010279 | 9.33 | 0 | 0.0075707 | 0.0116014 |
| FUTURE2_GROWTH | -0.1344461 | 0.0112619 | -11.94 | 0 | -0.1565263 | -0.112366 |
| AGE | 0.0553477 | 0.005298 | 10.45 | 0 | 0.0449604 | 0.065735 |
| GFA | 0.0029225 | 0.0004626 | 6.32 | 0 | 0.0020156 | 0.0038294 |
| D_2004 | -0.9637694 | 0.4001853 | -2.41 | 0.016 | -1.748376 | -0.1791631 |
| D_2005 | -2.698286 | 0.3894854 | -6.93 | 0 | -3.461914 | -1.934658 |
| D_2006 | -3.854692 | 0.3800657 | -10.14 | 0 | -4.599851 | -3.109532 |
| D_2007 | -4.918484 | 0.3677376 | -13.37 | 0 | -5.639473 | -4.197495 |
| D_2008 | -4.039437 | 0.5517341 | -7.32 | 0 | -5.121171 | -2.957704 |
| D_2009 | (dropped) | | | | | |
| cons | 30.47539 | 0.9087204 | 33.54 | 0 | 28.69375 | 32.25704 |

**Figure 9: Graph of Gross Yield and Rent (Model 3)**




minimum value rent : $45.07 GYIELD 9.72%

### 7.3 Shiller Test

To reaffirm and to focus on the connection between the future growth and the pricing methods, Shiller Test is conducted by running the future growth regression models with independent variables of the cap rate or the gross yield.

The results shown in Tables 17 and 18 do not differ from the previous results from the cap rate models or the gross yield models. The coefficients of both cap rate and gross yield in each model for Shiller Test are negative, but only the value of the gross yield coefficient is significant, which exactly matches the previous results from model 3 for the cap rate and the gross yield. Clearly, it can be said that only the gross yield is negatively correlated to the future growth, which means forward-looking behavior reflecting forecast of market rent into pricing.

**Table 17: Shiller Test Model 1 - Cap Rate**

| | | | | |
|---|---|---|---|---|
| Number of obs | = | 1417 | R-squared | = 0.1002 |
| F( 8, 1408) | = | 19.59 | Adj R-square | = 0.095 |
| Prob > F | = | 0 | Root MSE | = 9.171 |

| FUTURE2_GROWTH | Coef. | Std. Err. | t | P>t | [95% Conf. | Interval] |
|---|---|---|---|---|---|---|
| CAP_RATE | -0.0120495 | 0.1865156 | -0.06 | 0.948 | -0.3779279 | 0.353829 |
| AGE | 0.042289 | 0.0121303 | 3.49 | 0.001 | 0.0184936 | 0.0660844 |
| GFA | 0.0028816 | 0.0009364 | 3.08 | 0.002 | 0.0010448 | 0.0047185 |
| D_2004 | 3.099572 | 0.8733556 | 3.55 | 0 | 1.386354 | 4.81279 |
| D_2005 | 4.601712 | 0.8677384 | 5.3 | 0 | 2.899512 | 6.303911 |
| D_2006 | 3.211017 | 0.8889115 | 3.61 | 0 | 1.467284 | 4.954751 |
| D_2007 | -2.853554 | 0.9364935 | -3.05 | 0.002 | -4.690626 | -1.016481 |
| D_2008 | -0.6420106 | 1.421823 | -0.45 | 0.652 | -3.431129 | 2.147108 |
| D_2009 | (dropped) | | | | | |
| cons | -0.2358715 | 1.801475 | -0.13 | 0.896 | -3.769736 | 3.297993 |

**Table 18: Shiller Test Model 2 - Gross Yield**

| | | | | |
|---|---|---|---|---|
| Number of obs | = | 3907 | R-squared | = 0.1077 |
| F( 8, 3898) | = | 58.81 | Adj R-square | = 0.1059 |
| Prob > F | = | 0 | Root MSE | = 9.1031 |

| FUTURE2_GROWTH | Coef. | Std. Err. | t | P>t | [95% Conf. | Interval] |
|---|---|---|---|---|---|---|
| GYIELD | -0.1971372 | 0.0213113 | -9.25 | 0 | -0.2389195 | -0.1553549 |
| AGE | 0.048622 | 0.0074436 | 6.53 | 0 | 0.0340282 | 0.0632158 |
| GFA | 0.0018478 | 0.0006469 | 2.86 | 0.004 | 0.0005795 | 0.0031161 |
| D_2004 | 2.799342 | 0.5654413 | 4.95 | 0 | 1.690753 | 3.907931 |
| D_2005 | 3.792358 | 0.5510334 | 6.88 | 0 | 2.712017 | 4.872699 |
| D_2006 | 2.520129 | 0.5423756 | 4.65 | 0 | 1.456763 | 3.583496 |
| D_2007 | -3.242382 | 0.5275017 | -6.15 | 0 | -4.276587 | -2.208176 |
| D_2008 | -3.80656 | 0.7786285 | -4.89 | 0 | -5.333118 | -2.280002 |
| D_2009 | (dropped) | | | | | |
| cons | 2.877925 | 0.5985161 | 4.81 | 0 | 1.704491 | 4.05136 |

# Chapter 8 Conclusion

## 8.1 Summary of Results

So far, in this paper, the models of NOI, spread, cap rate, gross yield and Shiller Test were examined individually. At this time, it may be helpful to observe and compare the results as a group. Table 19 summarizes the results of the main variables in NOI, cap rate, gross yield, and Shiller Test models.

NOI is significantly related to GRENT with 0.9626 of coefficient and 26.0 t-stat. However, the relation is not linear but a shape of diminishing marginal utility as shown in Figure 8. In addition, NOI is affected by PAST5_GROWTH among the three growth rates.

The examination of pricing methods was followed, which is the main purpose of this thesis. In the cap rate model, it is true that GRENT has a significant explanatory power, but the impact on the model is much smaller than the impact in the gross yield model judging from the coefficients: -0.1372 in the cap rate model and -0.8642 in the gross yield model. Even though GRENT may be an indigenous variable in the gross yield model, the value of coefficient in the cap rate model seems too small.

In terms of growth rate, the cap rate is considered to be affected by PAST2_GROWTH with the highest absolute value of t-stat among the three growth rates, while the gross yield is affected by FUTURE2_GROWTH, which is the only one with negative sign. In addition, by comparison of each coefficient, the impact in the gross yield seems much bigger than in the cap rate: -0.018 in the cap rate model and -0.1344 in the gross yield model.

At last, Shiller Test is conducted with FUTURE2_GROWTH as a dependent variable and with CAP_RATE and GYIELD as a major independent variable. The parameter of CAP_RATE is statistically insignificant, but that of GYIELD is significant and it is about –0.2.

This Shiller Test confirms the result from the cap rate and the gross yield model, i.e. future rental growth of property can not be anticipated by the cap rate, but can be even partially anticipated by the gross yield.

**Table 19: Values of Main Variables for Asset Pricing Models**

| Main Variables | | Model | | | |
|---|---|---|---|---|---|
| | | **NOI** | **Cap Rate** | **Gross Yield** | **Shiller Test** |
| **GRENT** | **coefficient** | **0.9626** | **-0.1372** | **-0.8642** | **N/A** |
| | t-stat | 26.00 | -13.3800 | -14.4000 | |
| **PAST5_GROWTH** | **coefficient** | **-0.2066** | **-0.0138** | **0.2114** | **N/A** |
| | t-stat | -8.36 | -2.0200 | 9.1300 | |
| **PAST2_GROWTH** | **coefficient** | **-0.0097** | **-0.0180** | **0.0321** | **N/A** |
| | t-stat | -0.69 | -4.7800 | 2.5300 | |
| **FUTURE2_GROWTH** | **coefficient** | **0.0978** | **-0.0033** | **-0.1344** | **N/A** |
| | t-stat | 7.96 | -0.9500 | -11.9400 | |
| **Cap Rate** | **coefficient** | **N/A** | **N/A** | **N/A** | **-0.0120** |
| | t-stat | | | | -0.0600 |
| **Gross Yield** | **coefficient** | **N/A** | **N/A** | **N/A** | **-0.1971** |
| | t-stat | | | | -9.2500 |

* GRENT Value of Cap Rate: Model 2, GRENT Value of Gross Yield: Model 3

## 8.2 Conclusions

This study explores and examines whether or not investors behave rationally when they price the U.S. office properties. The empirical findings suggest that, although not perfect, the behaviors of the investors are rational, based on the fact that they correctly, or at least partially, forecast to reflect market information, such as the property's rental growth, into pricing.

This analysis employs the actual property level data such as transaction prices and rents of the transacted properties to eliminate issues arising from substituting artificial data for real prices and rents. With those actual data, we revisit and examine the typical pricing method of cap rate, and also introduce another pricing way of gross yield. Further, Shiller Test is conducted to discover whether the future rental growth can be predicted by those two pricing methods.

In terms of the pricing methods, the gross yield reflects a property's future rental growth, while the cap rate is mostly correlated to the relatively short-term rental growth in the past. The different movement between the cap rate and the gross yield may be attributed to the spread of gross rent over NOI since the spread does not move proportionately to the rent. It also means that NOI does not have a linear relation with the rent, and is unlikely to reflect market information. Finally, Shiller Test confirms that the future rental growth of a property can be forecasted by the gross yield, not by the cap rate.

From these findings, a conclusion can be drawn that the behaviors of the investors in the US office property market are rational since they correctly forecast future incomes and reflect them into pricings by means of gross yields rather than cap rates.

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