MAARTEN JENNEN

Empirical Essays on Office Market Dynamics

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Bewegingen bestudeerd

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Voorwoord (Preface)

“Promoveren is vooruitzien” zo is te lezen in de aanhef van het promotiereglement van de Erasmus Universiteit Rotterdam. Een promotietraject bestaat uit vele tijdrovende stappen, waarbij de promovendus grotendeels zelf zorg draagt voor de tijdige uitvoering. Promoveren is dus inderdaad vooruitzien. Een promotietraject staat echter ook garant voor tegenslag, tijdsdruk en twijfel. Het is daardoor nog maar de vraag of iemand met volledig vooruitzicht ooit aan een promotie zou willen beginnen. Met zekerheid durf ik echter te stellen dat de doorzetter wordt beloond met een leerzame tijd die zorg draagt voor zowel persoonlijke als inhoudelijke verdieping.

Tijdens de afgelopen vier jaar heb ik vele mensen ontmoet die hun bijdrage hebben geleverd aan het ontstaan van dit proefschrift. Helaas is het onmogelijk iedereen op deze plek te bedanken. Een aantal mensen met een zeer speciale bijdrage aan mijn proefschrift wil ik echter graag persoonlijk noemen. In de eerste plaats gaat mijn grote dank uit naar mijn promotoren Dirk Brounen en Kees Koedijk.

Beste Dirk, onze eerste ontmoeting vond plaats tijdens mijn eerste dag aan de Rotterdam School of Management (RSM). Op dat moment konden wij beiden nog niet vermoeden dat onze samenwerking zo intensief zou worden. Mijn eerste maanden aan de RSM waren met nogal wat onzekerheid omgeven maar mede dankzij jouw steun is die rook snel opgetrokken. Als wielerliefhebber heb jij je tegen mij, maar ook op radio en tv, vaak uitgedrukt in wielertermen, graag wil ik je in diezelfde termen bedanken. Mijn promotietraject kende de hoogtelijnen van een Alpenrit uit jouw geliefde *Tour de France* met als verschil dat de bergen uit de *hors catégorie* in het begin van de koers lagen in plaats van aan de finish. Als promotor had je de afgelopen jaren alle gelegenheid en mogelijkheden om mij als waterdrager in te zetten, maar dat heb je niet gedaan. Ik wil je bedanken voor het feit dat je mij de kans en het vertrouwen hebt gegeven om, onder jouw intensieve begeleiding, mijn eigen koers uit te zetten zonder mij steeds af te moeten laten zakken naar de ploegleiderwagen. Ik heb de afgelopen jaren veel van jouw trainingen opgestoken en heb mede daardoor inmiddels het nodige vertrouwen om ook mijn academische fiets zonder zijwieltjes te berijden.

Beste Kees, via je vriend, collega en *business partner* Piet Eichholtz heb je mij de gelegenheid gegeven om een promotietraject binnen de RSM te starten. Het laatste jaar van mijn promotie heb je je werkzaamheden als decaan van de economische faculteit van Tilburg voortgezet, maar ook met deze geografische afstand ben jij altijd geïnteresseerd geweest in mijn projecten. Graag wil ik je bedanken voor de steun en het vertrouwen die je mij de afgelopen jaren hebt gegeven.

Collega's van de vakgroep Finance van de RSM; jullie hebben de afgelopen jaren gezorgd voor een prettige omgeving waarbinnen het fijn werken, "werken" en sporten was. Graag wil ik jullie allen daarvoor uitdrukkelijk bedanken. Speciale dank aan mijn kamer- en sportgenoten Patrick, Melissa, Marie, Mathijs, Willem en Chris; het was plezierig om al die uren met jullie door te brengen! Daarnaast zal ik ook mijn vastgoedcollega's in Maastricht niet vergeten. Piet Eichholtz heeft een brug gelegd tussen de universiteiten in Maastricht en Rotterdam en heeft er hiermee voor gezorgd dat de afgelopen jaren zeer enerverend en leerzaam zijn geworden. Nils en Thies, die ik door ons aller reislustigheid vaker in de V.S. dan in Nederland ben tegengekomen; bedankt voor de mooie momenten tijdens onze internationale conferenties!

In order to expand my knowledge of real estate I took the opportunity to take a number of courses at the National University of Singapore. With hindsight I can say that six months in Singapore not only expanded my knowledge of real estate, but also expanded my horizon of life. In particular I would like to express my gratitude to professor Ong and professor Fu whose knowledge and personalities contributed to my development as a researcher.

Naast de vastgoedkennis die ik in Singapore heb opgedaan, heb ik ook veel geleerd van mijn medewerking aan verschillende projecten van de vakgroep bedrijfsonroerendgoed van de NVM. De afgelopen vier jaar heeft de NVM BOG mijn promotieplaats aan de RSM gefinancierd. Deze investering in academisch vastgoedonderzoek is een blijk van professionaliteit, waarvoor mijn grote dank.

Een verder woord van dank voor mijn vrienden. Anke, Bert, Cécile, Daphne, Evelien, Gaby, Guido, Ivo, Lucienne, Raymond, Remko, Roel, Ronald en Tim. Hoewel we elkaar de laatste paar jaar niet meer minimaal twee keer per week ontmoetten ben ik blij dat onze vriendschap stand heeft gehouden en dat jullie de weekenden in het zuiden altijd weer van een mooie kraag voorzien. Ivo, Lizzy, Roul en Sylvia, met veel plezier voorzie ik de Randstad samen met jullie regelmatig van een zachte-G, laten we dat in de toekomst blijven doen.

Lieve Pa en Ma, de keuze om een uitdaging in Rotterdam aan te gaan betekende ook een keuze voor verhuizen uit mijn geliefde zuiden van het land. Ik weet dat jullie het soms lastig hadden met deze keuze maar geloof mij; dat gevoel was geheel wederzijds. Jullie onvoorwaardelijke steun tijdens de afgelopen jaren hebben sterk bijgedragen aan de mooie tijd die ik heb gehad. Bas, Karin, Luke en Kiki; mijn bezoekjes aan jullie fijne gezin in Elsloo staan altijd garant voor veel plezier en energie. De afstand tussen Den Haag en Limburg heb ik de afgelopen jaren vaak en met veel plezier afgelegd en ik zal dat ook zeker blijven doen.

Als laatste wil ik mijn vriendin Tanja bedanken. Lieve Tanja, ongeveer vier en een half jaar geleden kreeg ik de mogelijkheid om in het “verre” Rotterdam aan een promotie traject van vier jaar te beginnen. In die tijd was jij nog bezig met het afronden van je scriptie aan de Universiteit van Maastricht maar het kostte je weinig tijd om te besluiten dat jij de uitdaging samen met mij aan wilde gaan. Jij hebt, naast de successen en plezier, bij tijd en wijlen ook mijn tegenslag, tijdsdruk en twijfel als geen ander van dichtbij meegemaakt. De afgelopen jaren ben ik regelmatig van huis weggeweest voor conferenties en mijn verblijf van zes maanden in Singapore. Jij wist dat deze reizen veel voor mij betekenden en hebt mij dan ook, hoewel dat zeker niet altijd makkelijk was, steeds weer gesteund. Op geen van de hoofdstukken in dit proefschrift sta je als co-auteur vermeld, maar je indirecte bijdrage aan elk van de projecten was substantieel en vitaal. Met de afronding van jouw studie aan de Amsterdam School of Real Estate en mijn proefschrift is de tijd weer in grote mate van ons. Ik ga daar graag samen met jou van genieten!

Contents

Chapter 1
Introduction

This dissertation focuses on office buildings from a broad, but always financial, perspective. Knowledge about the financial underpinning of office buildings is important because of their threefold impact on society. First of all, offices provide a working environment for employees in service industries. In the Netherlands alone, the stock of office space is estimated at 44 million square meters, providing a place to work for almost 2 million clerks.[1] The quality and location of office buildings therefore has an impact on the productivity and well being of numerous people who spend a large part of their life in, and commuting to and from, office buildings. Secondly, the value stored in office constructions implies that a substantive amount of money is invested in offices, either by being directly owned by the occupier, by an institutional investor or by a larger group of investors through a securitization process. The third cause for a genuine interest in office buildings is their impact on the worlds' horizons. Thinking about major cities, one thinks about characteristic skylines comprised of office skyscrapers. These factors combined make office buildings an almost universal part of life.

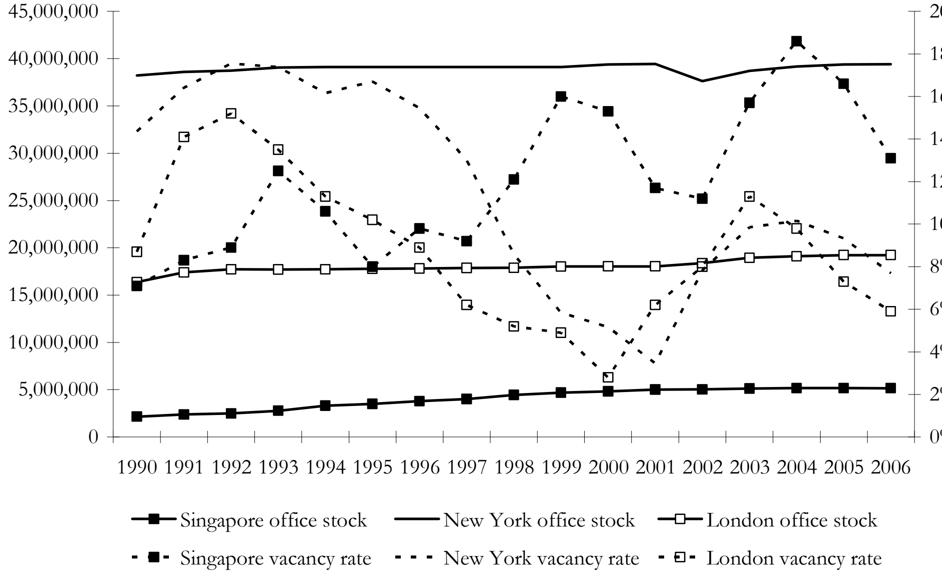
While skylines naturally change slowly over time, there is a very volatile financial market underneath. A vacant office building does not generate any income for its owner and as such has a direct link with financial performance. Figure 1.1 shows development in office stock and vacancy rates for Singapore, New York and London over the period 1990-2006. The Figure shows that changes in office stock are gradual[2] but that vacancy rates change drastically over time. Obtaining better understanding of the factors driving the volatility of office markets is of great importance to investors, developers and governments. This dissertation improves our knowledge of office markets and can assist stakeholders in office markets in their decision-making.

[1] Estimates based on Bak (2006) and the industry guideline of 25 m^2 per employee.

[2] The quick change in office stock in New York as a result of the collapse of the Twin Towers is visible in Figure 1.1, but, of course, very exceptional.

Figure 1.1 ■ Office stock and vacancy rates in Singapore, New York and London

The Figure shows office stock in square meters (left hand axis) and local vacancy rates (right hand axis) for three major office markets.



The remainder of this introduction consists of two parts. First I will provide a discussion of office market dynamics while the final part of this introduction provides a short summary of the six following chapters of this dissertation.

1.1 Office Market Dynamics

Demand for office space is driven by employment in office occupying industries. A widely used definition for office employment includes the Finance, Insurance and Real Estate (FIRE), and business services industries. According to this definition about 26 million people are expected to be employed in office buildings in the U.S. in 2008.

In perfect markets, changes in this figure would be met with proportional changes in office stock. The office floor space would accordingly follow the economic cycle and vacancies would not exist. Unfortunately, things are not perfect and the office stock is inelastic with respect to decreases in demand but elastic when demand rises. As a result of this relation temporal surges in vacancy rates occur which make large portions of the office stock non-income producing. For example, in 2000 vacancy rates on the Amsterdam office market were, driven by the Dotcom boom, below 3%.[3] Shortly after the turn of the millennium, demand for office space dropped sharply after huge layoffs at office occupying companies. This drop in demand, coupled with the completion of projects under development, lead to a sharp increase in vacancy rates; peaking at approximately 20% in 2005. The long lived nature of office buildings, where downward changes in capacity are gradual, provides a feeding ground for lasting mismatches between supply and demand and costly affairs for office investors.

Another complicating factor for office investors is the much faster economic than structural depreciation of buildings. Offices form the sign board of companies and therefore esthetic values play an important role in settlement choices besides the practical usability of the building. The preference for modern exteriors, and a development industry that has an incentive to add new projects to the market, results in a tendency for older buildings to remain vacant even when demand rises.

Demand and supply have also been out of line in the past due to institutional circumstances. An infamous example in this league is the favorable tax treatment of real estate investment in the United States during the Reagan era of the 1980s. A wall of money seeking investment in real estate was swiftly transformed to buildings by the development industry, without an underlying need for more capacity. The logical result of this recipe for disaster was an unprecedented surge in vacancy rates and ultimately loss of money.

One consequence of this massive allocation mismatch was a substantial increase in data collection and office market research to obtain better understanding of the underlying factors driving supply and demand. The increase in research attention led to the development of office market models such as presented by Hekman (1985) who studies the boom-bust cycle of office construction and the determinants of changes in office rents. Wheaton (1987) introduced a stock flow model for the office market. This model consists of office demand, construction and rent change equations. The study of the cyclic behavior of the U.S. office market shows that rents react to the deviation of vacancy rates from their natural level. Later work (e.g. Hendershott, 1996 and Hendershott et al., 1999) expanded scholarly work on office rent dynamics by introducing new pieces to the rent change conundrum. Lately (see for example Hendershott, MacGregor and Tse, 2002 and Englund et al. 2008b) empirical research has been expanded with the inclusion of error correction models.

Most existing research on office market dynamics has focused on the U.S. market. One justification for this focus in research attention is simply the size of office markets in the United States. The combination of big cities and service sector

[3] Data provided by Jones Lang LaSalle.

employment mass causes the presence of numerous substantial office markets within one country. Another reason for a focus of research attention on the U.S. in the past has a more pragmatic foundation and is related to a data availability constraint in non-U.S. markets. However, with the growth of office markets and data collection efforts in Europe and Asia a whole new market for research is being excavated. The shown willingness of private parties in Europe to share their valuable data is an encouraging sign for the future of European office market research.

1.2 Outline

This dissertation includes six chapters related to office market dynamics and location choices. On a broad brush level they cover the lifespan of an office building from construction decision, through location choice and income generating capacity, towards securitization. What follows next is a short discussion of the research topic and main findings of each chapter.

In chapter two I examine the pre-birth phase of office buildings. Preceding the completion of every office building is a process of decision-making. Real assets take a certain time to build and especially with large scale investments such as office buildings the decision process and actual construction takes up to several years. Moreover, after construction the asset will remain for several decades. This long lived nature of office buildings implies that investors have to include estimates of future demand in their construction decision. In this chapter we test whether forward looking variables derived from the stock market can be used as implicit variables in construction decision modeling. The study area is Singapore and Hong Kong. These two city states offer a unique opportunity where local real estate markets cover the same ground as the national stock market. The findings presented in chapter two show that expectations derived from the stock market can indeed be used as input variables in a model of office construction.

Once the construction decision has been made, it is important to construct the building at the right location. The impact of location choice on income generating capacity of the office building is the main research question covered in chapter three. Statistics show that office employment is concentrated in large cities. But even within these cities it is apparent that office buildings cluster in certain locations. The need for face to face contact in non-routine decision-making is, besides the preference for the "right address", a reason mentioned for the clustering of office space (Archer and Smith, 2003). In this chapter I construct an office density measure based on geographic information system (GIS) technology and study the effect of clustering on office rents in the Amsterdam office market. After controlling for characteristics that influence rent levels, I find that rents in areas with a dense office stock are higher than rents in areas with relatively less office space. The chapter also shows that this effect is present irrespective of the phase of the office market cycle.

The next chapter takes a broader look at the location choice and examines the link between population density and financial performance for a broad group of Dutch firms. Urban economic literature evolves around the question of why people cluster in cities. The positive relation between density on the one hand and wages, land rents and productivity, on the other hand has long been recognized. In this chapter I look at the relation between density and financial performance. Profitability is the main reason why companies exist in capitalistic economies, but its link with population density has not been studied before. The analysis presented in this chapter reveals that, after taking into account various control variables, the relation between density and financial performance at the firm level has been negative in the Netherlands over the last decade. This striking result deserves further research attention but several possible explanations for the conclusion are presented in chapter four.

Chapter five continues the office building life span covered in this dissertation and examines the macro economic factors influencing rent levels. At the firm level prestige could have an impact on office ownership, but from an investment perspective rental income is the sole reason for holding office buildings in the portfolio. In a multi asset portfolio office buildings contest for allocation with a broad range of alternative assets. For investors it is therefore important to have a view on the factors that influence demand for office space and as such have an impact on rent levels. In chapter five I examine rent determinants for ten major European office markets and test whether the use of refined data at the local level improves office modeling. The study shows that changes in office rents are mainly caused by changes in office employment, the deviation of rents from equilibrium levels and lagged changes in office rents. I also show that the use of local instead of national data on office employment does not improve the fit of the model significantly due to the high correlation between local and national data for the cities covered in this chapter.

The following chapter continues to add insight on the determinants of changes in office rents. In chapter six I study a panel of the fifteen largest office markets in the U.S. and focus on the impact of a non-negativity constraint of vacancy rates. The analysis presented in this chapter shows that changes in office rents, due to an increase in office employment, are significantly larger when vacancy rates are below their long term average. The results presented in this chapter do not only apply to the panel including all cities but also hold for clusters based on similarity in rent and employment changes.

Chapters five and six of this dissertation focused on rent determinants. As rent generating capacity is the main reason for holding office buildings in an investment portfolio, investors will use their knowledge on rent determinants in their allocation decision. The decision to invest in office space in a certain location is followed by a decision on the investment format. Allocation of money towards office buildings can be direct: buying the actual bricks and mortar or indirect: buying shares of property funds that hold office buildings. Chapter seven looks at the short and long run relation between these two practically different, but fundamentally linked, investment vehicles. The main question is whether real estate funds specialized in office buildings generate a risk and return profile that is comparable to the underlying office market. In chapter 7 I show that the two markets can take different paths in the short run but are integrated over longer time horizons.

Chapter 2
Office Construction in Singapore and Hong Kong:
Testing Real Option Implications[4]

2.1 Introduction

Real option theories of irreversible investment decisions (Abel 1983; Dixit and Pindyck 1994) have advanced the empirical literature of real estate investment analysis by improving the prediction of the timing of new construction. Traditional analysis of real estate investment decisions focuses mostly on the response of new construction to demand shocks. Studies of commercial office investment, for example, predict construction by lagged growth in office employment and lagged rents (Hekman 1985), by lagged vacancy rates (Rosen 1984) and by lagged office stock relative to office employment (Wheaton 1987; Wheaton, Torto and Evans 1997). More recent studies allow construction decisions to be influenced also by the cost of capital and volatility as suggested by the real option theories. Sivitanidou and Sivitanides (2000), for example, study office construction in the fifteen largest U.S. metropolitan office markets from 1982 to 1998. Their findings show that construction decreases with the cost of capital and the volatility of the demand growth. Holland, Ott and Riddiough (2000) report similar findings in a study of the aggregate construction of four categories of commercial real estate in the U.S. from 1972 to 1992.

[4] This chapter is based on Fu and Jennen (forthcoming in the Journal of Real Estate Finance and Economics, 2008). We are grateful to Richard Buttimer and other participants in the 2007 Maastricht-Cambridge-MIT (MCM) Real Estate Finance and Investment Symposium in Cambridge, MA, for their helpful feedback. Furthermore we would like to thank our referee and the editors of the JREFE Special Issue, David Geltner and Piet Eichholtz for their comments.

The extant real-option-based empirical studies of real estate investment are inadequate in a number of respects. First, they leave several important real option implications untested. In particular, Capozza and Li (1994 and 2002) show that volatility not only delays irreversible investments but also influences the way the investment timing decision is affected by real interest rates and expected rental income growth. Capozza and Li (2001) is the only empirical study that examines the influence of volatility on the way construction responds to interest rate changes, but fails to take adequate control of demand shocks in a cross sectional study of residential markets. In the present study, we seek to examine how volatility affects the impact of interest rate changes and expected demand growth on construction in commercial office markets.

Second, the extant studies provide inadequate control of the demand for new construction. Sivitanidou and Sivitanides (2000), for example, use the office rents relative to construction costs, and office vacancy rates to account for the demand for new construction. However, the vacancy rate always converges to a normal vacancy rate as rents adjust to clear the market regardless of the gap between the building stock and its equilibrium level; hence the vacancy rate is a good indicator for price adjustment but a poor indicator for new construction demand. Furthermore, office rents and the construction costs are not necessarily cointegrated, since the difference between the two (in real terms) reflects the real land rent, which is typically nonstationary. Including this nonstationary regressor in the analysis leads to a mis-specification of the construction model. Holland, Ott and Riddiough (2000) overcome this problem of nonstationary regressors by differencing the construction quantity on the left-hand side of their regression equations and all the explanatory variables on the right-hand side. However, in so doing they eliminate much useful information on disequilibrium gaps contained in the price levels and, not surprisingly, find construction hardly to respond to the price changes. We propose a more satisfactory measure of the demand for new construction based on a stable long-run equilibrium relationship between the office stock and the office employment in a city. When combined, the office stock and office employment form a cointegrating vector, whose variation over time indicates the supply gap to be offset by new construction.

Third, the extant studies usually apply a myopic approach and construct the measures of expected demand growth and volatility based on past growth rates. Holland, Ott and Riddiough (2000) represent an exception in that they use a forward-looking implied volatility measure derived from commercial real estate debt prices. Reliable prediction of building activities based on real option models requires forward-looking measures of demand growth expectations. The present study derives such a measure from the forward-looking behavior of local asset prices. Specifically, we employ the observations from Singapore and Hong Kong stock markets to test the real option models. Both city states are major business centers in Asia and the local stock market indices reflect the demand for local business services and hence provide good signals for the forward-looking local office demand growth.[5]

The remainder of this chapter is organized as follows. We summarize the implications of the real option models for real estate construction in Section 2.2, which is followed by the discussion of our empirical model and data in Section 2.3. We present our findings in Section 2.4 and conclude in Section 2.5.

2.2 Real Option Rules for Real Estate Investment

Real option models prescribe rules for the optimal timing of making irreversible investments. Such rules have important implications for asset prices. Real estate construction is an important class of irreversible investments. Titman (1985) is one of the first studies that examine how uncertainty can affect urban land prices. Capozza and Helsley (1989 and 1990) examine the implications of the optimal timing of land conversion at urban boundaries for urban land rents and prices. In their model, uncertainty raises the hurdle rent that the urban land rent must exceed at the boundary to trigger optimal conversion, delaying the land conversion and pushing up the urban land rent and price. Capozza and Sick (1994) provide a fuller analysis of the effect of demand growth, volatility and the risk premium on the hurdle rent and hence the price of developed land. Capozza and Li (1994 and 2002) extend the real option model of urban land conversion by allowing variable capital intensity in land development. Earlier empirical studies often focus on testing the real option implications for asset prices; examples include Capozza and Schwann (1989) and Quigg (1993), who examine the influence of real options on the prices of urban land and commercial properties respectively. Capozza and Li (2001), Sivitanidou and Sivitanides (2000), and Holland, Ott and Riddiough (2000) are among the early empirical work focusing directly on the influence of real options on investment behavior in real estate markets; each of these studies, however, focuses on a partial set of the real option implications for real estate investments. Our objective in the present study is to test a set of real option implications that goes beyond the set of implications tested in extant empirical studies. This section summarizes the full set of real option implications for real estate investments as developed in the analytical work of Capozza and Sick (1994) and Capozza and Li (1994 and 2002).

[5] The same may not be true for big countries like U.S., where the stock market indices would reflect the national office demand growth but local office markets need not be highly correlated with the national office demand (Hekman, 1985).

The real option rules for the optimal timing of irreversible real estate investment can be prescribed in terms of a hurdle rent X^*. The underlying demand for real estate is indicated by rent level X, which grows at rate g and a diffusion variance σ^2. The investment or conversion takes place as soon as X reaches X^*; hence a higher X^* implies a longer delay before X reaches the conversion trigger. Conversion takes place at a capital intensity K^* on a given land parcel to produce floor area $Q(K^*)$. The choice of optimal K can influence the timing of conversion depending on the elasticity of substitution between capital and land. The hurdle rent X^* equals the risk adjusted cost of capital $r+\varphi/2$ multiplied by the average capital cost of construction $K^*/Q(K^*)$, as shown in *Eq.* (2.1):[6]

$$X^* = \left(r + \frac{\varphi}{2}\right)\frac{K^*}{Q(K^*)} \tag{2.1}$$

where r is the real interest rate and $\varphi = -\left(g - \lambda - \frac{\sigma^2}{2}\right) + \sqrt{\left(g - \lambda - \frac{\sigma^2}{2}\right)^2 + 2\sigma^2 r}$ is the risk adjustment, which increases with the variance σ^2 ($\varphi \geq 0; \varphi = 0$ when $\sigma^2 = 0$) and interest rate r but decreases with the expected demand growth net of a risk premium, $g-\lambda$. λ is the risk premium associated with the systematic risk of the investment project. *Eq.* (2.1) is a generalization of the Jorgensonian rule to invest when the cash flow equals the user cost of capital (Jorgenson 1963). The optimal capital intensity K^* is chosen such that the marginal revenue of K, $Q'(K^*)\cdot X^*$, equals the interest rate net of the risk-adjusted growth rate, $r-(g-\lambda)$. The average cost of construction increases with the capital intensity as the marginal product of capital diminishes. When construction is a CES function of K (holding land area fixed) such that $Q(K) = [a + (1-a)\cdot K^{(\pi-1)/\pi}]^{\pi/(\pi-1)}$, with the elasticity of substitution $\pi \geq 0$, the average cost of construction is given by[7]

$$\frac{K^*}{Q(K^*)} = \left(\frac{1-a}{1-\sigma^2/\varphi}\right)^{\pi/(1-\pi)} \tag{2.2}$$

where σ^2/φ varies from $g/r<1$ to 1 as σ^2 increases from 0 to ∞. Capozza and Li (2002) assume $\pi<1$, so that K^* and the average construction cost at which the conversion takes place increase with volatility σ^2 and the risk-adjusted growth rate $g-\lambda$, but decreases with r. Table 2.1 summarizes the comparative statics for hurdle rent X^*, which forms the hypotheses for the empirical analysis in this chapter.

[6] This is equation (21) in Capozza and Li (2002).
[7] See equation (27) in Capozza and Li (2002).

Table 2.1 ■ Real option implications for real estate investment decision

This Table summarizes the relation between the hurdle rent X^* for new construction and four key variables affecting the real option value. Each sign indicates the direction in which the hurdle rent will change when the value of the variable increases, given the level of volatility (σ^2) and elasticity of substitution between capital and land (π). *Panel a* shows the effect of the expected growth rate (g) on the hurdle rent. *Panel b* shows the effect of the real interest rate (r). *Panels c* and *Panel d* show the effect of the risk premium (λ) and volatility (σ^2) respectively.

			π		
Variable			0	Low	High
Panel a		$\sigma^2 = 0$	0	+	+
	g	Low σ^2	-	+	+
		High σ^2	-	-	+
Panel b		$\sigma^2 = 0$	+	+	-
	r	Low σ^2	+	+	-
		High σ^2	+	-	-
Panel c	λ	Low σ^2	+	-	-
		High σ^2	+	+	-
Panel d	σ^2		+	+	+

2.1.1 Certainty case

Under certainty σ^2 =0 and φ =0, the growth rate g does not affect X^* when the cost of construction is fixed. When capital is substitutable for land (π>0), a higher g raises X^* as the land conversion will take place at a higher capital intensity K^*. A higher interest rate r increases X^* by raising the cost of capital; but when π is high, a higher r can decrease X^* by reducing K^*.

2.1.2 Uncertainty case

A higher volatility or total risk σ^2 always increases X^* and hence delays construction and increases the capital intensity K^* at which the land is developed. Uncertainty makes the effect of g on X^* more negative, as a higher g reduces the risk adjustment φ. Note that the risk premium λ always offsets g and hence has an opposite effect on X^* as g does. The effect of interest rate r on X^* also depends on the volatility. Although a higher r always increases the risk-adjusted cost of capital $r+\varphi/2$, it reduces K^* and the average cost of construction, with a stronger impact on K^* when the volatility is higher.

2.3 Model Specification and Data

2.3.1 Model specification

Following the literature, we postulate that new construction responds to demand indicators, the cost of capital, and variables embedded in real option theory. As explained in Section 2.2, the last two factors are fully summarized by the hurdle rent X^*. Table 2.1 spells out how the hurdle rent varies by the real interest rate r, expected demand growth g, risk premium λ, volatility σ^2 and the elasticity of substitution π, as predicted by the real option models. A higher X^* means that a greater gap between the demand and the available office stock (hence a higher X) is required in order to motivate new construction. Table 2.1 thus forms the hypotheses for testing the real option implications for office construction.

Let G denote the gap between the long-run equilibrium office stock and the presently available office stock OS. G is decreasing in OS. The percentage change in OS between period t and t-1 is denoted by $\Delta_t\ln(OS)$, where Δ_t denotes difference between period t and t-1. $\Delta_t\ln(OS)$ represents net new construction. Thus our basic model for new construction can be written as:

$$\Delta_t \ln(OS) = \alpha_1(G_{t-1} - X^*_{t-1}) \tag{2.3}$$

where $\alpha_1>0$ indicates the speed at which new construction responds to the equilibrium gap in stock and X^* represents the hurdle gap (without loss of generality we assume the hurdle gap to equal hurdle rent). Variables that raise hurdle rent X^* reduce new construction.

Extant studies employ three types of indicators to measure the gap G; they are (1) real estate prices or rents relative to construction costs, (2) vacancy rates, and (3) occupancy demand to available stock, where the occupancy demand equals total employment in the office-use sector multiplied by the space demand per employee that decreases with office rents. The first measure would result in a nonstationary G, as the difference between the rent and the construction cost is the land rent, which is likely to be nonstationary over time. *Eq.* (2.3) would be misspecified if the stationary $\Delta_t \ln(OS)$ is to be regressed on a nonstationary G. The second measure reflects more the adjustment in rents required to clear the space market than the new construction required to restore the long-run equilibrium level of stock. The third measure suffers the similar problem as the second, as rents will always adjust to equate the occupancy demand with whatever amount of stock available in the market.

We propose to measure G with a cointegration vector between the office stock OS and office employment OE. Both OS and OE are endogenous variables but they will adjust so that

$$G = \theta \cdot \ln(OE) - \ln(OS) \tag{2.4}$$

is a cointegration vector; in other words, G as defined by *Eq.* (2.4) is stationary in the long run. The elasticity parameter θ indicates a long-run equilibrating relationship between OE and OS. OS must grow θ percent in order to accommodate each percentage growth in OE or OE can only grow $1/\theta$ of whatever percentage growth in OS that takes place. We expect θ to be less than unity due to improving efficiency in office space use over time. The sources of the efficiency improvement would include the introduction of more flexible office concepts where desk space is used more efficiently, the increase in digitalization and virtual meeting rooms which demand less space and a general tendency of companies to review their space consumption more effectively.

We specify the hurdle rent X^* as a linear function of the variables listed in Table 2.1. In addition, we include the interactions between volatility σ^2 and the interest rate r and growth g to test how the effects of these two variables depend on the volatility. Thus:

$$\begin{aligned} X^* = {} & \beta_0 + \beta_1 \cdot \sigma + \beta_2 \cdot r + \beta_3 \cdot r \cdot \sigma^2 + \beta_4 \cdot g + \\ & \beta_5 \cdot g \cdot \sigma^2 + \beta_6 \cdot \lambda + \beta_7 \cdot \lambda_n \end{aligned} \tag{2.5}$$

where, λ_n is a forward-looking measure of expected change in λ, to be referred to as risk-premium news, to be explained shortly.

At this point we need to be specific about the timing of the variables. The change in the stock $\Delta_t \ln(OS)$ is a consequence of investment decisions made several years in advance due to the construction lag. We find that a lag of 3 years best fits our data and seems most plausible as land acquisition, planning and construction of high-rise office towers in both city states would require substantial time (Sivitanidou and Sivitanides (2000) find a delivery time for office construction between 3.2 and 3.6 years in the U.S.). Thus on an annual basis, we assume $\Delta_t \ln(OS)$ in year t to be influenced by the determinants of X^* observed three years in advance at the end of year t-4. We further assume that at the end of t-4 the investors can project the office stock $OS_{t\text{-}1}$ based on the stock $OS_{t\text{-}4}$ and the building project commencement information. The investors can also project employment at t-3, $OE_{t\text{-}3}$.

Combining *Eqs.* (2.3), (2.4) and (2.5), adding lagged adjustments, and according to the timing assumptions discussed above, we have the following empirical model of office construction:

$$\begin{aligned}\Delta_t \ln(OS) = {} & \alpha_1[\theta \cdot \ln(OE_{t-3}) - \ln(OS_{t-1}) - (\beta_0 + \beta_1 \cdot \sigma_{t-4} + \beta_2 \cdot r_{t-4} + \beta_3 \cdot r_{t-4} \cdot \sigma_{t-4}^2 + \beta_4 \cdot g_{t-4} \\ & + \beta_6 \cdot g_{t-4} \cdot \sigma_{t-4}^2 + \beta_7 \cdot \lambda_{t-4} + \beta_8 \cdot \lambda_{n,t-4})] + \alpha_2 \Delta_{t-1} \ln(OS) + \alpha_3 \Delta_{t-2} \ln(OE) + \varepsilon_t\end{aligned} \tag{2.6}$$

where ε_t is a random residual error. According to Table 2.1, we expect that volatility σ increases X^* (β_1>0) and hence slows construction Δ_t ln(OS). We also expect σ^2 to reduce the positive interest rate effect on X^* (β_3<0) and to strengthen the negative effect of growth expectation g on X^* (β_6<0). The sign of β_2 and β_4 will depend on the elasticity of substitution between capital and land; β_2 (β_4) would be positive (negative) when the elasticity of substitution π is low and negative (positive) when π is high. We have no direct measure of π; however, we will examine whether β_4 is more positive in the earlier part of our sample period when the capital intensity of office construction is relatively lower and the marginal product of capital may be higher. We expect that β_7 has the opposite sign of β_4 in line with relations in Table 2.1.

The sign of β_8 is not *a priori* certain as the extant real option models assume a constant risk premium. We speculate that an anticipated rise in risk premium in the future will lower the current hurdle rent (β_8 <0), as the value of the option to wait is reduced due to anticipated higher cost of capital in the future.

2.3.2 Data and variable construction

We apply *Eq.* (2.6) to examine office construction in Singapore and Hong Kong. The office markets in both city states experienced tremendous growth since the beginning of 1980s; Appendix I in section 2.6 provides a brief overview of the economic development in the two markets. For Singapore we have semi-annual observations (we denote observations in the first semi-annual period as S1 and second half as S2) from 1980 to 2006 and for Hong Kong, annual observations from 1978 to 2006 (plus projected office stock in 2007). The variables and their sample statistics are presented in Table 2.2. The majority of the variables we use in our analysis is available from DataStream. These variables are described below.

Table 2.2 ■ Variable description and sample statistics

This Table describes the variables used in this study and reports their summary statistics. N is the number of observations over the sample period. *Panel a* shows the variables for Singapore, where observations are on a semi-annual basis (S1 stands for the 1st half and S2 for the 2nd half). *Panel b* shows the variables for Hong Kong, where observations are on an annual basis.

Panel a

Variables	Description	Mean	Std. Dev.	Sample period	N
$\ln(OS_t/OS_{t-1})$	Semi-annual growth rate; private office floor area	0.028	0.025	1979S2-2006S2	55
$\ln(OE_t/OE_{t-1})$	Semi-annual growth rate; FIRE employment	0.029	0.035	1979S2-2006S2	55
OE_t/OS_t	FIRE employment per sqm of private office floor area	0.065	0.005	1979S2-2006S2	55
r_t	Real interest rate; average of 2nd Q of current S and 1st Q of next S 3-month SIBOR rate minus 4 quarter forward CPI inflation rate	0.050	0.033	1980S1-2005S2	52
$\sigma 1_t^2$	$Garch_{t+1}$=0.0012+0.4276·v_t^2+0.642·$Garch_t$, Student's t-distribution; 1st Q of S	0.024	0.022	1980S2-2006S1	52
$\sigma 2_t^2$	$Garch_{t+1}$; 2nd Q of S.	0.023	0.019	1980S2-2006S1	52
λ_t	Predicted excess return z_{t+1}, $(E_t)z_{t+1}$, based on VAR Equation ; 1st Q of S.	0.003	0.049	1980S2-2006S1	52
g_t	Cash-flow news, $\eta_{d,t}$; 2nd Q of S.	-0.006	0.096	1980S2-2005S2	51
$\lambda_{n,t}$	Risk-premium news, $\eta_{z,t}$; 2nd Q of S.	-0.022	0.148	1980S2-2005S2	51

Panel b

Variables	Description	Mean	Std. Dev.	Sample period	N
$\ln(OS_t/OS_{t-1})$	Annual growth rate; private office floor area	0.057	0.046	1979-2007	29
$\ln(OE_t/OE_{t-1})$	Annual growth rate; FIRE employment	0.058	0.050	1979-2006	28
OE_t/OS_t	FIRE employment per sqm of private office floor area	0.049	0.004	1979-2006	28
r_t	Real interest rate; average of 1st Q to 4th Q 6-month HIBOR rate minus 4 quarter forward CPI inflation rate.	0.014	0.050	1980-2006	27
$\sigma 1_t^2$	$Garch_{t+1}$=0.0003+0.215·ξ_t^2-0.284·ξ_t^2·(ξ_t <0) +0.924·$Garch_t$; ξ_t=v_t-0.0575·v_{t-1}; 1st Q.	0.023	0.016	1980-2006	27
$\sigma 4_t^2$	$Garch_{t+1}$; 4th Q.	0.025	0.017	1979-2005	27
λ_t	Predicted excess return z_{t+1}, $(E_t)z_{t+1}$, based on VAR Equation ; 1st Q.	0.033	0.069	1980-2006	27
g_t	Cash-flow news, $\eta_{d,t}$; 4th Q.	-0.023	0.062	1979-2005	27
$\lambda_{n,t}$	Risk-premium news, $\eta_{z,t}$; 4th Q.	0.017	0.140	1979-2005	27

2.3.2.1 Office stock (OS)

OS represents the total existing floor area of private office space at the end of each observation period. The historic series have been developed by the Urban Redevelopment Authority (Singapore) and the Buildings Department (Hong Kong). Given the large scale of some office buildings in major cities, office completions are often lumpy. We adjusted the 1986 *OS* in Hong Kong to allow for partial completion of a major office development completed in 1987. We did the same for Singapore for 1993 S1 office stock. The office stock grew on average by 2.8% per semi annual period in Singapore, with a standard deviation of 2.5%; in Hong Kong it grew by 5.7% per year, with a standard deviation of 4.6%.

2.3.2.2 Office employment (OE)

Office employment is represented by the number of employees in finance, insurance and real estate (FIRE) industries. Employment in FIRE is often used to measure the demand for office space in extant office market studies (see, e.g.

Wheaton 1987). *OE* grew by 2.9% on average on a semi-annual basis in Singapore, with a standard deviation of 3.5%; in Hong Kong it grew by 5.8% per year, with a standard deviation of 5.0%. The FIRE employment grew to 363,000 in Singapore in 2006 and to 491,500 in Hong Kong.

It is interesting to note that the average annual FIRE employment growth is almost the same in both city states. In both cities, the office stock growth is lower than the FIRE employment growth. Also interesting to note is that the demand shocks are more volatile than the supply adjustment, as the standard deviation of the FIRE employment growth is larger than that of the office stock growth.

2.3.2.3 Real interest rate (r)

In Singapore we use 3-month interbank offered rate (SIBOR) to measure the market interest rate. The Singapore Monetary Authority (MAS) publishes SIBOR rate since 1988. We use U.K. 3-month interbank offered rate to extend SIBOR rate back to 1980 (the two series have a correlation coefficient of 0.99 between 1988 and 2006). The real interest rate r is computed as the average SIBOR of the 2nd quarter of the current semi-annual period and the 1st quarter of the next semi-annual period minus the 4 quarter forward CPI inflation rate. For Hong Kong, r is computed as the 4 quarter average 6-month HIBOR rate starting 1st quarter of the year minus the 4 quarter forward CPI inflation rate. The real interest rate averaged 5.0% per annum in Singapore and 1.4% in Hong Kong, although the rate is more volatile in Hong Kong. The lower but more volatile real interest rate in Hong Kong is to a large extent due to the currency board system, which pegs Hong Kong dollar to U.S. dollar. The currency board system constrained Hong Kong's monetary adjustment to the local inflation rate; the negative real interest rates experienced in Hong Kong during the mid 1990s were consequences of such monetary constraints.

2.3.2.4 Stock-market-based forward-looking variables

We take advantage of the active stock markets in the two city states to construct several forward-looking variables for this study, including (1) volatility or total risk, (2) risk premium for systematic risk, (3) demand growth expectations, and (4) risk premium expectations. We do so using the log-linear present-value accounting framework of Campbell and Shiller (1988a,b). In this framework, an innovation in the stock-market excess return is accounted for by news about future cash flow growth, future risk premium (expected excess returns), and future interest rates. These news components can be estimated using a VAR model. We follow Campbell (1991) and use a VAR model of three variables, namely stock-market excess return, stock-market dividend yield, and money market rate, to estimate the innovation in the excess return and its constituent news components. Appendix II in section 2.7 describes the methodology and the VAR estimates. We use the Straits Times Index to represent the Singapore stock market and the Hang Seng Index for Hong Kong. These broad stock market indices would reflect the expectation for the overall local economic growth. We expect the office employment in the two city states, which generates the demand for office space, to be highly correlated with the general economy as these two economies are to a large extent driven by trade and business service export. Finance, trade and property sectors account for a major share of the market capitalization of the Hang Seng Index during our study period, whereas these sectors as well as export manufacturers account for a major share of the market capitalization of the Straits Times Index.[8] These sectors are the major drivers of office demand growth.

It would be interesting to test whether our results change when an index with only financial firms is used for the analysis but unfortunately such an index is unavailable for the full sample period. However, the Dow Jones Total Market Index (DJTMI) and its financial sub-index are available for Singapore and Hong Kong over the period 1992-2008 and they are highly correlated, indicating that our results would not change much.[9]

Let z_t denote the observed excess return of the stock market (total return minus the money market rate), d_t the cash flow growth in period t, E_t the expectation conditional on information available at time t, and $v_t \equiv (E_t – E_{t-1})z_t$ the innovation in z_t. The conditional expectations are computed based on the estimated VAR model using quarterly observations. The four stock-market-based variables in *Eq.* (2.6) are defined below (see Appendix II for a full description):

1) volatility, $\sigma_t^2 \equiv$ GARCH(1,1) of v_t,;
2) risk premium, $\lambda_t \equiv (E_t)z_{t+1}$;
3) change in demand growth expectation, or cash flow news, $g_t = \eta_{d,t} \equiv (E_t - E_{t-1})\sum_{j=0}^{\infty}\rho^j d_{t+j}$, where ρ<1 is a discount factor;

[8] A potential issue with the proposed methodology is related to the locality of the stock market indices and the relation of the broad stock market indices with office demand. Constituent analysis of the Straits Times index and Hang Seng index shows that over 85% of the companies listed in the Straits Times at the end of 2006 are based in Singapore while for the Hang Seng the local presence was 53.6% and changes to over 70% if the Hong Kong and Shanghai Banking Corporation (HSBC) whose headquarter is officially located in London is taken into account. We also find that nine out of ten companies whose headquarter is not located in Hong Kong are from China whose economy is strongly linked to the economy of Hong Kong.

[9] The correlation between the DJTMI and its financial sub-index is 0.94 for Singapore and 0.96 for Hong Kong over the period 1992-20008. The financial sub-indices have a correlation coefficient of 0.83 and 0.84, respectively, with the Straits Times index and the Hang Seng index.

4) change in risk premium expectation, or risk premium news, $\lambda_{n,t} = \eta_{z,t} \equiv (E_t - E_{t-1})\sum_{j=1}^{\infty}\rho^j z_{t+j}$.

A positive $\eta_{d,t}$ means a higher expectation of future demand growth, whereas a positive $\eta_{z,t}$ means a higher expectation of future risk premium. Holland, Ott and Riddiough (2000) measure the time varying beta of different real estate sectors as the source of variation in systematic risk. We focus our analysis on the time varying risk premium as the source of variation in systematic risk and assume the market beta for the office property sector to be constant over our study period.[10]

2.4 Empirical Findings

The estimates of *Eq.* (2.6) for Singapore are reported in *Panel a* of Table 2.3. In Column I, the long-run office stock elasticity with respect to office employment θ is jointly estimated with the determinants of the hurdle rent X^*. We choose a sample period of 1984S1-2002S2 to estimate θ, as the office construction was very constrained in the last couple of years of our full sample period (hence the θ value would be underestimated using the full sample period). We obtain a θ estimate close to 0.7. In other words, the office stock in Singapore would grow by about 7% for each 10% growth in the office employment. The slower growth in the office stock in the long run relative to the employment growth shows the increase in office space efficiency over time. We find the estimate of α_1 to be highly significant, indicating that the hurdle rent adjusted office stock gap, $G–X^*$, has a significant influence on the new construction. About 24% of the adjusted gap is closed by new construction each six months. In column II, we fix the long-run elasticity θ at 0.7 and examine the determinants of the hurdle rent X^* over the sample period of 1984S1-2005S2. The determinants are generally highly significant and have the expected sign. The volatility, measured by $(\sigma 1_{t-6} + \sigma 2_{t-7})/2$, has a very significant positive effect on X^*. Real interest rate increases X^* (β_2>0). As the real option model predicts, we find that the real interest rate effect on X^* decreases when the volatility is greater. We find that the growth rate g reduces X^*, as expected under uncertainty when π, the elasticity of substitution between capital and land, is low. To examine whether the effect of g may be affected by π and the volatility, we interact g with two dummy variables, one selects the earlier part of our sample period (1984S1-1990S2) and other selects the

[10] Beta on a company level is stable if the company remains in the same industry but could alter as a result of changes in technology, market or capital structure. Our analysis focuses on the beta of a broad industry, i.e. a portfolio of companies, which diversifies the impact of changes in beta on the company level.

Table 2.3 ■ Office construction response to equilibrium gap

This Table reports the coefficient estimates of the response in office construction to the equilibrium gap in office stock G and the hurdle rent X^*. The dependent variable is $\Delta_t \ln(OS) \equiv \ln(OS_t / OS_{t-1})$. The regression equation is $\Delta_t \ln(OS) = \alpha_1[G-X^*]+\alpha_2 \cdot \Delta_{t-1} \ln(OS)+\varepsilon_t$. *Panel a* reports the estimates for Singapore, where $G=\theta \ln(OE_{t-5})-\ln(OS_{t-1})$, with t being a semi-annual period, and $X^* = \beta_1 \cdot(\sigma 1_{t-6} + \sigma 2_{t-7})/2 + \beta_2 \cdot r_{t-7} + \beta_3 \cdot(r_{t-7} \cdot \sigma 2^2_{t-7} \cdot 100) + \beta_4 \cdot g_{t-7} + \beta_5 \cdot g_{t-7} \cdot(\text{Year}<1991) + \beta_6 \cdot g_{t-7} \cdot(\sigma 2^2_{t-7} >= 0.0165) + \beta_7 \cdot \lambda_{t-6} + \beta_8 \cdot \lambda_{n,t-7} + \alpha_2 \cdot \Delta_{t-1} \ln(OS) + C$. Column I shows the regression for sample period 1984S1 to 2002S2. Column II and III show the results for periods 1984S1 to 2005S2 and 1984S1 to 2006S2, respectively, with the value of θ fixed at 0.7. *Panel b* reports the estimates for Hong Kong, where $G=\theta \ln(OE_{t-3})-\ln(OS_{t-1})$, with t being an annual period, and $X^* = \beta_1 \cdot(\sigma 1^2_{t-4} + \sigma 2^2_{t-5})/2 + \beta_2 \cdot r_{t-4} + \beta_4 \cdot g_{t-5} + \beta_6 \cdot(g_{t-5} \cdot \sigma 2^2_{t-7} \cdot 100) + \beta_7 \cdot \lambda_{t-4} + \beta_8 \cdot \lambda_{n,t-5} + C$. The sample period for both Column I and II are from 1984 to 2007, with the value of θ fixed at 0.75 in Column II. t-statistics are in parentheses and are based on Newey-West HAC Standard Errors & Covariance (lag truncation=3 for Singapore and 2 for Hong Kong). *** denote statistical significance at 1% level, ** at 5% level, and * at 10% level.

Panel a	I	II	III	*Panel b*	I	II
α_1	0.240 ***	0.238 ***	0.199 ***	α_1	0.293 ***	0.277 ***
	(5.5)	(7.6)	(4.5)		(3.4)	(5.7)
θ	0.693 ***	0.7	0.7	θ	0.762 ***	0.75
	(16.7)				(12.9)	
β_1	1.162 ***	1.232 ***	1.411 ***	β_1	2.533	2.916 ***
	(4.0)	(7.0)	(5.1)		(1.1)	(3.1)
β_2	4.138 ***	4.119 ***	3.924 ***	β_2	0.537	0.603 **
	(6.3)	(12.7)	(7.5)		(1.2)	(2.1)
β_3	-0.289 ***	-0.317 ***	-0.342 ***			
	(4.0)	(6.4)	(4.3)			
β_4	-0.193 *	-0.186 **	-0.222 **	β_4	0.782	0.878 **
	(1.9)	(2.4)	(2.2)		(1.2)	(2.7)
β_5	0.360	0.649 **	0.606 **			
	(1.5)	(2.7)	(2.1)			
β_6	-0.303	-0.612 **	-0.558 *	β_6	-0.291	-0.320 ***
	(1.2)	(2.4)	(1.8)		(1.6)	(3.4)
β_7	0.648 **	0.772 ***	1.160 ***	β_7	1.112	1.232 **
	(2.1)	(3.1)	(2.7)		(1.2)	(2.5)
β_8	-0.233 ***	-0.284 ***	-0.315 ***	β_8	-0.329	-0.360 *
	(2.8)	(3.8)	(3.2)		(1.1)	(1.8)
α_2	0.209	0.349 **	0.358 **			
	(1.4)	(2.7)	(2.5)			
C	2.079 ***	2.031 ***	1.708 ***	C	1.857 ***	1.804 ***
	(6.7)	(7.7)	(4.6)		(5.0)	(5.9)
R^2	0.67	0.64	0.58	R^2	0.82	0.82
D.W.	2.30	2.14	1.90	D.W.	1.96	1.96
N	38	44	46	N	24	24

periods when the volatility is greater than the median value. We find that the effect of g is more positive in the earlier period, possibly because the elasticity π is higher in the earlier period as the office density in CBD would be much lower then (hence the possibility of building at a higher floor-to-area ratio when the demand increases further). As expected, the negative effect of g on X^* is much stronger during periods of relatively higher volatility. This result is consistent with the findings in Capozza and Li (2001). Finally, we find that the current risk premium λ increases X^* and hence slows new construction but an expected increase in λ in the future (a positive risk-premium news λ_n>0) lowers current X^*. In column III, we extend the sample period to include the last year in our sample, 2006, when the office market was very tight. The results remain unchanged but the R squared and the t-statistics are generally smaller.

Panel a in Figure 2.1 shows the trends in the equilibrium gap in office stock G and in the volatility $\sigma 1_{t-6} + \sigma 2_{t-7}$ and the real interest rate in Singapore. The decreasing G from the early 1980s to the early 1990s appears consistent with the generally decreasing market volatility and the real interest rate during the period. The gap was rising in the late 1990s and early 2000s, reflecting the increased volatility during the period as the economy was affected by several shocks, including the Asian Financial Crisis of 1997-1998, the dotcom bubble burst, and the 2002-2003 SARS epidemic.

Figure 2.1 ■ Trends in the equilibrium gap in office stock G, volatility, and real interest rate

This Figure shows time trends in volatility, the real interest rates; both on the left hand axis (lhs), and the equilibrium gap G in office stock on the right hand side axis (rhs). *Panel a* shows the figure for Singapore on a semi-annual basis over the period 1982S1-2006S2. Here we calculate the equilibrium gap in office stock G as $0.7 \cdot \ln(OE_{t+1}) - \ln(OS_{t+5})$. *Panel b* shows time trends for Hong Kong on annual basis over the period 1982-2006, where $G = 0.75 \cdot \ln(OE_{t+1}) - \ln(OS_{t+3})$. The lead period for G is chosen according to the construction lag.

Panel a

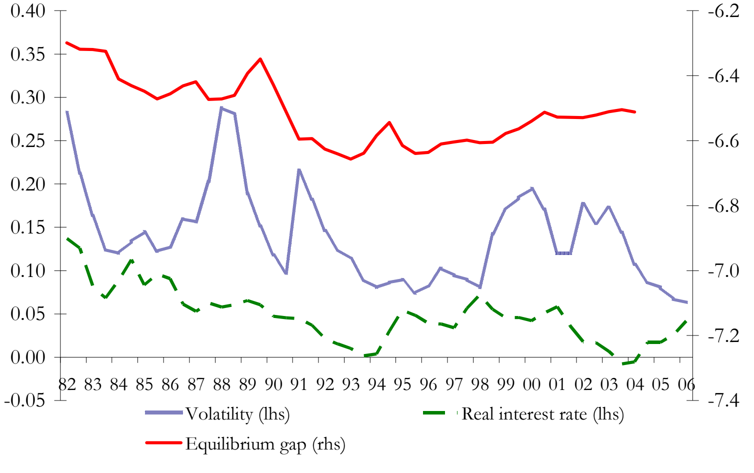
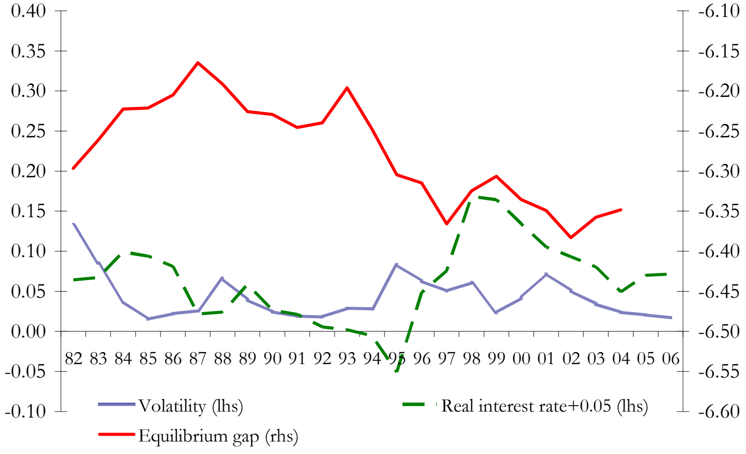


Figure 2.1 ■ Trends in the equilibrium gap in office stock G, volatility, and real interest rate (continued)

Panel b

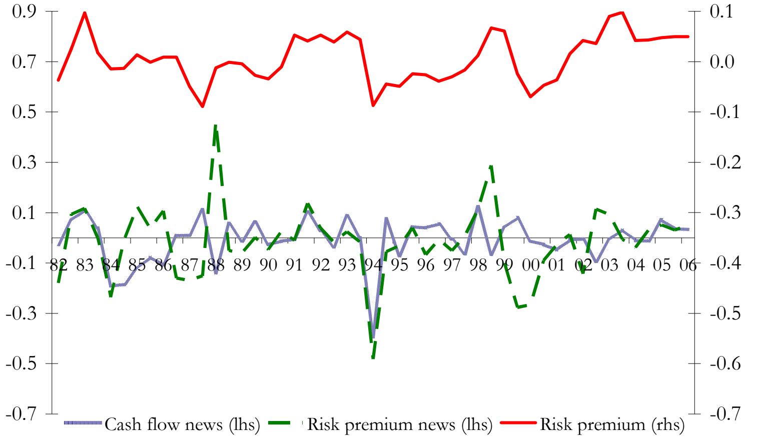


The estimates for *Eq*. (2.6) for Hong Kong are shown in *Panel b* of Table 2.3. They are similar to those for Singapore, except that, with much fewer observations at the annual frequency, we cannot include as many variables on the right-hand side of the equation. In column I, we have a θ estimate of 0.76. The higher elasticity of office stock with respect to office employment growth in Hong Kong may be due to a more restrictive definition of the office employment used in Hong Kong or due to less intensive space-use technology. In column II, we fix θ at 0.75 and examine the determinants of the hurdle rent X^*. We find the volatility and the real interest rate to increase the hurdle rent, as expected. We find a positive effect of the income growth g on X^*, perhaps reflecting a higher π in Hong Kong due to the generally more generous plot ratio limits for commercial buildings in Hong Kong. Again, as predicted by the real option theories, we find the effect of g on X^* to be more negative when the volatility is greater. We find the current risk premium λ to increase X^* but the expectation for higher future risk premium λ_n to decrease X^*, although the latter effect is only marginally significant. *Panel a* in Figure 2.2 shows the trends in risk premium, cash flow news and risk premium news in Singapore. *Panel b* in Figures 2.1 and 2.2 show the trends in the office employment to office stock gap, market volatility, real interest rates, risk premium and the news variables in Hong Kong.

Figure 2.2 ■ Trends in cash flow news, risk premium news and risk premium

Panel a shows cash flow news and risk premium news on the left hand side axis (lhs) and the market risk premium on the right axis (rhs) for Singapore over the period 1982S1-2006S2. *Panel b* shows the same information for Hong Kong on an annual basis.

Panel a



Panel b

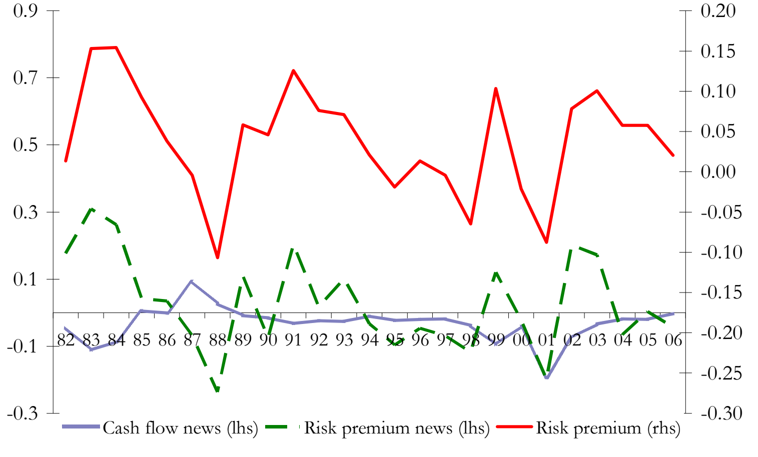


Table 2.4 ■ Estimates of long-run office rent and the equilibrium gap in office stock

This Table reports the regression estimates of the long-run trend in office rent. The dependent variable is $\ln(RI_t)$, where *RI* is the real office rent index for central area private office in Singapore and grade A private office in Hong Kong. The regression equation is $\ln(RI_t) = c_0 + c_1 \cdot \ln(OE_t) + c_2 \cdot (\theta \cdot \ln(OE_t) - \ln(OS_{t-1})) + c_3 \cdot (Vacancy\ rate_{t-1}) + c_4 \cdot AR(1) + \varepsilon_t$, where θ has a fixed value of 0.7 for Singapore and 0.75 for Hong Kong. The sample periods are 1987S2-2006S2 and 1981-2006, respectively, for Singapore and Hong Kong. *t*-statistics are in parentheses and are based on Newey-West HAC Standard Errors & Covariance (lag truncation=3 for Singapore and 2 for Hong Kong). *** denote statistical significance at 1% level, ** at 5% level, and * at 10% level.

	Singapore	Hong Kong
c_0	5.554 *	6.461 ***
	(1.8)	(7.2)
c_1	0.050	0.274 *
	(0.3)	(2.1)
c_2	0.860 **	1.556 ***
	(2.1)	(5.4)
c_3	-2.034 ***	-3.005 ***
	(2.9)	(2.8)
c_4	0.849 ***	0.292 **
	(13.4)	(2.4)
R^2	0.91	0.86
D.W.	1.35	1.90
N	39	26

We double check the long-run equilibrium relationship between the office employment and the office stock by examining the covariation between the gap $G' = \theta \cdot \ln(OE_t) - \ln(OS_{t-1})$ and the real office rent index (we assume that the rental demand in period t-1 reflects the office employment in period t). We regress the log of real rental index *RI* on log of office employment, G', and vacancy rate vr:

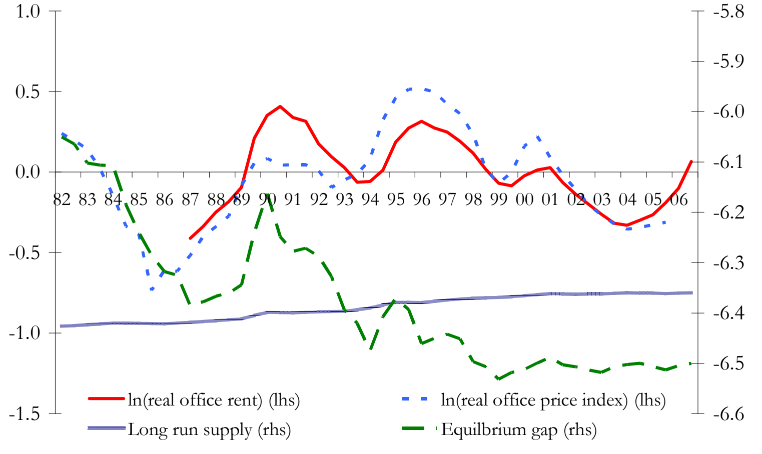
$$\ln(RI_t) = c_0 + c_1 \cdot \ln(OE_t) + c_2 \cdot (\theta \cdot \ln(OE_t) - \ln(OS_{t-1})) + c_3 \cdot vr_{t-1} + \xi_t \quad (2.7)$$

where the residual error ξ_t may follow a first-order autoregressive process. Coefficient c_1 reflects the long-run elasticity of office supply (a higher elasticity results in a lower c_1), c_2 reflects the office market cycles due to the lags in the supply adjustment to demand shocks, and c_3 reflects the delay in rental adjustment to clear the space market. We expect c_1 to be positive due imperfectly elastic long-run supply of office space, c_2 to be positive as rent moves pro-cyclically to demand shocks, and c_3 negative for rent adjusts to clear the market (where vr converges to the normal

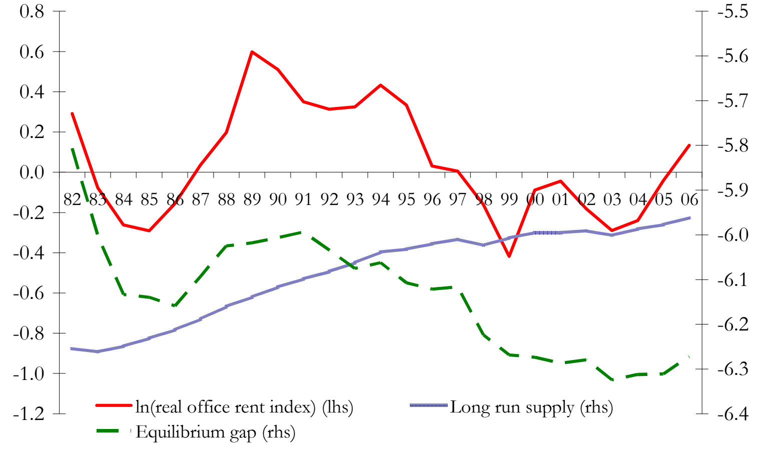
Figure 2.3 ■ Office rent (price), long-run office supply (LS), and the equilibrium gap in office stock (G)

Panel a shows ln(real office rent) = log(rent index/CPI), and ln(real office price index) = log(office price index/CPI), on the left hand axis (lhs) and long run supply = 0.05·log(FIRE employment·1000)-7 and the equilibrium gap = 0.7·ln(FIRE employment·1000)-ln(office space $_{t-1}$) on the right axis (rhs) for Singapore over the period 1982S1-2006S2. *Panel b* shows the same information for Hong Kong on an annual basis where long run supply equals 0.27·ln(FIRE employment)-9.5 and the equilibrium gap 0.75·ln(FIRE employment)-ln (office space $_{t-1}$).

Panel a



Panel b



vacancy rate). Table 2.4 reports the estimates of *Eq.* (2.7). We find c_2 and c_3 to be significant with expected signs in both office markets. We find c_1 much smaller in Singapore than in Hong Kong; the land supply for commercial office development is arguably more restrictive in Hong Kong than in Singapore. The estimates of c_2 appear comparable on the annual basis between the two markets. The residual error is more persistent in Singapore on a semi-annual basis than in Hong Kong on an annual basis, as expected. Overall, the θ values for Singapore and Hong Kong appear to be a good characterization of the long-run equilibrium relationship between the office stock and the FIRE office employment in these two markets. Figure 2.3 shows the office market cycles and trends in the two cities.

2.5 Conclusions

We have shown that the real option theories of land conversion (Capozza and Li 1994 and 2002) are well capable at predicting the new office construction observed in the two leading Asian business and financial centers, namely Singapore and Hong Kong. We show that investors respond not only to the gap in the office stock relative to its equilibrium level but also to the changes in the hurdle rent over time due to changes in the market volatility, real interest rates, and the expectations about future office demand growth. The most interesting finding is that the volatility not only directly raises the hurdle rent and hence delays new construction but also influences how investment decisions respond to the real interest rate and the growth expectations. We find that the effect of the interest rate and the growth expectation on the hurdle rent become more negative when the volatility is greater, as predicted by the real option models. Few extant empirical studies examine how the effect of the real interest rate and the growth expectation interact with the demand uncertainty. The two city states, Singapore and Hong Kong, offer observations that allow us to examine these important implications of the real option model for real estate investment. Both cities experienced strong growth in the office space demand and significant fluctuations both in demand growth and in real interest rate. Moreover, the availability of the local stock market indexes enables us to construct a more reliable forward-looking measure of the expected demand growth, which is crucial for testing the implications of the real option model.

Our findings have important policy implications. Kling and McCue (1987) find that the decline in interest rates explains the overbuilding in U.S. office markets in the early 1980s. Our findings show that monetary policies designed to cool down real estate investment (by raising real interest rates) could be ineffective and may even produce opposite effects when the demand volatility is high. Furthermore, strong demand growth needs not necessarily accelerate new construction; we find that investors in Hong Kong and Singapore often delayed the new construction when the expectation about the future demand growth rose, consistent with the prediction of the real option model when capital and land are substitutes. Capping the plot ratio could be one way to discourage the delay in new construction when the expected demand growth is strong. Our findings also suggest a useful direction to extend the real option models of irreversible investment. Extant real option models generally assume a constant risk premium. We show that anticipated changes in the risk premium can influence the timing of irreversible investments. In particular, our finding suggests that the current hurdle rent decreases when the future risk premium is expected to increase, a result yet to be corroborated by analytical modeling.

2.6 Appendix I ■ The background of the two office markets

Singapore and Hong Kong are two leading international business and finance centers in Asia. In 2004, 61% of the world's 100 top banks we present in Singapore while this figure was 63% for Hong Kong. Singapore is ranked 4th in global foreign exchange and OTC derivatives trading in 2004 and Hong Kong 7th. In 2005, Hong Kong has the 2nd largest stock market capitalization in Asia; Singapore is the 8th. At the end of 2006, Hong Kong has close to 10 million square meters of private office space; Singapore has over 5 million square meters.

Both city states lack natural resources within their small, densely populated geographic areas. They share a common beginning as British trading ports in South-East Asia in the 19th century. Both Singapore and Hong Kong underwent considerable economic growth between 1980 and 2005. During this period the population size increased by 80% in Singapore and 35% in Hong Kong, whereas real GDP increased by 560% and 270% respectively. Both economies have been transformed from a manufacturing export base to important international business service centers since the 1980s. Office employment and the total office market size quadrupled over the period in both cities. Despite the strong growth in the economy and the demand for office space, both economies went through major episodes of volatility during our study period, including the handover of Hong Kong to China by the British government in 1997, the Asia financial crisis in 1997-1998, and the SARS epidemic during 2002-2003. These periods of high volatility provide opportunities for testing the influence of real options on office construction.

Both city states earned their economic success by pursuing free trade and free market policies and rank in the top three economies in terms of global competitiveness. Both governments play a strong role in the supply of new developable land in their cities.[11] New sites for commercial development are typically granted to private developers under long-term leasehold with specific land-use conditions such as the mix of use and maximum plot ratio. Building construction is required to commence within a certain period of time (typically a few years) upon the grant of the lease. Existing sites can be redeveloped upon successful application for modification of lease conditions. The commercial property development is largely market driven and land supply policies are generally guided by the objective of accommodating market demand. Land supply is generally constrained by the

[11] Ching and Fu (2003) discuss the land market institutions in Hong Kong.

infrastructure projects and, in the case of Hong Kong, by the Sino-British agreement in effect between 1984 and 1997.

2.7 Appendix II ■ Stock-market based forward-looking variables

Investors' expectations about future economic conditions are often capitalized in asset prices. The asset market where prices are most informative of the current economic news is perhaps the stock market. In this chapter we make use of the stock prices to back out the market expectations. In particular, we employ the log-linear present-value equation proposed by Campbell and Shiller (1988a,b) to decompose innovations in market excess returns into news about future cash-flow growth, future risk premium (expected excess returns), and future money market rates.

Let z_{t+1} denote the log return of the stock market between time t and t+1 in excess of the money market rate m_{t+1}; d_{t+1} the growth in cash flow between t and t+1; ρ<1 the long-run discount factor; and E_t expectation conditional on the information available at time t. An innovation is defined as the change in the expectation between time t and t+1 upon the new information arriving at t+1. Thus the innovation in the excess return z_{t+1} is defined as $v_{t+1} \equiv (E_{t+1} - E_t)z_{t+1} = z_{t+1} - E_t z_{t+1}$, i.e. the realized excess return at t+1 minus its expected value based on information available at time t. Following Campbell (1991), the decomposition of v_{t+1} can be expressed as:

$$\begin{aligned} v_{t+1} &= (E_{t+1} - E_t)\left\{\sum_{j=0}^{\infty} \rho^j d_{t+1+j} - \sum_{j=1}^{\infty} \rho^j z_{t+1+j} - \sum_{j=0}^{\infty} \rho^j m_{t+1+j}\right\} \\ &\equiv \eta_{d,t+1} - \eta_{z,t+1} - \eta_{m,t+1} \end{aligned} \tag{2.8}$$

where η_d, η_z, and η_m represent each of the summation in the first line of Equation (2.8) and denote respectively the cash-flow growth news, the risk-premium news, and the money-market-rate news. We use the term "news" to refer to changes in expectations due to new information. *Eq.* (2.8) states that a positive innovation in the excess return, v_{t+1}, must reflect at least one of the following events: an increased expectation about future cash flow growth, a reduced expectation about future risk premium (expected excess return), or a reduced expectation about future money market rate.

The market news η_d, η_z, and η_m can be estimated using a VAR model based on the stock market excess return z_t, log dividend yield y_t, and the money market rate m_t. Let vector $\mathbf{w}_t \equiv [z_t, y_t, m_t]'$. The VAR model can be written (assuming $\mathbf{w}$ is demeaned) as

$$\mathbf{w}_{t+1} = \mathbf{A} \cdot \mathbf{w}_t + \boldsymbol{\mu}_{t+1}, \tag{2.9}$$

where $\boldsymbol{\mu}_{t+1}$ is a vector of residuals. The estimates of the VAR coefficients **A** for Singapore and Hong Kong are summarized in Table 2.5.

Table 2.5 ■ Estimates of VAR coefficients

This Table shows the estimates of different VAR coefficients where z_t is quarterly stock market excess return, y_t is log quarterly dividend yield, and m_t is quarterly money market rate. *Panel a* shows the results for Singapore and *Panel b* the results for Hong Kong. *** denote statistical significance at 1% level, ** at 5% level, and * at 10% level.

	Dependent variable	z_t	y_t	m_t	R^2	Mean	St Dev
Panel a							
	z_{t+1}	0.042	0.189 ***	-2.187	0.125	0.006	0.137
		(0.4)	(3.3)	(1.5)			
	y_{t+1}	-0.077	0.759 ***	1.656	0.591	-3.754	0.23
		(0.7)	(11.0)	(1.0)			
	m_{t+1}	0.005 ***	-0.002 **	0.961 ***	0.926	0.016	0.009
		(2.7)	(2.2)	(35.2)			
Panel b							
	z_{t+1}	-0.122	0.202 ***	-3.983 **	0.150	0.025	0.163
		(1.3)	(3.5)	(2.2)			
	y_{t+1}	0.077	0.788 ***	3.532 *	0.676	-3.352	0.279
		(0.8)	(13.0)	(1.9)			
	m_{t+1}	0.008 ***	0.001	0.866 ***	0.780	0.016	0.009
		(3.1)	(0.6)	(18.1)			

Let **e**1 be an index vector such that $\mathbf{e}1'\cdot\mathbf{w}_t = z_t$. Similarly, **e**3 is an index vector such that $\mathbf{e}3'\cdot\mathbf{w}_t = r_t$. Campbell and Shiller (1988a,b) show that, by the recursive property of the VAR equation, the news components can be computed as:

$$\begin{aligned} \eta_{z,t+1} &= \mathbf{e}1'(1-\rho\mathbf{A})^{-1}\mathbf{A}\cdot\boldsymbol{\mu}_{t+1}, \\ \eta_{m,t+1} &= \mathbf{e}3'(1-\rho\mathbf{A})^{-1}\boldsymbol{\mu}_{t+1}, \\ \eta_{d,t+1} &= v_{t+1} + \eta_{z,t+1} + \eta_{m,t+1}, \end{aligned} \tag{2.10}$$

where $v_{t+1} = \mathbf{e}1'\cdot\boldsymbol{\mu}_{t+1}$. We calculate the news components with $\rho = 0.99$. For Singapore, $\eta_{z,t+1}= [-0.090, 0.815, -13.57]\cdot\boldsymbol{\mu}_{t+1}$, $\eta_{m,t+1}= [0.080, -0.075, 14.57]\cdot\boldsymbol{\mu}_{t+1}$; for Hong Kong, $\eta_{z,t+1}= [-0.091, 0.814, -5.47]\cdot\boldsymbol{\mu}_{t+1}$, $\eta_{m,t+1}= [0.056, 0.079, 7.42]\cdot\boldsymbol{\mu}_{t+1}$. Fu and Ng (2001) apply this methodology to computing the news components for both the property markets and the stock market in Hong Kong. They find positive correlation in the market news between the property markets and the stock market; however, the price adjustment to the news in the property markets is much slower than in the stock market.

We measure the volatility using a GARCH model of the variance in stock return innovations v_{t+1}^2. For Singapore v_{t+1}^2 is weakly serially correlated and a GARCH(1,1) model is fitted based on quarterly v_{t+1}^2. For Hong Kong, v_{t+1}^2 is not serially correlated and a GARCH(1,1) is fitted based on $(v_{t+1}-0.057\cdot v_t)^2$ with a threshold order of 1 to allow for asymmetric effect of the market shocks on the persistent volatility. As the sample statistics in Table 2.2 show, the average values of the volatility measure are remarkably similar in the two cities.

Chapter 3
The effect of clustering on office rents:
Evidence from the Amsterdam market[12]

3.1 Introduction

Utility maximizing behavior, within the boundaries set by availability and public institutions, drives entity settlement choices. The set and importance of utility maximizing variables differs between companies and across industries and depends on in- and output variables. The classical theory of office location (Heilbrun, 1987, pp. 118) states that office rents are based on face-to-face contact possibilities which are a decreasing function of distance to the Central Business District (CBD). This implies that, given the reliance of office firms on support services, proximity of other office buildings has a stimulating effect on office prices. This positive effect of face-to-face contact possibilities, which has been regarded as the most important centralizing force in post-industrial metropolitan regions, is embedded in office literature (see for example O'Hara, 1977, Clapp, 1980 and Bollinger, Ihlanfeldt and Bowes, 1998). Despite ongoing advances in information technology, face to face contact is still an important factor in office rent determination (Bollinger et al., 1998).

It is reasonable to assume that additional binding forces are at work in modern office markets. Research by Archer and Smith (2003) shows that geographical clustering is the result of industry economies of scale. The vicinity of additional office structures creates efficiency gains in the production of services and amenities demanded by offices as the number of office units increases, the so-called *demand*

[12] This chapter is based on Jennen and Brounen (forthcoming in Real Estate Economics, 2008). We would like to thank Chris Redfearn, Marno Verbeek and Kees Koedijk for valuable comments on earlier versions of this chapter and DTZ Zadelhoff, NVM and the Dutch Land Registry for data support. Furthermore we thank conference participants at the ERES annual meeting 2006 and the AREUEA international meeting 2006. We thank the editor Edward Coulson and two anonymous referees for suggestions that greatly improved our paper.

economies of scale. Furthermore, it is reasoned that being part of favorable recognized clusters adds value for offices as the tenants are occupying what is perceived as the "right address", effects which are commonly referred to as *presentation* or *image effects*. In this study we test for the presence of positive externalities in office clusters by examining the relation between office market density and rent rates in the Greater Amsterdam office market. Apart from occupying the "right address", firms can benefit from a dense office location through improved efficiency. An important notion that has to be taken into account is the separation between so called Marshall-Arrow-Romer externalities, also referred to as localization, and Jacobs (1969) externalities, which are also known as urbanization. Localization typically refers to clusters. A cluster is a critical mass of companies in a particular industry in a particular location (Porter, 1998). This location can be a country, state, a city or even, as in this study, a small part of a city. Typical benefits of clusters according to Krugman (1991) are the pooled market for specialized workers, limiting the risk of unemployment on the household level and labor shortage on the firm level, the production of nontradable specialized inputs and an improved production function for firms in localized industries. Urbanization externalities arise from transfers between industries (Abdel-Rahman and Anas, 2004) and relate to urban concentration that applies to all firms and industries in a single location (Malmberg, Malmberg and Lundequist, 2000). In the literature both types of externalities have been positively linked to productivity. We will try to separate both types of externalities in our analysis, and focus on the Marshall-Arrow-Romer externalities.

This study extends the existing literature by testing the rent effects of office clusters empirically outside the United States. We employ a unique longitudinal dataset that covers the Greater Amsterdam office market for the periods 2000-2001 and 2004-2005. This timeframe features a change from economic boom to recession and allows a test of implicit prices of contract and building characteristics during two very different office market stages. Using Geographic Information System (GIS) methodology we are able to control for location quality and define the density of office clusters over the geographic plane in novel ways. We control for differences in location quality by estimating the distance of each office building in our dataset to the nearest of 17 train stations in the Greater Amsterdam region and to the nearest of over 30 highway exits and approaches in the region.[13] A further control for location differences is the division of the study area in submarkets. Through the use of these carefully defined submarkets we pick up structural price differences between nine different submarkets. Finally, our study is first to test the rent effects of office clusters

[13] If location was the sole driving force for clustering then office rents would be explained by the distance from critical points such as the nearest train station and highway exit or approach. In this case we would expect no additional significant relationship between cluster size and office rents.

during changing office market conditions. We show that office market density has a significant and positive effect on office rent irrespective of the phase of the economy and that this result is not driven by the choice of clustering methodology.

The remainder of the chapter is organized as follows. Section 3.2 provides a brief review of office studies in the context of modern urban theory. Next we discuss part of the history and contemporary market conditions of the Greater Amsterdam office market in section 3.3. The subsequent sections discuss the data and the hedonic and GIS methodologies used in this study. Next, we provide hypotheses regarding the expected outcome of the analysis and the regression results. Along with the results we also test whether localization or urbanization effects dominate our findings by examining population, FIRE- and total employment in the Greater Amsterdam region. Finally, robustness checks exclude the effect of subjective area parameters before we round up with our main conclusions in section 3.8.

3.2 Suburban Office Literature

Urban form has been subject of numerous studies over several decades.[14] The most basic urban form is the monocentric city with decreasing land values as the distance from the dominant CBD increases.[15] Although this basic urban form can be found to a certain extent in cities like New York, Mexico City and Hong Kong, most modern cities show little resemblance with the monocentric city layout. The majority of cities combines a dominant center with urban sub-centers in which the bulk of employment is located.

The role that main and secondary centers play within contemporary residential land and property markets has been addressed by a series of both theoretical and empirical papers, suggesting these centers matter and that differential access to these centers gives rise to distinct profiles of residential densities, land and property markets.[16] Research on the role of secondary centers within commercial land and property markets is, however, more frequently based on theoretical than empirical work. In fact, Sivitanidou (1996) was one of the first to empirically test whether commercial firms value access to secondary employment centers by the use of a hedonic analysis on polycentric Los Angeles. Her results show that differential access

[14] See Mills (2004) for a discussion and further references.
[15] Notions on monocentric city forms were introduced nearly 40 years ago by Alonso (1964), Muth (1969) and Mills (1967) and have evolved into the Alonso-Muth-Mills model of land prices.
[16] See for example Gordon, Richardson, and Wong (1986), Heikkila et al. (1989), Helsey and Sullivan (1991), and McDonald and McMillen (1990).

to secondary centers of service employment generates nontrivial land market effects, thereby suggesting that commercial hedonic studies explicitly consider secondary center accessibility. In addition to validating the critical role that center access plays in the commercial land market, Sivitanidou (1996) finds evidence that suggests that other location amenities, such as neighborhood quality, also exert strong effects. This conclusion supports earlier analyses of Archer (1981), which suggests that worker amenities have largely been responsible for the suburbanization of white collar labor which, in turn, has driven office-commercial firms to the suburbs. Later work by Bollinger, Ihlanfeldt and Bowes (1998) finds very similar results when analyzing the spatial variation of office rents in the Atlanta region for the period 1990-96. The most recent contribution in this line of empirical evidence on suburban office patterns is offered by Archer and Smith (2003) who introduce industry economies of scale for "Class A" offices in Houston, Texas. The industry economies of scale models presented imply the patterns of variegated clustering that are observed and suggest a sequence of clusters, increasing in size and distance from the CBD.

The only known study which employs a continuous scale clustering approach similar to the one proposed in our study, although not based on GIS programs, is Clapp (1980), who finds a positive coefficient for the density measure by calculating the office stock in a two block radius surrounding offices for lease in the Los Angeles office market. Archer and Smith (2003) use visual grouping to test for the influence of cluster size on quoted rental rates for Houston area office buildings. They find a positive and significant influence of cluster size on office rental rates but employ stationary cluster size for visually identified office clusters. Wheaton (1984) finds a positive coefficient for a variable which uses a ratio of complex size to building size. While this variable is related to possibility for face to face contact and positive externalities, it fails to take into account the size of offices in close proximity not being part of the particular complex. Slade (2000) incorporates a number of buildings in a complex variable in his study of the Phoenix metropolitan area. This study does not take into account the size of the buildings within the complex and the size of office buildings in the area which are not part of the particular complex. Slade (2000) finds a negative coefficient for the number of buildings variable and hypothesises that this result is due to the characteristics of the complexes predominantly present in the dataset. Gat (1998), in a study of the Tel-Aviv office market, models the opportunity for face to face contact by including a variable for density of service employment within the district surrounding an office building and finds positive coefficients. To our knowledge we are the first study to apply GIS methodology to calculate office market density.

3.3 Sample Area: Greater Amsterdam

While Amsterdam was little more than a street along a dike in the thirteenth century it grew to become a metropolis and the capital of the Netherlands in the seventeenth century as world wide trade activity brought prosperity to the city. Because of this history Amsterdam has always been the trade center of the Netherlands and as such, the prime office location of the country. Nowadays, Amsterdam is still by far the largest office market with an estimated free-market size of 5.8 million square meters, or approximately 62.4 million square feet. Whereas the second and third office markets of the country are Rotterdam and The Hague with estimated sizes of 2.3 and 2.0 million square meters (or 24.7 and 21.5 million square feet) respectively. According to research based on figures published by the National Bureau of Statistics (CBS) in 2006 commercial and financial services play an important role in the Amsterdam economy. The weight of office occupying commercial and financial services in Amsterdam was 34% with a national average of only 21%.

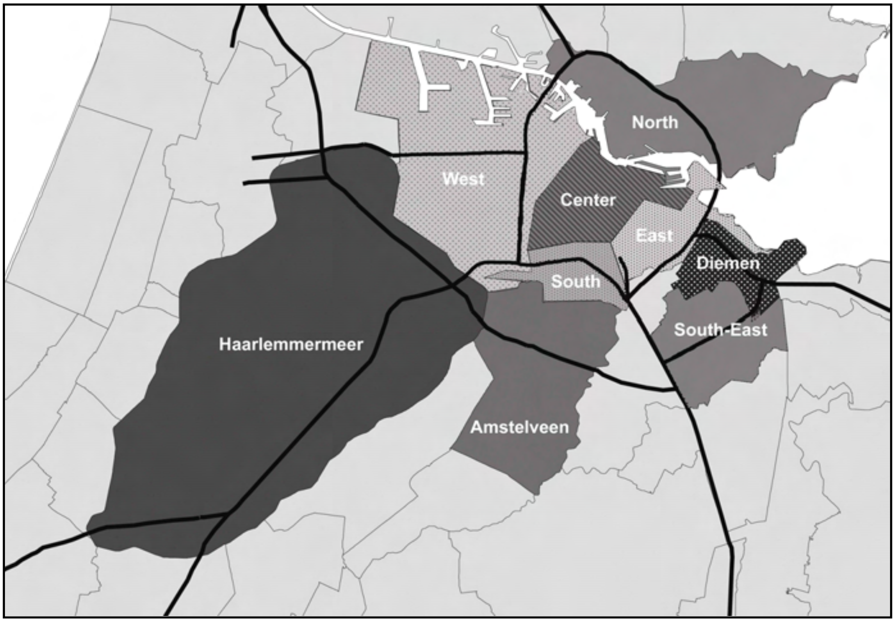
For a long time the area surrounding the crescent channels in the center of the city operated as the CBD but over the course of time traffic congestion, constructions laws and lack of space called for the creation of office submarkets outside the CBD. Figure 3.1 shows the shape of Greater Amsterdam, consisting of the municipalities Amsterdam, Amstelveen, Diemen and Haarlemmermeer.

Given the size of the municipality of Amsterdam and the broad range of office submarkets it houses we further divide this municipality into six submarkets as indicated in Figure 3.1. The methodology for this subdivision is based on Dunse and Jones (2002) who, after analysis of different *a-priori* and statistical methods, found the real estate agents' view to be the best method for market segmentation.

Typically, office construction reacts with a lag to economic expansion and Amsterdam was no exception to this trend as office construction started to take off in 1997 and continued until 2002 when the economy had turned from a boom to a recession. Building completions reacted with an even longer lag to changes in economic circumstances. Fuelled by changes in demand and new construction, vacancy levels decreased during the period 1994 until 2000 before commencing a sharp increase during the first years of the new millennium. In the remainder of this study we focus our analysis on the economic boom of the years 2000-2001 and the slump of 2004-2005. This separation enables us to test whether markets value specific characteristic differently during distinctive market circumstances.

Figure 3.1 ■ Map of Greater Amsterdam

This map provides an overview of the sub-centers of Amsterdam (Center, West, South, North, East and South-East) and surrounding municipalities (Haarlemmermeer, Amstelveen and Diemen) which form the study area. Highways are indicated by the black lines while the white areas show water surfaces. Non-indicated gray surfaces are mostly residential municipalities.



3.4 Data and Methodology

The dependent variables in this study are 1465 asking rents for offices in Greater Amsterdam originating from databases compiled by the international real estate agent DTZ and the Dutch Realtor Association (NVM). These asking rents are set by professional agents with extensive knowledge of the local office market. Asking rents are the predominant dependent variable of hedonic regression models in existing studies, but whether to use asking rent or transaction rent as the dependent variable is still open for debate. Dunse and Jones (1998) provide two explanations for the use of asking rents in their analyses. The first explanation is the proprietary nature of office transaction rents which makes analysis based on transaction rents often impossible. The second, more sensible, rationale mentioned is the existence of unknown incentives in quoted transaction rents which distort the analysis of rent levels. In order to test the difference between asking rents and transaction rents we combined the databases containing transaction and, far more numerous, asking rents based on address information and filtered out addresses with a recorded transaction within one year of asking rent publication. The combination resulted in a dataset of 88 transactions which shows an average transaction discount of 9% relative to the asking price and a high correlation between asking rents and coupled transactions of 0.88.[17] Given the high correlation between asking and transaction rents, the much larger size of the asking rent database, and the discussion presented above, we use asking rents as the dependent variable in our analysis. We also ran separate hedonic regressions for the 88 observations for which we have both the asking rent and transaction rent. This test indicates no significant differences when either asking or transaction rents are used as the dependent variable and clearly shows that the results in our study, which are based on transaction rents, are not driven by the definition of rent data.

The first phase of our study covers the years 2000 and 2001, an era of persistent economic growth and low vacancy rates. According to Jones Lang LaSalle, the vacancy rate on the Amsterdam office market was about 2.7% in 2000. As a result the high prevailing occupancy rates, the number of offices for lease was relatively low resulting in a sample of 233 asking rents for the period 2000-2001. Weak economic conditions and fast rising vacancy levels (17.7% in 2004), combined with an increase in office stock of about 13% over the years 2000-2004 result in 1232 asking rents for the period 2004-2005. These two sets of asking rents are in the remainder of this chapter referred to as the rent database. The independent variables with respect to building characteristics are gathered from databases provided by DTZ. Although our building characteristics differ from typical U.S. studies, they fit local office market conditions where buildings tend to be relatively low rise and lack internal amenities such as banks and shops. We base location characteristics on Geo-coded six digit postal code and house number information as provided by the Dutch Realtor Association (NVM) and the Dutch Land Registry and perform calculations with the ESRI ArcGIS and ArcView software packages. The unique characteristics of the Dutch Land Registry database allow for determination of latitude and longitude coordinates situated within the individual buildings, providing an extremely high precision in spatial calculations and pinpointing offices in a geographical setting. We determine clustering information on a database which contains address and size information for all office buildings in the Greater Amsterdam region, from now on referred to as the stock database. Table 3.1 provides an overview of summary

[17] In line with Glascock et al.(1990) we estimated a simple equation to test the relationship between the transaction rents (TRENT) and asking rents (ARENT). The result of the equation is as follows.

$$\text{TRENT} = \underset{(1.29)}{13.5} + \underset{(16.12)}{0.86}\,(\text{ARENT}),\ N=88,\ R^2(\text{adj})=0.76.$$

These results also indicate the high similarity of transaction and asking rents during the study period (t-statistics in parentheses).

statistics for all structural and spatial characteristics used in this study apart from clustering information which is presented in Table 3.2.[18]

Table 3.1 ■ Summary statistics

This Table shows the descriptive statistics for variables included in the regression analysis. *Panel a* shows summary statistics for rent, distance and object size related variables. *Panel b* shows the number of observations per dummy variable included in the analysis. The variable "After 1998/2002" reflects new buildings and covers different periods to take account of our rent database which covers the years 2000/2001 and 2004/2005. The total number of observations is 1465.

Panel a

	Mean	Median	Maximum	Minimum	Std. Dev.
Office rent(€ /m^2)	178	170	545	55	55
Distance to highway (m)	1199	1020	3804	48	866
Distance to trainstation (m)	1449	1049	6287	106	1298
Building size (m^2)	6995	4751	45000	220	6657
Contract size (m^2)	2870	1350	45000	42	4001
Contract / building size ratio	0.482	0.374	1	0.002	0.355

Panel b

	N		N
Pre-1900	48	Diemen	56
1901-1950	83	Amsterdam-East	70
1951-1970	81	Haarlemmermeer	389
1971-1990	636	Amsterdam-North	9
1991-1998/2002	479	Amsterdam-Southeast	249
After 1998/2002	138	Amsterdam-South	88
Amstelveen	119	Amsterdam-West	287
Amsterdam-Center	198	Refurbished	58

Panel a of Table 3.1 shows summary statistics for rent, distance and object size related variables. The office rent per square meters ranges between €55 and €545 with a mean of €178. Given the large number of highway junctions and train stations in the Amsterdam area we find that the maximum distance to the former is less than four kilometres while a train station can be found within 6.3 kilometres from each office building. The last variable in *Panel a* shows the ratio of contract size to building size. A larger ratio implies that the tenant rents a larger part of the overall building. On average the contracts in our database make up approximately half of the total building size. *Panel b* in Table 3.1 shows the number of observations per dummy variable included in the analysis. We observe that buildings from the 1970's till 1990's

[18] The variable "After 1998/2002" reflects new buildings and covers different periods to take account of our rent database which covers the years 2000/2001 and 2004/2005. For all objects in our database this variable reflects building age of less than three years irrespective of the sample period.

contribute the largest number which is a reflection of the rise of a service oriented economy during that period.

To isolate the rent impact of office clustering we apply a hedonic model specification. The general hedonic form is as follows:

$$p = f(X) + u \tag{3.1}$$

in which the price (or rent) p is explained by a vector of characteristics X with regression error term u.

3.5 Determining Continuous Office Density Measures

Following the paper by Archer and Smith (2003) we assume the presence of industry economies of scale and latent "right address" influences in office markets. These externalities contribute to the attractiveness of office clusters and are positively related to the size of office clusters. Where Archer and Smith (2003) make use of visual inspection to determine office clusters we depart from this methodology and employ GIS to determine the density of local office markets. This methodology, while being data and calculation intensive, allows for the creation of a true density measure without relying on possibly subjective approximations and as such provides an opportunity for replication in other geographic areas.

Industry economies of scale based on proximity of other office buildings are expected to decrease as distance to other structures increases. This notion of negative correlation between distance and contribution to density is well reflected in the First Law of Geography by Tobler (1970) which states that "All things are related, but nearby things are more related than distant things" and where distance acts as a deterrent of interaction in distance decay models. According to Fotheringham (1981) a distance decay parameter measures the relationship between observed interaction patterns and distance when all other determinants of interaction are constant. In the context of office density the distance decay incorporates the decreasing contribution of individual offices to density as distance increases. Spatial economic literature provides several possibilities to incorporate the effect of increasing distance on variable weights (see for example Skov-Petersen, 2006). In this chapter we test different methods to estimate office cluster size surrounding offices in the rent database. Cluster size is estimated with sharp threshold measures and several functions of exponential distance decay, which intuitively have a more appealing nature than sharp thresholds. This cluster size information is subsequently used as independent variable in the hedonic regression model. To root out the effect of choices made about the level of distance decay we perform robustness checks for different clustering measures within feasible limits.

According to Skov-Petersen (2006) a sharp threshold measure is to be preferred if no empirical data are available for estimation of parameters for higher order decay functions since they make for easier understanding of the background of the model and the resulting conclusions. For each observation *k* in our rent database we calculate cluster size as the summation of the surface area of the *n* office buildings that are located within the threshold vicinity *d*. In this procedure we use a weight factor *w*, that takes value one as long as the distance between office building *n* and observation *k* is less than threshold *d*, and zero otherwise. For this estimation we apply the following formula:

$$\text{Cluster}_k = \sum_{i=1}^{n} w_{ik}\,\text{size}_i \tag{3.2}$$

where,

$Cluster_k$ =	cluster size measured as the total floor area of office space for observation k
w_{ik} =	the weight of the contribution to density for each office *i* in the stock database to observation *k* in the rent database with, $w_{ik} = 1$ for $d_{ik} \leq$ threshold, $w_{ik} = 0$ for $d_{ik} >$ threshold and,
d_{ik} =	the distance between each office *k* in the rent database and each office *i* in the stock database
$size_i$ =	total floor area of office *i* in the stock database

Besides this simple threshold measure we also examine the effect of exponential distance decay on cluster size and subsequent rent levels. Contrary to the simple threshold methodology, an exponential form distance decay model is capable of incorporating the first law of geography in an intuitive way. Where the sharp threshold measure takes on a zero or one contribution to cluster size, the exponential form uses weights between zero and one depending on distance and the level of distance decay. *Eq.* (3.3) shows the exponential function of distance decay function:

$$\text{Cluster}_k = \sum_{k=1}^{n} \exp(-\lambda * d_{ik})\,\text{size}_i \tag{3.3}$$

where,

$\lambda =$ *the distance decay exponent*

The level of distance decay is influenced by the selection of parameter λ. A higher level of λ implies faster distance decay and therefore steeply decreasing weight with an increase in distance. For example, an office i of 20,000 ft^2 at 300 feet from office k contributes 10,976 ft^2 to cluster size for λ of level 0.002 and 49.6 ft^2 to cluster size for λ equal to 0.02. Previous research (for example Hansen, 1959) indicates that different levels of distance decay exist for different geographical regions and different activities. In line with expectations Hansen (1959) found, for example, that the radius of activity for interaction between home and school is smaller than the radius between home and work. An application of distance decay measures in office-commercial market research is Sivitanidou (1996). She finds for Los Angeles that value gradients flattened between 1989 and 1994. A finding that is attributed to advancements in information technology. Since the aim of this study is to test for presence of rental influence of cluster size and not to calculate the level of different clusters we test for the influence of different levels of λ on regression results.

Table 3.2 presents statistics for different measures of cluster size. Summary statistics are presented in the first half of the Table while correlation coefficients between the different clustering methodologies and parameter settings are presented in the lower panel. We observe positive correlations between the sharp threshold and exponential distance decay methodologies, although correlations become low when considering the extremes of parameter specifications. We compared both cluster definitions and find that the measure of cluster density is not driving our results. To illustrate the influence of the parameter settings for threshold and distance decay measures we repeat our analysis for a wide variety of parameter values at the end of our chapter. Figure 3.2 presents a 3D-illustration of variations in cluster size over the study area, based on a sharp threshold methodology with an area of 0.5 square kilometers based on office stock information for 2004.

Table 3.2 ■ Cluster density statistics

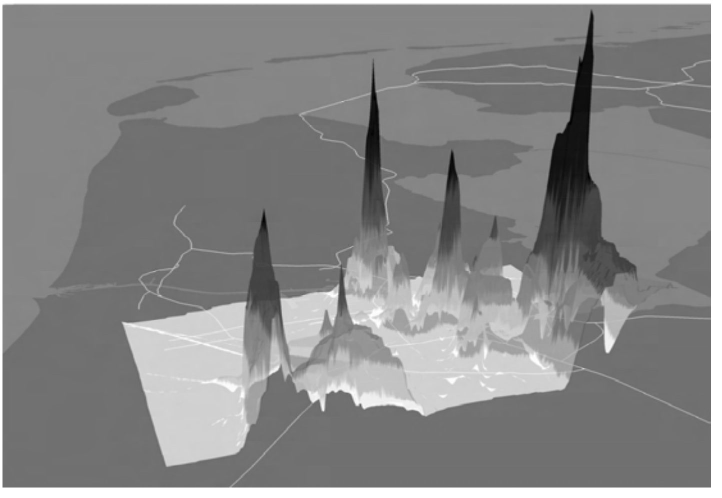
Based on address and size information on all office buildings in the Greater Amsterdam region and our database of vacant office space we calculate the office stock within different area measures. We present the outcomes for three sharp threshold measures and three different levels of exponential distance decay. The sharp threshold measures reflect radii of approximately 1305 ft., 2620 ft. and 5850 ft. respectively. The distance decay measures show summary statistics of cluster sizes based on exponential functions of distance decay with increasing penalties for distance. The lower part of Table 3.2 shows correlation coefficients for the different density measures.

	Area measure			Distance decay measure		
	0.5 km²	2.0 km²	4.0 km²	λ 0.001	λ 0.01	λ 0.1
Mean	106585	240283	338304	284480	18265	1500
Minimum	316	466	466	2284	0.00	0.00
Maximum	391063	770731	934809	603330	87149	56601
Standard dev.	87923	184972	238377	140432	17122	5396
Area 0.5 km²	1.00	0.91	0.84	0.80	0.86	0.25
Area 2.0 km²	0.91	1.00	0.96	0.87	0.77	0.18
Area 4.0 km²	0.84	0.96	1.00	0.93	0.71	0.12
λ 0.001	0.80	0.87	0.93	1.00	0.68	0.10
λ 0.01	0.86	0.77	0.71	0.68	1.00	0.47
λ 0.1	0.25	0.18	0.12	0.10	0.47	1.00

The dark peaks that appear in Figure 3.2 represent the office centers that are to be found in the Amsterdam area. The peaks clearly show the variegated clustering pattern of the Greater Amsterdam office market. Traditionally office rents have been modeled in U.S. studies with a variable that indicates the distance from the CBD, where larger distance is expected decrease rent levels. However, this type of variable is based upon a monocentric city layout which does not fit most modern cities. Figure 3.3, which can be regarded as a collection of 2D-graphs derived from Figure 3.2, shows that Amsterdam is no exception in this regard. Figure 3.3 displays changes in office market density as distance from the center of Amsterdam increases in eight points of the compass.

Figure 3.2 ■ 3D density map Greater Amsterdam office market

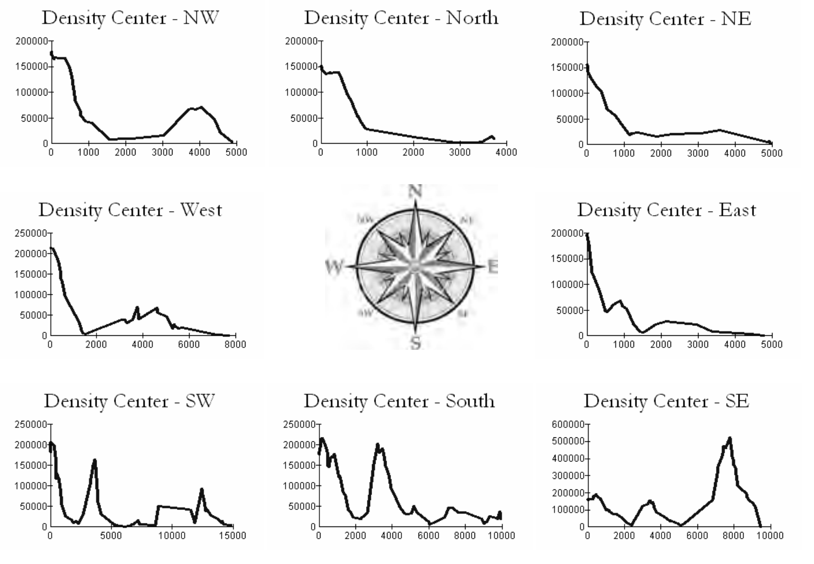
This Figure shows a 3D density map of the Greater Amsterdam office market for the 2004-2005 period based on the stock database containing address and size information of office space. Peaks in the Figure reflect the sum of office space within an area of 0.5 square kilometers surrounding each office building. An ArcGIS environment is used to make the density calculations based on geographic information and to show the information in the Figure.



Although the shape of the monocentric city layout with respect to the density of office buildings is found in northern and eastern directions, the other figures show that Greater Amsterdam fits the trend of changing urban landscapes. From traditional clustering of economic activity in downtown areas, a polycentric city layout emerges in all other points of the compass in line with urban patterns found in cities all over the world.

Figure 3.3 ■ Monocentric versus polycentric office market layout

This Figure indicates the mono- versus polycentric nature of the Greater Amsterdam office market by showing profile graphs of office market density in eight different points of the compass. Distance in meters from the city center is depicted on the x-axis. The y-axis shows the density of the office market for different distances from the center with density measured as the total amount of office floor space within 0.5 square kilometers in 2004-2005. Directions are close approximations of true points of the compass in order not to miss some density peaks.



3.6 Empirical Results

The data in our sample enables us to analyze the impact of cluster size and density while controlling for cross sectional variations in building- and location characteristics. Based on the hedonic model specification and data availability we estimate the following model:[19]

$$\begin{aligned}\log(\text{RENT}) = {} & \beta_0 + \xi_1\log(\text{Cluster measure}) + \omega_1 \log(\text{Building size}) + \omega_2\log(\text{Contract size}) \\ & + \omega_3\log(\text{Contract size})^2 + \omega_4\text{Contract/Building size ratio} + \delta_1\text{Amstelveen} \\ & + \delta_2\text{Center} + \delta_3\text{East} + \delta_4\text{Southeast} + \delta_5\text{South} + \delta_6\text{West} + \delta_7\text{North} + \delta_8\text{Haarlemmermeer} \\ & + \varphi_1\log(\text{Distance to highway}) + \varphi_2\log(\text{Distance to station}) + \rho_1\text{Refurbished} \\ & + \tau_1\text{Pre}-1900 + \tau_2 1901-1950 + \tau_3 1951-1970 + \tau_4 1971-1990 + \tau_5\text{After}1998/2002 \\ & + \tau_6\text{Period dummy} + \varepsilon\end{aligned} \tag{3.4}$$

[19] In order to prevent exact multicollinearity from entering our model given the dummy variables used to show the δ and τ variables we omit the municipality of Diemen and building period 1991-1998/2002 from the model.

While most of the variables speak for themselves, a further consideration of some variables is provided together with hypotheses considering the expected sign of the regression outcome. Our dependent variable here is the log asking rent on a square meter basis of the 1465 different contracts. We pooled the data for both time periods in our regression and controlled for time variations by including a time dummy that takes on value 1 if asking rent stems from the period 2004/5, and 0 otherwise. The central theme variable in this study is our measure of cluster size. Based on previous research and the opportunity for positive externalities associated with larger cluster size we expect $\xi_1 > 0$ indicating a rise in office rents as the floor space of offices in the vicinity increases.[20] We expect the building size variable, ω_1, to be positive in the regression analysis in line with Mills (1992), Dunse and Jones (1998) and Archer and Smith (2003) who hypothesise that the building size coefficient is positive because larger sizes allow for increased face-to-face contact. With respect to the contract size variable we hypothesize that $\omega_2 < 0$ given the, ceteris paribus, difficulty of leasing larger floor areas. However, we expect that the negative relation between contract size and rent rate holds only for contract sizes up to a certain level. Therefore we include a measure of squared contract size, ω_3, for which we anticipate a positive coefficient. Tenants occupying larger parts of a building, as indicates by the Contract/Building size ratio, generally have more rights to show their corporate identity on the building or to introduce services such as a central reception area. Based on these privileges we expect a positive coefficient for ω_4.

Variables indicated with δ represent the different geographical areas within Greater Amsterdam and reflect the percentage change in price from being, ceteris paribus, located in a certain area. Based on prevalent prime rental rates in the different geographic locations within the study area we expect $\delta_1 > 0$, $\delta_2 > 0$, $\delta_3 > 0$ and $\delta_6 > 0$ while the outcome for the other areas is an empirical issue. Crow-fly (Euclidean) distances between coordinates of offices and the nearest train station and highway junction are calculated to measure distance coefficients. Given the importance of accessibility the hypothesis is that $\varphi_1 < 0$ and $\varphi_2 < 0$, reflecting lower prices with increasing distance.

In line with results found by among others Nagai et al. (2000), Slade (2000) and Archer and Smith (2003) we expect to find a negative coefficient for the age variable in the regression. However, given the heritage encompassed in some very old buildings that can be found in the Greater Amsterdam region, for example canal side houses which have been converted to offices, we expect very old vintages to exhibit positive age coefficients. The hypothesis is that for very old buildings technological

[20] We have carefully considered the possibility of multicollinearity in our specification. The cross-correlation matrix that includes all explanatory variables shows no signs of distorting relations between variables.

deficiencies are more than compensated for by prestige. While construction year is available in annual format, building age is converted into different age categories for regression purposes to enable detection of vintage differences.[21] Based on previous studies and vintage effects for very old buildings we expect to find $\tau_1 > 0$, $\tau_2 > 0$, $\tau_3 < 0$, $\tau_4 < 0$ and $\tau_5 > 0$. We expect a negative coefficient for the Period dummy variable τ_6 given the change in office market conditions from tight to loose over our study period.

Table 3.3 presents the results for three sets of model specification. We start with the estimation of a standard hedonic model excluding measures of office clustering and present the results in column I. In columns II and II we present the results for two different specifications for cluster size, a sharp threshold measure of 0.5 squared kilometres and a distance decay function in line with *Eq*. (3.3) with λ 0.001, respectively. Table 3.3 shows that most location and size characteristics have significant coefficients with expected signs. For instance we find that office rents vary significantly across submarkets, with Amsterdam Center and South as most expensive markets, and that the age of the building matters significantly. Our results also show that older buildings yield lower rents when compared to structures that were constructed during the nineties but do not observe a positive vintage effect for very old buildings. In line with prior research, floor space in larger office structures is associated with higher rent levels. We also find that leasing large spaces in one contract typically increases the rent rate for all contract sizes in our database. Finally, with respect to the office location we find that structures located closer to train stations generally generate higher rent levels, while the proximity to highways tends to decrease the appeal of office contracts. We also tested for the influence of railway station importance, in line with station scores as presented in Ghebreegziabiher, Pels, Rietveld (2007), but found no additional influence of this score on office rents besides the effect already captured by the proximity of the nearest train station.

[21] An age squared variable as used in U.S. office market studies is not suitable for the Amsterdam office market because it assumes a symmetric shape of rental differences which is unrealistic in a city with some very old buildings.

Table 3.3 ■ Results hedonic density models

This Table shows coefficients and significance levels for different regression settings. The dependent variable is log(asking rent). Cluster type I reflects a sharp threshold measure of 0.5 squared kilometres and Cluster type II a distance decay function in line with *Eq.* (3.3) with λ 0.001. Building size, contract size, squared contract size, distance to highway, distance to station and cluster size measures are all in logarithmic form. The omitted variables are the region Diemen and the office cluster which was constructed during the nineties. White standard errors appear in parentheses. * indicates significance at the 1% level, ** indicates significance at the 5% level, *** indicates significance at the 10% level.

	I	II	III
Constant	5.080* (0.228)	4.344* (0.230)	3.872* (0.287)
Cluster type I		0.057* (0.007)	
Cluster type II			0.078* (0.013)
Building size (m2)	0.113* (0.017)	0.089* (0.017)	0.105* (0.017)
Contract size (m2)	-0.156* (0.044)	-0.149* (0.043)	-0.132* (0.044)
Contract size squared (m2)	0.007** (0.003)	0.006*** (0.003)	0.005 (0.003)
Amstelveen	0.283* (0.029)	0.244* (0.028)	0.271* (0.028)
Amsterdam-Center	0.533* (0.038)	0.511* (0.037)	0.472* (0.039)
Amsterdam-East	0.245* (0.038)	0.283* (0.037)	0.248* (0.039)
Amsterdam-Southeast	0.106* (0.023)	0.063* (0.023)	0.053** (0.024)
Amsterdam-South	0.500* (0.028)	0.509* (0.028)	0.475* (0.029)
Amsterdam-West	0.110* (0.024)	0.114* (0.024)	0.094* (0.024)
Amsterdam-North	-0.090** (0.045)	-0.108** (0.045)	-0.046 (0.048)
Haarlemmermeer	0.052** (0.022)	0.030 (0.022)	0.049** (0.022)
Distance to highway (m)	0.024* (0.009)	0.026* (0.008)	0.032* (0.009)
Distance to trainstation (m)	-0.052* (0.007)	-0.010 (0.008)	-0.021** (0.008)
Refurbished	0.041 (0.027)	0.045*** (0.025)	0.039 (0.026)
Pre-1900	-0.131* (0.046)	-0.157* (0.047)	-0.148* (0.045)
1901-1950	-0.048 (0.052)	-0.059 (0.051)	-0.070 (0.052)
1951-1970	-0.188* (0.020)	-0.169* (0.021)	-0.186* (0.020)
1971-1990	-0.169* (0.012)	-0.171* (0.012)	-0.179* (0.013)
After 1998/2002	-0.079* (0.023)	-0.042** (0.021)	-0.039*** (0.020)
Contract / building size ratio	0.128* (0.042)	0.126* (0.042)	0.138* (0.042)
Period dummy	-0.083* (0.016)	-0.091* (0.015)	-0.091* (0.016)
R-squared	0.533	0.559	0.552
Adjusted R-squared	0.526	0.552	0.545

The characteristic matter of this investigation, the effects of office clusters, is represented by the Cluster type I and Cluster type II variables. The cluster I variable tells us how much office space an office user will run into when walking in a radius of approximately 400 meters, the equivalent of 1310 feet, from its own building. In the second column of Table 3.3 we find a positive coefficient for cluster size, which shows that if cluster density would rise with one standard deviation from the mean (an increase of 82.49%, see Table 3.2) due to new construction activity, rent levels would increase approximately 4.73%. Assuming we pay the sample mean rent of €178 per square meter of office space, such an increase in office density would raise rents with €8.42 per square meter. The Cluster type II variable in Table 3.3 implies that objects located nearby are considered more important, while office space which is located at more remote distance will hardly change the value of this cluster measure. The regression results show that this alternative cluster yields a similar positive impact on office rents.

Data availability also allows for a test of differences in coefficients between very different market circumstances. Based on analysis including interaction terms with the 'Period dummy' variable we find no significant differences between coefficients during tight or loose office market conditions, apart for the coefficients for two subcenters where rents decrease significantly due to local market circumstances.[22] These results indicate that building and location characteristics are wanted or unwanted irrespective of office market conditions.

The clustering measure we apply in this study implicitly tests for the influence of localization externalities which are based on sector specific employment. However, urbanization effects, a resultant of general urban concentration, can also have an influence on productivity. We test whether sector specific employment or general economic concentration dominates office clusters by examining the Greater Amsterdam on a four digit postal code level. For each of the 120 four digit postal code districts we know the area in square meters, the number of inhabitants and the, industry specific, number of employees. The latter data stem from the LISA database which includes address, industry and employment information for each commercial or public entity in our study area. Being on an entity level the dataset reflects address of occupation instead of address of residence for each employee.

[22] The coefficient of the Cluster Type I measure with the period interaction term is 0.009 (t-stat 0.471) and 0.002 (t-stat 0.267) for the Cluster Type II measure. These figures show that there is no significant difference in density premium between the two time periods analyzed in this study.

Table 3.4 ■ Indicators for localization versus urbanization

This Table shows correlations between the total surface of office stock, the number of inhabitants, the number of employees in finance, insurance and real estate companies and the number of employees in other industries. All data are compiled on a four digit postal code level. The number of inhabitants is based on address of residence while the number of employees is based on the address of occupation.

	Office stock	Inhabitants	FIRE employment	Non FIRE employment
Office stock	1	-0.04	0.81	0.29
Inhabitants	-0.04	1	0.13	0.12
FIRE employment	0.81	0.13	1	0.53
Non FIRE employment	0.29	0.12	0.53	1

Table 3.4 shows the correlation between office stock, population size, FIRE- and non-FIRE employment and displays the expected strong positive relationship between office stock and employment in FIRE industries.[23] A less obvious result is the low correlation between office stock and the number of inhabitants. If office clusters reside in densely populated areas, there would be a strong indication for the presence of urbanization effects. Based on the results presented in Table 3.4 we conclude that the effect of clustering on office rents is dominated by localization externalities as it is apparent that office clusters and general urban concentration are no substitutes. We observe very large office clusters in scarcely populated areas and very dense residential neighbourhoods in regions with hardly any office space. However, we cannot conclude that there are no urbanization externalities arising from employment outside the FIRE-industry, although we do observe that localization effects dominate areas with a high office density.

In this chapter we introduce a continuous density measure in office market research. While the effect of proximity of other office buildings on rental rates has been indicated in the past, the use of a GIS based continuous density measure is novel. Given the high requirement on data availability and data quality the question whether a density measure should be included in office market research is justifiable. To test whether the inclusion of the total office stock based density measure improves the fit of regression models II and III compared to model I we apply an F-test in which we test the null hypothesis that inclusion of a density measure does not improve the explanatory power of the pricing formula.

Table 3.5 shows highly significant f statistics at the 1% significance level for all specifications of the unrestricted models which indicates that the model which incorporates continuous scale density measures performs significantly better than the models that exclude office clustering information.

[23] A test for the correlation between total employment, in line with urbanization externalities, and office stock yields results that are the average of the FIRE and non-FIRE industry correlations.

Table 3.5 ■ Joint test of significance of goodness of fit regression models

This Table shows the output of a joint test of significance of goodness of fit for different versions of the OLS regression model. We apply the following version of an f-test to measure the significance of differences in goodness of fit between model specifications that exclude density measurement and specifications with density measures:

$$f = \frac{\left(R_1^2 - R_0^2\right)/J}{\left(1 - R_1^2\right)/\left(N - K\right)}$$

where R_1^2 and R_0^2 represent the goodness-of-fit measures for the model with (unrestricted) and without (restricted) the density measures respectively. *J* represents the degrees of freedom of the unrestricted model minus the degrees of freedom of the restricted model and *(N-K)* is the degrees of freedom of the unrestricted model. N shows the number of observations used in model specification. R^2 indicates the goodness of fit for the consecutive models while K and J indicate the number of independent variables in the unrestricted model (including density measures as used in model II and III) and the difference in degrees of freedom between the unrestricted and restricted model (excluding density measures as in model I) respectively. Critical values are the one-sided F-tests for the 1% and 5% significance levels. The *f*-statistic indicates outcome of the F-test, where f-statistic > critical value indicates that unrestricted model performs significantly better than the restricted model at the indicated significance levels.

	I	II	III
N	1465	1465	1465
R^2	0.533	0.559	0.552
K		22	22
J		1	1
Critical value			
1%		6.63	6.63
5%		3.84	3.84
f-statistic		83.43	59.43

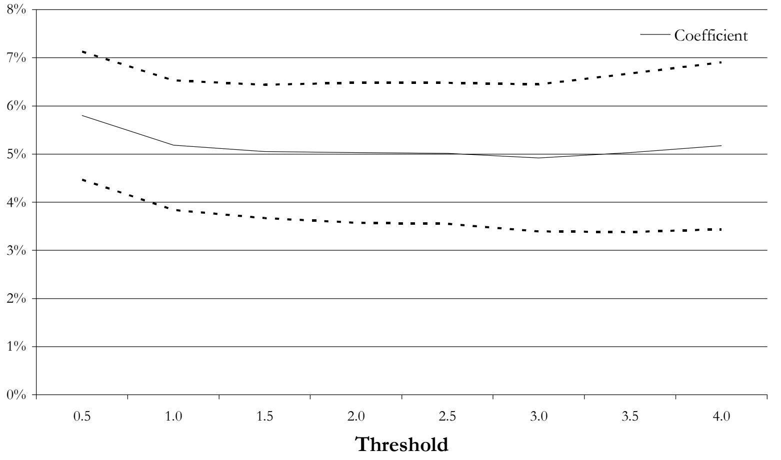
3.7 Robustness Checks

The results of our empirical research confirm the presence of industry economies of scale in suburban office markets. We find that investors can expect higher income from office space as office market density increases in both an upward and downward moving office market. In order to limit the potential impact of our definition of cluster size, through the choice of the essential cut-off point for relevant distances and distance sensitivity parameters we perform robustness checks using different cluster parameters within a feasible range. The results of this exercise are displayed in Figure 3.4.

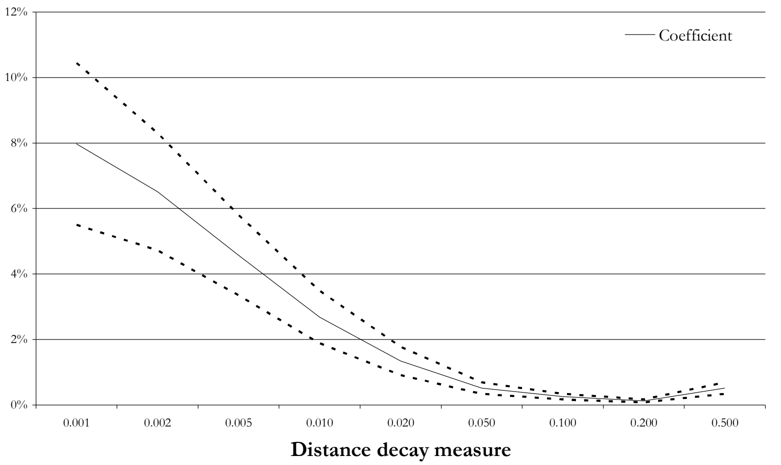
Figure 3.4 ■ Regression coefficients of cluster variables for different cut-off points

Panel a displays regression coefficients for different measures of area size in square kilometer as depicted on the x-axis. Panel b presents regression coefficients for different distance decay parameters which are depicted on the x-axis. The y-axis shows the influence of office market density, ceteris paribus, on office rent levels. The dotted lines indicate 95% confidence bounds.

Panel a



Panel b



The results presented in Figure 3.4 show that changing the underlying parameters to set our cluster measures does not drive our findings regarding the relevance of cluster size on office rents. We find very similar coefficients when using different area limits. When changing the distance tolerance measure, lambda, we find decreasing coefficients which are due to the limitation in the variation of cluster sizes. However, in all cases we find statistically significant, and practically meaningful, positive coefficients.

3.8 Conclusions

While modern day cities show little resemblance with the traditional monocentric city layout, the clustering of offices in the Greater Amsterdam market shows that binding forces are still at work. Several reasons have been mentioned for the occurrence of office clustering and this study examines the rental effect of the clustering of offices after controlling for building and location characteristics. Application of GIS technology facilitates the formation of continuous scale density measures, which were subsequently linked to each individual office in the cross sectional regression sample as an additional trait besides commonly used structural and spatial building characteristics.

Our results show that clustering results in higher rental rates, irrespective of the prevalent economic circumstances, and that this effect is dominated by localization externalities. This finding is present despite the ongoing discussion about advances in information technology and declines in transportation costs, which should result in diminishing rental effects of clustering. The implication of our findings is important for public institutions, developers, and real estate investors as we show that office space yields higher income as the density of the local office market increases. We find that doubling the local office market size increases rent rates by over 4.5%. Our results show that the definition of cluster size does not drive our findings, and that the use of advanced GIS methods enables us to quantify rather hazy issues like herding and clustering in a very exact manner. The relevance and the applicability of our results on clusters create possibilities to incorporate the issue in subsequent studies on rent determinants.

Chapter 4
Agglomeration Effects and Financial Performance[24]

4.1 Introduction

The impact of agglomeration on productivity is of central importance to the economy and has been extensively researched. Extant studies find, in general, that density has a positive influence on total factor productivity to compensate for an increase in costs.[25] However, while productivity is an important feature of agglomeration it is not the primary element firms in competitive industries aim at. A positive relation between productivity and density should not drive location choice if the drawbacks of agglomeration more than eliminate the advantages of higher total factor productivity. The elimination of this advantage is not imaginary, as density generally increases real estate costs and wages (Glaeser and Mare, 2001), which are the two main operating costs of companies (Brounen and Eichholtz, 2005). This chapter empirically tests the tradeoff between the costs and benefits of agglomeration. Since these are not limited to land rent, wages, and productivity, we need a variable that measures the net effect of costs and benefits. This measure is a firm's profitability. Therefore, the focus of this study is on the relation between density and profitability.[26]

According to the well-known concept of spatial equilibrium there should be no positive or negative relation between density and profitability. Higher (lower) profitability in denser areas should attract (distract) companies to (from) these areas

[24] This chapter is based on a working paper by Jennen and Verwijmeren (2008).
[25] For an extensive review of this literature see Holmes and Stevens (2004).
[26] Papers that examine the relation between location and profitability include Boassen and MacPherson (2001), and Vaessen and Keeble (1995). Boassen and MacPherson study listed U.S. firms in the pharmaceutical industry and find the returns to be higher for clustered firms than for non-clustered firms. Vaessen and Keeble use survey results to study growth-oriented firms in the U.K. and find the profits of firms in various regional environments to be relatively similar. Pirinsky and Wang (2006) study the effect of corporate headquarter location on stock returns. They find strong co-movement in the stock returns of firms headquartered in the same geographic area.

until equilibrium is restored. However, the presence of amenities that enrich the life of firms' decision makers is likely to result in decisions that are not solely focused on maximizing a firm's profits. Especially for firms where decision makers need to live close to their business, practical and behavioral reasons exist why firms locate in areas that are not financially optimal. For example, Glaeser (2007) argues that moving costs and spatial preferences of the CEOs result in non-perfect profit maximalization at the firm level. We therefore treat the relation between density and financial performance as an empirical question.

Ideally, a test of this relation exclusively incorporates single-establishment firms. In these firms, the decision makers are generally physically present at the firm's location. Also, examining single-establishment firms excludes the effect of firms that are located in various areas with different density levels: the performance of these firms cannot be attributed solely to the density of the headquarters location. By exploiting a database with information on firms' locations and their financial performance, we are the first to empirically test the tradeoff between the costs and benefits of agglomeration for single-establishment firms.

Our country of analysis is the Netherlands. Several reasons make this country an interesting basis for analysis. First, the Netherlands ranks high in population density when compared to other countries in the world. Bangladesh and Taiwan are the only countries with a population above ten million that show higher population density. Despite the high overall population density there is a large dispersion of urbanization across the Netherlands. Consequently, urbanization differences are an important factor in settlement choices for Dutch firms. A second factor that makes the Netherlands an interesting market for analysis is the availability of unique and very detailed information on both the company and the geographic level. The company data set comprises financial information of a large number of private companies, which facilitates a wide analysis of the potential effects. Detailed geographic information originates from the Dutch Central Bureau of Statistics and includes employment, land use, and land area information on two levels of geographic aggregation.

Our sample consists of 13,161 privately owned firms for which financial information is available.[27] Regarding the relations between agglomeration and productivity, we corroborate results of other papers (e.g., Ciccone and Hall, 1996; Ciccone, 2002): density and productivity are positively related. Doubling the density increases the turnover per employee on average with 6.0% for firms included in our sample. We further find evidence that the labor costs per employee and land costs rise

[27] The sample size differs across specifications in our empirical analysis due to incomplete reporting of variables. As we base our analysis on privately owned firms, disclosure of information is not subject to the same regulations as for public firms. We have 3,597 firms with all the necessary information to be included in our estimations of the effects of density on a firm's profitability.

with density. More specifically, we find the labor costs per employee to rise with 6.3% when the population density doubles, while land costs increase with 42.0% for a doubling of the population density.

Productivity, wages, and land costs are not the only three factors that relate to density. Other benefits and costs include insurance costs, transportation costs, and labor availability. To examine the combined effect of these benefits and costs, we focus on a firm’s profitability, as measured by the five-year average of a firm’s return on assets. In our analysis we make the distinction between effects related to urbanization (density of general economic activity) and localization (density of industry specific employment).

For urbanization, we find that density has a negative effect on firms’ profitability. For Corop areas – a subdivision that divides the Netherlands into 40 regions – a doubling of the employment density will decrease the average return on assets by more than one percentage point. The same goes for density measures that focus on the number of inhabitants or addresses in an area. The negative relation between density and performance is also present in an analysis on the municipality level, although with lower coefficients and significance levels.

We test the effect of localization by examining industry-related effects. We find significantly negative effects between density and performance for firms in the ‘manufacturing’, ‘construction’, and ‘wholesale and trade’ industry. When examining the ‘transport, storage and communication’ and ‘real estate, renting and business activities’ industry, we find that in these industries agglomeration and performance are not significantly related.

Our study contributes to the literature by combining empirical tests of the costs and benefits of agglomeration. Given that the majority of prior work deals with the relation between density and productivity – a relation which is generally found to be positive – the positive effects of agglomeration are overrepresented in the literature. By incorporating potential costs of agglomeration in our tests, we show that the net effect of settling in high density areas is on average negative. These findings potentially explain recent trends of deconcentration of employment (Carlino and Chatterjee, 2002). However, we stress that our test is based on an examination of single-establishment firms. For firms with multiple establishments, like virtually every public firm, and knowledge intensive industries the choice of (headquarter) location might strongly depend on prestige and skilled labor availability.

The remainder of this chapter is organized as follows. We start with a description of the agglomeration literature in section 4.2. Section 4.3 provides a description of our data. In section 4.4 we examine the benefits and costs of agglomeration. Our analysis on agglomeration and profitability is presented in section 4.5. Section 4.6 provides robustness tests and section 4.7 concludes.

4.2 Literature on the Effects of Agglomeration

Differences in total factor productivity as a result of unequal urbanization and localization across locations has been at the heart of urban economics at least since Marshall (1920) discussed technological spillovers between adjacent firms. Traditionally, cities emerged near natural transportation nodes and natural resources. With the advent of industrialization, firms started to benefit from communal presence and the benefits of face to face contact between firms and clients (see, for example, Archer and Smith, 2003; Clapp, 1980; Dunse and Jones, 2002; and Mills, 2004). However, the post-industrial era brings advancements in technology that might diminish the need for cities as a ground for knowledge spillovers (Bollinger et al., 1998).[28]

A simple model introduced by Roback (1982) shows how wages and land rents interact to allocate workers to locations with various quantities of amenities. In equilibrium, with both capital and labor completely mobile across cities, the combination of wages and land rents in each location satisfies two conditions. The first condition relates to workers and shows that locations with a high level of unproductive amenities have high rents to avoid overconcentration of workers. No arbitrage relations require that individuals must be indifferent across space if the flow of wages plus amenities minus housing costs and transportation costs is taken into account (Glaeser, 2007). The second, or firm condition, states that the presence of unproductive amenities requires low land rents to attract firms. Firms are indifferent over space since the spatial equilibrium condition holds that the unit cost equals product price and differences in wages are offset by differences in total factor productivity.

Existing studies that focus on the effect of agglomeration on productivity can be divided into a localization and urbanization strand. Localization typically relates to clusters. A cluster is a critical mass of companies in a particular field in a particular location, whether it is a country, state or even a city (Porter, 1998). According to Porter, productivity can be increased by improving factor inputs in efficiency and quality which should ultimately result in cluster areas with high levels of

[28] Glaeser (1998) provides an extensive discussion of whether cities are dying and concludes that information spillovers will continue to be important, even in an age of cheap and fast communication possibilities.

specialization. The United States show numerous examples of clustering of economic activity. Silicon Valley is the prime contemporary example of industry clustering for microelectronics, biotechnology and venture capital, but clusters also include for example Hollywood for the movie industry, Las Vegas for casino and entertainment, Rochester for imaging equipment, and Wichita for farm equipment.

Clustering of industry specific activity creates several benefits at the firm and household level. Krugman (1991) mentions three of these benefits. The first is the pooled market for workers with industry specific skills in a confined area which limits the risk of unemployment on the household level and labor shortage on the industry level. Second, localization supports the production of nontradable specialized inputs necessary at the firm level. Lastly, localization improves the production function for companies in localized industries when compared to their isolated peers. On a micro level, clustering of economic activity has been examined on a city level of analysis. Archer and Smith (2003) and Jennen and Brounen (2008) study the effect of office clustering on office rents for Houston and Amsterdam, respectively. Both studies find that offices that accommodate highly skilled, non-routine employment, cluster within cities and show that office rents increase with local office market density.

The second strand of literature related to agglomeration economies focuses on urbanization. More specifically, it deals with the relation between the density of economic activity and productivity. Density of economic activity is a measure for the intensity of labor and human and physical capital within a confined geographic area. Early work in this field studies agglomeration economies by relating city size to technological spillovers (for a discussion of this literature, see Ciccone and Hall, 1996). Henderson (1974) shows that, in equilibrium, disamenities on the side of households because of agglomeration, such as for example congestion, pollution, and crime, are offset by productivity advances for competitive firms. These productivity advances can lead to high sustainable profits, which are partly redirected towards the employees in the form of higher wages. Ciccone and Hall (1996) and Ciccone (2002) study agglomeration effects by linking employment density to labor productivity for U.S. states and European Nuts 3 regions, respectively.[29] Ciccone and Hall (1996) measure productivity as the Gross State Output per acre for 46 states and the District of Columbia, while Ciccone (2002) uses value added at factor costs and salaried employment for 628 Nuts 3 regions in France, Germany, Italy, Spain, and the U.K.. These studies show that doubling of employment density raises average labor productivity approximately 6 percent in the U.S., while agglomeration effects in

[29] The NUTS Classification (La Nomenclature des Unités Territoriales Statistiques) is introduced by the Statistical Office of European Communities (EuroStat) in cooperation with other EU bodies for the needs of classifying unified territorial structures. Currently, E.U. member states are divided into 4 NUTS levels from country level NUTS 0 to smaller scale NUTS 3.

Europe are slightly smaller. Carlino et al. (2007) link urban density to the rate of invention, and find that doubling the employment density increases the patents per capita by 20%.

However, besides agglomeration benefits there are also diseconomies of agglomeration on the firm level. Typically, density is associated with higher wage and accommodation costs. Glaeser and Mare (2001) show for example that employees who live in cities earn a wage premium of 33% over workers that do not live in metropolitan areas. Accommodation costs, which are a function of land rents, rise with population density in line with ideas dating back to von Thünen in the nineteenth century. Other negative effects of agglomeration are for example higher pollution and crime, and related insurance costs.

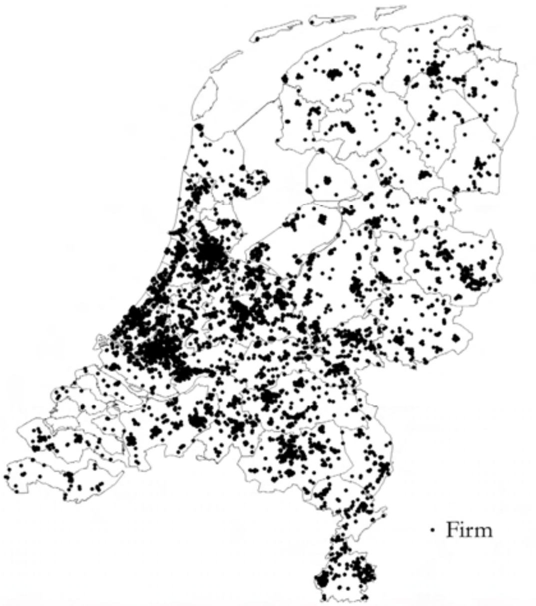
4.3 Data

In this section we introduce the data used in our empirical analysis. For the calculation of firm level performance we employ a sample of Dutch firms from Bureau van Dijk's REACH database. This database provides information on Dutch firms, and is survivor-bias free: the database still contains data on firms that do not exist anymore.[30] Our first selection comprises firms for which the REACH database reports profitability (ebitda), which are 32,553 organizations. We delete firms that do not report their location, and exclude financial institutions and utilities because of problems associated with measuring leverage and return on assets for these industries. We further exclude firms that are listed, firms that have multiple establishments, and firms that migrated to an area with a different density in the last eight years of their reporting. In addition, we exclude firms with names that include the words 'holding', 'group', 'international', 'Europe', or its Dutch equivalents. Our final sample, after truncating variables at the 1st and 99th percentile, comprises 13,161 firms. Figure 4.1 shows the dispersion of these firms across the Netherlands based on the six digit postal code coordinates. Although the observations are widely spread across the country, the majority of observations are in the mid-west of the Netherlands. A similar pattern is present for the 3,597 firms with all the necessary information to be included in our estimations of the effects of density on a firm's profitability.

[30] In robustness tests, we have tested whether our results would change if we only include firms that still exist. We find that both the signs and significance of our main results remain unaltered.

Figure 4.1 ■ Firm location and population density on COROP level

This Figure shows the location of each firm in our sample based on a six digit postal code. The geographic areas represent the 40 Corop regions in the Netherlands.



We define our profitability measure as the five-year average of the return on assets. The returns on assets are the earnings before interest, taxes and depreciation (ebitda) divided by the total assets at the end of the book-year. In robustness checks we will employ different time periods to measure average return on assets. We compute the five-year average of the return on assets for the final year in which the firm is included in the REACH database. Hence, each firm only appears once in our sample. Industries are selected in line with the statistical Classification of Economic Activities in the European Community, Rev. 1.1 (2002), which is comparable to a SIC code in the U.S.. We include various control variables in our regression estimation on density and profitability, like a firm's size, industry, leverage, age, and risk. We control for a firm's age as profitability is generally related to the life cycle of a firm. We also include a proxy for risk as risky firms are expected to obtain higher average return on assets. The risk profile of a company is calculated by taking the standard deviation of the reported profits (ebitda) over the last five years.

Besides firm information we also employ various sets of aggregated and disaggregated geographic and employment data. Physical space in our empirical analysis is defined as either municipalities or so-called Corop areas, which are equal to EuroStat's Nuts 3 regions. The Netherlands is divided into 12 provinces which can be further divided into 40 Corop areas and subsequently 443 municipalities. For each Corop area we gather the number of employees per industry per year since 1995 from the EuroStat database. Further geographic information used in our analysis includes the total land area of each municipality and Corop region. We employ these data to calculate employment density statistics.

We measure urbanization with three different variables which are employment, population, and address density. Employment and population density are respectively the number of employees or inhabitants per square kilometer of land area within a municipality or Corop region. Relative differences between these two measures of agglomeration exist if the population is ageing, when there is a high number of inhabitants below working age, residential areas are basically dormitory towns, or when the economic circumstances result in high local unemployment rates. Address density is a measure for the concentration of human activity. It measures the average number of addresses (including residential, commercial, and public properties) in a one kilometer radius area around each address within the defined agglomeration. We measure localization as the number of full time equivalent employees for each industry within Corop areas and municipalities per square kilometer of land.

Table 4.1 reports summary statistics of the variables in our study. We report individual sample statistics instead of common sample statistics as different combinations of variables appear in the various regression models of this chapter.

The median size of the firms in our sample, measured as the value of total assets, is € 4.265 million. Given that these firms are privately owned, we observe a relatively high median leverage of 0.699. The median firm age is 19 years, and the median five-year return on assets is just over 10 percent. The median number of employees per km^2 is 368 in a Corop area and 606 in municipalities.

Table 4.1 ■ Summary statistics

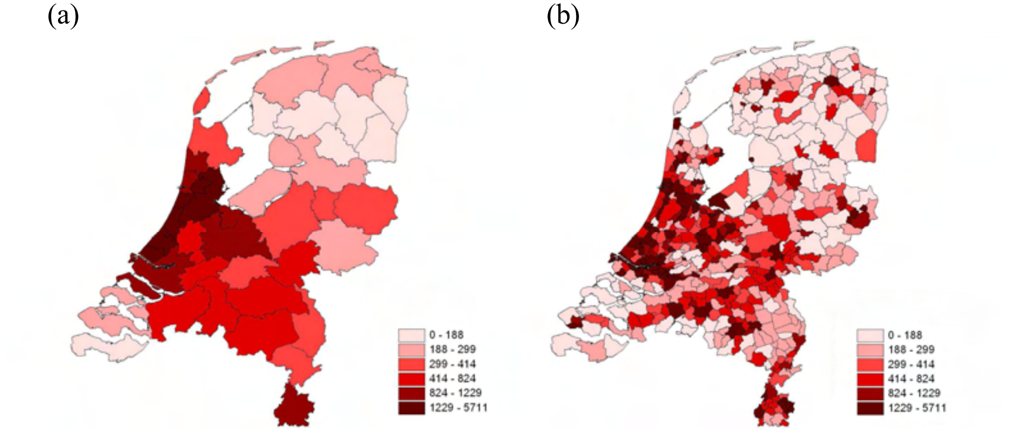
This Table reports summary statistics for our total sample. Total assets are in millions of Euros. Leverage is total debt divided by total assets. Firm age is the year of reporting minus the year the firm was founded. ROA stands for return on assets and is calculated by dividing the earnings before interest, taxes, and depreciation by the total assets. Risk is measured as the standard deviation of the return on assets over the last five years of the firm's reporting. Total assets and leverage are reported for the firm's last year of reporting. Turnover per employee and payment per employee are total turnover and total salary costs divided by the total number of employees. Land costs reflect the price of residential land per square meter. Employment and population density is measured as respectively the number of employees or inhabitants per square kilometer of land area within a Corop region or municipality. Address density is a measure for the concentration of human activity. It measures the average number of addresses (including residential, commercial, and public properties) in a one kilometer radius area around each address within the defined agglomeration.

Firm characteristics	**N**	**Mean**	**Median**
Total assets	13,161	29.557	4.265
Leverage	10,893	0.618	0.669
Firm age	13,161	36.512	19.000
Five-year mean ROA	4,085	0.116	0.101
Risk	4,085	0.093	0.063
Turnover per employee	6,743	519	167
Payment per employee	1,429	42	39
Land costs	13,161	451	433
Density measures (Corop)			
Employees per km^2	13,161	457	368
Inhabitants per km^2	13,161	963	845
Address density	13,161	2,087	1,649
Density measures (Municipality)			
Employees per km^2	13,161	4,931	606
Inhabitants per km^2	13,161	1,374	709
Address density	13,161	1,562	1,150

Figure 4.2 shows the dispersion of population density across the country on a Corop and municipality level. A comparison of Figure 4.1 and Figure 4.2 shows that areas with high population density share high firm density.

Figure 4.2 ■ Population density on Corop and municipality level

This Figure shows the population density, measured as the number of inhabitants per square kilometer of land area. Panel (a) shows population density for 40 Corop areas and Panel (b) for 443 municipalities in the Netherlands.



The dispersion of density measures across the country is high. Clearly visible is the high concentration of population in the west, an area known as the Randstad (including the cities Amsterdam, Rotterdam, The Hague, and Utrecht). Another densely populated area is the most southern part of the country. Low density areas appear in the predominantly rural northern and eastern parts of the Netherlands.

4.4 Costs and Benefits of Agglomeration

In section 4.2 we discussed prior work indicating that density positively influences total factor productivity. To test the relation between density and productivity for the firms in our sample, we regress the turnover per employee on the total number of employees within the firm. To examine a downside of agglomeration we test whether wages and land rent are higher in densely populated areas.

4.4.1 Testing the benefits of agglomeration

When testing the relation between employment density and turnover per employee for the firms in our sample, we control for firm size, firm age, and industry effects. We set the firm age variable to twenty for observations with firm age values above twenty, since firms are likely to have reached maturity by then. Throughout the chapter, we will employ geographically clustered standard errors. This means that we cluster standard errors by Corop when we estimate an effect of density for Corop regions, and cluster standard errors by municipality when we estimate an effect of density for municipalities.

Table 4.2 ■ Density and the revenues per employee

This Table reports the influence of density on firms' productivity, and tests the model Productivity = γ_0 + γ_1Density + γ_2Size + γ_3Firm age + γ_4Industry + ε. Productivity is measured as the total turnover divided by the total number of employees. Density is the number of employees per km^2. Firm size is measured as total assets. We take the natural logarithm of the productivity, density, and size variable. The variable firm age has a maximum of 20. T-test statistics are based on geographically clustered standard errors and appear in parentheses. ***, **, * indicate significance at the 1%, 5%, and 10% level, respectively.

	Turnover per employee	
	Corop	Municipality
Employees per km^2	0.060***	0.004
	(3.03)	(0.46)
Size	0.777***	0.775***
	(43.73)	(39.77)
Firm age	-0.034***	-0.035***
	(-13.88)	(-10.98)
Industry dummies	Yes	Yes
N	6,743	6,743
R^2	0.332	0.328

In general, the results point towards a positive relation between productivity and industry specific employment density: the coefficient of the effect of urbanization on productivity is positive on both the Corop and the municipality level. The influence on the municipality level is however not statistically significant. In a Corop area, doubling the location density – in terms of employees per km^2 – increases the productivity by 6.0%. The influence of neighboring areas is larger on the municipality level which could be the reason for noise in our findings for municipalities. Larger firms have a higher productivity, ceteris paribus, whereas the age of the firm has a negative impact on the turnover per employee.

4.4.2 Testing the costs of agglomeration

To examine potential downsides of agglomeration we test whether the employment costs per employee and the land price per square meter are higher in dense areas for the firms in our sample. Although employment and land costs are only two of the downsides, they are potentially the most influential as they constitute some of the main costs of companies. Table 4.3 shows the effect of density on the average payment per employee and on land costs per square meter.

Table 4.3 ■ Density, employment costs, and land costs

This Table reports the influence of density on firms' direct employment costs, i.e. wages. We test the model Employment costs = $\gamma_0 + \gamma_1$Density + γ_2Size + γ_3Firm age + γ_4Industry + ε. Employment costs are measured as the total salary costs divided by the total number of employees. Land costs reflect the price of residential land per square meter. Density is the number of employees per km^2. Firm size is measured as total assets. We take the natural logarithm of the employment cost, land cost, density, and size variable. The variable firm age has a maximum of 20. T-test statistics are based on geographically clustered standard errors and appear in parentheses. ***, **, * indicate significance at the 1%, 5%, and 10% level, respectively.

	Payment per employee		**Land costs**
	Corop	Municipality	Corop
Employees per km^2	0.063***	0.021***	0.420***
	(6.59)	(4.66)	(8.67)
Size	0.056***	0.057***	-0.001
	(4.99)	(3.53)	(-0.06)
Firm age	-0.011	-0.007	0.001***
	(-0.57)	(-0.33)	(2.79)
Industry dummies	Yes	Yes	Yes
N	1,429	1,429	13,161
R^2	0.086	0.073	0.755

The wage per employee is calculated by dividing the total salary costs by the number of employees present at the last year of reporting. The land price variable is the average price paid per square meter of land with a residential zoning plan within the Corop regions in 2006. The data stem from the Dutch Land Registry, which files all property and land transactions in the Netherlands.

We control for size, age, and industry effects. It can be seen that salaries are higher in dense areas, ceteris paribus. Increasing the density by 100% will increase the average pay per employee with 6.3% for Corop areas. On a municipality level, this percentage is 2.1%. Land costs also rise with population density. More specifically, doubling the density increases the cost of land by 42.0%. We only report land costs in Corop areas as the price per square meter of land is not available at municipality levels.

4.5 Agglomeration and Financial Performance

In this section we will empirically test the impact of location density on a firm's profitability.

4.5.1 Urbanization in a Corop region and financial performance

We will first test the relation between density and financial performance on Corop levels. We measure density in three ways: the number of employees per km^2, the number of inhabitants per km^2, and the address density. Table 4.4 shows the results.

The density variables have a significant negative influence on the average five-year profitability. The statistical significance holds for all of the density measures employed in Table 4.4. An increase of the density (employees per km^2) with 100% will decrease the average return on assets by 0.012. For instance settling in Rotterdam (488 employees/km^2) instead of Almere (258 employees/km^2) increases the density measure with 89%. For a firm that has an average return on assets of 10% in Almere, a similar firm in Rotterdam has an expected average return of 8.9% (0.1 – 0.012 * 0.89). The coefficients for inhabitants per km^2 and address density are -0.013 and -0.020, respectively.

Table 4.4 ■ Density of Corop and firm performance

This Table reports the influence of Corop density on firm performance, and tests the model Profitability = γ_0 + γ_1Density + γ_2Size + γ_3Leverage + γ_4Firm age + γ_5Risk + γ_6Industry + ε. Profitability is measured as the five-year average return on assets. Density is the number of employees per km^2, the number of inhabitants per km^2, or the address density. We take the natural logarithm of the density variables. Size is the logarithm of total assets. Leverage is total debt divided by total assets. The variable firm age has a maximum of 20. Risk is measured as the standard deviation of the return on assets over the last five years of the firm's reporting. T-test statistics are based on geographically clustered standard errors and appear in parentheses. ***, **, * indicate significance at the 1%, 5%, and 10% level, respectively.

	Five-year mean ROA		
Employees per km^2	-0.012**		
	(-2.65)		
Inhabitants per km^2		-0.013**	
		(-2.50)	
Address density			-0.020***
			(-3.68)
Size	0.019***	0.018***	0.019***
	(4.63)	(4.56)	(4.67)
Leverage	-0.079***	-0.079***	-0.079***
	(-6.65)	(-6.63)	(-6.63)
Firm age	0.001	0.001	0.001
	(1.01)	(1.02)	(0.98)
Risk	0.266***	0.266***	0.266***
	(4.70)	(4.70)	(4.72)
Industry dummies	Yes	Yes	Yes
N	3,597	3,597	3,597
R^2	0.065	0.065	0.066

Table 4.4 further shows that larger firms are on average more profitable. It has to be taken into account that our sample comprises single-establishment firms, which are on average relatively small compared to multiple-location firms, but have a stronger link with their place of business. Leverage decreases the average earnings before interest, taxes, and depreciation as a percentage of total assets. In accordance with a

risk-return tradeoff, firms with higher earnings volatility have on average higher return on assets.

4.5.2 Urbanization in a municipality region and financial performance

In the Netherlands there are multiple areas in which relatively dense municipalities are surrounded by regions with lower density. Examples are cities in the rural North of the country. In a Corop, the resulting density variable will balance the high and low density regions. To examine whether the mitigation of high density cities has an impact on the results of Table 4.4, we analyze the influence of density on municipality level in Table 4.5.

Table 4.5 shows that the significantly negative relation between the employees per km^2 and profitability is also present on the municipality level. The other two measures for urbanization are not significant. Also, the economical impact of density is smaller on municipality level than on Corop level: the coefficient decreases from -0.012 in Table 4.4 to -0.004 in Table 4.5 for the variable employees per km^2.

Our finding that the impact of density is stronger on Corop levels can be explained by the fact that density on a Corop level is more moderate. On the municipality level the density measure often differs substantially among adjoining regions, as could be seen in Figure 4.1. Firms that settle in relatively low-density municipalities may still be influenced by adjoining high-density regions. These interaction problems are lower for Corop areas, due to their size and moderation.

4.5.3 Localization and performance

As reviewed in section 4.2, there have been various studies on the effects of clusters. A typical example of a cluster is Silicon Valley. Although Silicon Valley would not correspond to the highest density levels in terms of for employees or inhabitants per km^2, it does correspond to a high value for industry related employment per km^2. The clustering of technological companies in Silicon Valley is not likely to largely influence the profitability of for example, an agricultural company in this area. It could however largely benefit other technological firms. In the Netherlands, areas like Silicon Valley are scarce and certainly less pronounced. Still, clustering is a worldwide phenomenon and therefore also exists in the Netherlands (Kloosterman and Lambregts, 2001). In this section we will test the influence of industry related density on firm performance.

Table 4.5 ■ Density of municipality and firm performance

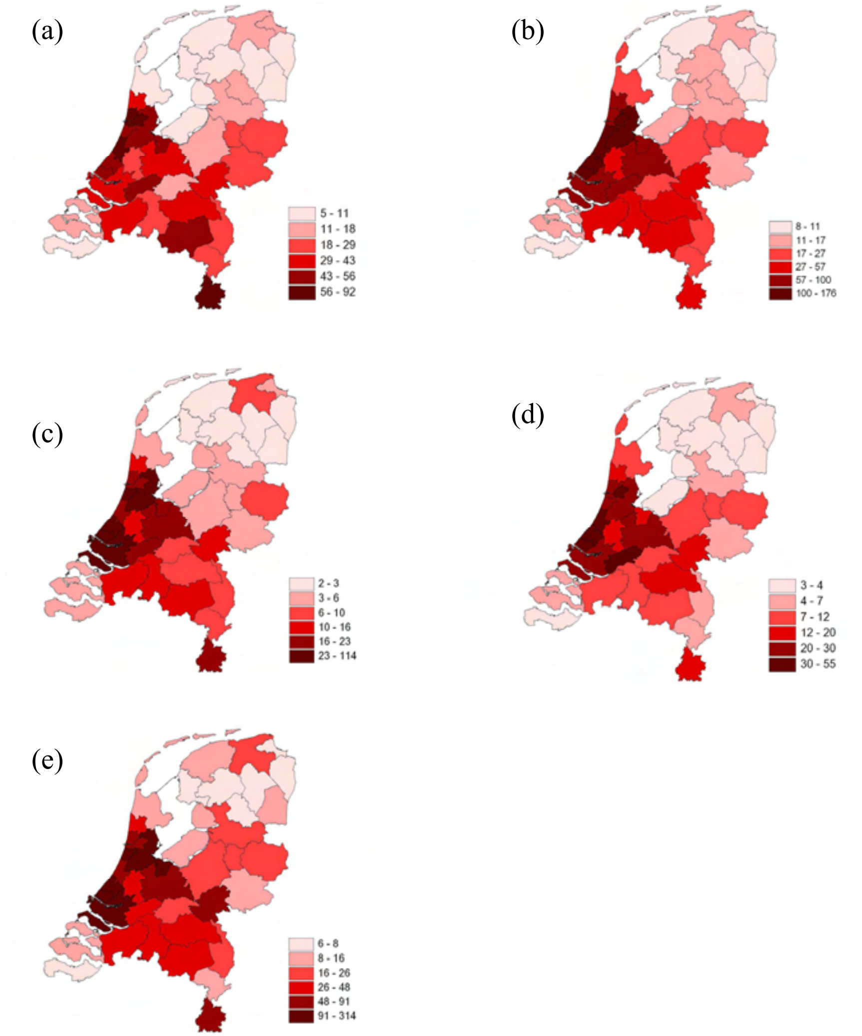
This Table reports the influence of municipality density on firm performance, and tests the model Profitability = $\gamma_0 + \gamma_1$Density + γ_2Size + γ_3Leverage + γ_4Firm age + γ_5Risk + γ_6Industry + ε. Profitability is measured as the average five-year return on assets. Density is the number of employees per km^2, the number of inhabitants per km^2, or the address density. We take the natural logarithm of the density variables. Size is the logarithm of total assets. Leverage is total debt divided by total assets. The variable firm age has a maximum of 20. Risk is measured as the standard deviation of the return on assets over the last five years of the firm's reporting. T-test statistics are based on geographically clustered standard errors and appear in parentheses. ***, **, * indicate significance at the 1%, 5%, and 10% level, respectively.

	Five-year mean ROA		
Employees per km^2	-0.004***		
	(-2.69)		
Inhabitants per km^2		-0.004	
		(-1.21)	
Address density			-0.005
			(-1.24)
Size	0.018***	0.017***	0.017***
	(4.28)	(4.20)	(4.21)
Leverage	-0.080***	-0.080***	-0.080***
	(-7.82)	(-7.71)	(-7.72)
Firm age	0.001	0.001	0.001
	(0.70)	(0.72)	(0.74)
Risk	0.236***	0.237***	0.238***
	(3.55)	(3.56)	(3.59)
Industry dummies	Yes	Yes	Yes
N	3,597	3,597	3,597
R^2	0.060	0.058	0.059

We only estimate our model for industries with more than 150 observations. These industries are 'manufacturing', 'construction', 'wholesale and trade', 'transport, storage and communication', and 'real estate, renting, and business services'. Figure 4.3 shows the dispersion of industry specific employment on a Corop level across the country and displays comparable patterns across industries.

Figure 4.3 ■ Employment density for specific industries

This Figure shows the density of employment for industry classifications in accordance with the statistical Classification of Economic Activities in the European Community, Rev. 1.1 (2002). Employment density is measured as the number of employees per square kilometer, for 40 Corop areas in the Netherlands for different industries. Panel (a) shows information for the 'manufacturing' industry. Panel (b) represents the 'wholesale and trade' industry and Panel (c), (d) and (e) represent the 'transport, storage and communication', 'construction' and 'real estate, renting and business activities' industries respectively. Scales are based on quantiles.



Testing localization effects is not based on relative specialization but on absolute levels of industry specific employment density. Although industry specific employment resembles urbanization patterns to a large extent, some industry specialization differences are visible. All industries show density peaks in the west of the country and in the densely populated southern tip of the Netherlands. The construction industry is most evenly spread across Corop regions while 'real estate, renting and business activities' is the industry with the highest dispersion across the country. Table 4.6 shows the results of our regression analysis.

It can be seen that the relation between industry related density and performance for firms in the 'manufacturing' industry is negative (significant at the 10% level), with a coefficient of -0.017. For the 'construction,''wholesale and trade,' and 'real estate, renting, and business services' industries the coefficients are -0.018, -0.014, and -0.008, respectively. The effect of industry related density on performance is insignificant for the industry of 'transport, storage and communication'. The results are similar on a municipality level (not reported). In general, we can conclude that the negative relation between density and financial performance is apparent for both localization and urbanization issues.

Table 4.6 ■ Industry-related density and firm performance

This Table reports the influence of industry-related density in a Corop area on firm performance, and tests the model Profitability = $\gamma_0 + \gamma_1$Density + γ_2Size + γ_3Leverage + γ_4Firm age + γ_5Risk + ε. Profitability is computed as the five-year average return on assets. Density is the number of industry-specific employees per km^2. We take the natural logarithm of the density variable. Size is the logarithm of total assets. Leverage is total debt divided by total assets. The variable firm age has a maximum of 20. Risk is measured as the standard deviation of the return on assets over the last five years of the firm's reporting. T-test statistics are based on geographically clustered standard errors and appear in parentheses. ***, **, * indicate significance at the 1%, 5%, and 10% level, respectively.

	Five-year mean ROA				
	Manufacturing	Construction	Trade	Transportation	Real estate, renting, and business services
Constant	0.192***	0.153**	0.103***	0.012	0.093***
	(3.55)	(2.12)	(2.80)	(0.18)	(2.92)
Employees per km^2	-0.017*	-0.018**	-0.014**	-0.008	-0.008*
	(-1.98)	(-2.07)	(-2.03)	(-0.73)	(-1.85)
Size	0.003	0.033**	0.021***	0.025**	0.022***
	(0.24)	(2.36)	(3.69)	(2.38)	(3.13)
Leverage	-0.122***	-0.099***	-0.081***	-0.091**	-0.043*
	(-4.99)	(-2.74)	(-4.80)	(-2.54)	(-1.71)
Firm age	0.002	-0.003	0.001	0.003	-0.001
	(1.45)	(-1.35)	(0.99)	(1.25)	(-0.43)
Risk	0.225	0.207**	0.619***	0.781***	0.145
	(1.18)	(2.05)	(7.74)	(2.86)	(1.34)
N	874	395	1,186	184	628
R^2	0.065	0.060	0.153	0.153	0.028

4.6 Robustness Tests

In this section, we will test the robustness of our findings for our measure of profitability, endogeneity issues, and the unequal density of production in an area.

4.6.1 Measures of profitability

Our employed measure of profitability in section 4.5 is the five-year average of the return on assets. The returns on assets are the earnings before interest, taxes and depreciation (ebitda) divided by the total assets at the end of the book-year. We redo our analyses with different measures of profitability. We find that the negative influence of higher density is robust for three-year return on assets and eight-year return on assets. When we select average EBIT as a percentage of total assets our basic results also remain unaltered. We further test for the robustness of our scaling variable. In earlier tests, we scaled profitability by total assets. In a robustness test, we scale by total assets minus fixed assets like buildings and land, as the value of these assets are likely to relate to the density of the location due to a substitution of labor for capital when labor is more expensive. We find that the results remain significant at the same significance levels (although the alternative scaling slightly lowers the t-statistics in our analyses).

4.6.2 Endogeneity

The choice whether to start a company in a high or a low density area might be endogenous. That is, whether or not a firm is founded in a high density area can depend on various characteristics, like the firm's industry. This does not necessarily pose problems for our estimation results. However, when these characteristics also have an effect on the firm's profitability, it does create a bias.

We will estimate a two-stage model in which we control for two effects on whether or not to start-up a firm in a high density area. The first effect we take into account is the firm's industry. The type of industry and location relate, as for some industries specific natural resources have to be present (e.g., mining companies). The second effect is start-up cohorts: over time, the popularity of certain cities, areas, or density levels may have fluctuated. We let a start-up cohort consist of twenty years.

Our model will control for selection bias, based on Heckman's (1979) treatment effect. This self-selection model deals with the possibility that the dependent variable is endogenous beyond the impact of observable characteristics. Firms may self-select into their preferred choice: there can be unobserved characteristics, like the place of residence of a company's founder, that have an effect on where to locate a firm.

We convert our density measure to a binary variable: the dummy 'high density' will equal one for firms in which the Corop's or municipality's number of employees per km^2 is above the median, and zero for locations with below-median employees per km^2.

Table 4.7. Self-selection test

This Table reports the influence of density on firm performance while controlling for self-selection issues. We first estimate a probit model on the choice of settling in a low or high density area. The explanatory variables in this model are industry dummies and start-up cohorts. Then we calculate the inverse Mills ratio. We add this ratio to our basic estimation model Profitability = $\gamma_0 + \gamma_1$Density + γ_2Size + γ_3Leverage + γ_4Firm age + γ_5Risk + γ_6Industry + ε, to control for possible selection bias. Profitability is measured as the average five-year return on assets. 'High density' equals one when the Corop's or municipality's density score for the number of employees per km^2 is above the median, and is zero otherwise. Size is the logarithm of total assets. Leverage is total debt divided by total assets. The variable firm age has a maximum of 20. Risk is measured as the standard deviation of the return on assets over the last five years of the firm's reporting. T-test statistics appear in parentheses. ***, **, * indicate significance at the 1%, 5%, and 10% level, respectively.

	Five-year mean ROA	
	Corop	Municipality
High density	-0.247**	-0.053
	(-2.02)	(-0.46)
Size	0.017***	0.018***
	(4.78)	(5.00)
Leverage	-0.077***	-0.079***
	(-8.48)	(-8.30)
Firm age	0.001	0.001
	(1.36)	(0.95)
Risk	0.265***	0.237***
	(10.63)	(9.19)
Inverse Mills ratio	0.141*	0.026
	(1.87)	(0.36)
Industry dummies	Yes	Yes
N	3,597	3,597

We first estimate a probit model on the choice to start a firm in a high or low density area and then calculate the inverse Mills ratio. This ratio is added to the regression as an additional variable to correct for possible selection bias.

The density dummies in Table 4.7 have a negative sign. Apparently, density and performance are also negatively related when controlling for selection bias. The impact of the density dummy on the Corop level is significant at the 5% level, while at the municipality level it is not. The inverse Mills ratio provides information on self-selection. As this ratio is significant at the 10% level for the Corop estimation, we find some self-selection to be present. We do not find a self-selection bias for our estimations on municipality levels.

The difference between the dummies on a Corop and municipality level is partially due to the construction of the dummies: the municipality dummy equals one when the number of employees per km^2 exceeds 606 (which is the median). In a Corop area the median is only 368. Furthermore, the explanatory power of the density dummies is less than the explanatory power of the density variables in our previous analyses, as converting a variable into a dummy automatically implies a loss of information.

4.6.3 Unequal density of production

Throughout this chapter we have used measures of agglomeration that are scaled by the land area of the Corop or municipality. One potential problem raised by Ciccone (2002), is the assumption of constant production density throughout the geographic areas. This assumption is unrealistic as some areas have large portions of agricultural land combined with dense agglomerations. If the companies in our sample operate in the denser parts of the area, the low average employment density of the overall region could be misleading. To test this effect we estimate the relation between firm performance and agglomeration by using the non-agricultural employment per non-agricultural square kilometer of land area. We only perform the analysis on a Corop level as the impact of agricultural land use on results would be largest for this level of geographic aggregation. Non-agricultural employment is the total employment in the Corop minus the number of employees in farming, forestry, and fishery industries. The measure for non-agricultural land area is the total land area of the Corop region minus land used by companies that earn at least 2/3 of their revenue from agricultural or commercial forestry activities and is provided by the Dutch Central Bureau of Statistics. Our analysis indicates that the proportion of agricultural land varies between 13% and 78% with an average of 54%. The weight of agricultural employment has a range from 0.2% to 8.8% and is on average 1.8%. We replicate the estimation in Table 4.5 for non-agricultural land and employment, and find the results to be relatively similar: a doubling in non-agricultural employment density decreases the average return on assets by 1.5%, which is slightly more than the 1.2% for general urbanization.

4.7 Conclusion

Although the benefits and costs of agglomeration have been widely documented, the tradeoff between these factors is a relatively uncultivated area. In this chapter we study agglomeration effects in the Netherlands. With a detailed database of single-establishment companies, we are able to capture the productivity benefits of agglomeration density: firms that settle in dense areas portrait a higher turnover per employee. We also find the costs of agglomeration to be present in our sample: labor costs per employee and land rents are considerably higher in dense areas.

Our study focuses on combining the costs and benefits into a single measure, which is financial performance. In case the benefits of density overshadow the costs, firms in denser areas should outperform their equivalents in areas with lower density. When the costs of agglomeration are higher than the benefits, we expect firms in regions with lower density to perform better.

We find that the density of an area has a negative effect on firm performance. This effect is more present in Corop regions than in municipalities. We measure urbanization in various ways: employees per km^2, inhabitants per km^2, and address density. The existence of the negative effect turns out to be irrespective of our measurement of density. When testing for localization effects, we find that industry-related density also does not have a positive relation with performance in the Netherlands. For the ‘manufacturing’, ‘construction’, ‘wholesale and trade’, and ‘real estate, renting, and business services’ industries the relation is even significantly negative.

Our findings are particularly interesting in light of a spatial equilibrium. The no arbitrage relationship of firms states that firms must be indifferent over space (Glaeser, 2007). Why would firms still settle in dense cities, given that these locations are negatively related with return on assets? One would expect each firm to settle in an area that provides the most favorable conditions, which creates a spatial equilibrium.

A potential explanation for our results is that circumstances change over time, thereby shifting settlement conditions over time and space. In a changing society the optimal location twenty years ago may not be the optimal location today, while moving costs of firms are certainly not zero as assumed by standard equilibrium models. The cost of living in the largest cities rose sharply with an increase in house prices over the last decades. These changes in house prices push up wage demands in the cities and subsequently increase labor costs for companies in these areas. Given that relocating is costly, temporal disequilibria can exist. Also, others factors, like prestige, might drive location choices. Especially for the relatively small firms in our sample, the preferences of the owners will have an effect on the location choice. An entrepreneur is likely to start his business in a region he is familiar with. In line with Glaeser (2007), it is also likely that entrepreneurs choose their firm's location close to a region in which they would like to live, balancing profitability and the general quality of life.

Another potential explanation for our results is that density is related to risk in a way that is not captured by the industry dummies, earnings variability, and other control variables in our regression specification. A potential lower probability of bankruptcy in dense areas can explain why firms in these areas have lower returns on assets.

A direction for further research is to examine factors that may lead to disequilibria. Also, evidence on countries other than the Netherlands will be important: industry-related density in the Netherlands cannot be compared to various clusters around the world, like Silicon Valley in the U.S.. We do not question the positive effects of these clusters. Furthermore, since our study focuses on firms with a single location, it would be interesting to examine the relation between location density and financial performance for somewhat larger, public firms. As these firms are substantially different in terms of size, scope, and networks, the choice of location encounters many new facets.

Chapter 5
Local Office Rent Dynamics:
A Tale of Ten Cities[31]

5.1 Introduction

Understanding rent dynamics across real estate cycles has been at the heart of the real estate literature ever since Blank and Winnick (1953) provided a simple theoretical framework in which residential rent changes were modeled as a function of vacancy rates. Shilling, Sirmans and Corgell (1987) were among the firsts to apply this model to explain local U.S. office rents, while Wheaton and Torto (1988) estimated the model for the aggregate U.S. office market. In this chapter we use an error correction model in line with Hendershott, MacGregor and White (2002) to model office rents for ten cities across five European countries over the period 1990-2006. We extend existing methodology and findings by examining an international panel of cities, and by incorporating two geographic aggregation levels of economic data. To model changes in real prime office rents we use national economic and employment series and the most detailed local versions of these data available for European cities; the Nuts 3 level which corresponds to *Départements* in France, *Kreise* in Germany, *Corop-regions* in the Netherlands, *Provincias* in Spain, and *Counties* in the U.K..[32] Through the analysis of premier and second ties office market cities in each country we are able to test whether local data availability is more important for smaller cities that make up less of the national aggregate than for the premier office markets of each country.

31 This chapter is based on Brounen and Jennen (forthcoming in the Journal of Real Estate Finance and Economics, 2008). We are grateful to Jones Lang LaSalle, Experian and Agora Data for data support. Furthermore we thank participants in the ARES Annual Meeting 2007 in San Francisco and participants in the ERES Annual Meeting 2007 in London for helpful comments. In particular we thank Pat Hendershott, Bryan MacGregor, an anonymous referee and the editor, C. F. Sirmans for valuable comments on earlier versions of this chapter.

32 Nuts stands for 'Nomenclature of Territorial Units for Statistics' in French. For a fuller discussion of spatial aggregation definitions in Europe we like to refer to Ciccone (2002).

The concentration of office centers of variable size and importance in various countries within a relatively small geographical area makes the exploration of return determinants for European office markets, as executed in this study, an interesting case. To facilitate the analysis of the local nature of the markets we selected the primary and a secondary office market for; the United Kingdom, Spain, Germany, France, and The Netherlands. Based on this selection we constructed a dataset consisting of London and Glasgow; Madrid and Barcelona; Frankfurt and Düsseldorf; Paris and Lyon; and Amsterdam and Rotterdam. During our sample period the average correlation between real prime rent changes of pairs of first and second tier office cities within one country equals only 0.36. Hence, there is little reason, *a priori*, to expect that national economic growth figures are accurate for modeling changes in real prime rents given that changes in this variable differ strongly between cities within one country.

Results of a two stage error correction model indicate that office rents adjust to short-run changes in office related economic activity, lagged changes in rents, and to the deviation of rents from their long-run values. We vary the definition of office related economic activity using service employment and GDP, but find only marginal differences in model performance. Furthermore, our results offer no proof that ECM models for office rents improve significantly by specifying economic growth figures beyond the national aggregated level. Office markets of large cities are driven by economic developments that reach beyond city boundaries due to the concentration of (inter)national conglomerates in large cities, so it is no direct surprise that changes in GDP on a local level do not perform better in explaining local office rents. However, this would not hold for employment figures. Service sector employment on a local level should influence local demand for office space and therefore changes in office rents. However, due to the high correlation between local and national level changes in service sector employment we find no significant differences in model fit.

The remainder of the chapter continues as follows. Section 2 discusses relevant literature and the methodology we use in the analysis. Section 3 presents the data. In section 4 we discuss the findings. Section 5 concludes.

5.2 Modeling Office Rents

Over the last two decades numerous contributions provided valuable new insights into the determinants of office rents. However, the vast majority of these studies links local office rents to excess vacancy levels or national aggregated economic data and only a small portion of this literature looks outside the U.S.. A focus on national aggregated data is surprising given that office markets are considered local. This local focus is due to the high proportion of office use which is derived from local demand (Hanink, 1996). A model based on aggregate data provides an accurate picture of the determinants of office returns only if all variables move in the same direction for each of the individual local markets. Early work by Hekman (1985) showed that office rents adjust in response to both local and national economic conditions which makes office studies based on national data potentially inaccurate. This is due to a shift / share problem in which the shift component is related to different compositions of employment sectors across cities and unequal growth rates of these sectors within cities. The share component is a result of different growth rates of cities themselves (Hekman, 1985). We overcome this pivotal problem by employing a dataset which includes disaggregated, or local, variables to study local office markets and compare results with models based on national economic data.

Office rent literature has evolved differently across continents. The U.S. office literature focuses on vacancy rates and models office rents as a function of deviations from the natural vacancy rate that is required to clear the market. Wheaton and Torto (1988) use U.S. national time series data on office rents and vacancy rates and find that excess vacancy rates affect real rents, while the natural vacancy rate is influenced by variables such as the local tenant structure, average lease terms in the market, expected absorption rates and operating costs. Hendershott (1996), in a study of the Sydney office market, introduced a more general rent adjustment model in which changes in real rents are a function of vacancy and rent deviations from equilibrium levels. *Eq.* (5.1) shows the basic form of this type of real estate rent modeling:

$$\%\Delta R_t = \alpha\left(v_t^* - v_{t-1}\right) + \beta\left(R_t^* - R_{t-1}\right) \tag{5.1}$$

where v_t^* is the estimated natural vacancy rate, v_{t-1} the lagged vacancy rate, R_t^* the time-varying equilibrium real office rent, and R_{t-1} the lagged rent level. R_t^* is a function of the depreciation rate, operating expenses, the real risk free interest rate, the risk premium and real replacement costs. Estimates for Sydney (Hendershott, 1996) and London (Hendershott, Lizieri and Matysiak, 1999) show that the determinants of R^* can differ substantially across markets. The applicability of office rent models in line with *Eq.* (5.1) for our study of European cities is limited due to the relative subjective determination of the variables that constitute R^*. McDonald (2002) applies an alternative rent equation on the data from the Hendershott, Lizieri and Matysiak (1999) study. The model is based on McDonald (2000) and includes separate equations for demand for occupied space and demand for vacant space. Demand for occupied space (*Q)* is:

$$Q_t = Q_0 - b_1 R_t + b_2 E_t \tag{5.2}$$

where Q is a function of rent per square foot (R) and a measure for office employment (E). The demand for vacant space is a positive function of mobility in the market and negatively influenced by the office rent level. At a given level of mobility of office employment in the market the demand for vacant space (V) equals:

$$V_t = V_0 - \beta R_t \tag{5.3}$$

Rearranging *Eqs.* (5.2) and (5.3) and solving for R leads to a reduced form equilibrium rent equation where rent is a function of office employment, the total stock of space (S)[33] and the parameters shown in *Eqs.* (5.2) and (5.3).

$$R_t = \frac{(Q_0 + V_0)}{(\beta + b_1)} + \frac{b_2}{(\beta + b_1)} E_t - \frac{1}{(\beta + b_1)} S_t \tag{5.4}$$

McDonald (2002) finds that equilibrium rent is a positive function of the level of employment in office occupying industries and a negative function of stock of space.

While U.S. researchers have been building upon a long history of office vacancy and rental data, European office market research has generally been hindered by data availability constraints. In particular the unavailability of supply side variables directed European research towards reduced form equations, and tests of a wide array of possible office rent determinants. The general model specification for reduced form models as applied in European office markets typically includes a vector of economic demand side variables in combination with, where available, a vector of real estate supply side variables. Widely used demand side variables are changes in GDP, service sector employment, lagged short-term interest rates and unemployment rates. One of the earliest works in this respect is Giussani, Hsia and Tsolacos (1992) who studied ten European cities and use a model consisting of demand side variables over a nine year period starting in 1983. Although the influence of supply side variables on changes in office rents is acknowledged, actual inclusion is left out of the analysis due to data constraints. D'Arcy, McGough and Tsolacos (1997) study office rent changes of 22 European cities over the period 1982-1994 and use changes in national GDP and short-term interest rates as explanatory variables. Extensions of the model with office market size and measures of economic growth and change in the local economy did not provide additional insights. Advances in data availability for European commercial real estate have allowed for the inclusion of supply side variables in office market research. D'Arcy, McGough and Tsolacos (1999) use GDP, service sector employment and stock of office floor space for the Dublin office market during

[33] Total stock of office space (S) equals per definition demand for occupied space (Q) plus demand for vacant space (V).

the 1970-1997 period and find that changes in real GDP lagged one period and changes in the stock of office space lagged three periods are the key determinants of changes in rental values. De Wit and van Dijk (2003) study determinants of direct office investment returns for 46 major office districts across Asia, Europe and the United states. Demand side variables included in their panel data model are changes in GDP/GMP, unemployment rates, and inflation. Supply side variables are change in office stock and change in vacancy rates.

Hendershott, MacGregor and Tse (2002) and Hendershott, MacGregor and White (2002) elegantly combine the two continental strands of office literature in an Error Correction Model (ECM). In this study we apply this methodology for a panel of international cities of different importance to the national economy and apply both national and local economic activity variables. The inclusion of premier and secondary office cities and application of national and the most detailed local data allows for a test of the shift-share issue in European office market research. The model is derived as a reduced-form estimation equation for the occupied office space and does not require estimates for variables such as depreciation rates and operating expenses. Demand for space (*D*) is modeled as a function of real effective rent (*R*) and a measure for office demand related economic activity (*EA*):[34]

$$D = \lambda_0 R^{\lambda_1} EA^{\lambda_2} \tag{5.5}$$

where the λ_i's are constants with the price elasticity, λ_1, expected to be negative and λ_2, the income elasticity, positive. Demand for office space is a function of *R* and *EA* as in *Eq.* (5.5) and equals the product of available office space (*SU*) and one minus the prevailing office vacancy rate (*v*):

$$D(R, EA) = (1 - v)SU \tag{5.6}$$

Eq. (5.6) shows that real estate markets clear towards equilibrium through changes in rents and vacancy levels. Including contemporaneous vacancy rates in the rent equation leads to misspecification as vacancy rates are not exogenous in the equilibrium rent model. For this reason we use a separate equation to model the vacancy rate which subsequently enters the error correction model as a fitted variable $\hat{v}$. We model vacancy rates with a simple autoregression model analogous to Grenadier (1995). After testing different autoregression functions we find that an AR(2) model provided the best fit for the ten cities that form the basis of our study.

[34] Demand for office space, as demonstrated by the European office modeling strand, is influenced by changes in economic factors such as GDP, value added for office related industries and employment in office occupying industries.

Adjusted R^2 for the ten cities included in our analysis of the AR(2) model over the period 1990-2006 range from 0.54 to 0.87 with an average of 0.75.

Rearranging *Eqs.* (5.5) and (5.6) by logarithmic transformation, including fitted vacancy rates, and solving for real rent levels results in the long run rent specification identified in *Eq.* (5.7):

$$\ln R_t = \gamma_0 + \gamma_1 \ln EA_t + \gamma_2 \ln\left[(1-\hat{v}_t) * SU_t\right] + u_t \tag{5.7}$$

Economic activity is proxied in the literature with variables such as retail sales and consumer expenditure for retail space while demand for office space was modeled with value added of office related industries, finance, insurance and real estate employment, and general GDP. Inclusion of different economic activity measures in a single equation is prone to multicollinearity issues leading to insignificant coefficients in multiple regression analysis (see for example Giussani, Hsia and Tsolacos 1992; Gordon, Mosbaugh and Canter, 1996; and de Wit and van Dijk, 2003).[35] Supply side variables in *Eq.* (5.7) are less frequent in empirical research for European real estate due to limited attention from local professionals for gathering supply side data. Hendershott, MacGregor and Tse (2002) include a supply side variable in their model of the London office market but find insignificant results for changes in office supply. Similar results were found in the Hendershott, MacGregor and White (2002) paper for a panel of regions in the U.K. excluding London. Hendershott, MacGregor and White (2002), lacking data on vacancy rates, use an alternative specification of *Eq.* (5.7). In this equation the effect of vacancy rates on equilibrium rent levels is embedded in the error term resulting in a rent specification analogous to the specification in McDonald (2000, 2002) where rent is a function of employment and office supply.

The ECM we use to model changes in real prime rents in a panel data approach estimates long-run equilibrium relationships and short-term corrections. Due to frictions, as already indicated by Wheaton (1987) in a study of the cyclic behavior of the U.S. office market, office markets usually do not clear within short-run periods of time. We measure this imbalance as the residual of *Eq.* (5.7) and subsequently use the residual as a factor in the short-run model. The rationale behind this inclusion is that the residual reflects the disequilibrium in the market and that disequilibria in office markets are leveled during consecutive periods.

The disequilibrium measure can be used in the short-run model only if the trending variables used in *Eq.* (5.7) are cointegrated. Cointegration is present if the

[35] Inclusion of principal component analysis (PCA) with orthogonalized variables overcomes the multicollinearity issue but limits the insight in rent drivers as the true nature of the principal components is unclear.

residuals of a function of the level data are stationary. We test for a unit root, and subsequent non-stationarity in the error term, with a Levin, Lin and Chu (2002) test. Taking differences of *Eq.* (5.7), excluding the residual, and adding the lagged residual, leads to the short-run rent adjustment model as depicted in *Eq.* (5.8) with an added lagged dependent variable to allow for the autoregression present in the change in real rent series.[36]

$$\begin{aligned}\Delta \ln R_t &= \alpha_0 + \alpha_1 \Delta \ln EA_t + \alpha_2 \Delta \ln[(1-\hat{v}_t) * SU_t] \\ &\quad + \alpha_3 u_{t-1} + \alpha_4 \Delta \ln R_{t-1} + \varepsilon\end{aligned} \tag{5.8}$$

According to *Eq.* (5.8) office rents react to short-run changes in causal variables, lagged residuals of the long-run model, as a reflection of market imbalances and lagged changes in office rents.[37]

5.3 European Office Market Data

With the exception of London, research on European office markets has always been hampered by availability of proper property data. Fortunately, as time progressed databases grew, enabling international research projects to uncover the driving forces behind European commercial property dynamics. The data we apply in this study includes annual office market data offered by Jones Lang LaSalle dating back to 1990. Our dataset covers prime rents, existing stock of office space, and vacancy rates for the two most important office cities from five different countries. Prime office rents represent the top open-market rent that could be expected for a notional office unit of the highest quality and specification in the best location in a market, as at the survey date. The rent quoted normally reflects prime units of over 500 m² of lettable floor space, which excludes rents that represent a premium level paid for a small quantity of space. The prime rents reflect an occupational lease that is standard for the local market. It is a face rent, that does not reflect the financial impact of tenant incentives, and excludes service charges and local taxes. It represents Jones Lang LaSalle's market view and is based on an analysis/review of actual transactions for prime office space, excluding any unrepresentative deals. Where an insufficient number of deals

[36] A regression of rent changes for all cities on one period lagged rent changes results in a coefficient of 0.32 which is significant at the 1% level.

[37] Modeling results lead to expectations that $\alpha 0$ equals zero, α_1 and α_4 are positive, and α_2, and α_3 are negative. α_3 indicates the speed of adjustment towards equilibrium. If α_3 equals -1 there is full equilibrium restoration after one period while α_3 between zero and -1 or larger than -1 indicate partial- and over- adjustment respectively.

have been made for prime office space, an assessment of rental value is provided by reference to transactions generally in that market adjusted accordingly to equate to prime. The selection of countries is driven by data availability and city suitability. Office markets that are clearly driven by public sector employment such as Brussels in Belgium, which exhibits a strong European Union impact, and The Hague, as the government residence of the Netherlands, were excluded. We only include countries that offer us full data coverage for both the office market and economic parameters and that enable a premier and secondary city analysis. The premier office markets from the countries included in our study are London, Madrid, Frankfurt, Paris, and Amsterdam. The selection of second tier office market is based on the criterion that the office markets are large enough to house substantial office occupying corporations and to be covered by our databases, but are at the same time less important and sizeable than the aforementioned primary markets. In Table 5.1 we show that the set of secondary office cities consists of Glasgow, Barcelona, Düsseldorf, Lyon, and Rotterdam.

From the statistics of Table 5.1 we can clearly see that the key office markets in all five countries are considerably larger than their second tier counterparts.[38] The smallest geographic area for which economic data are available in Spain is based on *provincias* and is considerably larger than Nuts 3 regions in other countries. The economic center of each *provincia* is, however, the city on which we base our analysis.

[38] Due to differences in definitions for local markets between Nuts 3 areas, which are defined by national authorities and office markets, as determined by Jones Lang LaSalle, it is not feasible to compare local office market densities.

Table 5.1 ■ Office Market Statistics

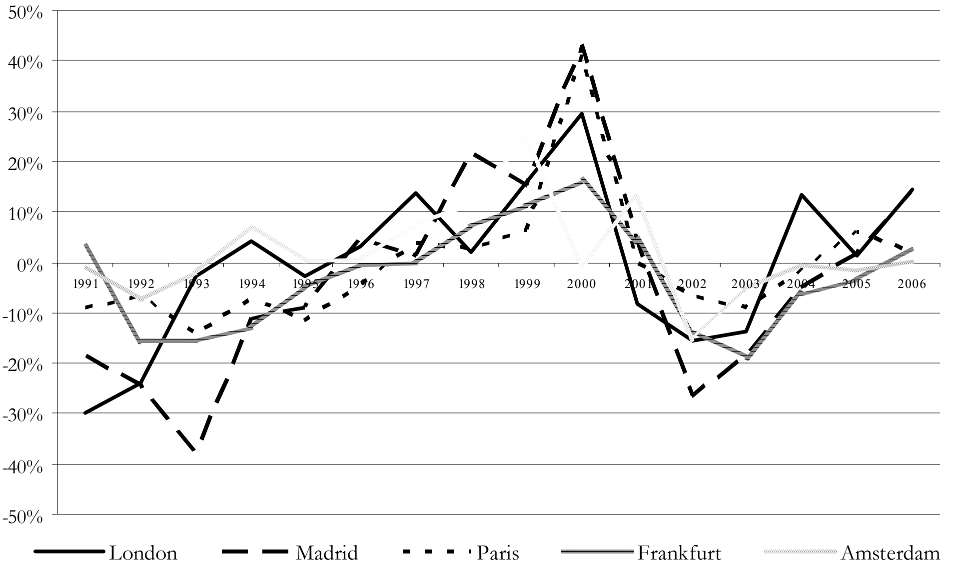
This Table shows statistics on population and land area totals for the countries and cities included in the study in 2006. Population is measured as the number of inhabitants in '000s. Land area is in square kilometers and excludes inland waters. Nuts 3 name is the official name of the region according to EuroStat classification of geographic areas. Office space is in square meters and '000s and based on geographic areas as defined by Jones Lang LaSalle.

Country	Population	Land Area	City	Nuts 3 name	Population	Land Area	Office Space
United Kingdom	60,284	243,820	London	Inner London	3,001	321	19,333
			Glasgow	Glasgow City	569	175	1,445
Spain	43,807	505,997	Madrid	Madrid	5,984	8,028	13,743
			Barcelona	Barcelona	5,140	7,729	5,038
Germany	82,642	357,030	Frankfurt	Frankfurt am Main, Kreisfreie Stadt	650	248	11,610
			Düsseldorf	Düsseldorf, Kreisfreie Stadt	572	217	8,447
France	60,850	543,965	Paris	Paris	2,149	105	49,125
			Lyon	Rhône	1,656	3,249	4,314
The Netherlands	16,426	33,938	Amsterdam	Groot-Amsterdam	1,214	732	6,987
			Rotterdam	Groot-Rijnmond	1,368	1,188	3,685

The dependent variable in this study is changes in real prime rents. Prime rents are for the better quality central office space and as such do not always reflect changes for the overall office market although Class A offices make up a large share of office space in major cities. In line with Hendershott, Lizieri and Matysiak (1999) we use the GDP deflator to transform nominal changes into real prime rent changes. Figure 5.1 presents the history of our dependent variable over the study period for the premier tier cities.

Figure 5.1 ■ Changes in real prime office rents (premier tier cities)

This Figure shows annual percentage changes in real prime rent levels for the largest office markets per country included in the study over the period 1991-2006. Nominal rents are converted to real rents with the GDP deflator.



The prime office markets in Europe underwent a full cycle over the period 1991-2006 with overall a reduction in rent decreases over the period 1992-1996, increasing rents over the period 1996-2001 and decreasing rents in the period 2002-2004 with mixed positive changes during the last years. Table 5.2 presents summary statistics of variables shown in Figure 5.1 where the values in parentheses indicate the year in which the respective minimum or maximum prime rent change was achieved. Table 5.2 shows that the heydays of European office markets took place around the Dotcom boom of the years preceding the change of the millennium. Amsterdam is the only market with positive average real rent changes and Madrid is the city that combines the largest average drop with the highest volatility although much of the decrease was established during the first three years of the sample.

Table 5.2 ■ Statistics of real prime rent changes premier tier cities

This Table shows summary statistics for changes in real prime rents for the largest office markets per country in our sample. The largest negative change is indicated with Min and the largest positive change is indicated with Max. The numbers in parentheses shows the year in which the Min and Max per office market occurred. Average indicates the mean change in real prime rent over the sample period and St. Dev. shows the annual standard deviation of changes in real prime rents.

	London	Madrid	Paris	Frankfurt	Amsterdam
Min	-35.28%	-47.69%	-15.38%	-20.73%	-16.90%
	(1991)	(1993)	(1993)	(2003)	(2002)
Max	25.77%	35.72%	34.47%	14.91%	21.66%
	(2000)	(2000)	(2000)	(2000)	(1999)
Average	-1.17%	-4.95%	-1.23%	-3.60%	1.50%
St. Dev.	16.33%	21.21%	11.57%	10.66%	8.86%

The second tier office markets shown in Figure 5.2 and Table 5.3 display a pattern comparable to the larger cities but with less volatility. Again it is the Spanish city that exhibits the largest average drop in real rents; a direct resultant of changes during the first five years covered and high inflation. Although contemporaneous correlations indicate low similarities between markets, Figure 5.1 and Figure 5.2 indicate a pattern of rent changes that shows peaks and troughs of prime rent changes within two years across cities following developments in the broader economy.

Figure 5.2 ■ Changes in real prime office rents (second tier cities)

This Figure shows annual percentage changes in real prime rent levels for the second largest office markets per country included in the study over the period 1991-2006. Nominal rents are converted to real rents with the GDP deflator.

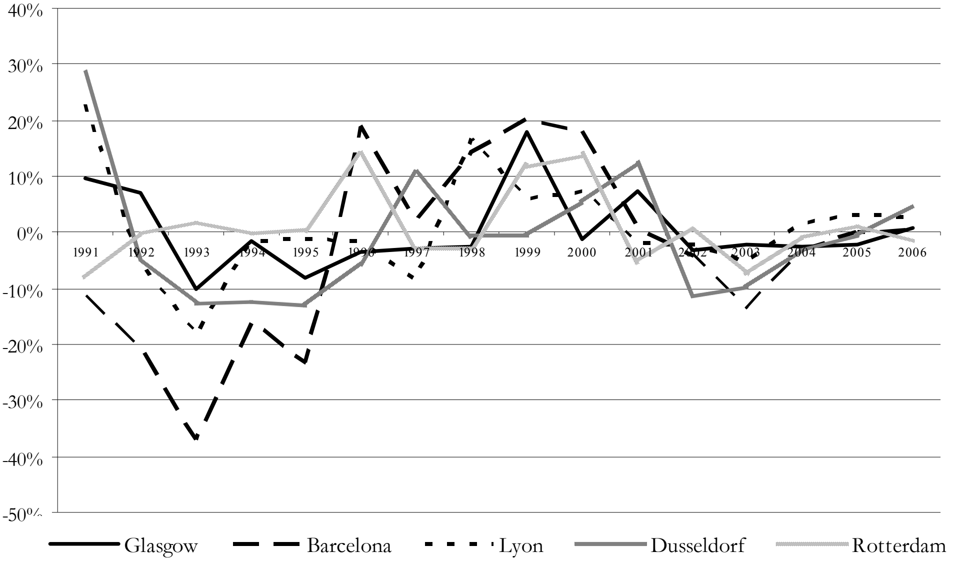


Table 5.3 ■ Statistics of real prime rent changes second tier cities

This Table shows summary statistics changes in real prime rents for the second largest office market per country in our sample. The largest negative change is indicated with Min and the largest positive change is indicated with Max. The numbers in parentheses shows the year in which the Min and Max per office market occurred. Average indicates the mean change in real prime rent over the sample period and St. Dev. shows the annual standard deviation of changes in real prime rents.

	Glasgow	Barcelona	Lyon	Düsseldorf	Rotterdam
Min	-10.75%	-46.25%	-20.36%	-13.88%	-8.54%
	(1993)	(1993)	(1993)	(1995)	(1991)
Max	16.40%	18.33%	20.47%	24.97%	12.73%
	(1999)	(1999)	(1991)	(1991)	(2000)
Average	-0.07%	-4.91%	0.44%	-1.41%	0.66%
St. Dev.	6.81%	17.81%	9.40%	10.80%	6.44%

The weight of full time equivalent employment in office occupying services industries as a percentage of total employment is on average 72 percent on a national level whereas the premier and second tier office cities shows weights of 87 and 78 percent respectively. The weight of GDP in the national aggregate is on average 11 percent for the premier cities and 6 percent for the secondary office markets while their weight in total population is 6 and 5 percent respectively. This clearly illustrates the dominant position the premier office cities take within their respective national economies. The premier tier cities included in our study, being the financial hearts of the countries, house a large number of (inter)national headquarters which makes them mostly vulnerable to economic shocks on the macro level. Second tier cities with more local based companies are expected to exhibit more relation with local economic changes.

Table 5.4 displays values of dependent and independent variables included in our analysis for the years 1991 and 2006 and some summary statistics over the sample period.

Table 5.4 ■ Summary statistics economic variables

This Table shows summary statistics for the variables included in the analysis where all nominal values have been converted to real values with a GDP deflator. Real prime rent indicates the rent per square meter in Euros (expect for London and Glasgow where rent levels are in Pounds). The office stock reports the total area of office space in thousands of square meters within the local office market as defined by Jones Lang LaSalle. Vacancy rate reflects local vacant office space as a percentage of office stock. Serv. Industry FTE national is the number of full time equivalent employees occupied in service industry within the country. Serv. Industry FTE local reflects the same information on a local (Nuts 3) level. Real GDP national is the national gross domestic product in local currencies (*mln). Real GDP local shows the same information on a local level. 1991 indicates the level of variables in the year 1991. 2006 indicates the level of variables in the year 2006. Average indicates the average level of the variable over the period 1991-2006. Average Δ shows the average annual change over the period 1991-2006. St dev Δ shows the standard deviation of annual changes over the period 1991-2006.

Paris

	Real prime rent	Office stock	Vacancy rate	Serv. Industry FTE national	Serv. Industry FTE local	Real GDP national	Real GDP local
1991	625	37,658	4%	14,192	1,457	1,170,254	128,280
2006	564	49,125	5%	16,802	1,448	1,232,447	120,394
Average	525	43,279	6%	15,273	1,426	1,198,672	124,085
Average Δ	-1.2%	2.0%	2.2%	1.1%	-0.1%	0.3%	-0.6%
St dev Δ	11.6%	1.4%	31.1%	1.0%	1.8%	1.7%	2.3%

Lyon

	Real prime rent	Office stock	Vacancy rate	Serv. Industry FTE national	Serv. Industry FTE local	Real GDP national	Real GDP local
1991	187	3,250	8%	14,192	451	1,170,254	38,106
2006	164	4,314	6%	16,802	528	1,232,447	42,753
Average	155	3,773	6%	15,273	480	1,198,672	40,027
Average Δ	0.4%	2.3%	2.7%	1.1%	0.9%	0.3%	0.6%
St dev Δ	9.4%	2.8%	26.9%	1.0%	1.5%	1.7%	2.2%

Frankfurt

	Real prime rent	Office stock	Vacancy rate	Serv. Industry FTE national	Serv. Industry FTE local	Real GDP national	Real GDP local
1991	535	7,500	2%	20,326	402	1,628,371	35,048
2006	293	11,610	17%	23,229	452	1,657,370	35,047
Average	373	9,497	8%	21,960	422	1,593,047	34,387
Average Δ	-3.6%	2.7%	13.6%	0.9%	0.8%	0.1%	0.0%
St dev Δ	10.7%	1.9%	48.6%	0.8%	1.8%	2.0%	3.0%

Dusseldorf

	Real prime rent	Office stock	Vacancy rate	Serv. Industry FTE national	Serv. Industry FTE local	Real GDP national	Real GDP local
1991	315	4,690	1%	20,326	299	1,628,371	27,658
2006	196	8,447	12%	23,229	330	1,657,370	27,741
Average	223	6,640	6%	21,960	315	1,593,047	27,012
Average Δ	-1.4%	4.1%	16.3%	0.9%	0.7%	0.1%	0.0%
St dev Δ	10.8%	4.8%	31.6%	0.8%	1.5%	2.0%	2.3%

Table 5.4 ■ Summary statistics economic variables (continued)

London

	Real prime rent	Office stock	Vacancy rate	Serv. Industry FTE national	Serv. Industry FTE local	Real GDP national	Real GDP local
1991	492	17,402	14%	15,877	1,704	1,022,519	113,533
2006	580	19,333	6%	19,684	2,114	1,031,684	119,672
Average	486	18,085	9%	17,451	1,892	1,025,067	116,815
Average Δ	-1.2%	1.0%	-2.5%	1.3%	1.0%	-0.5%	-0.4%
St dev Δ	16.3%	1.6%	34.2%	1.2%	2.8%	2.6%	4.1%

Glasgow

	Real prime rent	Office stock	Vacancy rate	Serv. Industry FTE national	Serv. Industry FTE local	Real GDP national	Real GDP local
1991	183	1,455	11%	15,877	243	1,022,519	14,438
2006	165	1,445	6%	19,684	302	1,031,684	13,776
Average	168	1,446	8%	17,451	266	1,025,067	13,813
Average Δ	-0.1%	0.0%	-0.1%	1.3%	1.4%	-0.5%	-0.9%
St dev Δ	6.8%	1.3%	28.0%	1.2%	2.2%	2.6%	3.1%

Madrid

	Real prime rent	Office stock	Vacancy rate	Serv. Industry FTE national	Serv. Industry FTE local	Real GDP national	Real GDP local
1991	339	9,574	4%	8,823	1,679	577,603	99,761
2006	188	13,743	5%	12,315	2,382	497,953	88,391
Average	208	11,461	6%	9,946	1,904	519,421	91,002
Average Δ	-4.9%	2.4%	1.3%	2.3%	2.4%	-1.2%	-1.1%
St dev Δ	21.2%	1.7%	48.7%	1.5%	1.6%	2.5%	2.6%

Barcelona

	Real prime rent	Office stock	Vacancy rate	Serv. Industry FTE national	Serv. Industry FTE local	Real GDP national	Real GDP local
1991	287	3,520	5%	8,823	1,118	577,603	82,826
2006	148	5,038	5%	12,315	1,604	497,953	69,542
Average	167	4,328	6%	9,946	1,285	519,421	74,452
Average Δ	-4.9%	2.4%	-0.1%	2.3%	2.5%	-1.2%	-1.3%
St dev Δ	17.8%	1.5%	37.6%	1.5%	1.5%	2.5%	2.3%

Amsterdam

	Real prime rent	Office stock	Vacancy rate	Serv. Industry FTE national	Serv. Industry FTE local	Real GDP national	Real GDP local
1991	198	5,053	6%	3,713	476	320,548	34,158
2006	254	6,987	17%	4,479	552	359,661	41,254
Average	235	5,856	8%	4,197	519	347,412	37,963
Average Δ	1.5%	2.5%	6.3%	1.3%	1.1%	0.7%	1.2%
St dev Δ	8.9%	1.9%	34.8%	1.6%	2.7%	4.2%	4.3%

Rotterdam

	Real prime rent	Office stock	Vacancy rate	Serv. Industry FTE national	Serv. Industry FTE local	Real GDP national	Real GDP local
1991	121	2,915	9%	3,713	348	320,548	29,082
2006	146	3,685	8%	4,479	410	359,661	30,672
Average	139	3,315	7%	4,197	386	347,412	30,116
Average Δ	0.7%	1.7%	0.1%	1.3%	1.2%	0.7%	0.3%
St dev Δ	6.4%	1.6%	23.0%	1.6%	1.9%	4.2%	4.2%

The summary statistics show that large cities are generally more volatile than their smaller counterparts on a country by country basis. Changes in real prime rents and vacancy rates are nine out of ten times more volatile in the largest city of the country. For the economic variables changes in service sector employment and real GDP we observe the larger cities are for each pair more volatile than their smaller counterparts although differences can be small. We show that over the sample period real GDP (constant 2002 PPS) increased in four out of five countries while the same holds for only half of the cities. Like the office stock, service sector employment grew in nine out of ten cities between 1991 and 2006.

An overview of the correlations of the variables used in this chapter is provided in Table 5.5 and shows that correlations, for all cities within the tier, and years combined, between national and local economic variables are high and statistically significant at the 1% level. One of the most striking results in Table 5.5 is the high correlation between national and local economic figures for both tiers of cities included in our analysis. A possible explanation for this finding is that the cities included in our sample constitute a large weight in the national aggregates and are therefore naturally linked to the aggregate figure. Despite the inclusion of second tier cities, with by definition smaller economies than the premier cities, we do not find that these cities are less correlated with the national aggregate. Furthermore, the most detailed regional data available for Europe are on a Nuts 3 level which, for some cities, can still include a large area of land and large number of inhabitants. This sometimes limited level of detail naturally limits discrepancies between national and local data. While the correlation between changes in real prime rent and dependent variables is strong and significant for the premier tier cities this is far less present in Panel B. Further analysis on a city level reveals that this result is not based on outliers but consistent for the majority of cities within the tier.

Table 5.5 ■ Cross-correlations among real estate and economic variables

This Table shows correlations between changes in real prime rents [indicated as (1)] and real estate supply and demand [(2) and (3)] variables and indicators of economic growth traditionally related to changes on office markets on a national [(4) and (6)]; and on a local [(5) and (7)] level. *Panel a* shows figures for the premier tier cities; *Panel b* for the second tier cities. **, * indicates that correlation is significant at 0.01, 0.05 level (2-tailed) respectively.

Panel a

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Δ Real prime rent (1)	1.00	-0.43**	-0.60**	0.53**	0.51**	0.68**	0.70**
Δ Total stock (2)	-0.43**	1.00	0.52**	-0.28*	-0.23*	-0.35**	-0.36**
Δ Vacancy rate (3)	-0.60**	0.52**	1.00	-0.38**	-0.34**	-0.41**	-0.44**
Δ Service sector employment (national) (4)	0.53**	-0.28*	-0.38**	1.00	0.79**	0.41**	0.45**
Δ Service sector employment (local) (5)	0.51**	-0.23*	-0.34**	0.79**	1.00	0.37**	0.53**
Δ Real GDP (national) (6)	0.68**	-0.35**	-0.41**	0.41**	0.37**	1.00	0.90**
Δ Real GDP (local) (7)	0.70**	-0.36**	-0.44**	0.45**	0.53**	0.90**	1.00

Panel b

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Δ Real prime rent (1)	1.00	-0.05	-0.22	0.37**	0.25	0.41**	0.38**
Δ Total stock (2)	-0.05	1.00	0.19	-0.13	-0.27*	-0.07	-0.08
Δ Vacancy rate (3)	-0.22	0.19	1.00	-0.37**	-0.25*	-0.43**	-0.45**
Δ Service sector employment (national) (4)	0.37**	-0.13	-0.37**	1.00	0.76**	0.46**	0.41**
Δ Service sector employment (local) (5)	0.25	-0.27*	-0.25*	0.76**	1.00	0.20	0.28*
Δ Real GDP (national) (6)	0.41**	-0.07	-0.43**	0.46**	0.20	1.00	0.93**
Δ Real GDP (local) (7)	0.38**	-0.08	-0.45**	0.41**	0.28*	0.93**	1.00

5.4 Regression Results

In this section we present the results for the two stage error correction model for changes in prime office rents. Given our *a priori* hypothesis that second tier cities gain most by modeling office rents on local data we present the analysis in two separate sections; Table 5.6 displays the results for the large cities and Table 5.7 for the second tier cities. The top panels of both tables display the results for the long run model based on level data which is used to calculate the difference between the existing rent level and the rent level that is expected based on long run relations between dependent and independent variables. The estimation process is performed twice based on two levels of geographic aggregation. The first two columns show the results for economic data on an aggregate national level and the last two columns for data on a local, Nuts 3, level. We further differentiate for the type of economic data included in the analysis; Model 1 in columns one and three show the results when we use employment in service industries on a full time equivalent basis as the measure for economic activity and Model 2 in columns two and four display results for a real GDP based analysis.

Results show that the long run model has an adjusted R-squared of approximately 0.85 for all specifications of the model and Durbin Watson coefficients considerably below unity. These results are comparable to the findings of Hendershott, MacGregor and White (2002) and are a direct result of the trending variables used in the long-run model. From the top panel of Table 5.6 we derive that the implied price and income elasticity, λ_1 and λ_2 of *Eq.* (5.5), as $1/\gamma_2$ and $-\gamma_1/\gamma_2$ for the model based on national data are -2.91 and 4.44, respectively, for the model including service industry employment as the economic activity variable[39]. Hence, if rents increase with ten percent we expect that demand declines with 29.1 percent, and by the same token if employment in service industry would rise with 10 percent we expect demand for office supply to increase with 44.4 percent.

[39] Elasticities for the model based on local economic data are comparable in sign and magnitude. Unfortunately the coefficient for the supply and vacancy variables as included in our long term model are highly insignificant which casts doubts on the usability of elasticity measures.

Table 5.6 ■ ECM results for premier tier office markets

This Table reports the error correction model of office rents for the five largest office markets per country included in our database. The long-run model $lnR_t = \alpha_0 + \alpha_1 lnEA_t + \alpha_2 ln[(1 - v\hat{}_t)OS_t] + u_t$ is estimated as a cross section fixed effect model. The dependent variable is real prime rent. Economic activity (EA) is estimated with two different specifications. Model 1 shows the results of the test when EA is estimated as FTE employment in the service industry. Model 2 shows results for EA estimated as GDP. v^ is the fitted vacancy rate as determined with an AR(2) model. OS is the stock of office floor space in square meters. The short-run model $\Delta lnR_t = \alpha_0 + \alpha_1 \Delta lnEA_t + \alpha_2 \Delta ln[(1 - v\hat{}_t)OS_t] + \alpha_4 u_{t-1} + \alpha_5 \Delta lnR_{t-1} + \varepsilon_t$ is estimated as a cross section fixed effect model. Δ measures the one period change in variables. u_{t-1} is the one period lagged residual of the long-run model and used as the error correction term in the short run model. ΔlnR_{t-1} is the one period lagged change in real prime rents. The long-run and short-run models are estimated on two levels of geographic aggregation indicated as "National" and "Local". Choice of geographic aggregation influences the measure of EA being either on a national or local level. DW is the Durbin-Watson statistic. Standard error statistics appear in parentheses. ***, **, * indicate significance at the 1%, 5% and 10% level respectively.

	National		Local	
	Model 1	Model 2	Model 1	Model 2
Long-run model				
Constant	-5.337**	-36.162*	-1.839	-22.974*
	(2.401)	(6.041)	(2.202)	(3.264)
ln(FTE Service Industry)	1.529*		1.448*	
	(0.576)		(0.419)	
ln(GDP)		3.061*		2.538*
		(0.530)		(0.350)
ln[(1 - Fitted Vacancy Rate)*(Office Stock)]	-0.344	0.030	-0.257	0.045
	(0.536)	(0.257)	(0.414)	(0.223)
N	75	75	75	75
R^2-adj	0.847	0.887	0.856	0.905
DW	0.612	0.584	0.622	0.679
Short-run model				
Constant	-0.021	0.000	-0.005	0.000
	(0.019)	(0.012)	(0.015)	(0.013)
Δ ln(FTE Service Industry)	2.301**		1.316**	
	(0.948)		(0.602)	
Δ ln(GDP)		1.924*		2.184*
		(0.383)		(0.455)
Δ ln[(1 - Fitted Vacancy Rate)*(Office Stock)]	-0.192	-0.025	-0.147	0.048
	(0.400)	(0.391)	(0.421)	(0.395)
Error Correction Term$_{(t-1)}$	-0.429*	-0.444*	-0.464*	-0.390*
	(0.070)	(0.084)	(0.072)	(0.079)
Δ ln(R)$_{(t-1)}$	0.455*	0.360*	0.462*	0.372*
	(0.089)	(0.083)	(0.093)	(0.085)
N	70	70	70	70
R^2-adj	0.574	0.589	0.543	0.572
DW	2.161	2.083	2.192	2.050

When distinguishing between national aggregates and local economic data, Table 5.6 shows that for the long-run model we find somewhat stronger results when economic activity is determined on Nuts 3-level, however, differences are marginal at best. From this long-run model as depicted in the top panel of Table 5.6, only the residual is used in the corresponding short-term rent adjustment model. With the stationarity of residuals assured we can include the residual as an explanatory variable in the short-run rent adjustment model[40]. The regression results for this short-run model are presented in the bottom panel of Table 5.6. In model 1, in which service employment is the proxy for economic activity, we find the employment, and error correction coefficients are correctly signed. In the short-run office rents tend to increase with service employment. Furthermore, we find that office rents partially adjust to the lagged market imbalance, measured as the deviation of rent from its long-run value[41]. We find GDP to be the most powerful proxy for economic activity, although differences in results are marginal. Again, we also find that when switching to local economic variables, our results hardly differ from the findings based on national aggregates.

In the final step of our analysis we repeat the complete analysis for the set of secondary office markets. In Table 5.7 we present the results for this exercise. Again the long-run model is presented in the top panel, with the short-run model depicted below. For the long-run model we find less explanatory power for these secondary markets, compared to the previous results for the largest markets. Contrary to the results presented in Table 5.6 we now find significant coefficients for the office stock variable, which results in more plausible elasticities of -1.94 and 6.04 for price and income. Again, we tested the residuals from this long-run model for stationarity and unit roots and subsequently included the residual term into the short-run model that is presented in the second portion of Table 5.7. In contrast with our expectations we find no clear evidence that local model specifications work better for explaining the rent dynamics of secondary office markets. Comparing results of lower panel of Table 5.7 leads to mixed conclusions. When considering service employment, national data appear to perform best, while the opposite is true for GDP. Moreover, in line with our results in Table 5.6 we again find the expected negative signs the error correction term and significantly positive relations the lagged rent changes. The economic activity measures have a consistent and positive impact on office rents, while the combined vacancy rates and office stock variable does not appear to have any significant influence on the short-run behavior of European office rents.

[40] Levin, Lin and Chu (2002) unit root tests for panel data indicate that residuals from the long-run model are stationary.

[41] Given that the error correction coefficient takes values between -0.390 and -0.464 we must conclude that there is partial adjustment to the long-run equilibrium.

Table 5.7 ■ ECM results for second tier office markets

This Table reports the error correction model of office rents for the five smallest office markets per country included in our database. The long-run model $lnR_t = \alpha_0 + \alpha_1 lnEA_t + \alpha_2 ln[(1 - v\hat{}_t)OS_t] + u_t$ is estimated as a cross section fixed effect model. The dependent variable is real prime rent. Economic activity (EA) is estimated with two different specifications. Model 1 shows the results of the test when EA is estimated as FTE employment in the service industry. Model 2 shows results for EA estimated as GDP. v^ is the fitted vacancy rate as determined with an AR(2) model. OS is the stock of office floor space in square meters. The short-run model $\Delta lnR_t = \alpha_0 + \alpha_1 \Delta lnEA_t + \alpha_2 \Delta ln[(1 - v\hat{}_t)OS_t] + \alpha_4 u_{t-1} + \alpha_5 \Delta lnR_{t-1} + \varepsilon_t$ is estimated as a cross section fixed effect model. Δ measures the one period change in variables. u_{t-1} is the one period lagged residual of the long-run model and used as the error correction term in the short run model. ΔlnR_{t-1} is the one period lagged change in real prime rents. The long-run and short-run models are estimated on two levels of geographic aggregation indicated as "National" and "Local". Choice of geographic aggregation influences the measure of EA being either on a national or local level. DW is the Durbin-Watson statistic. Standard error statistics appear in parentheses. ***, **, * indicate significance at the 1%, 5% and 10% level respectively.

	National		Local	
	Model 1	Model 2	Model 1	Model 2
Long-run model				
Constant	-1.261	-16.249*	2.232**	-5.492
	(1.606)	(4.854)	(1.163)	(3.305)
ln(FTE Service Industry)	1.118*		0.961**	
	(0.248)		(0.220)	
ln(GDP)		1.739*		1.099*
		(0.404)		(0.354)
ln[(1 - Fitted Vacancy Rate)*(Office Stock)]	-0.515*	-0.288***	-0.374**	-0.100
	(0.192)	(0.163)	(0.174)	(0.157)
N	74	74	74	74
R^2-adj	0.686	0.679	0.681	0.642
DW	0.664	0.552	0.657	0.488
Short-run model				
Constant	-0.023	-0.008	-0.016	-0.009
	(0.014)	(0.009)	(0.012)	(0.009)
Δ ln(FTE Service Industry)	1.384**		0.877***	
	(0.682)		(0.462)	
Δ ln(GDP)		0.835**		1.029*
		(0.339)		(0.339)
Δ ln[(1 - Fitted Vacancy Rate)*(Office Stock)]	0.119	0.219	0.223	0.160
	(0.274)	(0.273)	(0.276)	(0.269)
Error Correction Term$_{(t-1)}$	-0.450*	-0.356*	-0.448*	-0.401*
	(0.076)	(0.074)	(0.075)	(0.074)
Δ ln(R)$_{(t-1)}$	0.314*	0.308*	0.338*	0.308*
	(0.083)	(0.078)	(0.080)	(0.078)
N	69	69	69	69
R^2-adj	0.446	0.447	0.435	0.463
DW	2.501	2.588	2.526	2.585

5.5 Conclusion and Discussion

Understanding the dynamics of local office markets is key for investors, tenants and local governments. This study provides new insights in the dynamics of European office markets by capturing long-run equilibrium relationships of demand and supply variables and their short-term corrections. The prime distinctive feature of this study is the use of economic variables on two separate levels of geographic aggregation; i.e. the national and local level. We employ a two equation error correction model on unique data provided by Jones Lang LaSalle, EuroStat and Experian for five premier and five second tier European office markets. We cover the period 1990 until 2007 and our results indicate that prime office rents are significantly influenced by short-run changes in measures of economic activity, one period lagged changes in rents and we show that prime office rents partially adjust towards long-run equilibrium levels after one year. We vary the definition of economic activity using service employment, and GDP but find only marginal differences in our model performance. Our results do not provide any evidence that economic variables defined at the local level perform better in a model of local office rent dynamics than their national counterparts for our sample of European office markets. *A priori* different results were expected given the potential shift-share problem in office market research (Hekman, 1985). This problem states that national aggregates provide wrong estimates for local office markets if local variables do not move in tandem with the national aggregates due to different growth rates of the cities themselves or different growth rates of industries within the cities. Results of this study indicate that national and local changes in economic variables do to a large extent move in tandem for the cities included in our analysis, leading to indistinguishable results between models based on local or national specified data. This result is to a large extent a resultant of the contribution the office markets included in our analysis have in the national aggregates of economic activity. On average we find that the co-movement between national aggregates and local economic developments is much lower for smaller sized cities for which no rent data are available.

Chapter 6
Asymmetric Properties of Office Rent Adjustments[42]

6.1 Introduction

In this study, which is in basic methodology similar to Chapter 5, we show that the impact of increases in demand for office space on changes in office rents depends on the disequilibrium in the demand-supply relationship. If vacancy rates are below their long term average office rents react significantly stronger to positive changes in office employment when compared to periods of abundant supply. Understanding rent dynamics is key to both users and investors in office markets; markets that have developed into a significant proportion of the overall economy. According to the U.S. Bureau of Labor Statistics office employment accounts for over 19 percent of non-farm employment. This statistic represents a total of 26 million office based employees in the U.S. by the end of 2007. For metropolitan areas like San Francisco, Washington DC and New York the weight of office employment can reach peaks of close to 30 percent.

Office rents are also a key input variable for construction decisions and to a large extent determine the profitability of new office investments. Hence, a vast strand of academic literature has developed over the years, which aims at cracking the DNA code of office rents. In these models, rents are typically related to changes in employment, office supply and vacancy levels. However, in almost all of these studies the authors assume that these relationships are symmetric, and thus that changes in employment will have similar scale effects irrespective of the level of the vacancy rate. Early studies by Wheaton (1987) already showed that vacancy rates evolve around a natural rate, and that given the non-negativity constraint vacancy rates tend to reach

[42] This chapter is based on a working paper by Brounen and Jennen (2008). I would like to thank Torto Wheaton Research for data support and Pat Hendershott, Peter Englund, Bryan MacGregor and participants at the Amsterdam Cambridge Symposium (Amsterdam, 2008) and AREUEA International Meeting (Istanbul, 2008) for their feedback.

more distinctive peaks than troughs. Therefore, an increase in office employment, when vacancy rates are low, is likely to have a very different impact on rents, than when rates are high. Englund, Gunnelin, Hendershott and Söderberg (2008a) are the first to include these asymmetric properties into their model calibration. They explicitly studied asymmetric rent adjustments depending on the level of vacancy rates when modeling Stockholm office rents for the period 1977-2002 and reported a significant increase in the explanatory power of their rent models due to this inclusion.

This study will add to the existing literature by applying an asymmetric rent adjustment model to a unique panel set of quarterly data covering fifteen metropolitan areas (MSA's) in the United States over the period 1990-2007. Measured by net rentable area of office floor space these MSA's are the largest in the U.S. and include Atlanta, Boston, Chicago, Dallas, Denver, Detroit, Houston, Los Angeles, Minneapolis, New York, Philadelphia, Pittsburgh, San Francisco and Washington DC. Besides a panel that includes all MSA's in one specification we also estimate the model based on different clusters. We group MSA's with multi dimensional scaling based on similarity in rent- or employment dynamics and run panel data regressions based on these clusters. The clustering methodology benefits from an increase in the number of observations when compared to analysis on a MSA level while keeping the in-group homogeneity as large as possible. Our results show that changes in office employment have a larger impact on office rents when vacancy rates are below their long term average. This finding implies for office investments that new demand does not influence rent rates in a symmetric way but is most influential when prevailing vacancy rates are relatively low. We also show that the coefficients are similar in sign and magnitude across clusters.

The chapter continues as follows. After discussing the office market literature that is most relevant for our research, we discuss the rent adjustment model that will be applied in the subsequent analysis. Before discussing our results, we first present our dataset and review the main attributes of the markets that are included in our sample. In our results we explicitly compare results that were yielded from competitive model specifications; models with and without asymmetric properties. Besides discussing pooled panel results we also look at results for clusters of cities. The main findings will be summarized in our conclusions.

6.2 Modeling Office Rent Adjustments

The earliest office literature focused on vacancy rates and typically modeled office rent dynamics as a function of deviations from the natural vacancy rate that is required to clear the market. Wheaton and Torto (1988) use U.S. national time series data on office rent levels and vacancy rates and find that excess vacancy rates affect real rents, while the natural vacancy rate is influenced by variables such as the local tenant structure, average lease terms in the market, expected absorption rates and operating costs. The main problem with this specification is the assumption that office rents keep on decreasing as long as the prevailing vacancy rate is above the perceived natural rate which does not fit actual relationships. Hendershott (1996), in a study of the Sydney office market, introduced a more general rent adjustment model in which changes in real rents are a function of vacancy and rent deviations from equilibrium levels. *Eq.* (6.1) shows the basic form of this type of real estate rent modeling.

$$\%\Delta R_t = \alpha\left(\nu_t^* - \nu_{t-1}\right) + \beta\left(R_t^* - R_{t-1}\right) \tag{6.1}$$

Where ν_t^* is the estimated natural vacancy rate and R_t^* is the time-varying equilibrium real office rent. This model offers a more general adjustment path for office rents with pleasing long-run properties, as effective rents are specified as adjustments to gaps between both the natural and actual vacancy rates and equilibrium and actual gross rents. With this equation, vacancy rates do not have to overshoot following a supply shock. After high vacancy rates have dragged rents significantly below equilibrium, the known eventual return to equilibrium acts as a force causing real rents to rise, even when the vacancy rate is still above the natural rate. This model is estimated by Hendershott, Lizieri and Matysiak (1999) using data from the City of London for the period 1977-1996 and shows that the model tracks the market dynamics.

Hendershott, MacGregor and Tse (2002) and Hendershott, MacGregor and White (2002) extend these rent adjustment models by deriving a model that incorporates supply and demand factors within an Error Correction Model (ECM). This model is derived as a reduced-form estimation equation for the occupied office space and has the benefit that it does not require estimates for variables such as depreciation rates and operating expenses as is shown in Hendershott, MacGregor and Tse (2002) where both a rent adjustment equation in line with *Eq.* (6.1) and an error correction model are estimated. Demand for space (*D*) is modeled as a function of real effective rent (*R*) and a proxy for office employment (*E*)[43]:

$$D = \lambda_0 R^{\lambda_1} E^{\lambda_2} \tag{6.2}$$

Where the λ_i's are constants with the price elasticity, λ_1, expected to be negative and λ_2, the income elasticity, positive. Demand for office space, a function of *R* and *E* as in *Eq.* (6.2), equals the product of available office space (*SU*) and one minus the prevailing office vacancy rate (*v*):

$$D(R,E) = (1-v)SU \tag{6.3}$$

Given that real estate markets clear towards equilibrium through changes in rents and vacancy levels (as shown in *Eq.* (6.3)), vacancy enters the error correction model as a fitted variable indicated as $\hat{v}$ in order to prevent endogeneity problems. The procedure we use to model vacancy levels is in line with Hendershott, MacGregor and Tse (2002) and consists of an AR(4) model based on quarterly observations. Adjusted R^2 for the ten cities included in our analysis of the AR(4) model over the period 1990-2006 range from 0.93 to 0.95. Rearranging *Eqs.* (6.2) and (6.3) by logarithmic transformation, including fitted vacancy levels, and extracting real rent levels results in *Eq.* (6.4).

$$\ln R_{i,t} = \gamma_0 + \gamma_1 \ln E_{i,t} + \gamma_2 \ln\left[(1-\hat{v}_{i,t})SU_{i,t}\right] + u_{i,t} \tag{6.4}$$

Where the subscripts *i* and *t* denote individual MSA's and quarters respectively. The ECM which is used to model changes in real prime rents in a panel data approach estimates long run equilibrium relationships and short-term corrections. Due to frictions, as already indicated by Wheaton (1987) in a study of the cyclic behavior of the U.S. office market, office markets usually do not clear within short-run periods of time. We measure this imbalance as the residual of *Eq.* (6.4) and subsequently introduce this variable as a factor in the short-run model. The rationale for including the residual in the rent adjustment model is the delay in restoration of equilibriums in real estate markets due to factors such as long term contracts and high search costs. *Eq.* (6.5) shows the disequilibrium.

$$u_{i,t} = \ln R_{i,t} - \gamma_0 - \gamma_1 \ln E_{i,t} - \gamma_2 \ln\left[(1-\hat{v}_{i,t})\,SU_{i,t}\right] \tag{6.5}$$

[43] In the data section we elaborate on the definition of office related employment.

Inclusion of the dependent variable in *Eq.* (6.5) in the rent adjustment model is possible if the variable is stationary which is equal to the independent variables being cointegrated. Since we base our model on panel data we apply the Levin, Lin and Chu (2002) panel unit root test.[44] Taking log differences of *Eq.* (6.4) and adding the stationary residual from *Eq.* (6.5) leads to the short-run rent adjustment model as depicted in *Eq.* (6.6) with an added lagged dependent variable to include the autoregression present in the change in real rent series.[45]

$$\Delta \ln R_{i,t} = \alpha_0 + \alpha_1 \Delta \ln E_{i,t} + \alpha_2 \Delta \ln\left[(1-\hat{v}_{i,t})SU_{i,t}\right] + \alpha_3 u_{i,t-1} + \alpha_4 \Delta \ln R_{i,t-1} + \varepsilon_{i,t} \tag{6.6}$$

According to *Eq.* (6.6) office rents react to short-run changes in causal variables and to lagged residuals of the long-run model, as a reflection of market imbalances.[46] The immediate responses to employment shocks and changes in occupied space are given by the coefficients α_1 and α_2.

We use an extended version of *Eq.* (6.6) to capture the asymmetry in office rent adjustments. By including an interaction term between positive changes in $\ln E_{i,t}$ and a dummy variable, that takes value 1 if the vacancy rate is below the MSA long term average vacancy rate and 0 otherwise, we test the hypothesis that office rents react stronger to changes in office employment when the market is tight. This results in the following rent adjustment equation:

$$\Delta \ln R_{i,t} = \alpha_0 + \alpha_1 \Delta \ln E_{i,t} + \alpha_2 \Delta \ln\left[(1-\hat{v}_{i,t})SU_{i,t}\right] + \alpha_3 u_{i,t-1} + \alpha_4 \Delta \ln R_{i,t-1} + \alpha_5 [\Delta \ln E_{i,t}(+)]VR\ dummy_{i.t} + \varepsilon_{i,t} \tag{6.7}$$

Figure 6.1 shows for each MSA when the prevailing vacancy rate was above or below the local long term average vacancy rate.

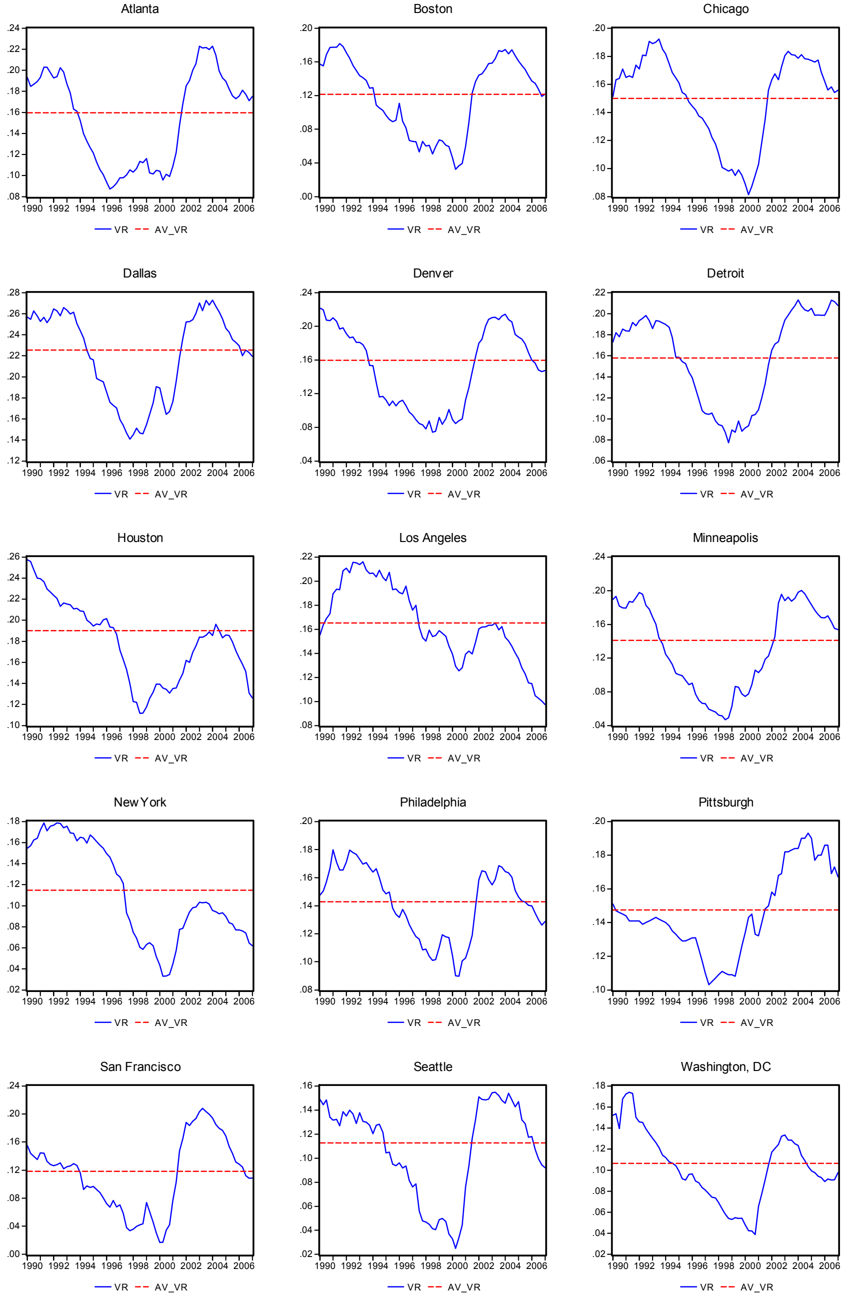
[44] Tests for the presence of a unit root in the regression error terms shows that all residuals used in our study are stationary. Test outcomes are not displayed in this chapter, but available on request.

[45] A regression of rent changes on rent changes lagged one period result in a coefficient of 0.32 which is significant at the 1% level.

[46] Modeling results are expected to indicate that α_0 equals zero, α_1, α_4, and α_5 are positive, while, α_2 and α_3 are expected to display a negative sign. α_3 indicates the speed of adjustment towards equilibrium. If α_3 equals -1 there is full equilibrium restoration after one period while α_3 between zero and -1 or larger than -1 indicate partial- and over- adjustment respectively.

Figure 6.1 ■ Vacancy rates and MSA average vacancy rates

This Figure shows the quarterly vacancy rate (VR) on a MSA level and the local average vacancy rate (AV_VR) over the study period 1990-2007.



We estimate and evaluate models presented in *Eqs.* (6.6) and (6.7) to test the effects of including the asymmetric properties based on our panel data of fifteen MSA's over 69 quarters, resulting in a sample of 1035 observations. So far the office literature has been dominated by papers focusing on explaining the rent dynamics of one single office market. Examples are London by Wheaton, Torto and Evans (1997), Hendershott, Lizieri and Matysiak (1999), and Farelly and Sanderson (2005), Stockholm by Gunnelin and Söderberg (2003), Englund, Gunnelin, Hendershott and Söderberg (2008a,b), Sydney by Hendershott (1996), San Francisco by Rosen, (1984), Hong Kong by Hui and Yu, (2006), Dublin by D'Arcy, McGough and Tsolacos, (1999), and Boston by McClure, (1991).

Few studies exist that analyze multiple markets. D'Arcy, McGough and Tsolacos (1997) examine 22 European cities and use pooled analysis with city dummies based on size of office stock, growth of real GDP and growth in service sector employment. Giussani, Hsia and Tsolacos (1992) estimate rent models for 10 European cities. Different demand side variables are tested in a pooled regression and for the individual cities. They find that coefficients are comparable in sign and magnitude across cities. Hendershott, MacGregor and White (2002) estimate panel data error correction models for retail and office property rents for eleven regions in the U.K. covering 29 years. They estimate separate regional models and combine regions in panels based on communality in income and price elasticities. The main finding is that, while economic divers can vary between regions, that there is no evidence of differences in the operation of the regional property markets outside London. De Wit and van Dijk (2003) test rent models for static and dynamic panels for 46 office district across Asia, Europe and the U.S. and up to 56 quarterly observations per district.

6.3 U.S. Office Market Data

The data set in this study consists of quarterly, MSA level, real estate and employment data covering the period 1990-2007. Torto Wheaton Research (TWR) is the source of our real estate data which combines an extensive geographical coverage with a broad set of relevant real estate data. For the 15 largest office markets in the U.S. we have data on office completions, net absorption of office space, the net rentable area of office space in the MSA, office market vacancy rates and the TWR office rent index.[47] Data on office completions reflects the square footage of office

[47] The data gathering and compilation methodology of TWR has been discussed in detail in Wheaton, Torto and Southard (1997).

space completed each period or new space under construction due to completion in near future. The figure on net absorption reflects the net change in competitively leased space per period in square feet. The square footage is the amount of new space being brought into a market over a period of time, minus the change in vacant space over that same time period. Net rentable area data contain all office buildings whose size exceeds for most markets 20,000 or 30,000 square feet and results from information gathered by local CB Commercial offices throughout the United States. Information on office market vacancy rates is the result of an extensive survey by CB Commercial, which covers the vast majority of competitively rented buildings.

Different forms of office rent indices have been applied in extant literature. Private companies that provide the data apply different methodologies when constructing indices and face the problem of determining the true rent paid on a contract. This problem is caused by the incentive that property owners and tenants have not to disclose rent rates as this would limit future negotiation bandwidths. Furthermore, property owners offer all kinds of incentives in cash and kind to attract potential tenants. As the value of the incentives is positively related to the prevalent vacancy rate there is no fixed adjustment possible over time. McDonald (2002) discusses five different measures of rent per square foot that have been employed in empirical office market research and ranks the different rent indices in increasing accuracy as follows: [I] asking rent (gross and net), [II] face rent on new leases (gross and net), [III] consideration rent averaged over the term of the lease (rent levels are adjusted for broker commission and months of free rent but both on gross and net basis) [IV] consideration rent index (corrected for building and contract details) and [V] effective net rent that measures the net present value of cash flows over the term of the lease. The TWR office rent index that we use in our study is of type [IV] and is based on information contained in CB Commercial deals. Sivitanides (1997) and Mourizou-Sivitanidou (2002) are examples of papers that use data by the same provider which is based on hedonic methodology as employed by Wheaton and Torto (1994) and Webb and Fisher (1996). Englund, Gunnelin, Hendershott and Söderberg (2008b) create a similar hedonic rent index for Stockholm for the period 1972-2002.

Being at the heart of the negotiations and deals provides CB Commercial with a broad set of contract and building details that subsequently enter the office rent index in the form of control variables. The basic rent specification equation is as follows:

$$\log(R) = \alpha_0 + \alpha_1 SQFT + \alpha_2 TERM + \alpha_3 HIGH + \alpha_4 NEW + \alpha_5 GROSS + \sum_{i=1979}^{1993} \beta_i D_i + 30\sum_{j=1}^{30} \delta_j S_j \tag{6.8}$$

where,

R = total consideration rent per square foot per year

$SQFT$ = square feet of lease

$TERM$ = length of the lease in years

$HIGH$ = dummy variable (1 for 5+ stories, 0 otherwise)

NEW = dummy variable (1 for new building, 0 otherwise)

$GROSS$ = dummy variable (1 for gross rent, 0 otherwise)

D_i = dummy variable for each period

S_j = dummy variable for up to 30 submarkets in MSA

The TWR rent index which is used in this study shows the rent for a five year, 10,000 foot gross rent lease in an existing building which is located in an average area in the MSA. The rent modeling presented in this study is based on real, instead of the reported nominal, rent levels. The U.S. Bureau of Labor Statistics provides consumer price indices (CPI) on a detailed MSA level which we use to adjust the nominal rent indices. The MSA level CPI is constructed with the first quarter of 1987 as base level, therefore all reported real rent levels are in Q1 1987 dollar values.

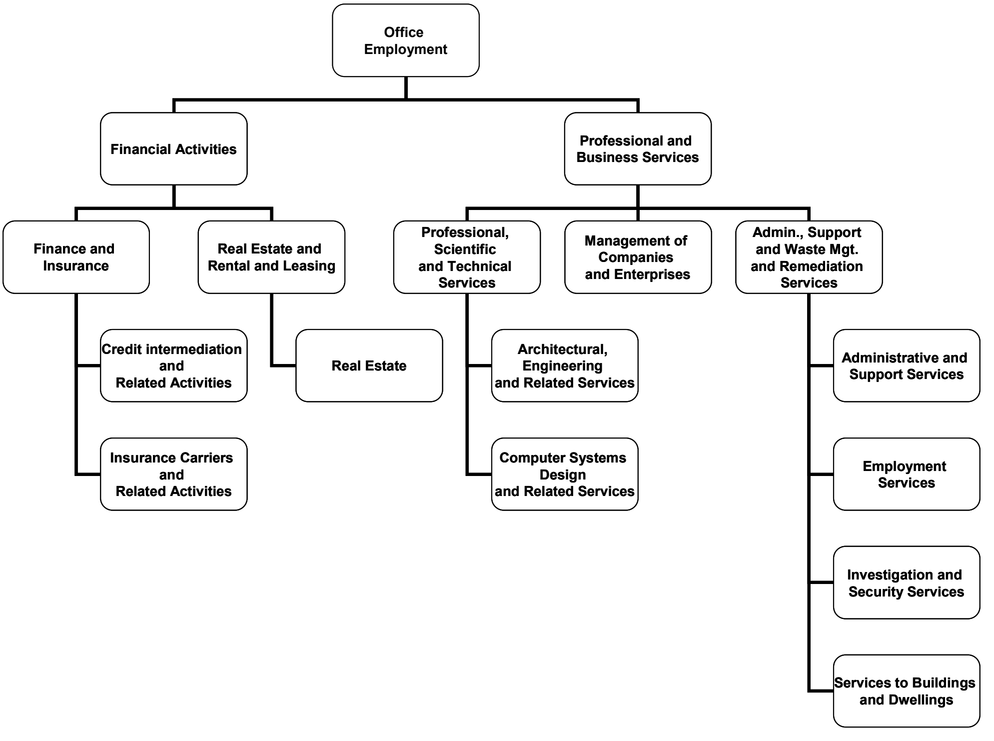
Our model of office rent changes builds upon changes in real estate variables and an office space demand factor. In line with existing literature we measure demand for office space as the number of people employed in office occupying industries. We gather employment data from the U.S. Bureau of Labor Statistics which provides a detailed overview of MSA level employment for a broad range of industry classifications. The definition of what employment sectors constitute office demand is not uniform across studies of office market dynamics. An extensive literature study of measures of office employment shows that most studies use employment in finance, insurance and real estate (FIRE), and service industries as a proxy for office employment. This type of office employment definition is used by for example Hekman (1985), Wheaton (1987), Wheaton, Torto and Evans (1997), Sivitanides (1997), Sivitanides (1998), Shilton (1998) Hendershott Lizieri and Matysiak (1999), Mourouzi-Sivitanidou (2002)[48], Hendershott, MacGregor and White (2002), Farrelly and Sanderson (2005), and Englund, Gunnelin, Hendershott and Söderberg (2008a,b). Other studies use a narrower approximation of office employment which only includes FIRE industries (see for example Rosen (1984), Hui and Yu (2006) and Pollakowski, Wachter and Lynford (1992)). Modeling office rents for small geographic areas such as financial heart of London (a.k.a. "The City") or the financial district of Manhattan is probably well approximated with the narrower definition of

[48] She includes the ratio of FIRE to other office employment to take account on the idea that FIRE employment takes more square feet per employee.

office employment. However, for broader geographic areas, such as the MSA's we use in this study, we propose the broader measure such as employed in the majority of office rent studies. Figure 6.2 provides an overview of the industries that make up office employment according to the definition we use in this study.

Figure 6.2 ■ Office Employment Make-Up

This Figure shows the composition of office employment. Office employment is defined as number of employees occupied in financial activities and professional and business services. Moving down through the Figure each line combines the upper industry with the sub-industries it is composed of.



The weight of professional and business service employment in total office employment, measured as the sum of FIRE and service sector employment, is on average 0.67 for all 15 MSA's. The weight ranges between 0.58 for New York, a MSA with a strong financial and thus FIRE employment base, and 0.77 for Washington DC where services play a relatively large role. The service component of office employment increased for all MSA's over the study period. The average change in FIRE employment is 21% between 1990 and 2007 (-8% in New York, up to 54% in Denver) while the average change in professional and business services is 54% (18% in Pittsburgh and 120% in Dallas). The average change across MSA's in total office employment over our study period is 42%.

One potential problem with the office employment data is the strong seasonal component in the "administration and support and waste management and remediation services" industry which works through to the overall office employment figure. In a perfect market companies would adjust their demand for space on a frequent basis; thereby minimizing rent costs. However, companies cannot adjust their space demand continuously due to moving costs, search time and long-term contracts. For this reason we expect companies to maximize their utility by renting floor space that lies somewhere between the maximum and minimum requirement to house all employees over contract duration. To overcome the impact of seasonality on our demand variable we use a four quarter moving average measure for the industry with high seasonal changes.[49]

Table 6.1 shows the correlation between changes in office employment for the whole country, the weighted average of MSA's included in this study[50], and the individual MSA's. The average correlation of changes in employment across all MSA's is 0.48; reflecting strong differences in employment growth or changes in employment composition across the sample. The Table shows that Atlanta, Detroit, Houston, Los Angeles and Pittsburgh are the MSA's with the lowest correlation with other markets and that these are the only MSA's that exhibit statistically non-significant correlations.

[49]We also tried the U.S. Statistics Bureau X12 procedure to delete the seasonality, but despite its theoretical superiority, peaks and troughs remain which does not fit demand for real estate assets.
[50]Where weights are based on the number of people employed in office occupying industries.

Table 6.1 ■ Correlation change in Office Employment

This Table shows the correlation of changes in office employment between pairs of MSA's, the national change in office employment (Total U.S.) and an employment weighted average of the 15 MSA's included in the study (15 MSA's). (**) and (*) indicate statistical significance at 0.01 and 0.05 levels respectively.

	Total US	15 MSAs	Atlanta	Boston	Chicago	Dallas	Denver	Detroit	Houston	Los Angeles	Minneapolis	New York	Philadelphia	Pittsburgh	San Francisco	Seattle	Washington, DC
Total US	1	.829(**)	.656(**)	.732(**)	.663(**)	.763(**)	.653(**)	.539(**)	.355(**)	.473(**)	.545(**)	.704(**)	.670(**)	.245(*)	.618(**)	.693(**)	.554(**)
15 MSAs	.829(**)	1	.642(**)	.896(**)	.786(**)	.831(**)	.725(**)	.552(**)	.533(**)	.640(**)	.673(**)	.910(**)	.734(**)	.446(**)	.699(**)	.781(**)	.722(**)
Atlanta	.656(**)	.642(**)	1	.569(**)	.611(**)	.568(**)	.591(**)	.592(**)	0.162	0.220	.484(**)	.481(**)	.417(**)	0.219	.439(**)	.450(**)	.339(**)
Boston	.732(**)	.896(**)	.569(**)	1	.710(**)	.681(**)	.674(**)	.457(**)	.460(**)	.499(**)	.664(**)	.827(**)	.620(**)	.443(**)	.617(**)	.674(**)	.645(**)
Chicago	.663(**)	.786(**)	.611(**)	.710(**)	1	.666(**)	.659(**)	.506(**)	.450(**)	.370(**)	.589(**)	.601(**)	.588(**)	.286(*)	.498(**)	.580(**)	.459(**)
Dallas	.763(**)	.831(**)	.568(**)	.681(**)	.666(**)	1	.672(**)	.430(**)	.605(**)	.429(**)	.504(**)	.704(**)	.612(**)	.331(**)	.676(**)	.751(**)	.490(**)
Denver	.653(**)	.725(**)	.591(**)	.674(**)	.659(**)	.672(**)	1	.468(**)	.491(**)	.273(*)	.583(**)	.571(**)	.454(**)	.276(*)	.658(**)	.682(**)	.379(**)
Detroit	.539(**)	.552(**)	.592(**)	.457(**)	.506(**)	.430(**)	.468(**)	1	0.112	.342(**)	.432(**)	.354(**)	.279(*)	0.088	.340(**)	.359(**)	.297(*)
Houston	.355(**)	.533(**)	0.162	.460(**)	.450(**)	.605(**)	.491(**)	0.112	1	.275(*)	.279(*)	.399(**)	.412(**)	0.199	.522(**)	.569(**)	.298(*)
Los Angeles	.473(**)	.640(**)	0.220	.499(**)	.370(**)	.429(**)	.273(*)	.342(**)	.275(*)	1	.297(*)	.563(**)	.345(**)	0.131	.311(**)	.401(**)	.449(**)
Minneapolis	.545(**)	.673(**)	.484(**)	.664(**)	.589(**)	.504(**)	.583(**)	.432(**)	.279(*)	.297(*)	1	.593(**)	.424(**)	.301(*)	.481(**)	.541(**)	.358(**)
New York	.704(**)	.910(**)	.481(**)	.827(**)	.601(**)	.704(**)	.571(**)	.354(**)	.399(**)	.563(**)	.593(**)	1	.701(**)	.480(**)	.551(**)	.674(**)	.706(**)
Philadelphia	.670(**)	.734(**)	.417(**)	.620(**)	.588(**)	.612(**)	.454(**)	.279(*)	.412(**)	.345(**)	.424(**)	.701(**)	1	.429(**)	.399(**)	.645(**)	.612(**)
Pittsburgh	.245(*)	.446(**)	0.219	.443(**)	.286(*)	.331(**)	.276(*)	0.088	0.199	0.131	.301(*)	.480(**)	.429(**)	1	.280(*)	.448(**)	.482(**)
San Francisco	.618(**)	.699(**)	.439(**)	.617(**)	.498(**)	.676(**)	.658(**)	.340(**)	.522(**)	.311(**)	.481(**)	.551(**)	.399(**)	.280(*)	1	.645(**)	.456(**)
Seattle	.693(**)	.781(**)	.450(**)	.674(**)	.580(**)	.751(**)	.682(**)	.359(**)	.569(**)	.401(**)	.541(**)	.674(**)	.645(**)	.448(**)	.645(**)	1	.491(**)
Washington, DC	.554(**)	.722(**)	.339(**)	.645(**)	.459(**)	.490(**)	.379(**)	.297(*)	.298(*)	.449(**)	.358(**)	.706(**)	.612(**)	.482(**)	.456(**)	.491(**)	1

Table 6.2 ■ Descriptive Statistics

This Table shows descriptive office market statistics for 15 U.S. MSA's over the period 1988 till the first quarter of 2007. *Panel a* shows descriptive statistics for net rentable area which is the sum of rentable floor space of all office buildings in the MSA. Figures are in '000s of square feet. *Panel b* shows summary statistics of Torto Wheaton Research real rent (in 1987.1 constant dollars) in U.S.$ per square foot. *Panel c* shows summary statistics for the vacancy rate.

Panel a

MSA	Mean	Min.	Year / Quarter Min	Max	Year / Quarter Max
Atlanta	97,534	65,299	88Q1	126,691	07Q1
Boston	134,036	110,054	88Q1	154,920	07Q1
Chicago	193,125	160,835	88Q1	218,883	07Q1
Dallas	119,491	107,327	88Q1	139,324	07Q1
Denver	72,428	64,437	88Q1	85,372	07Q1
Detroit	62,018	50,664	88Q1	70,391	07Q1
Houston	127,040	121,447	88Q1	137,171	07Q1
Los Angeles	159,395	129,121	88Q1	173,390	07Q1
Minneapolis	57,723	47,998	88Q1	65,113	06Q4
New York	418,706	397,501	88Q1	427,568	07Q1
Philadelphia	87,196	68,891	88Q1	100,200	07Q1
Pittsburgh	59,027	53,050	88Q1	65,274	06Q4
San Francisco	73,119	63,071	88Q1	83,542	07Q1
Seattle	61,192	43,793	88Q1	75,599	07Q1
Washington, DC	211,601	159,481	88Q1	262,044	07Q1
All	128,909	43,793		427,568	

Panel b

MSA	Mean	Min.	Year / Quarter Min	Max	Year / Quarter Max
Atlanta	11.6	10.0	93Q2	13.1	88Q2
Boston	17.0	12.8	92Q4	27.0	00Q4
Chicago	15.2	12.9	05Q3	18.3	88Q2
Dallas	11.0	9.1	93Q4	14.6	98Q4
Denver	9.8	8.2	91Q4	12.8	00Q2
Detroit	11.0	9.1	07Q1	14.1	88Q4
Houston	9.7	8.3	93Q4	11.6	00Q3
Los Angeles	13.6	11.3	95Q1	17.0	88Q1
Minneapolis	14.5	11.7	92Q4	18.3	88Q2
New York	24.4	18.3	93Q4	34.6	01Q1
Philadelphia	12.5	10.2	06Q3	16.2	89Q4
Pittsburgh	11.7	9.6	06Q3	13.1	00Q2
San Francisco	14.1	10.9	05Q1	23.1	00Q2
Seattle	14.3	12.2	04Q4	18.6	98Q4
Washington, DC	17.8	14.5	93Q2	23.5	00Q4
All	13.9	8.2		34.6	

Panel c

MSA	Mean	Min.	Year / Quarter Min	Max	Year / Quarter Max
Atlanta	16.0%	8.7%	96Q2	22.3%	04Q1
Boston	12.1%	3.3%	00Q2	18.2%	91Q3
Chicago	15.0%	8.1%	00Q2	19.2%	93Q3
Dallas	22.5%	14.1%	97Q4	28.3%	88Q2
Denver	16.0%	7.4%	98Q3	27.3%	88Q1
Detroit	15.8%	7.8%	98Q4	21.3%	04Q1
Houston	19.0%	11.2%	98Q3	30.3%	88Q1
Los Angeles	16.5%	9.7%	07Q1	21.6%	93Q2
Minneapolis	14.1%	4.7%	98Q3	21.9%	88Q3
New York	11.5%	3.3%	00Q2	17.9%	91Q2
Philadelphia	14.3%	9.0%	00Q3	18.0%	91Q1
Pittsburgh	14.7%	10.3%	97Q2	19.3%	04Q4
San Francisco	11.8%	1.7%	00Q1	20.8%	03Q2
Seattle	11.3%	2.5%	00Q2	17.2%	89Q2
Washington, DC	10.6%	3.9%	00Q4	17.4%	91Q2
All	14.7%	1.7%		30.3%	

Table 6.2 provides an overview of summary statistics of office data for the 15 MSA's covered in this study. New York is by far the largest office market at the end of 2006 with a total square footage of over 400 million; over 60% larger than the second in line, Los Angeles and more than 6.5 times the size of Minneapolis which is the smallest office market covered in this study. Average real rents in 1987 constant dollars range between $9.7 in Houston and $24.4 in New York. Summary statistics for the vacancy rate show that all cities, when examining the mean over the study period, report double digit vacancy rates. Vacancy rates over the study period range between 1.7%, in San Francisco near the end of the Dotcom boom, to 30.3% in Houston towards the end of the 1980's.

Figure 6.3 displays the time series of vacancy rates, real rent levels and the number of employees in office occupying industries over the period 1990-2007. The Figure shows that the vacancy rate for all MSA's over the study period is often a close mirror image of real rent index despite the disturbing influence of new construction and hidden vacancy rates, as discussed in Englund et al. (2008b). Vacancy rates show similar patterns across all MSA's and are characterized by high but steady levels over the years 1988-1994, which was a period characterized by a downturn in the U.S. economy partly due to the collapse of the junk bond market and a credit crunch. Over the whole, vacancy rates decreased over the period 1995-1998 preceding a period of low vacancy rates during the economic boom period 1998-2000.

The latter period clearly shows the non-negativity constraint of vacancy rates as vacancies reached their local minima during the years 1998-2000, triggering new construction and the lowest space usage per employee over the study period as shown in Figure 6.4.[51]

[51] We measure space usage per employee in square feet as: (net rentable area*(1-vacancy rate))/office employment).

Figure 6.3 ■ Office market dynamics

This Figure shows the dynamics in vacancy rate (VR, left axis in %, dotted line), the Torto Wheaton Research office rent index in real terms (Real_rent, left axis in constant 1987.1 dollars, straight line) in U.S.$ per square foot, and office employment (OE, right axis in '000s employees, interrupted line) for all 15 MSA's covered in this study.

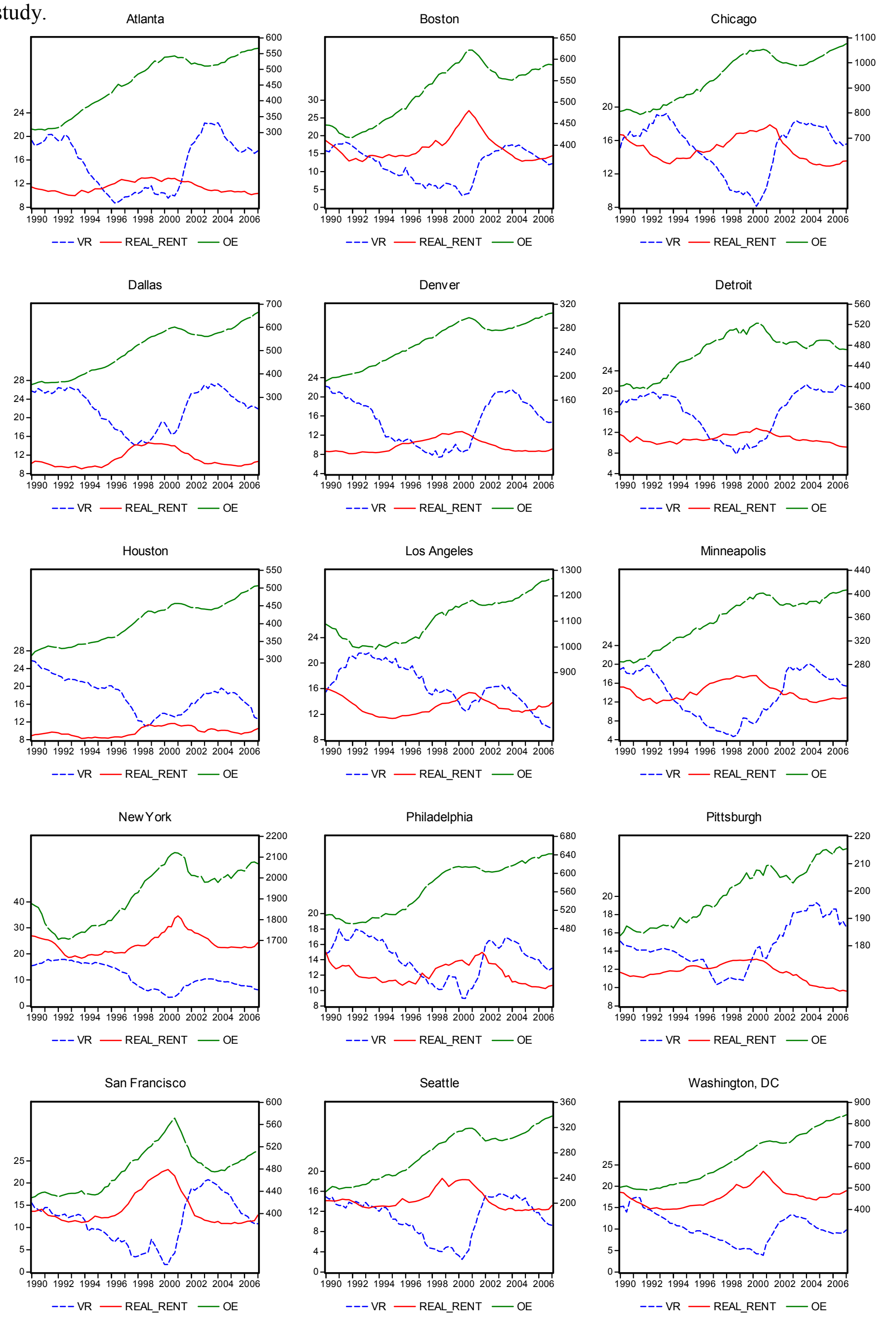
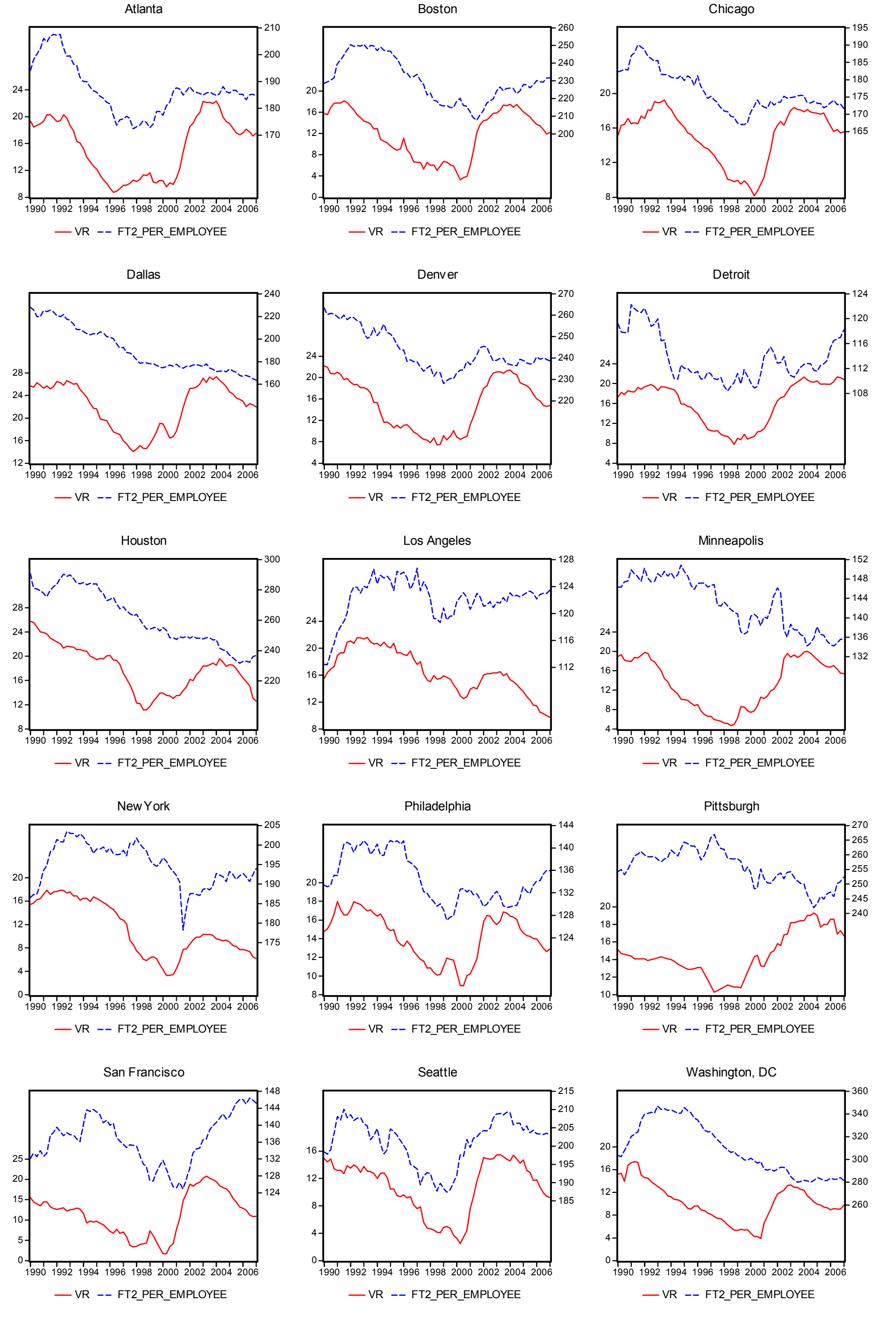


Figure 6.4 ■ Occupied office space per office employee

This Figure shows vacancy rate dynamics (VR, left axis in %) and the office space usage per employee (FT2_per_employee, left axis in ft ^{2} per employee) calculated as [(1-VR) * net rentable floor space]/office employment



After the turn of the millennium the U.S. economy hit hard times with the crash of the Dotcom bubble and the September 11 attacks on New York and Washington DC. The combination of ongoing new supply and decreasing employment at office occupying companies in all 15 MSA's lead to a steep increase in vacancy rates over the period 2000-2003.

Real rent levels show similar patterns across MSA's over time. Rent expressed in constant 1987 dollars show large dispersion across cities. In the first quarter of 2000 real rent levels were as low as $11.29 in Houston, which alternates with Denver for the lowest rent per square foot and as high as $28.51 in New York, where renting office space was most expensive over the whole study period. The discrepancy between the highest and lowest rent values is fairly consistent over time. On average the highest rent is 2.64 times the lowest rent over all quarters with a range of 2.1 to 3.6 over the study period.

6.4 Empirical Results

This section presents the results for the two stage error correction model for changes in real office rents. One of the contributions of this study is the addition of a test of asymmetry in rent response to changes in office employment. Therefore we estimate both a symmetric and an asymmetric model specification, based on *Eqs.* (6.6) and (6.7) respectively. Table 6.3 displays the results for the full panel including all 15 MSA's. The top panel displays the results for the long run model. We base this model on non-differenced data and use it to calculate the prevailing rent disequilibrium.

The long run model does not differ between the symmetric and asymmetric model as it is merely used to determine the equilibrium rent level. Our regression results show that the long run model has an adjusted R-squared of approximately 0.80 with a Durbin Watson coefficient considerably below unity. The coefficients and model fit estimates from the long run model are comparable to the findings for European office markets as reported in Hendershott, MacGregor and White (2002) and Brounen and Jennen (2008), and are a direct result of the trending variables used in the long-run model.

Table 6.3 ■ Regression results (all cities)

This Table reports the error correction model of office rents for a panel of 15 MSA's included in the study based on quarterly observations over the period 1990-2007. The long-run model $\ln R_t = \alpha_0 + \alpha_1 \ln E_t + \alpha_2 \ln[1\text{-}v\hat{}_t]SU_t$ is estimated as a cross section fixed effect model. The dependent variable is real office rent in 1987.1 constant U.S. dollars. We estimate office employment (E_t) as the sum of employment in finance, insurance, real estate, professional- and business services. $[1\text{-}v\hat{}_t]SU_t$ is an estimate for occupied space, where $v\hat{}$ is the fitted vacancy rate based on an AR(4) model and SU is the supply of office space in square feet. The results include the symmetric and asymmetric models which differ in the short-run model only. The symmetric short-run model $\Delta \ln R_t = \alpha_0 + \alpha_1 \Delta \ln E_t + \alpha_2 \Delta \ln[1\text{-}v\hat{}_t]SU_{t\ t} + \alpha_3 u_{t-1} + \alpha_4 \Delta \ln R_{t-1}$ is estimated as a cross section fixed effect model. Δ measures the one period change in variables. u_{t-1} is the one period lagged residual of the long-run model. $\Delta \ln R_{t-1}$ is the one period lagged change in real prime rents. The asymmetric short-run model $\Delta \ln R_t = \alpha_0 + \alpha_1 \Delta \ln E_t + \alpha_2 \Delta \ln[1\text{-}v\hat{}_t]SU_t + \alpha_3 u_{t-1} + \alpha_4 \Delta \ln R_{t-1} + \alpha_5 [\Delta \ln E+_t]\text{VR\_DUMMY}_t$ is estimated as a cross section fixed effect model. $[\Delta \ln E+_t]$ reflects positive one period changes in office employment and takes value zero is the change in employment is negative. VR_DUMMY_t is a dummy variable that takes value 1 if the vacancy rate in time $_t$ is below the MSA average vacancy rate, and 0 otherwise. DW is the Durbin-Watson statistic. Standard error statistics appear in parentheses. ***, **, * indicate significance at the 1%, 5% and 10% level respectively.

	All City Panel	
	Symmetric Model	Asymmetric Model
Long-run model		
Constant	8.559 ***	8.559 ***
	(0.968)	(0.968)
ln (E_t)	1.292 ***	1.292 ***
	(0.095)	(0.095)
ln [(1-v^$_t$)SU$_t$]	-1.225 ***	-1.225 ***
	(0.132)	(0.132)
N	990	990
R^2-adj	0.799	0.799
DW	0.060	0.060
Short-run model		
Constant	-0.002 ***	-0.003 ***
	(0.000)	(0.000)
Δ ln (E_t)	2.499 ***	1.503 ***
	(0.272)	(0.314)
Δ ln [(1-v^$_t$)SU$_t$]	0.584 **	0.156 *
	(0.279)	(0.275)
u_{t-1}	-0.008 ***	-0.015 ***
	(0.002)	(0.002)
Δ ln R_{t-1}	0.419 ***	0.399 ***
	(0.030)	(0.029)
[Δ ln E+$_t$] * VR_DUMMY$_t$	---	2.406 ***
		(0.401)
N	975	975
R^2-adj	0.399	0.421
DW	1.913	1.918

The bottom panel in Table 6.3 shows the result for the differenced rent model. In the symmetric model specification we show that rents react positively to changes in office employment and lagged changes in office rents. The coefficient for the error correction term is between zero and minus one which indicates a partial adjustment towards equilibrium over quarterly periods. The magnitude of this estimate is however very small, pointing at very slow adjustment over time.[52] The measure for occupied space shows an unexpected positive sign which is however only significant at the 5% level. The second short run model specification presented in Table 6.3 presents the results for the asymmetric model. Coefficients in the asymmetric model are similar to the symmetric model in both sign, magnitude and statistical significance, with an even lower significance for the occupied space variable. The positive and significant coefficient for the asymmetry variable shows that rents react significantly stronger to an increase in office employment when vacancy rates are below the long term average, when compared to times of abundant vacant space. This finding is in line with expectations. If vacancy rates are high, new demand for space will first alleviate the owners of non-income producing vacant space before a clear effect on office rents is visible. When vacancy rates are low the effect of additional demand for office space as a result of an increase in office employment is more directly related to office rents. However, including this asymmetric element in the model enhances the fit only marginally for the total panel.

6.5 Cluster Analysis

The panel results presented in Table 6.3 assume that the coefficients for the independent variables are equal across all MSA's. In order to relax this assumption we create panels based on similarity in the pattern of rent and office employment changes over the sample period. In this way we are able to maintain the benefit of large sample sizes, examine clusters with maximum between cluster heterogeneity, while keeping the within sample homogeneity as large as possible. Hendershott, MacGregor and White (2002) is the only other known study that groups regions based on some similarity. Their paper studies rent changes for a range of regions and estimates separate models for "London" and "Other" regions in the U.K. for 11 regions and 29 years. Clusters in the Hendershott, MacGregor and White (2002) paper are based on similarities of the income and price elasticities in the long-run models. In this study we use an alternative methodology in which we use multi dimensional scaling (MDS)

[52] The error correction term is -0.008 in the symmetric model specification for the whole panel. This figure implies that over the course of one year only 3.23% of the disequilibrium in rents is restored.

and subsequent hierarchical clustering analysis to group MSA in two clusters based on similarities in changes in rent and office employment over time. MDS is a powerful tool for visualizing correlations between pairs of cities or other instances (see for example Groenen and Franses (2000) for an application in stock market correlation analysis). MDS creates points in a low dimensional space where each dot reflects for example a city. Clusters of cities appear if dots in the low dimensional space appear close to each other in the output. The benefit over more traditional correlation analysis is the way MDS shows not only the similarity between individual pairs of instances but also the way in which all other observations are related. Besides the visual application, MDS output also includes common space coordinates which forms the input for the geographic representation of similarities. The common space coordinates form the input for hierarchical clustering analysis; the foundation for the actual cluster formation. We test different dimensional settings for the MDS and found, according to the guidelines by Kruskal (1964), that the use of three dimensions is optimal in our study. Our clusters based on communalities in rent and office employment changes over the study period are shown in Figure 6.5. *Panels a* and *b* show the clusters based on rent and employment changes, respectively. Based on real rent changes we form two clusters. One cluster consists of Boston, New York and San Francisco (further indicated as cluster A2) and the other cluster encompasses all other MSA's (cluster A1).

If we base the clusters on office employment changes, Figure 6.5 shows that three main clusters arise. One cluster consists of Atlanta and Detroit (cluster B3), a second cluster includes New York, Philadelphia, Pittsburg, Los Angeles and Washington DC (cluster B2) and the third cluster consists of the remaining MSA's (cluster B1).[53]

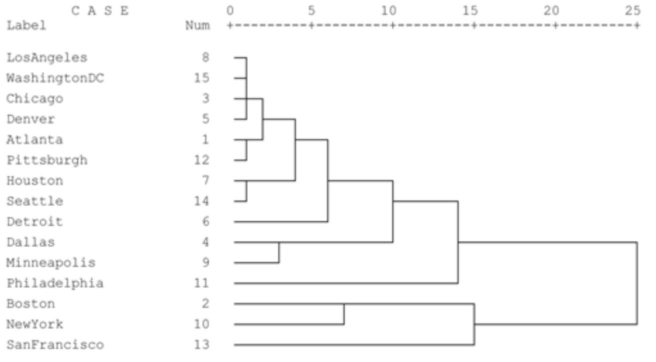
Table 6.4 shows the results of the symmetric and asymmetric model specification for clusters based on similarity in rent changes. Panel A1 shows the results for cluster A1. Coefficients and signs are comparable to the findings presented in Table 6.3 with a model fit that is slightly lower than the result for a panel including all MSA's. The error correction term shows that rents very slowly adjust towards equilibrium over the term of one quarter; a finding shared with all other model specifications presented in this study. Results of the short run model show that the impact of changes in our estimate of occupied space is not statistically different from zero. Again, we show that the rent adjustment as a result of an increase in office employment, the asymmetric model specification, is stronger when vacancy rates are below their long term

[53] One interesting finding from this clustering methodology based on similarities in office rent and employment changes is that clusters are not in line with geographic locations of the MSA's. Further analysis could provide more insight into the driving forces behind the correlations; possible causes are similarities in local GDP drivers or employment composition.

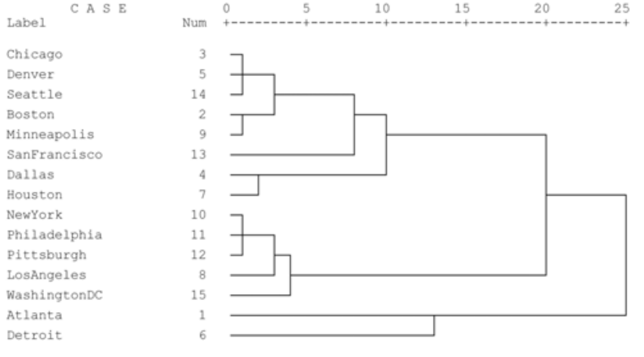
Figure 6.5 ■ Hierarchical clusters

This Figure shows the dendrogram which results after a hierarchical clustering analysis based on three dimensional common space coordinates. Common space coordinates are constructed with multi dimensional scaling. *Panel a* shows clusters based on changes in office rents and *Panel b* shows clusters based on changes in office employment

Panel a



Panel b



averages. The results for the remaining MSA's, as presented under Panel A2 in Table 6.4, are largely comparable in sign and magnitude with a strong increase in model fit when compared to the panel of all MSA and panel A1.

Table 6.4 ■ Regression results for clusters based on similarity in office rent changes

This Table reports the error correction model of office rents for a panel of 15 MSA's included in the study based on quarterly observations over the period 1990-2007. The sample is split in two Panels based on communality in office rent changes. The long-run model $\ln R_t = \alpha_0 + \alpha_1 \ln E_t + \alpha_2 \ln[1\text{-}v\hat{}_t\,]SU_t$ is estimated as a cross section fixed effect model. The dependent variable is real office rent in 1987.1 constant U.S. dollars. We estimate office employment (E_t) as the sum of employment in finance, insurance, real estate, professional- and business services. $[1\text{-}v\hat{}_t]SU_t$ is an estimate for occupied space, where $v\hat{}_t$ is the fitted vacancy rate based on an AR(4) model and SU_t is the supply of office space in square feet. The results include the symmetric and asymmetric models which differ in the short-run model only. The symmetric short-run model $\Delta\ln R_t = \alpha_0 + \alpha_1\Delta\ln E_t + \alpha_2\Delta\ln[1\text{-}v\hat{}_t\,]SU_{t\ t} + \alpha_3 u_{t-1} + \alpha_4\Delta\ln R_{t-1}$ is estimated as a cross section fixed effect model. Δ measures the one period change in variables. u_{t-1} is the one period lagged residual of the long-run model. $\Delta\ln R_{t-1}$ is the one period lagged change in real prime rents. The asymmetric short-run model $\Delta\ln R_t = \alpha_0 + \alpha_1\Delta\ln E_t + \alpha_2\Delta\ln[1\text{-}v\hat{}_t\,]SU_t + \alpha_3 u_{t-1} + \alpha_4\Delta\ln R_{t-1} + \alpha_5[\Delta\ln E+_t]\text{VR\_DUMMY}_t$ is estimated as a cross section fixed effect model. $[\Delta\ln E+_t]$ reflects positive one period changes in office employment and takes value zero is the change in employment is negative. VR_DUMMY_t is a dummy variable that takes value 1 if the vacancy rate in time $_t$ is below the MSA average vacancy rate, and 0 otherwise. DW is the Durbin-Watson statistic. Standard error statistics appear in parentheses. ***, **, * indicate significance at the 1%, 5% and 10% level respectively.

	Panel A1		Panel A2	
	Symmetric Model	Asymmetric Model	Symmetric Model	Asymmetric Model
Long-run model				
Constant	6.238 ***	6.238 ***	13.566 ***	13.566 ***
	(0.915)	(0.915)	(2.725)	(2.725)
ln (E_t)	0.896 ***	0.896 ***	3.071 ***	3.071 ***
	(0.091)	(0.091)	(0.255)	(0.255)
ln [(1-v^$_t$)SU$_t$]	-0.812 ***	-0.812 ***	-2.625 ***	-2.625 ***
	(0.126)	(0.126)	(0.352)	(0.352)
N	792	792	198	198
R^2-adj	0.752	0.752	0.784	0.784
DW	0.055	0.055	0.119	0.119
Short-run model				
Constant	-0.002 ***	-0.003 ***	-0.002 ***	-0.003 ***
	(0.000)	(0.000)	(0.001)	(0.001)
Δ ln (E_t)	2.121 ***	0.774 **	3.897 ***	3.139 ***
	(0.293)	(0.345)	(0.678)	(0.771)
Δ ln [(1-v^$_t$)SU$_t$]	0.456	0.413	0.901	0.886
	(0.307)	(0.298)	(0.651)	(0.645)
u_{t-1}	-0.009 ***	-0.021 ***	-0.012 **	-0.015 ***
	(0.003)	(0.003)	(0.005)	(0.005)
Δ ln R_{t-1}	0.400 ***	0.362 ***	0.415 ***	0.411 ***
	(0.034)	(0.033)	(0.068)	(0.067)
[Δ ln E+$_t$] * VR_DUMMY$_t$	---	2.962 ***	---	2.314 **
		(0.429)		(1.153)
N	780	780	195	195
R^2-adj	0.333	0.372	0.543	0.550
DW	1.897	1.907	1.936	1.944

Table 6.5 shows the results for the clusters based on similarity in changes in office employment across MSA's. Panels B1 and B2 are comparable to the results presented in Tables 6.3 and 6.4. Overall we find that all included variables are statistically significant with expected signs but also show that the variable that measures occupied space is barely or not significant. Panel B3 stands out with model fit considerably below the other model specifications in both the long-run and the short-run model. Changes in office employment, office demand and the asymmetry measure are not

Table 6.5 ■ Regression results for clusters based office employment changes

This Table reports the error correction model of office rents for a panel of 15 MSA's included in the study based on quarterly observations over the period 1990-2007. The sample is split in two Panels based on communality in office employment changes. The long-run model $\ln R_t = \alpha_0 + \alpha_1 \ln E_t + \alpha_2 \ln[1\text{-}v\hat{}_t\ ]SU_t$ is estimated as a cross section fixed effect model. The dependent variable is real office rent in 1987.1 constant U.S. dollars. We estimate office employment (E_t) as the sum of employment in finance, insurance, real estate, professional- and business services. $[1\text{-}v\hat{}_t]SU_t$ is an estimate for occupied space, where $v\hat{}_t$ is the fitted vacancy rate based on an AR(4) model and SU_t is the supply of office space in square feet. The results include the symmetric and asymmetric models which differ in the short-run model only. The symmetric short-run model $\Delta\ln R_t = \alpha_0 + \alpha_1\Delta\ln E_t + \alpha_2\Delta\ln[1\text{-}v\hat{}_t\ ]SU_{t\ t} + \alpha_3 u_{t-1} + \alpha_4\Delta\ln R_{t-1}$ is estimated as a cross section fixed effect model. Δ measures the one period change in variables. u_{t-1} is the one period lagged residual of the long-run model. $\Delta\ln R_{t-1}$ is the one period lagged change in real prime rents. The asymmetric short-run model $\Delta\ln R_t = \alpha_0 + \alpha_1\Delta\ln E_t + \alpha_2\Delta\ln[1\text{-}v\hat{}_t\ ]SU_t + \alpha_3 u_{t-1} + \alpha_4\Delta\ln R_{t-1} + \alpha_5[\Delta\ln E+_t]\text{VR\_DUMMY}_t$ is estimated as a cross section fixed effect model. $[\Delta\ln E+_t]$ reflects positive one period changes in office employment and takes value zero is the change in employment is negative. VR_DUMMY_t is a dummy variable that takes value 1 if the vacancy rate in time $_t$ is below the MSA average vacancy rate, and 0 otherwise. DW is the Durbin-Watson statistic. Standard error statistics appear in parentheses. ***, **, * indicate significance at the 1%, 5% and 10% level respectively.

	Panel B1		Panel B2		Panel B3	
	Symmetric Model	Asymmetric Model	Symmetric Model	Asymmetric Model	Symmetric Model	Asymmetric Model
Long-run model						
Constant	8.845 ***	8.845 ***	8.984 ***	8.984 ***	7.552 ***	7.552 ***
	1.337	1.337	1.733	1.733	1.190	1.190
ln (E_t)	1.291 ***	1.291 ***	1.251 ***	1.251 ***	1.025 ***	1.025 ***
	0.126	0.126	0.169	0.169	0.157	0.157
ln [(1-v^$_t$)SU$_t$]	-1.247 ***	-1.247 ***	-1.226 ***	-1.226 ***	-1.029 ***	-1.029 ***
	0.179	0.179	0.233	0.233	0.189	0.189
N	552	552	345	345	138	138
R^2-adj	0.684	0.684	0.872	0.872	0.366	0.366
DW	0.058	0.058	0.075	0.075	0.146	0.146
Short-run model						
Constant	-0.003 ***	-0.003 ***	-0.002 ***	-0.003 ***	-0.002 **	-0.002 **
	0.000	0.000	0.001	0.001	0.001	0.001
Δ ln (E_t)	2.549 ***	1.707 ***	3.225 ***	1.703 **	1.299 **	0.969
	0.382	0.482	0.579	0.829	0.601	0.748
Δ ln [(1-v^$_t$)SU$_t$]	0.663 *	0.591	0.979 *	0.826	0.577	0.579
	0.382	0.379	0.553	0.552	0.772	0.773
u_{t-1}	-0.013 ***	-0.016 ***	-0.004	-0.008 *	-0.018 *	-0.020 *
	0.003	0.003	0.004	0.005	0.011	0.011
Δ ln R_{t-1}	0.464 ***	0.456 ***	0.325 ***	0.306 ***	0.259 ***	0.254 ***
	0.042	0.041	0.055	0.055	0.087	0.087
[Δ ln E+$_t$] * VR_DUMMY$_t$	---	1.586 ***	---	2.481 **	---	0.593
		0.560		0.975		0.798
N	520	520	325	325	130	130
R^2-adj	0.463	0.469	0.307	0.318	0.189	0.187
DW	1.795	1.809	1.981	1.969	1.572	1.581

significant for the asymmetric model specification presented for cluster B3 while they are for most other specifications.

6.6 Conclusion

In this paper we use an error correction model for understanding the changes in real office rents for a panel of 15 U.S. MSA's over the period 1990-2007. We find that office rents react positively to a rise in office employment, lagged changes in office rents and that there is only very slow error correction towards estimated equilibrium rents. Given the non-negativity constraint of vacancy rates we extend the model by examining whether rents react to changes in employment conditional on the vacancy rate. Our results show that office rents react significantly stronger to increases in employment when vacancy rates are below the long-term average. We relax the assumption that all MSA's exhibit the same reaction to changes in independent variables by introducing results based on clustering. We base clusters on similarities in changes in rent and office employment with multi dimensional scaling. Generally we find that there are large differences in model fit across the clusters we examined, but that there are only small and insignificant differences in coefficients across clusters. We thus conclude that the cluster results confirm the results found for the panel that includes all MSA's.

Chapter 7
Direct versus Indirect Office Investments[54]

7.1 Introduction

Over the last few decades institutional investors around the globe have increased their interest in publicly traded real estate shares and have started using securitized real estate as a cost-efficient, more liquid alternative for direct real estate holdings. The question of whether publicly traded real estate shares behave similar to their underlying directly held counterparts has been at the heart of the real estate literature for many years. In this study we compare public and private real estate equities in the U.S., U.K. and Australia over the period 1985-2006 and focus on the office submarket of the real estate investment universe. Traditional and modern economic perspectives have different views on whether the chosen platform for investing in real estate should matter. As stated by Pagliari, Scherer and Monopoli (2005) traditional financial theory would suggest that "it's what is underneath the wrapper that matters in the long run". According to modern financial theory the legal entity holding the asset could have an impact on the long-run performance as for example tax status can differ between entities. Most studies that analyze the total return relationship between securitized and unsecuritized real estate find a weak link between the two asset classes. This makes many investors concerned about the degree to which securitized real estate vehicles reflect real estate attributes and what is the best platform to obtain exposure to real estate performance. The fact that real estate investment companies hold high percentages of real estate-related assets should result in a high correlation between their returns and the development of the underlying real estate markets. However, the securitized shape of these investment vehicles introduces a low-cost, trading-market dimension which is not present in the unsecuritized real estate market. This difference in trading-mechanism causes significant variations in market performance of securitized and unsecuritized real estate markets, which clouds their relationship and

[54] This chapter is based on a working paper by Brounen and Jennen (2008)

raises the question whether real estate shares offer the exposure to the real estate markets returns that investors seek.

The bulk of the literature devoted to the relation between public and private real estate focuses on the U.S. investment market. Quinn (1987) reported that when in October 1987 REIT prices fell by 14 percent in one month, doubts were strong on whether REITs still qualified as real estate investments. Anecdotes like this have created the general perception that REITs are hybrid financial assets that embody the economic characteristics of the underlying real estate markets combined with the volatility and sentiment of the general stock market. Because of their high volatility, Ross and Zisler (1987) consider REIT-indices to be inappropriate for measuring the returns of real estate investments. These early studies triggered a complete stream of research that uses observed return series and applies advanced econometrical tests in order to analyze the underlying relationship between real estate and real estate shares. Different methodologies have been employed to clear securitized and unsecuritized real estate returns from their particularities. Filtering techniques, which subtract the market microstructure influences from the observed securitized return series and unsmoothing methods, used to abate the disturbing influence of anchoring on appraisal based property values, are among these methodologies.

While the link between direct and indirect investments in real estate has been studied for over two decades, from an investors point of view the comparison has never been as straightforward as suggested. The listed real estate market is characterized by high liquidity, low transaction costs and small minimum investments, making it an attractive investment opportunity for both small and large investors. The direct real estate market on the other hand is known for its bulky investments with high transaction and management costs, low liquidity and substantial cluster risk but also a potential liquidity premium inaccessible to small investors. As a result of these characteristic differences, large institutional investors prefer the private equity side of real estate investments while individual and smaller institutional investors favor securitized real estate as shown by Pagliari, Scherer and Monopoli (2005). This finding suggests that there is something intrinsically preferable about unsecuritized real estate, as large investors are not restricted to investment in one type of real estate.

Besides the impact of portfolio size on the possibilities of investing in either category there is another important issue with investing in private property which has not been fully addressed in the extant literature. If research indicates that the two investment platforms form substitutes this does not imply that investors, regardless of their size, have equal opportunities of investing in either asset type. The direct real estate indices are compiled of data as gathered by private institutions such as the NCREIF and IPD. The underlying data are the aggregated investment returns on direct real estate holdings of broad groups of institutional investors. Literal replication of the portfolio of this broad group of investors is impossible due to the unique nature of property but even building a highly comparable portfolio would be cumbersome as the level of diversification in the indices is difficult to reach for a single investor. However, this difficulty of obtaining exposure related to the well known direct real estate indices is slowly fading as more and more derivatives based on for example NCREIF and IPD-indices are available. Investors with a desire to expand their exposure to direct real estate returns in a certain property type and country have the opportunity to obtain this exposure through derivatives on private property indices. This provides investors the opportunity of earning returns based on a well diversified underlying property pool without the necessity of large investment depth. Although real estate derivatives markets are small and shallow, the question of whether to invest directly or indirectly in real estate could become more important for a broader group of investors with the advent of property derivatives.

The vast majority of available studies analyzed the link between securitized real estate and its underlying property on an aggregated real estate level, which might distort the relationships due to differences in market allocations across the sub-sectors. In this study we strive for the highest level of homogeneity in product type and therefore focus on one property type: office markets. Based on this universe of public and private office investment opportunities we examine the shape of the underlying distributions and various lagged relationships to analyze similarities between two alternative platforms for investing in office space. We present the results after applying various statistical filtering techniques to correct for the effects of smoothing and leverage on a unique dataset that covers office markets from three different continents. By the end of 2007 no less than 108 real estate investment firms specialized in office real estate were traded publicly at stock exchanges around the globe. From these funds we select the property funds investing in Australian, British, or U.S. office buildings.[55] These firms offer us the rare opportunity to isolate the relationship between their stock performance and the returns yielded on the office markets they invested in.

Our results indicate that contemporaneous and lagged correlations between the two office investment platforms analyzed in this study are low; a result that remains after controlling for appraisal smoothing in the private return indices and differences in capital structure. In the long-run we find evidence that public and private investment vehicles are cointegrated at high significance levels when differences in index construction mechanisms are taken into account but hardly cointegrated when

[55] The selection for these three countries is based on the availability of large property funds specialized in office investments and the availability of unsecuritized real estate return series with a substantial history.

data are left in their smoothed and leveraged format. For investors seeking exposure to office property returns this implies that in the long-run there is a linear relation between investments in private and public platforms.

In the next section we briefly discuss the most relevant literature on the relationship between private and public real estate performance. Next, we present the international data that we have selected for this exercise, and we discuss the historic returns and apply econometric models to examine the relationships between the series. Sections five and six present the results that we obtain after applying the filtering techniques and comparing the residual real estate returns. We finish this chapter by summarizing the main findings in Section 7.6.

7.2 Literature Review

The earlier literature in the field focused on the relationship between equity REITs and the broader stock market. For diversification purposes it is interesting to see whether adding real estate stocks to a broader portfolio reduces the overall portfolio risk (see for example Paladino and Mayo (1995, 1998)). Later research focused on the question whether the platform that is chosen to invest in real estate matters. Studies like Giliberto (1990), Gyourko and Keim (1992), Geltner (1993a), Eichholtz and Hartzell (1996), and Quan and Titman (1997) use observed return series and apply advanced econometrical tests in order to analyze the underlying relationships between real estate and real estate shares. Liu et al. (1990) shows that the commercial real estate market is segmented from the stock market because of differences in costs, quality and the amount of information. A second stream of literature (see for example Giliberto (1993)) investigates the matter from an alternative angle by constructing and applying filtering techniques that subtract the market microstructure influences from the observed return series.

Appraisal-based return indices available from the unsecuritized real estate markets are smoothed, understating both the true volatility of real estate returns and the covariance with real estate stocks. In the appraisal process appraisers tend to rely on estimated values from the previous period, which creates aggregated series with high levels of first order autocorrelation. This appraisal technique smoothes the progress of the return series, resulting in an inherent time lag (see Firstenberg, Ross and Zisler (1988), or Geltner (1989b) and (1991)) and bias (see for example Giliberto (1988) and Geltner (1989a)). Therefore these direct real estate indices can not qualify as the true real estate return measure as the appraisal smoothing influence has to be accounted for.

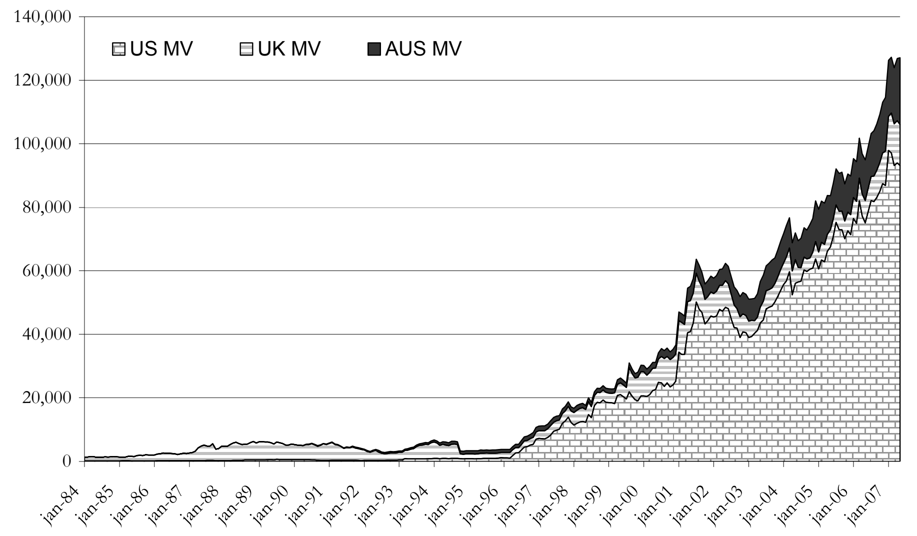
Pagliari and Webb (1995) examine dividends, investment values and dividend yields based on U.S. NAREIT and NCREIF indices over the period 1978 through 1994 and test the similarities of these different return components between listed and unlisted real estate. Their findings indicate that the long run path of prices exhibits the strongest relationship between the two real estate investment structures. While Pagliari and Webb (1995) acknowledge that the mix of property types between NAREIT equity indices and the NCREIF index differs, there is no reweighting of portfolio constituents in their empirical analysis. Later work by Pagliari, Scherer and Monopoli (2005) does take the different weights of property types in NAREIT and NCREIF indices into account. Property type differences are partly adjusted for by excluding noncore property REITs from the dataset. However, the dataset used to analyze similarities between securitized and unsecuritized real estate still exhibits strong differences in allocation to the different core property types (apartments, industrial, office and retail). Pagliari, Scherer and Monopoli (2005) find that there is no significant difference in return means and volatilities between public and private real estate equities. However, as property type weights are not fully comparable between the two indices used, conclusions based on this dataset are still subject to allocation differences. It is unclear whether differences are the result of differences between platforms or simply a resultant of different property type weights in the indices. We extend existing research by looking across national borders - Australia, United Kingdom and the United States - but at the same time by concentrating on one single submarket; offices, instead of the aggregated real estate investment market. We abstract from market microstructures by applying Geltner's (1993b) unsmoothing model on the private property returns and by excluding the leverage effect from the public return series. By applying these methods to our data we will find out whether investing in publicly listed office funds is really offering investors exposure to office market dynamics in the private market.

7.3 Data and Methodology

The dataset consists of two data types. We collect securitized real estate returns from Thomson's DataStream, based on office specialist filings by Global Property Research (GPR). Funds are filed as an office specialist if 1) the fund's market capitalization is in excess of USD 50mln, 2) the fund derives at least 75% of its operational turnover from investment activities and 3) the fund has a portfolio that contains at least 60% office real estate. Figure 7.1 shows how the market capitalization of these listed office funds developed in the three markets in the sample over the period 1984-2006. In 1984, investors had little options to choose from when considering investing in offices through stock-listed firms. The market comprised of only five office specialists, representing a mere USD 1.3bn of market value. By today, 48 office funds are traded in these three markets, of which most are listed on the U.S. stock markets. The total market value of this listed office market has increased 95 fold over the past twenty-four years and has matured into a viable alternative for both private and institutional investors who would like to put their money in office investments without having to build up and manage a portfolio of buildings themselves.

Figure 7.1 ■ The listed office markets since 1984

This Figure shows the development of market capitalization of office specialists in U.S. Dollars in the three markets covered in this study over the period 1984-2006.

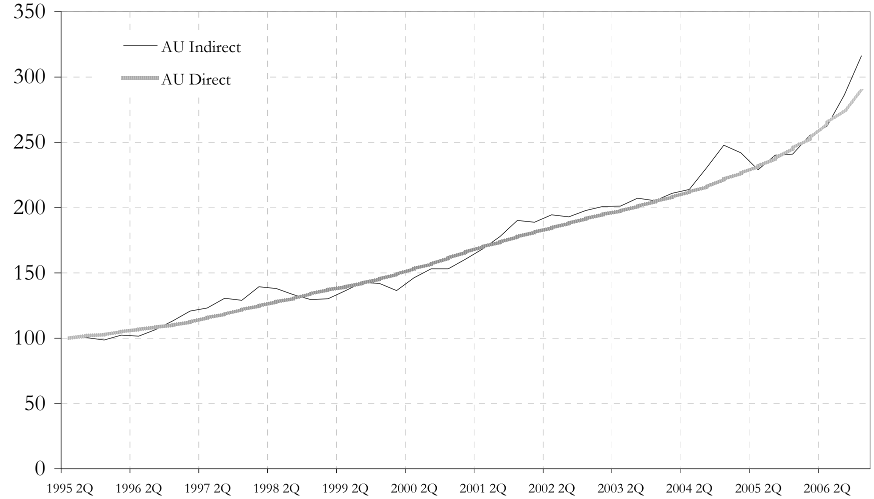


The second dataset we use in this study contains total, price and income returns for the underlying private markets from NCREIF (U.S.), IPD (U.K.), and the Property Council of Australia. When comparing the performance of these private office return indices with their equally-weighted public counterparts, we find little resemblance in their price dynamics during a period covering over two decades. Figure 7.2 offers this comparison for each market. For all three markets we find striking discrepancies between both time series, where private returns tend to be remarkably stable and public returns exhibit much more volatility.

Figure 7.2 ■ Public and private office return indices

Panel a shows an equally weighted total return index of office specialists listed on the Australian stock exchange (AU Indirect) and a total return index of investments in Australian office buildings as compiled by IPD/PCA (AU Direct) on a quarterly basis over the period 1995-2006. *Panel b* shows an equally weighted total return index of office specialists listed on the London Stock Exchange (U.K. Indirect) and a total return index of investments in U.K. office buildings as compiled by IPD/PCA (U.K. Direct) on a quarterly basis over the period 1987-2006. *Panel c* shows an equally weighted total return index of office specialists listed on United States Stock Exchanges (U.S. Indirect) and a total return index of investments in U.S. office buildings as compiled by NCREIF (U.S. Direct) on a quarterly basis over the period 1985-2006.

Panel a



Panel b

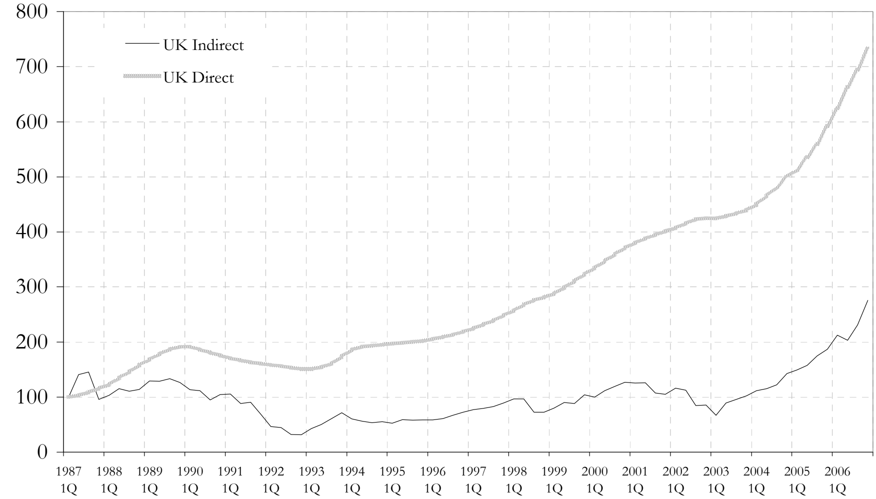
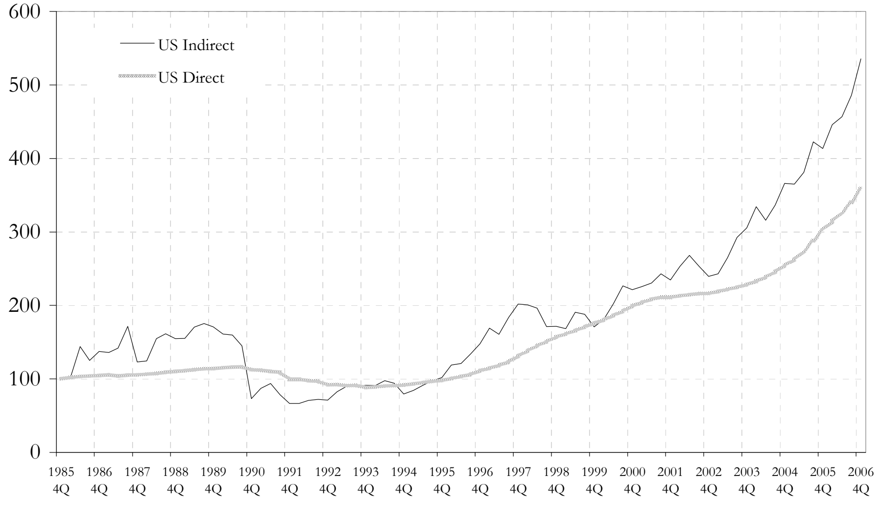


Figure 7.2 ■ Public and private office return indices (continued)

Panel c



Differences in performance between these two office investment platforms are also documented in Table 7.1, where we summarize the sample statistics for each market. Judging from the simple mean and standard deviations of both total returns series, our initial observations are confirmed. Public office returns are associated with significantly more volatility. At the same time we find high levels of autocorrelation for the private series that strongly indicate that serial correlation, the resultant of appraisal smoothing, is an issue in all three markets and needs to be resolved for allowing a fairer comparison. The contemporaneous cross-correlations between the public and private returns vary between 0.24 for the U.K. and 0.35 for Australia. Apparently, market dynamics are positively related in the short-run, but the relationship is weak at best. When splitting the total returns into direct and indirect returns, we find that the observed coherence between both markets stems from the indirect returns. This suggests that the capital gains of the private market and price returns in the public series are related more strongly than rental income and dividend yields.

Table 7.1 ■ Sample statistics raw series

Panel a shows sample statistics for the three countries used in our analysis over different time periods. We show summary statistics for securitized office investments through listed property funds (Public) and investments in office buildings (Private) as gathered by the Property Council of Australia, the Investment Property Databank (IPD) for the U.K. and the National Council of Real Estate Investment Fiduciaries (NCREIF) for the U.S. The full sample for Australia covers the years 1995-2006. Data availability does not allow for meaningful sub-sample analysis for Australia. For the U.K. the full sample covers the period 1987-2006 while sub-period 1 shows the analysis for the years 1987-1995 and sub-period 2 for the years 1996-2006. For the U.S. these periods are 1984-2006, 1984-1995 and 1996-2006 respectively. The mean quarterly total return (average) and standard deviation as investment risk indicator (St. Dev.) are provided for each country and period. Autocorrelation (Auto-corr) is calculated as an AR(1) where the total return in period t0 is regressed on the total return in period t-1. Coherence between the public and private markets is calculated with the contemporaneous correlation between the two real estate types (Cross-corr).
Panel b shows the same information as *Panel a* but with a return decomposition into direct return (dividend for public real estate and rental income for private real estate) and indirect return (price changes for both public as private real estate). Only full sample results are provided in *Panel b*.

	Australia		United Kingdom		United States	
	Public	Private	Public	Private	Public	Private
a. ***Full sample***						
Total return						
Average	2.74%	2.38%	2.57%	2.59%	3.09%	1.63%
St. Dev.	3.87%	0.85%	13.96%	2.79%	11.56%	2.30%
Auto-corr	0.09	0.57	0.20	0.89	-0.02	0.65
Cross-corr	0.35		0.24		0.28	
Sub-period 1						
Average	**	**	0.59%	2.11%	2.17%	0.34%
St. Dev.	**	**	16.93%	3.82%	14.64%	2.16%
Auto-corr	**	**	0.28	0.89	-0.04	0.30
Cross-corr	**		0.22		0.34	
Sub-period 2						
Average	**	**	4.20%	2.99%	4.08%	3.01%
St. Dev.	**	**	10.90%	1.43%	6.95%	1.52%
Auto-corr	**	**	-0.01	0.84	0.03	0.79
Cross-corr	**		0.28		0.14	
b. ***Full sample***						
Direct return						
Average	1.78%	1.85%	0.54%	1.86%	1.35%	1.90%
St. Dev.	0.29%	0.28%	0.48%	0.32%	1.17%	0.27%
Auto-corr	-0.10	0.04	-0.31	1.00	0.40%	0.96%
Cross-corr	-0.21		0.14		-0.16%	
Indirect return						
Average	0.97%	0.53%	2.03%	0.72%	1.74%	-0.27%
St. Dev.	3.85%	0.80%	13.98%	2.85%	11.82%	2.27%
Auto-corr	0.09	0.76	0.22	0.90	-0.01	0.64
Cross-corr	0.30		0.24		0.26	

7.4 Adjusting Real Estate Indices

Before drawing any conclusions from the data presented in Figure 7.2 and Table 7.1, we must acknowledge that there are important differences between the direct and indirect forms of real estate investing and the way the respective indices are constructed. The following paragraphs explain the appraisal smoothing and leverage issues and the way we cope with the difference in the analysis.

7.4.1 Adjusting private property indices for appraisal smoothing

All private real estate indices applied in this study are appraisal based which raises potential problems of appraisal noise and smoothing. Noise appears at the individual property level as appraisers are not always able to estimate the true market value of individual properties. This factor is negligible as the number of buildings that constitute the index increases. The scope of direct real estate indices used in this study makes the assumption that this type of error is cancelled out likely. The other problem with direct real estate indices, the smoothing issue, is not cancelled out with an increase in the number of constituents in the index. The issue of smoothing becomes visible when slicing total returns into indirect returns - price or capital - and direct returns - dividend or income. We find that most of the variation in risk between the public and private series is coming from the price series of the public market. The price returns of the private series contain very little time variations. Appraisers take part of last period's appraisal into account when valuing a property, thereby introducing an artificial serial correlation which dampens the volatility of appraisal based indices. Several methodologies have been suggested to overcome the issue of appraisal smoothing. The proposed methodologies include removal of all serial correlation present in the data (e.g. Stevenson (2000)) and reverse filter methodology as described in Geltner (1993b) and Barkham and Geltner (1995). In order to adjust for these data biases, we will apply Geltner's model which uses a reverse filter on the capital growth components of private real estate returns in order to recover the underlying true returns on property, as shown in *Eq.* (7.1).

$$r_t^u = \frac{(r_t^* - (1-a)r_{t-1}^*)}{a} \tag{7.1}$$

where, r_t^u is the unobserved true capital growth return, r_t^* is the observed appraisal-based capital growth and a is a time-invariant parameter between 0 and 1. If smoothing is absent, a's value will equal 1 such that the unobserved true return is completely independent of the observed return of the previous period, hence serial autocorrelation will be zero. Unfortunately, the value of *a* cannot be estimated statistically and relies on subjective judgment regarding the degree of smoothing in the property market. A survey of Giliberto (1992) suggests that property investors in the U.S. view property's true volatility as being half of that of equities, which inspired empirical studies like Barkham and Geltner (1995) and Stevenson (2000) to fix *a* such that the periodical risk measure of property equals half of that of the common stock market. In our analysis we use the same methodology and adjust the *a*- factor till the standard deviation of the direct property index in each country equals half the standard deviation of the local MSCI stock market index.

7.4.2 Adjusting public property indices for leverage

Differences in capital structure underlying public and private real estate indices form the second issue we should resolve to reach maximum homogeneity between the data series. The listed office specialists are all managing their capital structures in order to optimize the impact of potential positive leverage. Hence, all listed office returns incorporate the effects of leverage, while the private return indices are constructed on an equity-only basis. If we assume that total investment returns are larger than the cost of debt, the positive leverage effect results in higher returns for the levered company, besides a higher return volatility effect. Because of the difference in underlying capital structure we need to adjust public return series for the leverage effect if we want to facilitate a fair comparison between real estate investment platforms.

For unlevering the public return series we apply a methodology that is in line with Barkham and Geltner (1995) and use the average gearing level of funds included in the sample at a certain time period and the local interest rate on government bonds as a proxy for the cost of debt at the fund level. We use these estimated costs of debt in a simple weighted average cost of capital (WACC) model, which corrects for the influence of debt on the asset and liability sides of the balance sheet of these listed firms and returns. The unlevering formula we employ is the same as used by Geltner (1993a) and Fischer, Geltner and Webb (1994):

$$R_{P,t} = \frac{\{R_{E,t} - [1-(P/E)_t]R_{D,t}\}}{(P/E)_t} \tag{7.2}$$

where, $(P/E)_t$ is the property asset value to shareholder equity ratio for year t; $R_{E,t}$ is the equity return in year t; $R_{D,t}$ is the cost of debt in year t; and $R_{P,t}$ is the year t return to the underlying property assets cleared from any capital structure effects.

7.4.3 Unsmoothing private office returns

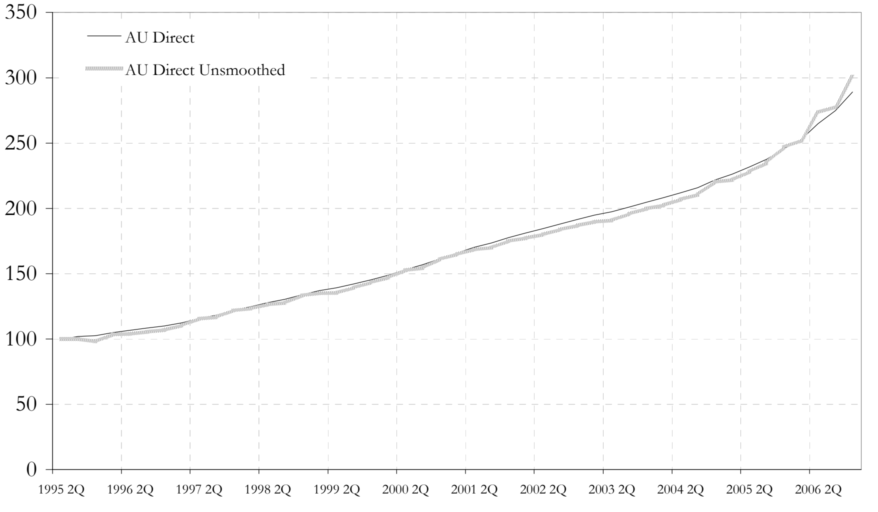
Both Figure 7.2 and Table 7.1 provide evidence that indicates that the appraisal-based private office return series suffer from smoothing. Returns are suspiciously stable and react late and mildly to economic events in all markets. Furthermore, the autocorrelation coefficients in Table 7.1 clearly show that these returns are very positively serially correlated, giving further support to the belief that appraisals are often based on past experiences instead of fresh estimations of changes in expectations.

We unsmooth the private office return series in all three markets using Geltner's (1993a) reverse filter model and by setting the a-factor such that the standard deviation of changes in the unsmoothed private office return index equal exactly half the standard deviation of the MSCI national index over a corresponding time period. The standard deviation of the MSCI total return index in Australia, the United Kingdom and United States was 9.37%, 8.10% and 6.85% respectively on a quarterly basis. The respective standard deviations of the direct property indices as used in this study were 0.8%, 2.8% and 2.4%. The Australian direct return index is extremely smooth as indicated by the low standard deviation. The difference between the standard deviation of the local MSCI index returns and returns on private office investment in the U.K. and U.S. is much smaller. Adjusting the a-factor till the standard deviation of the direct property return series equals 0.5 times the MSCI return standard deviation leads to a-factors of 0.04, 0.36 and 0.56 for Australia, the U.K. and U.S. respectively. Geltner (1993a) suggests that the a-factor has a feasible range of 0.33 to 0.5. This puts the levels found for the U.K. and U.S. approximately within the feasible range. Given the extremely low volatility of the Australian private property index and the relatively high volatility of the Australian MSCI stock market index the a-factor for Australia is 0.04. For the calculations in the remainder of this study we, arbitrarily, use the lower bound of the feasible range as set by Geltner (1993a) for Australia and the calculated figures for the U.K. and U.S.

Figure 7.3 ■ Unsmoothing private office return indices

Panel a shows total return indices of investments in Australian office buildings as compiled by IPD/PCA (AU Direct) and the unsmoothed version of the same index (AU Direct Unsmoothed) on a quarterly basis over the period 1995-2006. *Panel b* total return indices of investments in U.K. office buildings as compiled by IPD/PCA (U.K. Direct) and the unsmoothed version of the same index (U.K. Direct Unsmoothed) on a quarterly basis over the period 1987-2006. *Panel c* shows total return indices of investments in U.S. office buildings as compiled by NCREIF (U.S. Direct) and the unsmoothed version of the same index (U.S. Direct Unsmoothed) on a quarterly basis over the period 1985-2006.

Panel a



Panel b

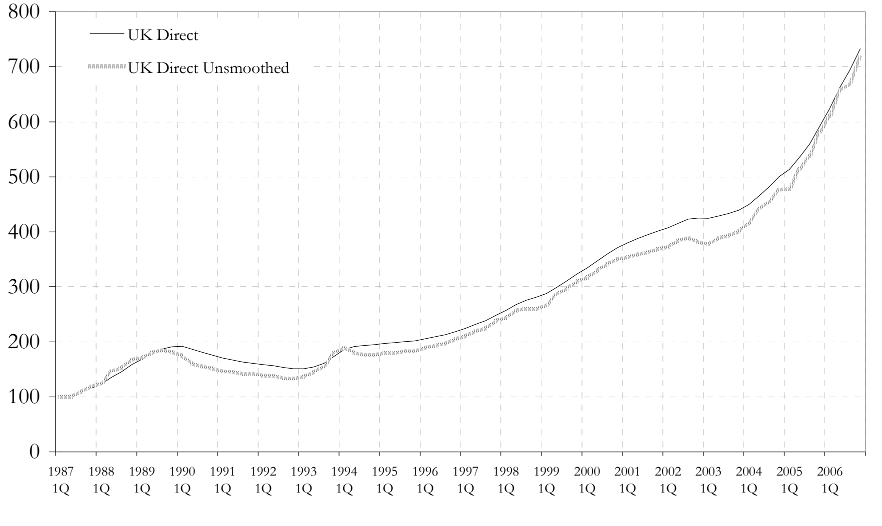


Figure 7.3 ■ Unsmoothing private office return indices (continued)

Panel c

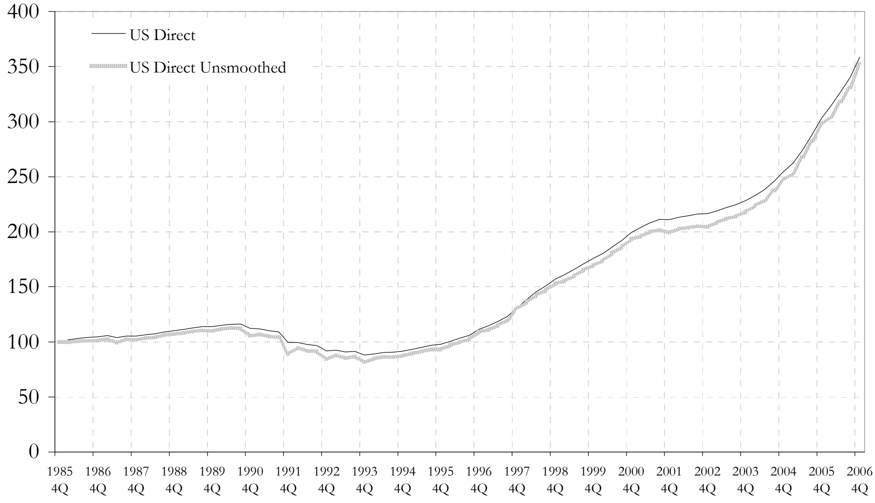


Figure 7.3, *Panel a* shows the results of the unsmoothed Australian private office returns. Unsmoothing the index tends to increase the time variation only mildly in Australia, but decreases the autocorrelation from a highly significant 0.72 to a statistically insignificant 0.15. As a result of our decision to set the *a*-factor for Australia at the lower boundary of 0.33, the standard deviation of returns increased only modestly from 0.80% to 1.32%. For the U.K. we find more pervasive results, which are presented in *Panel b* of Figure 7.3. Unsmoothing the private office returns in the U.K. using the calculated *a*-factor of 0.36, we observe an increase of the standard deviation from 2.81% to 4.14% which by construction is approximately half the standard deviation of the U.K. MSCI index. The autocorrelation of U.K. private investments changed from 0.89 to 0.47 after unsmoothing the series. Smoothed and unsmoothed total return indices for the U.S. private office investments are shown in *Panel c* of Figure 7.3. Obviously, unsmoothing increases the standard deviations by construction. The autocorrelation present in the return series deceases from 0.66 to 0.05 after unsmoothing.

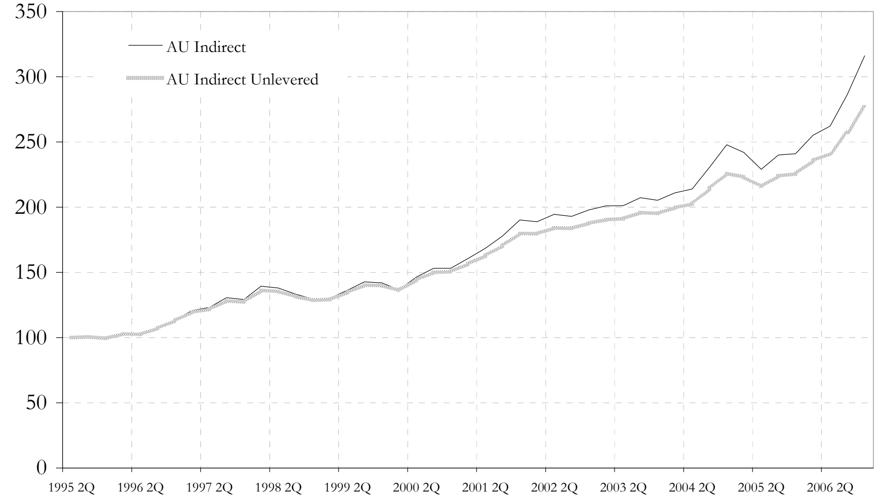
7.4.4 Unlevering Public Office Returns

The next step in the analysis is to exclude the leverage effect from the public office return series. Using the WACC-model for each country we find results as they are presented in Figure 7.4. We calculate the leverage ratio as the average contemporaneous gearing of listed office specialists. This procedure leads to different gearing levels across countries and time. The cost of debt is the contemporary return on government bonds.

Figure 7.4 ■ Unlevering public office return indices

Panel a shows a levered (AU Indirect) and unlevered (AU Indirect Unlevered) equally weighted total return index of office specialists listed on the Australian Stock Exchange on a quarterly basis over the period 1995-2006. *Panel b* shows a levered (U.K. Indirect) and unlevered (U.K. Indirect Unlevered) equally weighted total return index of office specialists listed on the London Stock Exchange on a quarterly basis over the period 1987-2006. *Panel c* shows a levered (U.S. Indirect) and unlevered (U.S. Indirect Unlevered) equally weighted total return index of office specialists listed on the United States Stock Exchanges on a quarterly basis over the period 1985-2006.

Panel a



Panel b

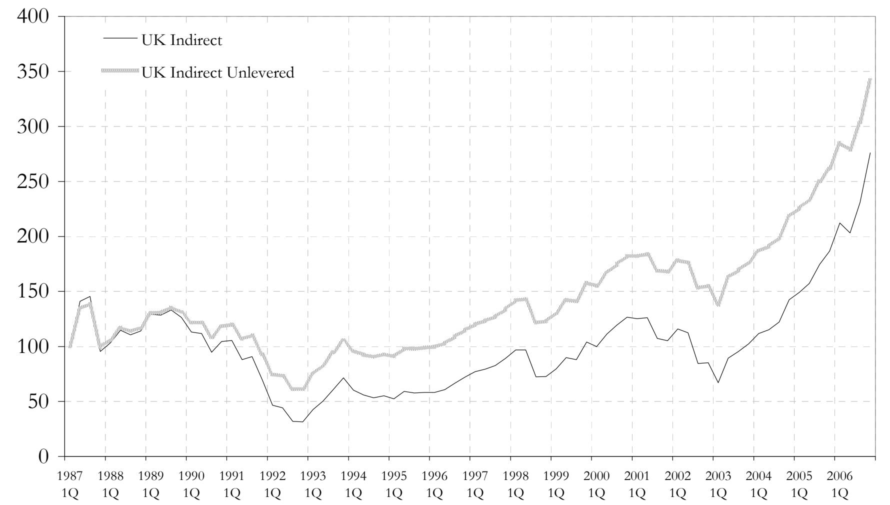
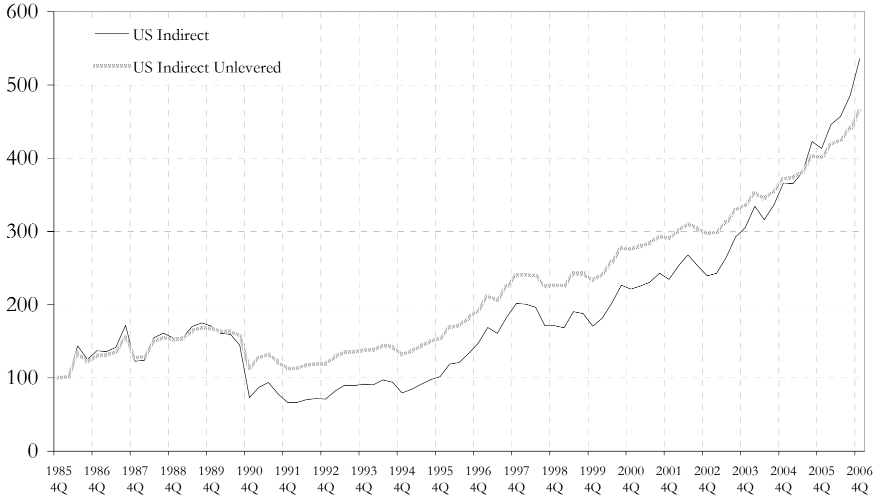


Figure 7.4 ■ Unlevering public office return indices (continued)

Panel c



In all three markets the unlevering procedure results in total return series that differ from the equity only return series. At times when the cost of debt is high, because of high interest levels, unlevering property returns has a positive effect on property returns compared to the equity series. This seems to be the case in the U.K. and U.S. during the early nineties, in the years when interest rates peaked. However, when interest rates fall or are low, unlevering equity returns to property returns tends to lower the returns. Here we subtract the positive leverage effect from equity return, thereby depressing returns to lower levels. We observe this relation in all three markets, especially during the most recent years when the cost of debt has been at a record low.

Moreover, unlevering the equity returns reduces the risk of return series in all markets. For Australia, U.K. and U.S. quarterly standard deviation fall back from 3.79% to 2.99%, from 13.77% to 9.09%, and from 11.26% to 6.86%, respectively.

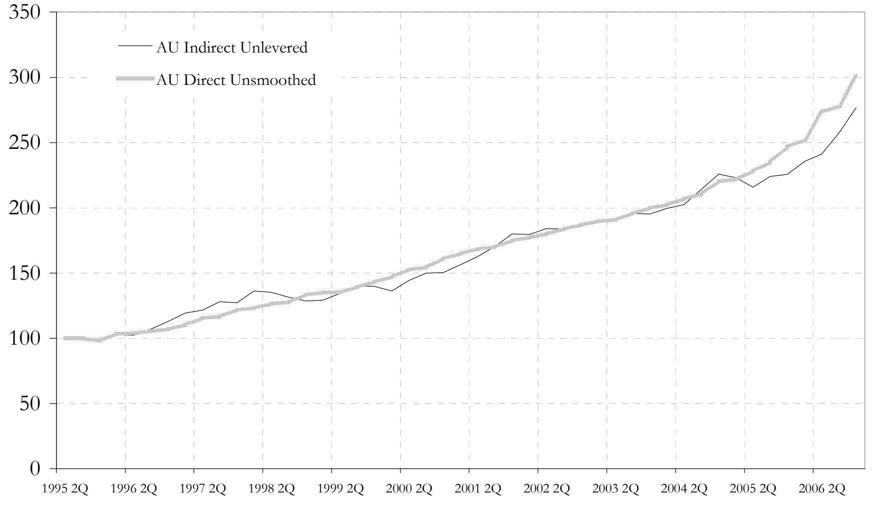
7.5 Comparing Public and Private Office Returns Again

To answer the question whether investing in publicly listed office funds truly offers exposure to the local office market dynamics that are observed in the private market, we need to compare both markets after their returns series have been either unlevered or unsmoothed. Investors would not obtain the smoothed private returns in the market, since they are an artefact of the appraisal process. Off course, the leverage effect would enter the investors' portfolio if they decide to invest in the publicly listed vehicles, but it does hamper a fair comparison with the underlying private market for which return series are based on equity only investments. In order to create a level playing field and compare like with like we use unlevered return series for both public and private investments[56]. Figure 7.5 shows this comparison.

Figure 7.5 ■ Comparing unlevered public and unsmoothed private office returns

Panel a shows an unlevered equally weighted total return index of office specialists listed on the Australian Stock Exchange (AU Indirect Unlevered) and an unsmoothed total return index of investments in Australian office buildings (using an *a*-factor of 0.33 to correct for artificial autocorrelation) as compiled by the Property Council of Australia/IPD (AU Direct Unsmoothed) on a quarterly basis over the period 1995-2006. *Panel b* shows an unlevered equally weighted total return index of office specialists listed on the London Stock Exchange (U.K. Indirect Unlevered) and an unsmoothed total return index of investments in Australian office buildings (using an *a*-factor of 0.36 to correct for artificial autocorrelation) as compiled by the IPD (U.K. Direct Unsmoothed) on a quarterly basis over the period 1987-2006. *Panel c* shows an unlevered equally weighted total return index of office specialists listed on U.S. Stock Exchanges (U.S. Indirect Unlevered) and an unsmoothed total return index of investments in U.S. office buildings (using an *a*-factor of 0.56 to correct for artificial autocorrelation) as compiled by the National Council of Real Estate Investment Fiduciaries (U.S. Direct Unsmoothed) on a quarterly basis over the period 1985-2006.

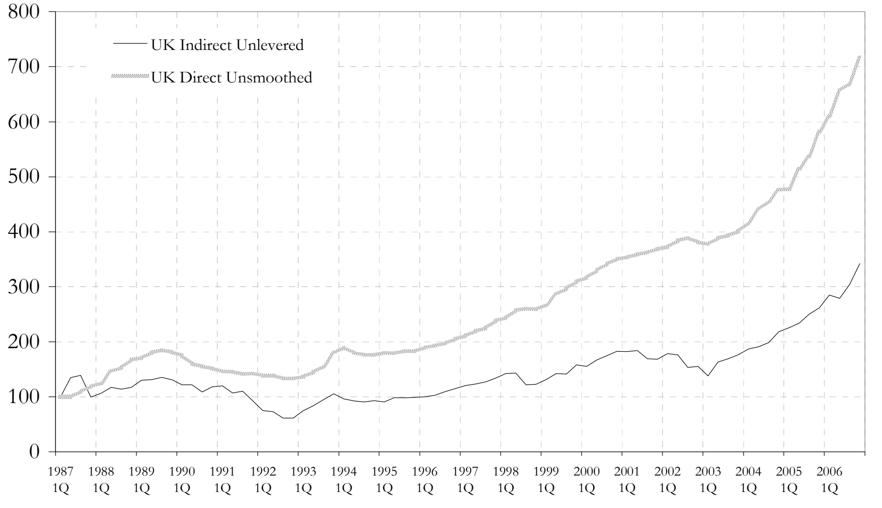
Panel a



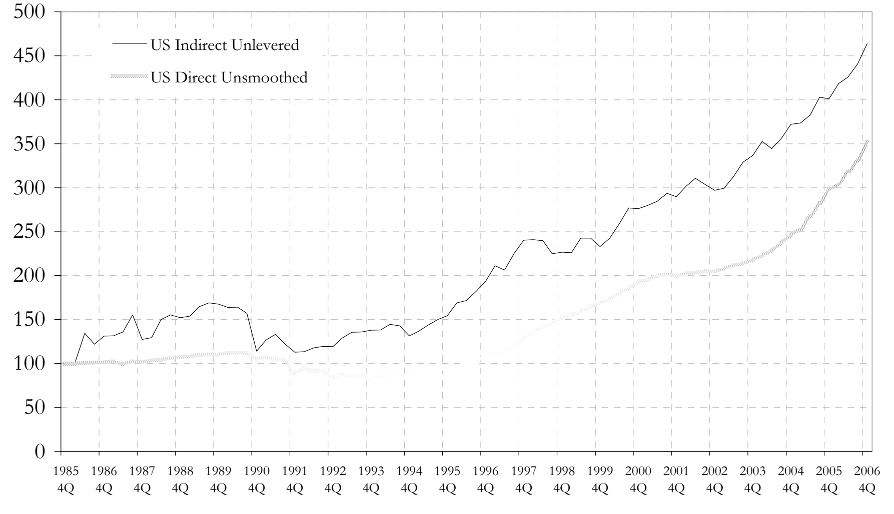
56 Another possibility would have been to leverage the private return indices to reach fair comparison.

Figure 7.5 ■ Comparing unlevered public and unsmoothed private office returns (continued)

Panel b



Panel c



Especially, the increase in risk due to the unsmoothing procedure is visible when comparing both figures. Visual inspection indicates that there is more similarity in time series behaviour after filtering both returns, when compared to the initial indices shown in Figure 7.2. For the U.K. we find time variations to appear much more synchronic than before, when private return were smoothed. A more specific comparison is offered in Table 7.2 where the sample statistics are offered for the unsmoothed and unlevered series.

Table 7.2 ■ Sample statistics unlevered and unsmoothed series

This Table shows sample statistics for the three countries used in our analysis over different time periods. We show summary statistics for unlevered securitized office investments through listed property funds (Public Unlevered) and unsmoothed investments in office buildings (Private Unsmoothed) as gathered by the Property Council of Australia, the Investment Property Databank (IPD) for the U.K. and the National Council of Real Estate Investment Fiduciaries (NCREIF) for the U.S. The full sample for Australia covers the years 1995-2006. Data availability does not allow for meaningful sub-sample analysis for Australia. For the U.K. the full sample covers the period 1987-2006 while sub-period 1 shows the analysis for the years 1987-1995 and sub-period 2 for the years 1996-2006. For the U.S. these periods are 1986-2006, 1986-1995 and 1996-2006 respectively. The mean quarterly total return (Average) and standard deviation as investment risk indicator (St. Dev.) are provided for each country and period. Autocorrelation (Auto-corr) is calculated as an AR(1) where the total return in period t0 is regressed on the total return in period t-1.

	Australia		United Kingdom		United States	
	Public Unlevered	Private Unsmoothed	Public Unlevered	Private Unsmoothed	Public Unlevered	Private Unsmoothed
Total return						
Average	2.28%	2.44%	1.98%	2.64%	2.08/%	1.59%
St. Dev.	2.90%	1.98%	9.10%	4.16%	6.86%	3.35%
Auto-corr	0.10	-0.27	0.13	0.50	-0.14	0.04
Sub-period 1						
Average	**	**	0.96%	2.04%	1.90%	0.28%
St. Dev.	**	**	11.14%	5.38%	8.90%	3.86%
Auto-corr	**	**	0.18	0.55	-0.17	-0.30
Sub-period 2						
Average	**	**	2.98%	3.21%	2.27%	2.99%
St. Dev.	**	**	6.51%	2.45%	3.56%	1.90%
Auto-corr	**	**	-0.01	0.19	0.04	0.49

Formal tests should reveal whether this apparent increase in similarity is present in a statistical sense. We test the coherence between the two investment platforms by examining correlation structures for the short-term, and by means of cointegration analysis regarding the longer-run relationships.

7.5.1 Correlation analysis

First we look at correlations of first differenced total return indices based on different lag structures. We look at different lags because, despite the unsmoothing procedure, listed securities might respond faster to events in the broader economy than the private data series. To account for possible lead/lag relations we test correlations with two period leads and lags. Table 7.3 shows the outcome of the correlation analysis.

Table 7.3 ■ Correlation of returns between direct and (lagged) indirect investments in offices

This Table shows the correlation between returns of unlevered indirect (public) investments in office property and unsmoothed direct (private) investments in the office property. No countries are indicated for the Indirect Unlevered series but returns reflect the return of the country as specified with the Direct Unsmoothed series. Numbers between parentheses indicate the respective lag in quarterly periods. **, * indicate that the correlation is significant at the 1% or 5% level (2-tailed) respectively.

	AU Direct Unsmoothed	UK Direct Unsmoothed	US Direct Unsmoothed
Indirect Unlevered (-2)	-0.05	0.22	-0.02
Indirect Unlevered (-1)	0.24	0.45 **	0.09
Indirect Unlevered	0.23	0.27 *	0.31 **
Indirect Unlevered (+1)	0.20	0.11	0.00
Indirect Unlevered (+2)	0.17	0.12	-0.01

The correlation analysis does not provide clear and general results for the countries used in this study. Contemporaneous correlation between private and public office investments are 0.23, 0.27 and 0.31 for Australia, the U.K. and U.S. respectively. These figures are marginally higher than the correlation between the two investment platforms based on the raw data series as reported in Table 7.1 for the U.K. and U.S. but lower for Australia. Correlations between private returns and one quarter lagged public returns are slightly higher in Australia and the U.K. which points towards faster information processing in the public market. For the U.S. we do not find an increase in correlation when lagged public returns are used.

7.5. Cointegration analysis

All indices used in this study[57] are integrated of order one (also referred to as being I(1) in the literature). As pointed out by Engle and Granger (1987) a linear combination of two or more non-stationary series may be stationary, in which case the series are said to be cointegrated. Two series, for example Y_t and X_t, that are themselves $I(1)$ are cointegrated and share a common trend if a value β exists that makes $Y_t - \beta X_t$ stationary (or $I(0)$). This implies that there are some influences that bind the two series over longer time periods. Public and private real estate investments share in principal the same underlying asset and are as such expected to be cointegrated. However, public real estate assets are known to trade at premiums or discounts to Net Asset Value (NAV) at certain points in time[58] and there are some institutional differences between investing in either asset type. We analyse whether the pairs of indices shown in Figure 7.2 and 7.5 are cointegrated with a Johansen Cointegration test which is based on Johansen (1991). Table 7.4 shows the results of

[57] See Figures 7.2 and 7.5 for an overview of all indices.

[58] For an overview of reasons for these premiums or discount to NAV see for example Barkham and Ward (1999).

this cointegration analysis for two types of cointegration measures (i.e. Trace Statistics and Max-Eigen Statistics).

Table 7.4 ■ Cointegration analysis

This Table shows the results of cointegration analysis between raw (*Panel a*) and adjusted (*Panel b*) direct and indirect property total return indices. For Australia (AU) we analyze the period 1995-2006, the United States (U.S.) 1986-2006 and United Kingdom (U.K.) 1987-2006. All series are on quarterly basis. We report outcomes based on two cointegration test methodologies (Trace Statistic and Max-Eigen Statistic). * and ** indicate at least 1 cointegrating equation at the 0.05 and 0.10 level respectively.

Panel a

	Smoothed and Levered data			
	Trace Statistic	Max-Eigen Statistic	Probability	Significance
AU	14.94	-	0.06	***
	-	9.11	0.28	
UK	11.26	-	0.19	
	-	7.75	0.41	
US	21.33	-	0.01	*
	-	16.28	0.02	**

Panel b

	Unsmoothed and Unlevered data			
	Trace Statistic	Max-Eigen Statistic	Probability	Significance
AU	43.36	-	0.00	*
	-	37.13	0.00	*
UK	27.52	-	0.00	*
	-	16.84	0.02	**
US	35.90	-	0.00	*
	-	33.14	0.00	*

From Table 7.4 we can conclude that the cointegrating relation improves if we compare results in *Panel b* to the results in *Panel a*. Raw (smoothed and levered) indices in Australia are cointegrated at a 0.10 significance level for only one measure while cointegration between the unsmoothed and unlevered indices is significant at a 0.01 level for both cointegration measures. A similar result is found for the U.K. although both cointegration measures are insignificant for the raw data for this country. For the U.S. we observe that cointegration is present at 0.01 or 0.05 level, depending on the measure, for the raw indices while both measures are significant at 0.01 level for the unsmoothed and unlevered data. Furthermore we find that the Trace and Max-Eigen Statistics increase by unsmoothing and unlevering the data for all countries.

7.6 Conclusion

Over the last two decades stock markets have been witnessing the birth and surge of listed real estate firms specialized in office markets. These office funds have been gathering size and liquidity, thereby offering both small and large investors the opportunity to invest in office markets without having to build and manage private property portfolios. This chapter analyzed whether these office funds offer the exposure that investors are looking for, exposure to office returns, or whether the stock listing has been drifting their performance away from the local office market dynamics.

At first glance we find little resemblance between the time series of total returns of public and private office markets. After adequately resolving smoothing issues for private returns and abstracting from the leverage effects in public returns, we find more coherence between the risk and return characteristics of both markets. However, on a contemporaneous basis we still observe a vast discrepancy in market dynamics, which means that in the short term both markets can be drifting apart, while in the long run performances tend to behave more alike.

Chapter 8
Summary and Concluding Comments

This dissertation consists of six studies and focuses on office market dynamics from a broad, but always financial, perspective. The different studies examine respectively forward looking behavior in the office construction decision; the effect of density on office rents and firm profitability; determinants of office rents for a range of cities in Europe and the United States; and similarities between the direct and indirect investment formats in office space.

In the first study we collect data on office construction, office based employment, interest rates and some variables derived from the stock market for Hong Kong and Singapore over the period 1980-2006. We use this information to create a model for office construction and advance the real-option-based empirical analysis of commercial real estate investment in three respects. First, we test several real option implications for real estate construction that have not been examined in the commercial real estate investment literature. In particular and in line with the predictions of real option models, we show that the effects of real interest rate and the expected demand growth on hurdle rent become more negative when the market volatility is greater. Second, we use a cointegrating vector of office employment and office stock to provide a better control of the demand for new construction than traditional indicators based on real estate prices and vacancy rates. Third, whereas the existing studies focus on the U.S. commercial real estate markets, we study two major office markets in Asia, namely Singapore and Hong Kong. We rely on the local stock market in the two city states to derive forward-looking measures of office demand growth expectations. The conclusions of this study provide new insights into the factors influencing irreversible investment decision making. The implications could be taken outside the real estate industry and provide an alternative framework for other industries. An interesting course for further research is to examine the effect of forward looking variables and its volatility for alternative markets where individuals have to make an assessment of irreversible investment timing decisions.

In the second paper we examine the rent effects of office clustering in the Amsterdam office market for the period 2000-2005. We isolate the rent effects of location density based on Geographic Information System (GIS) methodology, while controlling for variations in object characteristics in a cross sectional hedonic model. While controlling for the age, location and quality of the object we find a strong positive effect of being located in dense office areas. We find that the vicinity of other office objects is priced into rent levels, regardless of market conditions. Clustering of service sector companies within cities has long been recognized as the result of a need for *face-to-face* contact. The actual rent effect of this clustering has however only been examined scarcely. This paper extends the limited existing literature on the rent effect of office clustering by examining the influence of clusters outside the US, during changing economic tides and by application of novel methodology, based on objective clustering schemes. An interesting path for further research would be to examine whether the price of clusters diminishes over time as indirect communication possibilities take new forms with advances in information technology. Further changes in model format could examine whether the estimate of the effect of location on office rents can improve with the increase in geographic information availability and analyzing software. Based on the current available software packages distances have been measured using Euclidean distances. Further testing could reveal whether road distances lead to different conclusions in a dense urban setting.

The third paper is not directly related to office market dynamics but examines the tradeoff between the costs and benefits of agglomeration for a large sample of firms. The positive relation between urban density and productivity, wages and rents has been recognized for a long time, but the relation between density and profitability has been neglected in extant empirical studies. According to the concept of spatial equilibrium there should not be a significant relation between density and performance as companies in free economies can change location to optimize financial performance. In line with the existing literature, we find that population and employment density benefit productivity and increase labor and real estate costs. To test the tradeoff of benefits and drawbacks of agglomeration, we focus our analysis on the relation between agglomeration and profitability. For a sample of single-establishment Dutch firms, we find that on average the costs of settling in an area with a dense spatial distribution of employment outweigh the benefits; an effect that holds for both urbanization and localization measures. This surprising result contradicts expectations based on spatial equilibrium foundations. In chapter four we raise several possible explanations for our findings. These include the relatively faster increase in house prices in urban areas which could have affected wage demands disproportionally, moving costs which are neglected in theoretic models and non-financial settlement choices for the firms included in our sample. It is interesting to test whether the negative relation between urban density and firm performance holds over longer time periods and for other countries. Our results could have large implications for the notion of spatial equilibrium and further empirical testing would benefit the discussion on this matter.

In the next study we examine office rent adjustment models for ten major European office markets. The modeling captures long-run equilibrium relationships of demand and supply variables and their short-term corrections in a two equation error correction model. Besides our examination of a panel of European office markets we also contribute to the existing literature by testing whether the local nature of office markets makes a model based on national economic data inaccurate if local and national markets do not move in tandem. For this purpose we employ a dataset, which includes both disaggregated and national variables, to model changes in real prime rents for a group of premier and second tier office market cities across Europe for the period 1990-2006. We explicitly compare results that are derived from models that include different levels of geographic aggregation. Results of the two stage error correction model indicate that office rents adjust to short-run changes in office related economic activity, lagged rent changes, and to the deviation of rents from their long-run values. At the same time our results offer no proof that error correction models for office rents improve significantly by specifying economic growth figures beyond the national aggregated level for the cities included in our analysis. This last result contradicts expectations based on extant U.S. based studies. Reasonable explanations are the larger weight of the cities studied in the national aggregate and the smaller economies in Europe when compared to the United States. An interesting avenue for further research in this field includes the modeling of smaller European cities as these potentially have less resemblance with the national aggregate, making local economic data more important.

The following chapter continues our work on office rent modeling and applies an error correction model for understanding the changes in real office rents for a panel of 15 U.S. MSA's over the period 1990-2007. We find that office rents in all cities react positively to a rise in office employment and lagged rent changes, while lagged deviations from equilibrium rent levels exhibit a slow and partial adjustment over time. Given the non-negativity constraint of vacancy rates we extend the basic model by examining whether rents react to positive changes in employment conditional on the vacancy rate level. Our results show that office rents react significantly stronger to increases in employment when vacancy rates are below the long-term average. We also repeat the analysis for clusters of cities based on similarities in rent and employment dynamics using a methodology called multi dimensional scaling. The cluster results confirm the overall conclusions and show that our results are not solely valid for the whole panel of cities.

The final study of this dissertation examines the relation between direct and indirect investment in office space. Over the last two decades stock markets have been witnessing the birth and surge of listed real estate firms specialized in office markets. These office funds have been gathering size and liquidity, thereby offering both small and large investors the opportunity to invest in office markets without having to build and manage private property portfolios. In this study we analyze whether these office funds offer the exposure that investors are looking for, exposure to office returns, or whether the stock listing has been drifting their performance away from the underlying local office market dynamics. Our results indicate that correlations between the two office investment platforms are low; a result that remains after controlling for appraisal smoothing in the private return indices and differences in capital structure. In the long-run we find evidence that public and private investment vehicles are cointegrated at high significance levels when differences in index construction mechanisms are taken into account, but hardly cointegrated when data are left in their smoothed and leveraged format. This study adds to the existing literature by examining the relation between direct and indirect real estate investments for one property type. Extant studies examined the overall property market which blurs findings as property type weights are never exactly equal in the applied direct and indirect property indices. With a continued increase in transparency of fund investment holdings, chances for fund and property type specific research projects increase. The results of this future research should aid investors in their decision making process by increasing knowledge on value drivers for different property types.

Nederlandse Samenvatting (Summary in Dutch)

Inleiding

In dit proefschrift worden vijf onderzoeksvragen beantwoord die betrekking hebben op kantoorgebouwen en één onderzoeksvraag gerelateerd aan de verwante locatiekeuze van ondernemingen. Hoewel de onderzoeksvragen een breed scala aan onderwerpen belichten hebben ze allen een duidelijk financiële basis en volgen ze gezamenlijk in grove lijn de levensloop van een kantoorgebouw van ontwikkelingsbesluit, via locatiekeuze en huurinkomstenontwikkeling tot uiteindelijke investeringsvorm.

Kantoorgebouwen zijn alom vertegenwoordigd en zijn door tenminste drie factoren belangrijk voor de maatschappij. In de eerste plaats creëren kantoren de werkomgeving voor werknemers van vele dienstverlenende ondernemingen. Het belang van werkgelegenheid in dienstverlenende industrieën is de afgelopen decennia zowel in absolute als in relatieve zin gestegen in ontwikkelde economieën. Zodoende bevolken op dit moment vele werknemers van bijvoorbeeld banken, verzekeraars en overheden het grote aantal kantoorgebouwen dat ons omringt. De kwaliteit en locatie van deze gebouwen heeft hierdoor een directe en grote impact op de productiviteit en het welbevinden van vele mensen die dagelijks veel tijd besteden aan het reizen van en naar, of het werken in, kantoorruimtes. Een tweede factor die het belang van onderzoek naar de dynamiek op kantorenmarkten weergeeft is de grote hoeveelheid kapitaal die geïnvesteerd is in de gebouwen. Kantoorgebouwen zijn eigendom van de gebruikers of op directe of indirecte manier eigendom van grote of kleine beleggers. Dit maakt veel partijen voor een deel van hun vermogensontwikkeling afhankelijk van de situatie op de kantorenmarkt en dit zorgt weer voor een natuurlijke behoefte aan kennis over de ontwikkeling van deze situatie. De derde reden waarom kantoorgebouwen belangrijk zijn is meer visueel dan financieel en heeft betrekking op het aanzicht van steden dat gedomineerd wordt door kantoorgebouwen. De karakteristieke eigenschap van de skyline van steden als New York, Hong Kong, Chicago en Rotterdam wordt gevormd door de aanwezigheid van kantoorgebouwen, waardoor zelfs personen die niet in een kantoor werken er vrijwel dagelijks mee te maken hebben.

Door deze brede invloed van kantoorgebouwen op het alledaagse leven zijn de resultaten die in dit proefschrift worden gepresenteerd relevant voor een breed scala aan partijen die direct en indirect met kantoorgebouwen te maken krijgen. Hieronder vallen bijvoorbeeld beleggers, ontwikkelaars, kantoorgebruikers en verschillende overheidsinstanties.

De laatste decennia is veel onderzoek verricht naar de dynamiek op kantorenmarkten en hierdoor is in de loop der jaren een steeds duidelijker beeld ontstaan van de factoren die deze markt drijven. De belangrijkste impuls voor onderzoek naar drijvende factoren achter de dynamiek op de kantoren kwam van de substantiële misallocatie van kapitaal in de Verenigde Staten eind jaren ’80 van de vorige eeuw. Belastingvoordelen voor vastgoedinvesteringen tijdens het Reagan tijdperk leidden tot een golf van investeringen in kantoorgebouwen waarbij de onderliggende vraag naar kantoorcapaciteit geen gelijke tred hield met de ontwikkelingen aan de aanbodkant. De grote hoeveelheden kapitaal die in deze jaren verloren zijn gegaan hebben geleid tot een verhoogde behoefte aan kennis en een daarop volgende aandacht van onderzoekers naar de determinanten van vraag en aanbod op de kantorenmarkt.

De vraag kan rijzen wat de toegevoegde waarde is van een proefschrift met als Nederlandse titel “Dynamiek op de kantorenmarkt: bewegingen bestudeerd”, als er al meer dan twintig jaar onderzoek wordt gedaan naar dit onderwerp. Het antwoord op deze vraag wordt gevormd door de mogelijkheden die geboden worden door nieuwe modellen, datareeksen en computerprogramma’s. Door deze factoren te combineren is het mogelijk gebleken om in zes hoofdstukken niet eerder getoonde verbanden te leggen en niet eerder bestudeerde markten te analyseren en zodoende een relevante bijdrage aan de reeds bestaande kennis te leveren. Hieronder wordt een kort overzicht gegeven van de onderzoeksvraag en de belangrijkste resultaten per hoofdstuk zoals beschreven in dit proefschrift.

Overzicht

In hoofdstuk twee onderzoeken we kantorenmarkten voordat de eerste steen is gelegd. Het onderzoek richt zich op de vraag welke factoren gebruikt kunnen worden bij het modelleren van nieuwbouw op de kantorenmarkt en of reële optie theorieën hierbij een rol spelen. Eén van de kenmerkende factoren van vastgoedmarkten is dat tussen beslissing om aanbod te vergroten en uiteindelijke afronding van de bouw een aantal jaren verstrijkt. Daarnaast heeft de beslissing om een nieuw gebouw te ontwikkelen een lange termijn effect op het aanbod aangezien een gebouw een lange levensduur heeft. Door deze lange bouwperiode en levensduur moeten investeerders toekomstverwachtingen meenemen in hun investeringsbeslissing. Dit hoofdstuk levert een bijdrage aan de bestaande literatuur door te onderzoeken of aandelenmarkten een bron kunnen vormen voor extractie van deze niet direct waarneembare verwachtingen. Het empirisch deel van dit onderzoek heeft betrekking op de stadsstaten Singapore en Hong Kong. Uit onderzoek voor Amerikaanse markten (zie bijvoorbeeld Hekman (1985)) blijkt dat het gebruik van nationale data voor onderzoek van lokale vastgoedmarkten kan leiden tot onzuivere schattingen. Het voordeel van de twee in deze studie onderzochte stadsstaten is dat lokale analyse gelijk is aan nationale analyse. Verwachtingen gedistilleerd uit de Straits Times Index van Singapore zullen een sterke link hebben met verwachtingen voor de economie van Singapore terwijl de link tussen de New York Stock Exchange en bijvoorbeeld San Francisco of New York veel minder sterk kan worden verondersteld. We hebben in dit hoofdstuk verschillende nog niet eerder op de kantorenmarkt toegepaste veronderstellingen uit de reële optie theorie getoetst en vinden verschillende interessante verbanden tussen volatiliteit en investeringsbeslissing. Zo laat de analyse over de periode 1980-2006 zien dat het inderdaad mogelijk is om vooruitkijkende variabelen gedistilleerd uit de lokale aandelenmarkt te gebruiken voor het modelleren van nieuwbouw op de lokale kantorenmarkt.

Nadat de bouwbeslissing is genomen is het belangrijk om het gebouw op de juiste plek neer te zetten aangezien de locatie van vastgoedobjecten één van de belangrijkste waardebepalende factoren is. In hoofdstuk drie van dit proefschrift wordt dan ook onderzocht wat de relatie is tussen locatie van een kantoorpand en de hoogte van de huur per vierkante meter. In het bijzonder wordt hierbij onderzoek gedaan naar de huurprijsinvloed van andere kantoren in de directe omgeving van het pand waarin een bepaalde eenheid te huur staat. In bestaande literatuur is beschreven dat één van de belangrijkste redenen voor het clusteren van kantoren in steden de behoefte aan overlegmogelijkheden met andere bedrijven is; het zogenaamde *face-to-face* contact (zie bijvoorbeeld Archer en Smith (2003)). In de beperkte bestaande literatuur op het gebied van geclusterde kantoren is gebruik gemaakt van subjectieve cluster methodes die niet repliceerbaar zijn voor andere steden of gebieden. In hoofdstuk drie wordt een nieuwe manier geïntroduceerd die kan worden gebruikt om clusters van kantoren op een objectieve manier te bepalen. Dit gebeurt met behulp van een geografisch informatie systeem. Door de objectiviteit van de meting is deze methodologie ook toepasbaar voor andere geografische gebieden waardoor onderling vergelijk mogelijk wordt. Het empirisch onderzoek analyseert de Amsterdamse kantorenmarkt voor de jaren 2000-2001 en 2004-2005, periodes met respectievelijk zeer krappe en ruime condities op de plaatselijke kantorenmarkt. Uit het onderzoek blijkt dat hogere dichtheid op de lokale kantorenmarkt, na gecontroleerd te hebben voor een breed scala aan overige gebouw- en locatiekenmerken, een positief effect heeft op huurprijzen en dat dit prijsverhogende effect aanwezig is in zowel een krappe als ruimte markt.

Het volgende hoofdstuk neemt een bredere kijk op locatiekeuze en beschrijft een onderzoek naar de link tussen bevolkingsdichtheid en winstgevendheid van Nederlandse ondernemingen. Binnen het vakgebied van *Urban Economics*[59] is de vraag waarom mensen clusteren in steden één van de hoofdthema's (zie Glaeser, 2007). Reeds lange tijd is bekend dat er een positieve relatie is tussen bevolkingsdichtheid aan de ene kant en productiviteit, lonen en huurprijzen aan de andere kant. De belangrijke link tussen bevolkingsdichtheid en winstgevendheid is hierbij echter, voor zover mij bekend, niet eerder geanalyseerd. Volgens het principe van het ruimtelijk evenwicht[60] kunnen commerciële bedrijven hun winstgevendheid niet verhogen door van locatie te veranderen en zou er dus geen significant verschil moeten bestaan tussen bedrijven in stedelijke regio's en bedrijven in meer landelijke gebieden. De in het vierde hoofdstuk getoonde analyse van de Nederlandse markt laat echter zien dat de relatie tussen bevolkingsdichtheid en winstgevendheid het laatste decennium negatief is geweest. Deze verrassende conclusie verdient verdere onderzoeksaandacht maar enkele mogelijke verklaringen voor de bevindingen worden al in hoofdstuk vier geopperd. Hieronder vallen de relatief sterk gestegen huizenprijzen in Nederlandse steden die een effect hebben op de looneisen en niet-financiële persoonlijke redenen die de vestigingskeuze van de onderzochte groep bedrijven mede bepalen.

In hoofdstuk vijf wordt de levenscyclus van kantoorgebouwen weer opgepakt en wordt bekeken welke factoren van invloed zijn op het huurprijsniveau van een stedelijke kantorenmarkt. Hoewel voor "eigenaar-gebruiker"-panden prestige een rol kan spelen[61], zijn de huurinkomsten de bepalende factor in investeringbeslissingen voor beleggers in kantoorpanden. In de *multi-asset* portefeuille van beleggers concurreren kantoorgebouwen met een brede range aan andere mogelijke

[59] *Urban Economics* is de stroming in de literatuur die zicht richt op locatiekeuzes van bedrijven en huishoudens en de daaruit volgende consequenties. Hierbij worden methoden uit de economische wetenschappen gebruikt om stedelijke kwesties als misdaad, onderwijs, openbaarvervoer, huisvesting en locale overheidsfinanciering te analyseren. (zie www.economics.pomona.edu/lozano/econ153/econ153.lecture1.ppt en Wikipedia)

[60] Wellicht dat ruimtelijk evenwicht beter bekend is onder de Engelse term *spatial equilibrium*. Binnen een ruimtelijk evenwicht bestaat er voor zowel huishoudens als bedrijven geen reden om te verhuizen. Personen en bedrijven hebben hun eigen nut gemaximaliseerd en kunnen dit nut niet verhogen door van locatie te veranderen.

[61] Hierbij kan gedacht worden aan het hoofdkantoor van de ING bank in Amsterdam dat naast de huisvestingsfunctie duidelijk ook een visitekaartje voor de gehele onderneming vormt.

beleggingscategorieën. Het is voor mogelijke investeerders dan ook belangrijk om te weten welke economische factoren invloed hebben op de huurprijsontwikkeling. In dit hoofdstuk worden huurprijzen voor tien Europese steden geanalyseerd. In het bijzonder wordt hierbij gekeken of het gebruik van data op lokaal niveau andere resultaten oplevert dan data op landelijk niveau; zoals aangetoond voor Amerikaanse steden. Uit de resultaten blijkt dat veranderingen in kantoorhuren voornamelijk worden veroorzaakt door veranderingen in werkgelegenheid in kantoorhoudende industrieën, de afwijking van huurprijzen van berekende evenwichtsniveaus en vertraagde veranderingen in huurprijzen. Verrassend is dat voor de onderzochte grote Europese steden een model op basis van lokale data geen significant andere resultaten oplevert dan een model op basis van nationale data. De samenhang tussen veranderingen op lokaal en nationaal niveau is te groot om tot verschillen in uitkomsten te leiden. Deze bevindingen zijn duidelijk anders dan hetgeen verondersteld is op basis van Amerikaans onderzoek. Een mogelijke verklaring hiervoor zijn de kleinere economieën van Europese landen in vergelijking met de Verenigde Staten waardoor de samenhang tussen lokale en nationale gegevens hoger is. Interessant zou zijn om te bekijken of dezelfde resultaten ook gelden voor kleinere Europese steden maar helaas ontbreken de benodigde huurprijsdata voor deze analyse.

Hoofdstuk zes van het proefschrift is een onderzoek dat verder gaat binnen het thema van huurprijsdeterminanten. De hoofdvraag die in die hoofdstuk wordt beantwoord is de vraag of er sprake is van asymmetrie in de reactie van huurprijzen op positieve veranderingen in werkgelegenheid in kantoorhoudende industrieën. Doordat leegstand op de kantorenmarkt niet negatief kan zijn is de hypothese dat een toename in werkgelegenheid bij lage leegstandspercentages een grotere invloed heeft op huurprijs veranderingen dan bij veel leegstand. We testen deze hypothese voor een panel van de vijftien grootste kantorensteden van de Verenigde Staten over de periode 1990-2006. De resultaten laten zien dat er inderdaad sprake is van een asymmetrische reactie van huurprijzen op positieve veranderingen in werkgelegenheid binnen kantoorhoudende industrieën. In eerste instantie wordt dit resultaat getoond voor het gehele panel van vijftien steden. Deze conclusie gaat ervan uit dat de invloed van huurprijsdeterminanten op veranderingen in huurniveaus gelijk is voor alle onderzochte steden. In de laatste paragrafen wordt deze assumptie versmald door te kijken naar op basis van *multi dimensional scaling* gedefinieerde subpanels. De resultaten op basis van subpanels komen grotendeels overeen met de resultaten voor het gehele panel. Hierbij maakt het niet uit of de panels gebaseerd zijn op overeenkomsten in huurprijs- of werkgelegenheidveranderingen.

De tot dusver besproken hoofdstukken van dit proefschrift hebben betrekking op constructie beslissingen, locatiekeuze en huurprijsdeterminanten. De thema's die in deze hoofdstukken behandeld zijn hebben allen belangrijke implicaties voor beleggers in kantoorruimten. De resultaten die in deze hoofdstukken zijn gepresenteerd kunnen dan ook worden aangewend bij de investeringsbesluitvorming. Als een belegger besloten heeft om in kantoorruimte te investeren is de volgende vraag in welke vorm *exposure* in de kantorenmarkt wordt verkregen. Vastgoedbeleggingen kunnen namelijk op twee verschillende manieren plaatsvinden. In de eerste plaats is het mogelijk om gehele panden te kopen, dit wordt de directe manier van beleggen in onroerend goed genoemd. Daarnaast is het ook mogelijk om indirect in vastgoed te beleggen door aandelen te kopen in al dan niet op de beurs genoteerde vastgoedfondsen die op hun beurt een directe belegging in kantoren hebben.[62] In hoofdstuk zeven hebben we onderzocht of er grote verschillen bestaan tussen beide investeringsvormen door directe en indirecte kantoorbeleggingen in de Verenigde Staten, Australië en het Verenigd Koninkrijk met elkaar te vergelijken. De resultaten van dit hoofdstuk laten zien dat er op korte termijn wel degelijk verschillen zijn tussen de twee manieren van beleggen. Een mogelijke reden hiervoor is de hogere transparantie op de indirecte markt waardoor veranderingen in onderliggende waarden sneller in de prijs kunnen worden opgenomen. Wat we echter ook vinden is dat de verschillen op langere termijn veel kleiner worden en directe en indirecte investeringsvormen in kantoorruimte sterk aan elkaar gerelateerd zijn.

[62] Vastgoed dat is ondergebracht in een fonds wordt ook wel aangeduid als “securitized real estate”.

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Biography

Maarten Jennen was born in Heerlen on March 31, 1977. He attended Sint Michiel College in Geleen, at which he obtained an Atheneum diploma in 1996. From 1996 till 2001, Maarten studied at Maastricht University where he received his Master's degree in Economics with a specialization in Finance. In September 2001, he joined the Department of Finance at Maastricht University as a junior lecturer. In May 2004, he joined the Finance Department at the Rotterdam School of Management, Erasmus University as a PhD Candidate in Real Estate Finance. His PhD trajectory was financially supported by the NVM (a Dutch Commercial Real Estate brokerage association) and the Erasmus Research Institute of Management (ERIM). During his time as a PhD Candidate Maarten spent six months at the National University of Singapore and presented his work at several international conferences and seminars. Among these conferences and seminars are the AREUEA international meetings in Vancouver (2006) and Istanbul (2008), the AREUEA annual meeting in Chicago (2007), the ARES annual meetings in San Francisco (2007) and Captiva Island (2008), the ERES meetings in Weimar (2006) and London (2007) and the MIT/Maastricht/Cambridge meeting in Boston (2007). The article versions of chapters two, three and five of this dissertation have been accepted for publication in Real Estate Economics (chapter two) and the Journal of Real Estate Finance and Economics (chapters three and five). Currently, Maarten holds a position as Assistant Professor of Finance and Real Estate at the Rotterdam School of Management and Investment Analyst at the Research and Strategy Department of ING Real Estate Investment Management.

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EMPIRICAL ESSAYS ON OFFICE MARKET DYNAMICS

Office buildings are a major investment vehicle, provide a working environment for numerous employees across the globe and determine the skyline of major cities. Put differently: office buildings matter. This dissertation consists of six studies and focuses on office buildings from a broad, but always financial, perspective. The first study examines the effect of implications embedded in real option theory on office construction decisions by exploring the Singapore and Hong Kong office markets. In line with the predictions of real option models, we show that the effects of real interest rate and the expected demand growth on the hurdle rent become more negative when the market volatility is greater. The second study shows a model for measuring the effect of clustering of office space on rents. The results, based on the Amsterdam office market, show that office rents are higher in denser office areas. Our longitudinal data show that this effect is present irrespective of the phase of the office market cycle. The third study examines the relation between urban density and financial performance for a sample of Dutch firms. The analysis indicates that firms in densely populated areas have lower return on assets when compared to their counterparts in more rural areas. The following two studies examine office rent determinants in Europe and the United States respectively by applying two-stage error-correction-models. In contradiction to expectations based on U.S. office market research, we show that the use of local data does not significantly improve rent models in a study of ten European cities. For a panel of fifteen major office markets in the U.S. the results presented in the following chapter of this dissertation show that office rents react significantly stronger to positive changes in office employment when vacancy rates are relatively low. The final study shows the relation between direct and indirect office investment styles. Results indicate that the two formats are integrated over longer time periods, but can behave very differently over short time intervals.

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