Searching for Yield in Real Assets

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Abstract

Three empirical chapters addressing investments in real, alternative assets are presented in this thesis.

Chapter 2 focuses on fine art as an investment. In recent years, the art market has been characterized by final auction prices greatly exceeding the ex-ante estimates published by international auction houses. We define this difference as a rarity premium and build a 'Rarity Index' by aggregating the premia relative to the mean. We also investigate the benefits, outside financial performance, associated with art ownership and introduce the term of 'ownership yield', meant to encapsulate both aesthetic yield and features of conspicuous consumption. This ownership yield may account for the large differences between the values of rarity indexes we construct for three famous families of paintings over the period 2003 to 2013.

In Chapter 3, we turn our attention to residential real estate in alpha cities. We argue that relative price changes in prime property markets have greatly deviated from non-prime markets on a national level, while similarities across prime markets in different countries have increased. In order to illustrate the extent of these changes, we introduce a novel 'luxury ratio' and perform several statistical analyses on repeat-sales price indexes over the period 2003 to 2014. Taking the case of London, we show how the luxury ratio has evolved over the past two decades with respect to other UK cities. Results support the existence of an ownership yield in a world where high (and ultra-high) net worth individuals are growing in number and search for exclusiveness through the possession of distinctive residential property.

Chapter 4 targets two types of commercial real estate: data centers and shopping complexes (companies specializing in malls, shopping centers, and outlets). First, with price indexes based on US REITs, we analyze short-term and long-term relationships between the S&P 500 and several commercial real estate categories using Engle-Granger cointegration over the period 2009 to mid-2016. We find no cointegration between data centers and the S&P 500, or retail (representing shopping complexes) and the S&P 500, indicating that both sectors are not merely an attractive investment in their own right, but also portfolio diversifiers. Second, turning to individual firms, we perform a CAPM analysis of 41 international companies. Results show that, on average, price returns from data centers surpass those of shopping complexes; moreover, US companies specializing in malls, shopping centers, and outlets outperform those of similar firms abroad. Finally, we indicate a further avenue for data centers in relation to electricity storage, and explain implications for investors.

Declaration and Acknowledgements

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Table of Contents

List of Tables

List of Figures

Chapter 1. Introduction

1. Motivation

In times of economic uncertainty, investors look to alternative assets to achieve the best possible yield, capital appreciation, and diversification benefits. The most recent global financial crisis (gfc) of 2007 to 2009 has been no exception. Interest rates have plummeted from nearly 5 percent to less than 0.25 percent, making investments such as government bonds less attractive (See Figure 1.1). As a result, real estate and objects including art, gemstones, and other collectibles have drawn more attention. These are all goods which satisfy investor desire for tangible assets, serve as a store of value, and hedge against inflation. For example, a study by Renneboog and Spaenjers (2012) reveals that returns for white and colored diamonds between 1999 and 2010, a time period spanning two financial crises, exceeds inflation and traditional stock market returns. Their findings suggest the use of diamonds as a safe haven investment. In the case of art, Boyer (2011) finds evidence of an inverse relationship between the stock market and the art market in the short run, indicating that investors may be using art as a diversifying asset during periods of downturns in the stock market. Real estate has also been increasingly used as an investment vehicle. In 2015, global real estate value was nearly three times world GDP (Savills, 2016).

US T-BILL SEC MARKET 4 WEEK (D) - MIDDLE RATE
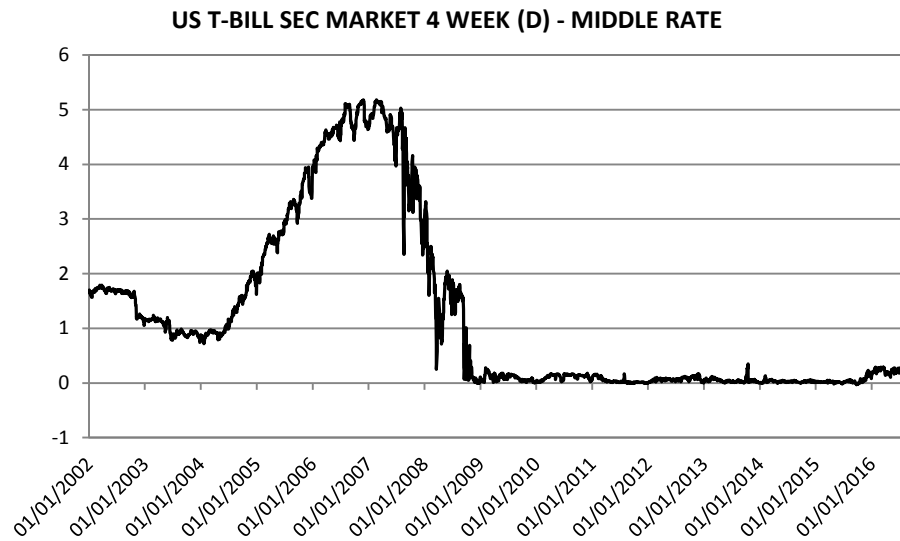
Figure 1.1. Interest rates from 2002 through 2016, represented by the US Treasury Bill four week middle rate

An increase in the population of high net worth individuals (HNWIs) and ultra-high net worth individuals (UHNWIs) has been a major factor in the popularity of alternative asset classes. HNWIs are generally defined as having financial assets – outside of their primary residence – in excess of one million USD. The number of UHNWIs, those with 30 million USD or more in financial assets, represent approximately 0.9% of the total HNWI population worldwide, but more than 35% of total HNWI financial wealth. In 2008, although the global population of HNWIs fell by approximately two and a half million and total wealth dropped by more than 3 trillion USD (the decline was mostly due to those in the one to five million USD range of wealth), figures quickly recovered in 2009 and reached new record highs by the end of 2010 (see Table 1.1 and Figure 1.2).

HNWIs invest heavily in real estate. They also invest in artwork, jewelry, and coins – known as 'treasure assets.' Whereas real estate holdings are the main asset and primary source of equity for the majority of home owners, it only

represents an average 2.6% of a billionaire's net worth (Wealth-X and UBS, 2014). In general, as income increases, the weight of housing expenditure declines (Bardos and Zaiats, 2011). A recent study by Barclays (2012) reports that, globally, the average percentage of wealth that affluent investors hold in treasure assets has increased to 9.6% of total net worth.

Table 1.1

Number of HNWIs (in millions), UHNWIs, and total financial
HNWI wealth (in trillions USD) from 2003 to 2013

Year	HNWIs	UHNWIs	HNWI Wealth
2003	7.7	70,000	28.8
2004	8.3	77,500	30.8
2005	8.8	85,405	33.4
2006	9.5	94,970	37.2
2007	10.1	103,300	40.7
2008	8.6	78,000	32.8
2009	10	93,100	39
2010	10.9	103,000	42.7
2011	11	100,000	42
2012	12	111,000	46.2
2013	13.7	128,300	56.6

Source: World Wealth Reports, 2003 to 2014
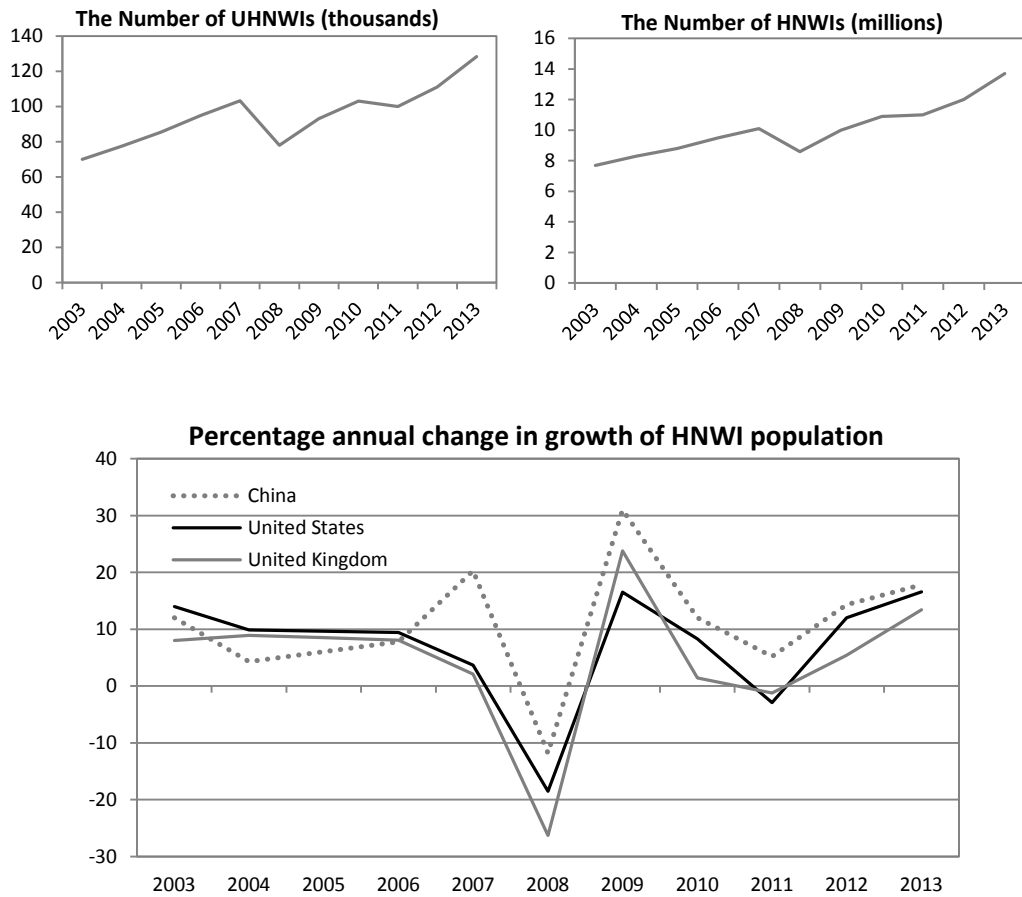
Figure 1.2. Top graphs represent the number of HNWIs and UHNWIs from 2003 to 2013. The bottom graph represents the percentage change, year on year, in the number of HNWIs in China, the US and the UK. Source: World Wealth Reports 2003 to 2014.

Scarcity drives the value of many real assets. Unique, physical goods are often characterized by shrinking supply and increasing demand. For example, art market activity for established genres such as Impressionism, Modern, and Old Masters is dictated by quality and scarcity, and the demand for top tier art greatly outweighs supply. Most masterpieces dating from the Renaissance through the start of the modern age may never be for sale again, as they already belong to permanent collections. Auction sales in recent years have been characterized by final sale prices greatly exceeding ex-ante estimates published by auction houses, as demonstrated by Geman and Velez (2015). Prime property markets in

alpha cities have also been characterized by extremely high prices, as a result of high demand and limited supply of desirable high-end real estate. Geman and Tunaru (2012) discuss supply and demand with respect to the real estate market.

The benefits of owning a scarce good can be linked to the theory of storage. Originally proposed by Keynes (1930), and later by Kaldor (1939) and Working (1948, 1949), the Theory of Storage states that there exists an intangible benefit - the convenience yield - from holding inventory, since it allows the owner of the physical commodity to advantageously react to changing supply and demand conditions. For example, if market supply is low, thus presenting a situation of scarcity, holders of inventory can sell their goods at a higher price or use it for their own benefit. If the opposite situation presents itself, then owners of inventory can withhold goods until more favorable circumstances arise. In the case of art and real estate, we show in Chapters 3 and 4 that there exist additional benefits associated with their ownership; we call the sum of these benefits the *ownership yield*.

The emergence of truly global markets, aided by new technology that makes information and buying platforms (for example, online auctions) available to market participants worldwide, has attracted new and potential investors to alternative asset classes such as art and real estate. These assets, largely popularized by the changing perspectives of investors, are the focus of Chapters 2, 3, and 4. The rest of Chapter 1 is organized as follows. In Section 2, we give an overview of art and real estate. Section 3 presents indexes used to track the performance of these markets, followed by ways of investing in Section 4. In Section 5, we give an overview of the research presented in Chapters 2, 3, and 4.

2. Alternative investments: art and real estate

2.1. Art

There has been much debate about whether art and other collectibles form an acceptable part of investment portfolios or if they are merely investments of passion. Whereas art was previously connected with connoisseurs buying for pure aesthetic enjoyment, it is now being acknowledged as a sound investment, bought for motives of portfolio diversification, capital appreciation, and hedge against inflation. In a study by Deloitte Luxembourg and ArtTactic (2013), 43% of private banks reported the growing importance of art as a diversifying asset in a balanced portfolio. There are numerous studies that compare the performance of the art market with more traditional asset classes (see, for example, Goetzmann, 1993; Goetzmann et al., 2011; and Chanel, 1995).

Art as an investment vehicle is hardly a new phenomenon. Documentation from the early 16th century describes a sophisticated, regulated, and relatively liquid art market in the town of Delft in the Netherlands; at the time, guilds in Dorestad and Utrecht were the sign of a vibrant merchants' activity. Works by artists were sold through dealers, auctions, exhibitions, estate auctions, or lotteries and raffles. Paintings constituted a very liquid class of assets because the tastes and quality standards of Delft citizens in the same social class were homogeneous compared with the broad range of tastes and standards of today's more globalized art market (Montias, 1982).

Throughout history, many important figures have built art collections with investment in mind. It is very fitting that Keynes, an important economist who started the Theory of Storage, had an extensive art collection. Moreover, his acquisitions were motivated in part by "the idea of art as an investment" (Scrase

and Croft, 1983). In total, Keynes spent a total of approximately 12,847 GBP on his art collection; its market value in 2013 was estimated to be just under 80 million GBP (Chambers et al., 2015).

The industry has changed dramatically over the past several decades. Since the 1960s, London and New York (due to their wealth, economic power, and favourable regulation) have been major centers of the art trade. The 1960s and early 1970s proved to be a turning point in the industry, even though some categories of art felt the negative effects of the 1973 oil crisis. Profiles of buyers at auctions changed from knowledgeable dealers (who bought works at lower prices for resale to private collectors) to more speculators, investors, and retail clients drawn to art as a hedge against inflation.

The growing popularity of buying art continued throughout the 1980s. Record auction prices in 1987, particularly of Modern and Contemporary art in New York, signalled the start of a boom cycle in the art industry. In 1990, a Van Gogh painting sold for 82.5 million USD and a Renoir for 78.1 million USD, both world record prices. Japanese buyers, mostly with purchases of Impressionist and Post-Impressionist art, fuelled this prosperous period, which ended in 1990 and coincided with the raising of interest rates by the Bank of Japan. Since the start of the millennium, the global art market has followed a trajectory of rapid growth, largely driven by the increase in the number of wealthy buyers from emerging economies (as discussed in Section 2.1). By 2011, the art market had nearly recovered from the 2008 financial downturn, with art sales nearing their pre-crisis high of 66 billion USD. In comparison, it took nearly a decade for the art market to recover following the financial recession of the 1990s (Knight Frank, 2013).

There is plenty of evidence supporting art as an investment, and not just an object to be collected. Numerous services attest to the growing popularity and acknowledgment of art as an asset class. A professionalization of the industry has taken place over the past decade, with large banks and other companies providing data, market analysis, and financial services. Given the increase in global demand for expensive artwork, there are many institutions which offer art-backed lending services, including Sotheby's, Christie's, Art Capital Group Inc., Citigroup, and Bank of America. In general, this service is only available to wealthy individuals or important cultural organizations that have an existing relationship with the lending institution. The amount for a loan can be as much as one million USD and some lenders require that an art collection meet a certain level of cultural importance in addition to monetary value. For example, art-backed loans from US Trust are only available to clients whose collections are of international repute and valued at a minimum of 10 million USD. The Chinese government also has plans to allow financial institutions to offer loans collateralized by art and other collectible goods. Campbell and Wiehenkamp (2008) even propose an Art Credit Default Swap, in which the borrower uses physical artwork as collateral; in turn, the lender can transfer the risk of the loan to a third party for a premium. The counterparty could be an art fund, art museum, hedge fund, or other investor willing to be exposed to price risk.

Additionally, there exist several fine art funds (discussed in Section 4) and artist pension funds. Established in 2004, the Artist Pension Trust requires that participating artists contribute one work every year over a period of 20 years (Gerlis, 2016). In exchange, each member receives 40 percent from the sales of the works contributed, while the rest of the members collectively share 32 percent of the profit. The remaining percentage is kept by the fund for operating costs.

Participants are essentially betting that the pool of artwork will appreciate over time, securing returns for their future retirement.

2.2 Residential real estate

Residential real estate has become a popular alternative investment, accounting for approximately 32% of HNWIs' investment portfolios (Knight Frank, 2015). According to a report by Wealth-X (2015), billionaires own an average of four residential properties, with a value totalling approximately 94 million US dollars. With globalization, there is more movement between countries for both business and leisure. Hence, wealth is also invested internationally. Global cities including London, New York, Hong Kong, Singapore, and Shanghai are all international financial centers, and considered liquid investments as far as residential real estate is concerned. The perceived liquidity of these markets makes them appealing to investors as a type of global reserve currency. For example, properties in desirable city locations are expected to re-sell easily to other investors.

There are many other features that add to the attraction of residential property as an asset class, including favorable transaction costs, socio-cultural factors, and safe haven status. The US and UK, for example, attract a large number of foreign investors because of low transaction costs, economic and political stability, and generous property rights (Fereidouni et al., 2013). In addition to buying residential real estate as a safe, long-term investment, there are often personal, business, or cultural reasons behind a purchase. Many Asian investors purchase property in the city where their children will be attending first class universities. Other investors are motivated by international business activities or attraction to the cultural status attached to a particular location.

Cvijanovic and Spaenjers (2015) show, through a dataset of residential real estate transactions in Paris, that foreign buyers who do not hold permanent residency "crowd out" Parisian residents in sought after locations, and demand for exclusive areas by such buyers increases when the economy is doing well, emphasizing the attraction of investing in luxury property. During 2012, foreign buyers accounted for approximately 85% of luxury property purchases in London and 50% in New York (Sassen, 2014). In Chapter 3, we specifically address high-end real estate markets in London, New York, and Hong Kong.

2.3. Commercial real estate

In addition to residential property, there are many categories of commercial real estate that have been popular investments since the global financial downturn of 2007 to 2009. A long period of low interest rates has meant low borrowing costs for real estate firms and high yields for investors from rents and sales of properties in commercial real estate portfolios. Data centers and retail are two categories which have enjoyed investor momentum in recent years. Both sectors are addressed in Chapter 4. However, these assets are often inaccessible (even for HNWIs) in terms of direct investment since they not only require enormous amounts of capital – in the hundreds of millions for a new data center, for example - but also more complex regulatory frameworks and expertise than required for a small portfolio of residential properties. Altenatively, exposure to these asset classes can be gained indirectly, for example, through publicly-listed real estate investment trusts (REITs). A report by PwC (2014) forecasts that worldwide inventory of commercial real estate will increase to a value of 45.3 trillion US dollars in 2020, from 29.0 trillion US dollars in 2012. Hence, commercial property will continue to play an increasing role in the successful

functioning of the economy and is likely to remain an attractive investment opportunity.

Since the global financial crisis, many commercial real estate firms have undergone tremendous developments in their management practices, infrastructure, and overall strategies in order to increase profit margins and investment appeal in the long-run. To improve performance, companies strive to acquire the best facilities and attract the highest quality tenants to populate their properties. Strategies including geographical diversification, incorporation of the latest technologies, and adapting to changing customer demands serve to increase income, investor confidence, and competitiveness on a global scale. For example, many US REITs have acquired more properties in Europe and Asia in recent years. Shopping centers, in response to competition from online retailers, are replacing traditional clothing and department stores with restaurants, fitness centers and entertainment venues. With advanced technology behind 'smart' energy becoming more affordable, real estate companies are also making buildings eco-friendly, which has proved highly beneficial in attracting new tenants and investors.

3. Price indexes and benchmarks

3.1. Methodologies

Since many of the alternative assets mentioned in Section 2 are not traded on an exchange, benchmarks of price performance are often provided by specialists in the field. Where prices are not readily available, indexes are often based on surveys, interviews, or appraisals to gauge the state of a particular market. Unlike traditional assets such as stocks and bonds, which are homogenous, real assets like art and real estate are heterogeneous. Each good

is uniquely defined by a set of characteristics. In the case of art, this could include provenance, artist reputation, technique, and medium (physical materials used in the creation of an artwork, for example, oil paints or pastels). For real estate, important features may consist of square footage, number of bedrooms, and location. These features may or may not change significantly over time. To address the heterogeneity of these assets, repeat-sales, hedonic, or averaging methodologies are often used to build price indexes. The repeat-sales method is based on sales pairs of the same good (whether a house, artwork or other collectible) and excludes all goods that have sold only once during the length of the index period. Hedonic indexes take into account the heterogeneous characteristics of each object and decompose its price into these characteristics. These features entirely depend on the index creator. Both methodologies have their advantages and drawbacks regarding the extent to which they can accurately reflect the performance of a market defined by heterogeneous assets. For examples of repeat-sales methodology applied to alternative assets, see Goetzmann, 1993; and Mei and Moses, 2002. For examples of hedonic indexes, see Chanel, 1995; and Buelens and Ginsburgh, 1993.

3.2. Art and collectibles

Several price indexes used as a gauge of the fine art market. Mei and Moses (2002) publish a family of art indexes, which were recently acquired by Sotheby's, one of a number of art-related companies who wish to have more data at their disposal. Other popular indexes include those provided by Art Market Research (AMR), Artprice, and Artfacts.net, many of which report art market returns for a number of genres based on results from major auction houses such as Sotheby's and Christie's. The use of auction sales data - auctions account for approximately half of all fine art sales - could result in several negative

consequences. First, well known, established auction houses tend to sell artwork by established artists, which could bias prices upwards. Another bias could result from the "winner's curse," or the tendency of the winning bidder in auction to overpay. Because of such occurrences in auction houses, returns from art indexes built with a repeat-sales methodology should be taken as an estimation or upper bound of average returns. Many art indexes are not available to the public, cost money, and are generally updated on an annual basis due to the illiquidity of the market. Commercial art indexes typically cost from 100 USD to several thousand USD for yearly subscriptions, and are often quoted by financial publications such as the Financial Times. In Chapter 2, we introduce an alternative 'Rarity Index', based on publicly available auction records that we view as more appropriate to the recent period.

3.3. Residential real estate

Many well-known and easily accessible price indexes for residential real estate are based on repeat-sales or hedonic regression methodologies. Some, such as the Case Shiller Metropolitan Statistical Area (MSA) indexes, are used as the underlying for financial derivatives. Using a repeat-sales methodology, the Case Shiller National Home Price Index is published quarterly and accounts for more than half the value of all housing inventory in the US. Indexes are also calculated on a monthly basis for 20 metropolitan areas and several condominium markets, including Boston, Chicago, Los Angeles, and New York.

Other house price indexes are used for informational purposes only, such as the UK House Price Index published by the UK Land Registry (and by similar government agencies for other countries). Originally using a repeat-sales methodology, the UK House Price Index changed to a hedonic regression model

in 2016. The index, calculated on a monthly frequency, uses a dataset of sales transactions for single family homes spanning from 1995 to the present. In addition to a national index, indexes are also available on a regional basis, as well as for every city and borough.

There are numerous sources of house price indexes in the private sector. Popular real estate sites such as RightMove, Zoopla, and Zillow publish their own indexes. These companies often incorporate the asking prices of all properties advertised on their websites, which may affect accuracy if houses included subsequently sell for a different price. Covering the US housing market, the Zillow Home Value Indices (ZHVI) are comprised of the median of actual and estimated market values of all properties within a market from Zillow's own database of more than 110 million homes. Their family of indexes covers several geographical areas in the US, from national and metropolitan to individual neighborhoods and ZIP codes. Additional information for the luxury property market, which is a very small sector of the residential property market, is available through specialists such as Knight Frank and Savills. Mortgage providers including Nationwide and Halifax in the UK also publish indexes based on proprietary databases of mortgage approvals.

3.4. Commercial real estate

Institutional benchmarks for commercial real estate sectors include indexes published by MSCI and FTSE EPRA/NAREIT, which are based on indirect real estate investment. For example, the Developed Index, one of the many indexes from The Global Real Estate Index series published by FTSE EPRA/NAREIT, is constructed from the return performance of REITs and listed real estate companies from around the world. Indirect real estate indexes are

typically broken down by real estate sector (including office, retail, and industrial) and country, in addition to global indexes also being available.

Other commercial real estate indexes, such as the NCREIF Property Indexes, are based on actual, or direct, transactions of leveraged properties. Properties are appraised quarterly in order to update the indexes. Published by MSCI, IPD indices also calculate total returns for direct real estate transactions. They cover retail, office, industrial, and residential properties held in professionally managed portfolios. Originating in the UK, IPD property fund indexes are now available for several other markets, including Australia, France, Germany, and Europe.

Many of these indexes, whether based on direct or indirect property returns, become the underlying for many traded financially instruments, including structured products and index-linked ETFs and ETNs.

4. Investing in art and real estate

4.1. Direct investment

Investment in art and real estate can be done directly, that is, by buying the physical asset; however, such assets are typically characterized by illiquidity, high transaction costs, limited financial regulation, and lack of market transparency (for example, more than 50% of art sales are done privately). Other issues include the potential for capital appreciation and future cash flows - since many are long term assets, there may be none, unless rental income is possible. The value of some collectibles is entirely subject to changing tastes, which could affect re-sales. In the case of artwork, there is always the risk of buying fakes, forgeries, or stolen items. Heterogeneity also signifies that goods are not perfectly substitutable. With regards to real estate, changes in tax policy, political

instability, or economic uncertainty could affect a purchase or sale. Investing directly in commercial real estate entails large capital outlay, easily in the tens or even hundreds of millions for a new office building, shopping complex, or data center.

4.2. Stocks, REITs and ETFs

Exposure to residential and commercial real estate can be gained through publicly-listed real estate investment trusts (REITs). This is a far easier alternative in terms of liquidity, transparency, and capital commitment. A REIT is a company that generates income from real estate which they own or finance. By law, at least 75% of a REIT's gross income must be derived from real estate and 90 percent of all taxable income must be paid out to shareholders in the form of dividends. Shareholders benefit from both the capital appreciation of shares and dividends received from the rental and sale of properties in the REIT portfolio.

Exchange traded funds (ETFs) are financial instruments that track the performance of real estate indexes. iShares offer several ETFs based on several popular benchmark indexes. For example, their US Real Estate ETF tracks the Dow Jones US Real Estate Index, while the iShares Residential Real Estate Capped ETF corresponds to the FTSE NAREIT Residential Capped Index and covers several real estate categories including self-storage, property trusts, healthcare, and apartments.

Since there exist no derivatives markets for those wishing to gain exposure to assets such as art, or certain subdivisions of real estate such as prime residential property, a passive trading strategy can employed. An investor could buy shares in companies associated with these markets or an index based on luxury goods. For example, the S&P Global Luxury Index includes 80

companies involved in the production, distribution, or provision of luxury goods or services. This index began trading on August 15, 2011 but historical data can be accessed from 2005. Categories making up the index include luxury automobiles, homebuilding, jewelry, wine, and auction houses such as Sotheby's. Similarly, the Dow Jones offers a Luxury Index which includes 30 reputable companies within the luxury goods and services sector. Trading was initiated on May 14, 2008 but historical data is also available from the year 2005 onwards.

4.3. Exchange traded derivatives

Since May 2006, real-estate derivatives in the form of futures and options, based on the Standard & Poor's/Case-Shiller Home Price Index, have traded on the Chicago Mercantile Exchange (CME). These financial instruments serve a wide array of market participants, from speculators and investors who wish to gain exposure, to property owners who need to hedge price risk (i.e., protect themselves against a sharp price fall in the housing market). Real estate derivatives also trade on the New York Stock Exchange (NYSE), based on the S&P/Case-Shiller Composite 10 Home Price Index, and on the London Stock Exchange (LSE) based on the Halifax House Price Index (HHPI), which uses a hedonic methodology.

Eurex, a European Exchange, has traded property index Futures since 2009. They offer annual Futures contracts on several MSCI-IPD UK Total Return Indices. Sectors included are office, retail, and industrial, in addition to shopping centers, retail warehouses, UK city offices and other sub-sectors. Additional Futures contracts based on other European property indexes may become available to investors in the near future. The pricing of real-estate derivatives is a complex matter since the underlying is not a homogeneous asset; hence, the

real-estate derivatives market is incomplete and using them as a hedging instrument will never be perfect (Fabozzi et al., 2009).

4.4. Private funds and other vehicles

In the case of art, there currently exist no Futures contracts, or other exchange-traded financial instruments; however, there are investment funds and other regional vehicles available to investors. Art funds typically generate returns with a buy and hold strategy. The physical artwork is acquired and then liquidated at the end of the life of the fund, which can range from a few months to several years, or alternatively at an optimal time, at any point during the life of the fund. Art Funds can be formal, in which case they are considered official, structured investment instruments, or informal. In the latter case, a group of investors (who may or may not have any expertise in the market) combine their resources to purchase a portfolio of artwork. Whether formal or informal, the goals of art funds are the same: capital appreciation and preservation through investment in high quality works of art. Examples of formal art funds include Brazil Golden Art and Anthea Art Investments AG. Perhaps the most well known art fund is The Fine Art Fund, started by The Fine Art Group in 2004. The Fine Art Group currently advises funds and co-investments of over 350 million USD. The majority of their investment inventory is privately sourced and their team includes expert art buyers.

5. Overview of research

In this thesis, we focus on art and real estate markets from a financial perspective, as alternative asset classes. Chapters 2, 3 and 4 address some of the shortfalls in the current tools and indexes available to investors. We offer alternative means of gauging the performance of these markets, in addition to

presenting new evidence of their portfolio diversification benefits. Our aim is to better inform investors of market performance, using information that is readily available.

Chapter 2 addresses the fine art market. We argue that the existing hedonic and repeat-sales art indexes fail to capture some fundamental features of the current art market. In response to these shortcomings, we construct an alternative index for three genres of paintings that are popular with investors - French Impressionism, Modern, and 20th century Chinese – over the period 2003 to 2013. Our index is based on the difference between pre-sale estimates published by major auction houses and final prices paid by buyers at auction. We define this difference as a 'rarity premium' and build a 'Rarity Index' by aggregating the rarity premia relative to the mean. In Chapter 2, we also discuss the many non-financial benefits that accrue to owners of artwork, which we term 'ownership yield.' We attribute these non-monetary benefits to the differences in rarity premia over the period of study.

We address prime residential real estate in Chapter 3. After first defining prime and non-prime residential property in the cities of London, New York and Hong Kong, we argue that similarities across prime residential real estate markets in these cities have greatly increased over the period 2003 to 2014. Empirical statistical analyses are used to show the extent of these changes. Additionally, through the introduction of a 'luxury ratio', we illustrate the divergence of prime and non-prime markets within each city over the time of study. We also address the 'ownership yield', first introduced in Chapter 2, as applied to luxury real estate, and the non-financial benefits that appeal to wealthy investors in this category.

Chapter 4 targets two types of commercial real estate that have not been extensively addressed in the literature: data centers and shopping complexes. In recent years, both sectors have become increasingly popular among investors because of high yields, capital appreciation and potential for diversification. We first analyze short-term and long-term relationships between the S&P 500 and several categories of commercial real estate over the period 2009 to 2016, using price indexes based on US REITs. We also perform a CAPM analysis on 41 international companies (primarily REITs) over a similar time period. Results are presented for each company, since financial performance is largely based on the quality of property management by the firm.

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Chapter 2. On Rarity Premium and Ownership Yield in Art

1. Introduction

The growth in trading activity of objects including art, diamonds, gemstones, collectible cars, and vintage wine has been immense in recent years. This phenomenon has generally been amplified since 2009, despite very strong stock market returns. Sale prices of paintings, our particular subject of interest, have been extraordinarily high while inflation has been extraordinarily low, indicating changes in the art market that deserve to be addressed.

Another new and remarkable feature observed in the recent period, compared to ten years ago, resides in the large differences between final sale prices and estimates quoted by international auction houses. We propose to define this spread as a *rarity premium* that high net worth individuals (HNWIs) are willing to pay in order to acquire paintings they view as unique. Following a discussion of existing art index methodologies in Section 2, we accordingly define a 'Rarity Index' in Section 3 by aggregating relative premia. In Section 5, we build a Rarity Index over the period 2003 to 2013 for three families of artwork: French Impressionist paintings, Modern paintings, and 20th century Chinese paintings.

In this Chapter, we also investigate the benefits associated with art outside financial performance. Besides the aesthetic yield discussed in the existing literature, we recognize, particularly in the very large rarity premia, an *ownership yield* in Section 4 that contains the element of conspicuous consumption introduced by Thorstein Veblen (1899). The *possession* component we include in the ownership yield is further evidenced by the number and values of paintings that are being accumulated in free ports. Concluding remarks are presented in Section 6.

2. Measuring the performance of the art market

2.1. Art indexes

There have been numerous studies on the creation of art indexes to represent returns in the art market. Such indexes are typically used to evaluate the performance of art compared with other asset classes and study the role of art investment in portfolio diversification. First applied to the art market by Anderson (1974), repeat-sales and hedonic indexes are the most widely used in the literature on art performance and investment, as well as being popular in the study of financial returns for other luxury goods including violins (Graddy and Margolis, 2011), diamonds (Renneboog and Spaenjers, 2012), and wine (Dimson et al., 2014).

As in the real estate market, repeat-sales (see, for example, Goetzmann, 1993; Pesando, 1993; Mei and Moses, 2002; and Goetzmann et al., 2011) are based on sales pairs of the same artwork, as a way of removing the issue of heterogeneity. Unlike traditional, homogeneous assets such as stocks and bonds, each artwork is unique and defined by a set of physical as well as non-tangible characteristics. The repeat-sales index is based on average returns across all sales pairs during each time interval t, where t typically represents one year. Hedonic indexes (see, for example, Chanel, 1995; Chanel et al., 1994; and Buelens and Ginsburgh, 1993) take into account the heterogeneous characteristics of each artwork. These features may or may not be time-varying. Following this logic, hedonic regressions decompose the price of the artwork into many of these characteristics - which could include medium, dimensions, artist, provenance, location of sale, etc. - and attach an implicit price to each.

2.2. Shortfalls of repeat-sales and hedonic indexes

There are many reasons why repeat-sales indexes are not suitable for the art industry of today. The most obvious drawback is that single sales are excluded from the set of observations. This limitation may be acceptable for alternative investments such as real estate - the Home Price Index published by the UK Land Registry is comprised of more than 7 million *sale pairs* of properties out of 19 million sales transactions from 1995 to the present – but in the case of art, unique masterpieces sell very infrequently at auctions. In the world of today, young HNWIs don't need to sell and the piece may only reappear in the setting of inheritance and estate dispersion decades later. For example, out of the 13,000 sale observations from 1653 to 1970 considered in a reference paper by Anderson (1974), only 1,730 were repeat-sales. More recently, Ashenfelter and Graddy (2003) created a hedonic and a repeat-sales index using the same sample of impressionist and modern art over the period 1980 to 1991. From the 8,792 observations used for the hedonic index, there were only 474 sales pairs available for the creation of the repeat-sales index. The Mei Moses World All Art index, which uses art sales data from the year 1810 onwards, has only approximately 40,000 repeat auction sale pairs with around 3,000 sale pairs added each year. Their index not only excludes all private sales, which comprise at least 50% of total art sales, but all single sales from auctions, thus reducing the sample size even further.

Another major and obvious drawback of the repeat-sales method is the interval between sales. Case and Shiller (1987) address this issue in the case of real estate by giving significantly less weight to sale pairs with long intervals. With art, a work may not reappear on the market for 20, 40, or even 200 plus years. Recently, paintings looted during the sad Nazi period came back to light after

more than 70 years in the dark. During such long intervals, an artwork could have been bought and sold on the private market several times - private sales are generally not included in repeat-sales indexes due to confidentiality of transactions. Furthermore, insurance, maintenance, appraisal, and storage costs could represent a substantial part of the price difference. For instance, in their 2014 May World All Art Tracking Report, Mei and Moses compute the average compound annual return (CAR) for seven artworks that had not been sold at auction for a remarkable 225 years. After centuries (literally) of costs associated with ownership and possible decline in the quality of the artworks, it is very doubtful that, with or without weighting to account for the interval between sales, a CAR of 3.5% is at all significant or relevant as a source of information for investors and other market participants seeking to understand the current state of the art market.

Hedonic art indexes, although they take into account all available sales, are heavily reliant on the choice of the factors that drive the market. The subjectivity of the approach means that relevant variables could easily be excluded, therefore resulting in a misleading index. Furthermore, factors that drive the market and the weight attached to their importance may change over time. This implies the need for a continuous re-evaluation of variables and the incorporation of time varying coefficients (Candela and Scorcu, 1997).

In conclusion, both types of art indexes are misrepresentative of the actual performance of the art market. It follows that they are also unsuitable for comparing the performance of the art market to more traditional asset classes or financial indexes, such as the S&P 500. In both methodologies, the issue of heterogeneity – particularly if the resulting index is composed of several different art genres – is never fully resolved. In the case of repeat-sales, even if great care

is taken to match sales of the same artwork, homogeneous results across all artwork are averaged together to create one point on the index. With the hedonic method, it is very unlikely that paintings can be completely standardized due to the unique nature of the good.

2.3. The changing dynamics of the art market

The existing approaches to art market performance are untested in the current situation of a large number of wealthy buyers and premiums paid for artwork. The increased popularity of fine art is largely due to a growing number of HNWIs and ultra-high net worth individuals (UHNWIs) in developed and developing economies such as Brazil, Russia, India, the Middle East, and China - China has had one of the greatest influences on the global art market in the last decade and is home to the third and fourth largest auction houses. In 2013, the global population of HNWIs increased by 1.76 million, with a record combined wealth of 56.62 trillion USD; this rise is the largest since 2000 (Capgemini and RBC Wealth Management, 2014). Between 2008 and 2013, the number of billionaires worldwide grew threefold to 2,170; this number is expected to grow to 3,900 by the year 2020 (Wealth-X and UBS, 2013). Most new entrants are from Asia, with China currently second to the US as the country with the largest billionaire population. Art is one of the biggest luxury asset holdings of UHNWIs. Goetzmann et al. (2011) establish that the income of the very wealthy and art prices are cointegrated. Hence, over the long term, the highest earners are very influential in the price performance of this market. The large increase in billionaires is new and has an impact on the holding time of paintings they acquire – 60 years may elapse before these paintings return to the market and are included in existing repeat-sales indexes. This is a new phenomenon in itself and is part of, but not identical to, wealth inequality.

Our proposed index allows for the inclusion of all auction sales by genre and sheds light on the premiums buyers have been willing to pay for unique paintings at auction in recent years. It reflects the changing dynamics in this industry, evidenced in particular by the latest increase in the number of international art fairs, art storage facilities, online sales platforms (which now allow for the purchase of works in excess of one million USD), and facilities for bidding online at renown auction houses such as Sotheby's and Christie's. These developments in the art industry make high quality artwork more accessible worldwide to those who can afford it.

3. An alternative art index

The great majority of important artwork is valued today via public auctions; therefore, auctions are vital in the determination of prices (see Ashenfelter and Graddy, 2003). An estimation range set by the auction house is meant to provide indicative information and encourage bidding among buyers, while also being competitive with rival auction houses - in those commodity markets where Futures Exchanges do not exist, "price discovery" also takes place in auctions, such as those held for tea in Mombasa, for example. The expectation of the realized sale price can be represented by the average of the high and low estimates published by the auction house or facility. These estimates are available to the public prior to the auction. It has been shown in the literature that the midpoint between the low and high price estimates is very highly correlated with the realized sale price (Ashenfelter, 1989). Louargand and McDaniel (1991) find that the midpoint is a valid predictor of the realized sale price – their analysis covers auction sales of American art and collectibles (including paintings, ceramics, silver, and glass) in 1989 and 1990. It has also

been shown that auction house estimates are better predictors of final sale prices than hedonic price functions (Abowd and Ashenfelter, 1988).

The recent "hype" in the art market has pushed up final prices to extraordinary levels compared to the predictors described above, hence the relevance of a *rarity premium* in order to account for this phenomenon. Art market activity for established art genres such as Impressionism, Modern, and Old Masters is dictated by quality and scarcity. Since most masterpieces dating from the Renaissance through the start of the modern age already belong to public collections and museums, they may remain permanently off the market. These institutions dominate the ownership of artwork, not only in the above mentioned categories but also in most other recognized or historically significant genres. Furthermore, the inventory of non-living artists can only decline, resulting in higher realized prices and thus higher rarity premiums. Therefore, the *rarity* of those unique paintings which come on to the market plays a key role in their demand, realized prices, and benefits obtained by their proprietors. Unlike studies testing for the Masterpiece effect (Ashenfelter and Graddy, 2003) - which is the idea that it is better to buy the most expensive pieces one can afford because they have a higher expected return - our rarity premium and index are not based on financial returns.

Using all available information, namely auction estimates - since the other half of the market consists of galleries and dealers and is characterized by private sales and confidentiality of transactions - we propose to write the realized price as follows

$$Realized\ Price = Mean\ Estimate + Rarity\ Premium \tag{1}$$

The rarity premium represents the amount a buyer is willing to pay above the estimate to secure a given artwork and is defined by

$$Rarity\ Premium = Realized\ Price - Mean\ Estimate \qquad (2)$$

Facing the risk that a painting will not appear on the market for decades, or perhaps never again, there exists a "rarity pressure" to pay an amount that exceeds the prior estimate - in the same way, a buying pressure can be observed in a commodity market at times of low supply. In art, the influence of shrinking inventories combined with increased demand from HNWIs and ballooning free ports magnifies the effect of rarity over time and also creates a preference for the "spot" good rather than future ownership (See Keynes, 1930). Consequently, the scarcity of artwork results in higher realized prices and thus a positive rarity premium. Since this premium is expressed in dollar terms, we further introduce a relative rarity premium in Eq. (3) as the ratio of the premium to the mean estimate. This ratio allows the comparing of rarity premia across paintings of different sizes and values. For example, a relative rarity premium of 0.5 signifies that the buyer paid 50% more than the auction estimate. The magnitude and currency effect are deleted and relative rarity premia can be compared for auctions taking place in China or the US.

Lastly, to measure how strong the purchase pressure for art is over time, we define a 'Rarity Index,' constructed as the average of relative premia across the n sales taking place over the period t, where t is a quarter

$$Rarity\ Index\ (t) = [\sum_{j=1}^{n}(Rarity\ Premium/Mean\ Estimate)]/n \qquad (3)$$

Averaging over the number of sales in the period allows for the representation of an uneven rate of sales over seasons. The Rarity Index, as mentioned above, gives a view across various geographical locations (including Paris, London,

Hong Kong, New York, Amsterdam, Beijing, etc.) where the physical auction sales take place. In our view, different genres must be recognized and the Rarity Indexes aggregate relative rarity premiums within a given family of artwork. Unlike existing indexes, our Rarity Indexes, defined through premiums paid by buyers as opposed to financial returns, propose an alternative perspective on the evolution of the art market.

The effect of rarity is evident in the news. The success of a Sotheby's auction sale in November 2013, yielding over 290 million USD, was partly attributed to the fact that several of the lots had either been off the market for decades or were being auctioned for the very first time (The Wall Street Journal, 2013a). A week later, Christie's achieved a world auction record by selling a prized Francis Bacon triptych for 142.2 million USD (with an ex-ante valuation of 85 million USD, hence a relative rarity premium exceeding 60%). This painting surpassed the record previously held by Edward Munch's "The Scream" as the most expensive piece sold at auction. Estimated at 80 million USD, "The Scream" sold for 120 million USD, with a relative rarity premium of 50%. Nine additional pieces in the same Christie's sale of Post-War and Contemporary art also set records, contributing to combined realized sales of 609 million USD, a record for any single auction sale to date.

As the inventory of top tier artwork becomes thinner and more expensive, evidenced in large part by the increasing difficulty of leading auction houses to secure important lots for their seasonal auctions, a number of art investors and collectors favor high quality alternatives such as female artists (a long-awaited moment) or lesser known artists of the same genre. For example, on February 6, 2013, a painting by female French Impressionist Berthe Morisot sold for nearly 7 million GBP at Christie's, more than 4 million GBP above the highest estimate,

hence a relative rarity premium greater than 50%. This was an unprecedented amount for a female artist of any period.

It follows that the rarer an item, the higher the rarity premium. While the most identifiable part of the benefit may be the aesthetic part, it is probably not the part that holds the highest value. The total value for the buyer lies in the possession of the rare asset, leading to various benefits contained within the *ownership yield.*

4. Ownership yield

4.1. Aesthetic yield and beyond

In the theory of storage established by Keynes (1930) and later by Kaldor (1939) and Working (1948, 1949), a key result is the identification of a benefit attached to the ownership of a commodity in inventory – this benefit being represented by the convenience yield – since it allows the holder of the physical good to advantageously react to tight supply conditions. In the case of fine art, the visual benefits are a type of aesthetic dividend and may outweigh costs including maintenance, insurance and storage. Following other authors, we use the term "aesthetic yield" to define the pure visual enjoyment that accrues to the owner of the physical artwork.

The notion of aesthetic yield is mentioned repeatedly in the literature on art investment, beginning with Anderson (1974), Stein (1977), and Baumol (1986). McAndrew and Thompson (2007) use the term "aesthetic yield" to describe the non-monetary dividend enjoyed by collectors and investors. Campbell (2008) states that, although investing in art is deemed risky, the aesthetic benefit attached is potentially greater than any monetary gain or loss. In addition, Ashenfelter and Graddy (2003) mention the payment of "dividends in

the form of the pleasure the viewer receives" and Goetzmann (1993) uses the term "aesthetic dividend flow" to compare the aesthetic benefits of art with the more traditional monetary returns on stocks - benefits very similar in nature to those contained in the convenience yield of Kaldor (1939). In a more recent report on wealth provided by Knight Frank (2013), the term "aesthetic dividend" is mentioned yet again in reference to the visual pleasure that may replace a financial reward.

However, the aesthetic yield, if defined as the visual pleasure an artwork grants its proprietor, does not encompass other important non-monetary benefits connected to owning a piece of art. Thus, we propose to extend the previous studies, which mostly focus on the aesthetic dividends, and introduce the new concept of *ownership yield* as the total benefit attached to art possession, of which aesthetics only play a part. We argue that the ownership yield is the driving force behind very high prices being paid for artwork, thereby supporting large rarity premia in recent years.

4.2. Ownership yield as an extension of conspicuous consumption

We propose to include two distinct components in the *ownership yield*: the benefits derived from visual pleasure, or aesthetic yield; and the satisfaction derived from the possession of a rare good. Both components are positive. Rarity contributes to the "contentment" and "pride" derived from art ownership. The changing dynamics of the art industry, vastly complex and driven by wealth, merits a re-examination of the incentives which drives acquirers of these unique goods. An art purchase, particularly of desirable top tier masterpieces (or art "trophies"), may be motivated by *conspicuous possession*, which greatly characterizes the recent period. Veblen (1899) introduced the remarkable

expression of *conspicuous consumption* to represent the act of buying luxury goods and services in order to display one's wealth. It takes all of its value at times when international billionaires are not only buying expensive luxury items, such as watches equipped with greatly complex mechanisms and presented in special fairs, but also competing with one another (except for the brief recess of 2008), on the size of 'super-yachts' featuring multiple swimming pools and gymnasiums, with an irreverent display of wealth. Mandel (2009) associates art ownership with a "conspicuous consumption utility dividend" attached to opulence visibility. The cointegrating relationships between art prices and high incomes found by Goetzmann et al. (2011) also suggest that art may be used as a conspicuous consumption good for HNWIs and UHNWIs. For instance, a painting of high quality and price is purchased with the intention to gain (or maintain) social status, prestige, and admiration or envy from others. In the case of corporations such as banks and law firms, art collections exhibited in the corridors are meant to give a positive corporate image to clients and employees.

Ownership can also yield social rewards and privileges, which may include access to exclusive gallery openings, museum functions, and VIP treatment at seasonal art events and fairs. UHNWIs meet at international art fairs, including the Frieze Art Fair in London, Art Basel in Switzerland, and Venice Biennale. The number of Contemporary art fairs in London has grown from just one in 1999 to nearly twenty in 2013, with at least ninety Contemporary art fairs being held worldwide each year. If we take into account all genres, approximately two hundred art fairs are held every year, with events in Asia growing in both number and international repute. The act of attending and purchasing an artwork at an art fair or auction is a means of displaying wealth. In fact, looking at the number of articles lately published on art in the financial press (Wall Street

Journal, Financial Times, etc.), one can state that art has become a conspicuous asset class in its own right.

Lending to an important museum or cultural institution yields benefits, which are embedded in the ownership yield. The proprietors gain status, in addition to explicit acknowledgment of their philanthropy; their names are printed in an exhibition catalogue, press release, or museum room plaque. These benefits are clearly part of conspicuous possession. Furthermore, lending can positively reflect on a painting's authenticity and thus increase the value of the artwork. It is the most sought after artwork which has a higher probability of being solicited by a prestigious museum's collection.

The fact that some of the best artwork is hidden away in a growing number of free ports clearly demonstrates that owners do not need to display their collections and enjoy the visual gains of the aesthetic yield in order to be content. Storage of the world's most expensive artwork has traditionally been provided by Swiss free ports - for example, the Geneva free port now houses over one million pieces of art worth more than 100 billion Swiss francs in total - but new large-scale storage facilities in Beijing, Singapore, and Luxembourg are meeting new demand. Free ports were originally built to store commodities; for instance, the Geneva free port was built in the 19th century to store grains (The Economist, 2013). However, the most recent trend is the construction of specialized, climate controlled repositories for valuable goods belonging to the very wealthy. Whereas older free ports are characterized by plain, unassuming facades and purely functional structures, newer free ports are aesthetically pleasing, with architectural designs that rival modern museums. Wealthy individuals historically built art collections out of personal enjoyment, but more and more buyers see art as a portable store of value and vehicle for social status

that does not involve displaying the object, but rather storing it safely in a free port (New York Times, 2012). The average value of a painting stored in a free port is impossible to estimate since, in the majority of free ports, individuals do not have to declare the value of items stored; at best, lower bounds are quoted in the financial press.

Singapore Freeport Ltd is currently the world's largest free port and the first in Asia dedicated to the storage of fine art and collectibles. It offers complete confidentiality with regards to the nature of goods, their value, and the identity of the owner; hence, this storage facility has a competitive advantage over Switzerland where, due to new laws, clients are now required to provide descriptions, values, and country of origin for all items stored. Opened in September 2014, the Luxembourg Freeport also provides specialist services for its clients, including art appraisal, maintenance, private showrooms, and even collateralized loans. With clientele not only including private collectors but also investment funds, galleries, museums, and auction houses, free ports have become an acceptable place of business for the trade of art and other high end luxury goods, especially since sales transactions are typically free of taxes - these are generally payable in the country of destination when the good leaves the free port. Although the advantages of free ports are only possible because items stored are technically 'in transit', these warehouses have evolved from a temporary place of storage to a more permanent one, leaving to proprietors the sole benefit of possession.

To conclude, we wish to recall the famous "water/diamond paradox" of John Law who recognized the relative scarcity of a good as the origin of the value of a good in society. This value is definitely captured in the *rarity premium* and the *ownership yield*.

5. Rarity indexes: data and results

5.1. Auction data

Our dataset is chosen to reflect the changing art market in the past decade, and includes the increasingly important Chinese market, whose presence was not prominent until the early 2000s. Previous to this study, China was not the vibrant economy it is today, with a GDP approaching that of the US. We use estimates and realized prices from Sotheby's and Christie's - all locations included - to carry out auction sale analyses of original paintings by artists in three genres: French Impressionist paintings, Modern paintings, and 20th century Chinese paintings. Artists for each of the three genres were chosen prior to data collection based on historically accepted categorizations (in the case of French Impressionism and Modern paintings) or important art market reports (from Artron in the case of 20th century Chinese paintings). Their artwork is also well represented at international auction houses, including Sotheby's and Christie's. A full list of artists is available in the Appendix.

We limit our focus to unique paintings in established markets since historical trajectories of performance in terms of price and artist reputation are available. Mixed media, works on paper, and sales with incomplete information are excluded from the dataset. In general, auction prices are used as a benchmark in both auction and commercial (private), divisions of the art market since these auctions provide "price discovery" in absence of exchange-traded Futures markets. Auction sales account for approximately 50% of global art market sales and are led by Sotheby's and Christie's, followed by China's Poly International Auction Company (established in 2005) and China Guardian Auctions Co. (opened in 1993). Many buyers prefer to conduct business in

reputable international auction houses in order to avoid the problems of dubious provenance, counterfeits, and lack of transparency. These problems may be encountered when buying from lesser known sources in national art markets or lesser known auction houses.

Most major art auctions, art fairs, and other art sales typically take place in the autumn and spring, with autumn sales (namely November) setting the performance barometer for the year ahead. Since major auctions for the three genres studied in this paper occur in the spring and fall, we focus our analyses on Quarters 2 and 4. Indeed, months in these periods, for example, October, November, April, May, and June, could provide liquid maturities for an art Futures market to come - as it happens for some agricultural commodities Futures that trade for isolated maturities across the calendar year.

Taking into account Quarters 2 and 4, from Q2 2003 to Q4 2013, our dataset includes 1,147 realized sales by a group of 14 artists in the category of French Impressionist paintings, 3,698 realized sales by 80 artists in the category of Modern paintings, and 2,456 sales by 60 artists in the genre of Chinese paintings. We can see from Table 2.1 and Figure 2.1 that the number of sales for each category, despite new records being set not only for individual sales, but also auction sales and annual sales, has not surpassed the numbers of previous years. This is direct evidence that inventory is scarce and cannot keep up with increased demand. The SARS epidemic of 2003 was the main cause of a very poor spring auction season in China; as a result, many auctions were cancelled, explaining why there are zero observations in Q2 2003 for Chinese paintings.

Table 2.1
Breakdown of realized sales at auction.

	French Impressionist			Modern			Chinese		
	Total	AAE	BAE	Total	AAE	BAE	Total	AAE	BAE
Q2 2003	22	13	9	67	50	17	0	0	0
Q4 2003	34	15	19	119	82	36	17	15	2
Q2 2004	72	43	29	162	128	33	27	26	1
Q4 2004	40	17	23	116	83	32	55	49	6
Q2 2005	74	50	22	141	110	31	53	48	5
Q4 2005	61	43	18	168	139	28	84	81	3
Q2 2006	78	50	28	196	164	31	119	118	1
Q4 2006	57	46	11	212	176	36	173	155	16
Q2 2007	77	56	20	244	191	49	184	174	10
Q4 2007	62	40	22	237	195	41	201	193	8
Q2 2008	60	37	23	213	154	59	165	147	17
Q4 2008	35	9	26	160	70	86	145	84	52
Q2 2009	43	36	5	104	78	26	84	67	16
Q4 2009	43	33	9	150	113	35	100	90	8
Q2 2010	50	36	13	167	131	32	118	104	14
Q4 2010	21	13	8	107	86	21	64	51	11
Q2 2011	61	40	21	180	132	46	164	145	16
Q4 2011	39	19	18	175	119	54	164	132	32
Q2 2012	54	39	14	173	122	49	141	108	27
Q4 2012	46	32	14	203	130	72	113	88	23
Q2 2013	64	49	14	215	153	59	124	103	15
Q4 2013	54	36	17	189	135	51	161	129	29

Notes:
Total: the total number of realized sales per quarter; **AAE:** the number of realized sales that achieved a price (hammer price plus buyer's premium) above the average estimate; **BAE:** realized sales that achieved a price below the average estimate.
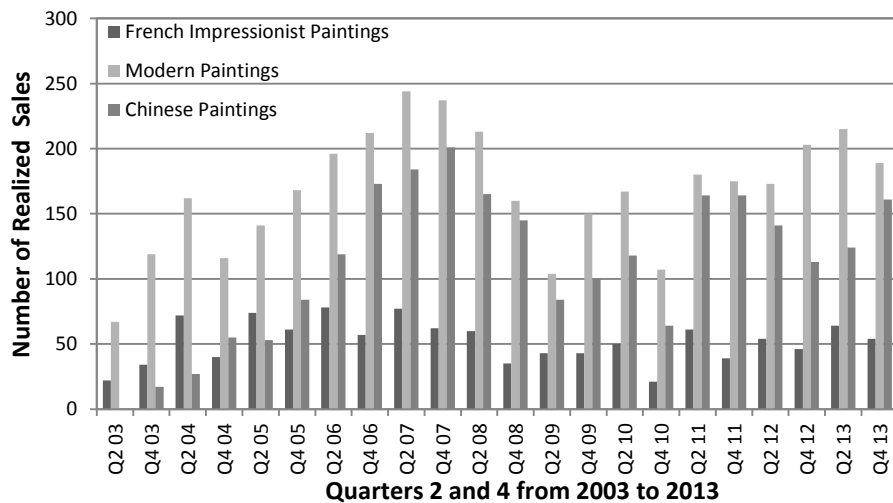
Figure 2.1. The number of realized sales from 2003 to 2013

In addition to low and high estimates for each painting, we use realized prices provided by the auction houses, which consist of two quantities: the hammer price and the buyer's fee. The realized price reflects the total amount a buyer is willing to pay for an artwork. The hammer price is the final bid price, i.e., the highest price offered by a buyer for a particular item. The buyer's fee, an amount paid by the buyer to the auction house for their services, depends on the final bid price and ranges approximately from 10% to 25% of the hammer price, pushing the total to staggering amounts; any additional costs and fees, such as insurance, storage, and handling are not included. Prior to the auction of an item, a confidential reserve price is set, which is the minimum price at which the seller, that is, the current owner of the object, will agree to a sale. This reserve price, which may be at or below the low estimate published by the auction house, is typically around 75% of the low estimate. Under no circumstances is the reserve price revealed to the public. The seller also pays a percentage fee - called the seller's fee - to the auction house for services rendered. We use the term "buyer's fee" instead of the often used auction terminology "buyer's premium" when referring to commissions so as not to confuse the meaning with our rarity premium.

Paintings that are unsold at auction or, in the terminology of the auctioneer, "bought-in" are not included in this study. There are many reasons why a painting may fail to sell at auction, including changes in the condition of the painting, lack of interest by buyers due to changing tastes or unrealistic expectations of sellers and auction houses. If bought-in paintings were incorporated into our sample, it may have the effect of scaling down average rarity premiums that compose our index. However, since there are many unknown factors, including reserve prices and subsequent sales in the opaque

private market, we do not address this sub-sample, as is the case in much of the literature on art indexes.

5.2. Empirical results and discussion

The art market is a heterogeneous one and *relative rarity premiums* in our sample range widely, from -85% to 2586%. In the Chinese painting genre, 7 out of 22 Quarters have maximum relative rarity premiums above 1,000%, while values for French Impressionist and Modern paintings lie within a substantially smaller range. To mitigate these large variations, we introduced a 'Rarity Index' in Eq. (3), which aggregates the relative rarity premiums paid by buyers in a given quarter. The Rarity Index is depicted in Figure 2.2 for each genre, with corresponding values in Table 2.2. The trajectory of the index reflects, for each family, the buying pressure over time.

Table 2.2
Percentage values of Rarity Indexes for the categories of French Impressionist, Modern, and Chinese paintings.

	French Impressionism	Modern	Chinese
Q2 2003	8.37	42.6	NA
Q4 2003	10.58	38.2	54.52
Q2 2004	19.69	49.18	125.18
Q4 2004	13.32	34.72	88.84
Q2 2005	28.36	45.18	197.23
Q4 2005	41.01	60.99	206.46
Q2 2006	30.77	48.18	264.82
Q4 2006	34.97	77.41	153.7
Q2 2007	47.68	57.93	187.52
Q4 2007	27.39	52.7	165.19
Q2 2008	23.2	48.85	104.42
Q4 2008	-3.02	9.81	17.4
Q2 2009	44.74	28.76	71.18
Q4 2009	50.82	47.61	74.38
Q2 2010	33.33	41.53	77.16
Q4 2010	32.09	35.02	51.63
Q2 2011	33.94	44.41	152.4
Q4 2011	16.08	25.86	63.85
Q2 2012	37.03	22.48	40.28
Q4 2012	36.19	27.31	38.33
Q2 2013	43.9	55.09	54.95
Q4 2013	40.5	33.07	58.06
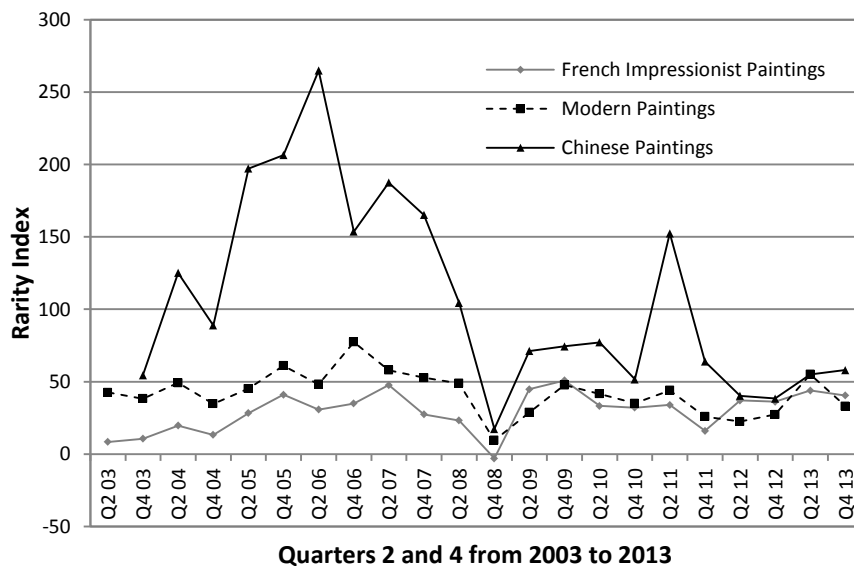
Figure 2.2. Rarity Indexes for three categories of paintings – French Impressionist, Modern, and Chinese – during the period Q2 2003 to Q4 2013.

We observe that, for all three families of paintings, the Rarity Index has always been positive since 2003, except for a very short period in Q4 2008 when the French Impressionist Paintings Index exhibited a slightly negative dip. This shows that, during and after the financial crisis, art - like gold - was viewed as a store of value, in contrast to other commodities and equities whose prices collapsed from the second half of 2008.

The Rarity Index prior to Q4 2008 is higher for the Modern and Chinese categories compared with the period following Q4 2008. This could be explained by the fact that collectors and investors have been less inclined to overpay for expensive artwork of lesser reputation in recent times. In contrast, the average for French Impressionist paintings has increased, showing a greater willingness on the part of buyers to pay a higher rarity premium for prized paintings in this category. With the exception of three Quarters, the Rarity Index for Chinese paintings has been higher than 50% over the whole period, suggesting the importance of wealthy Chinese buyers in the art market or the anticipation by other collectors that Chinese paintings will be desirable in the long run.

As in many sectors of the world economy, China has had a formidable impact on the global art market in the last decade and the explosion of this market, particularly from 2003 to 2007, is apparent in Figure 2.2. The number of art imports and exports crossing China's borders, with trade dominated by Hong Kong, grew at a staggering rate between 2000 and 2007 in order to satisfy the rising demand for this unique type of luxury good. Exports of art, mainly to the US, UK, and France, increased from 139.5 million EUR in 2000 to 329.1 million EUR in 2007, while imports, primarily from the US, UK, and Japan, of art over the same period rose from 138.5 million EUR in 2000 to a massive 524.7 million EUR in 2007 (TEFAF, 2009). The steep decline in 2008 not only corresponds to the

effects of the global recession but also several other adverse events, including extreme weather incidents (snowstorms in the South of China and an earthquake in Wenchuan), a volatile stock market, and additional macroeconomic pressures in China which undermined investors' confidence. In 2012, China fell from the lead position in the art auction market. A slowing economy and reduction in the activity of investors, combined with a scarcity of desirable top tier works available for sale, resulted in a contraction of auction sales by 30%. This affected both the demand and supply side of the Chinese art market (TEFAF, 2013). As a result, the US resumed its position as the largest art market, with China second, and the UK in third position.

In the midst of these events, the art auction market continues to achieve new highs. In 2013, annual auction sales for Christie's totalled 5.9 billion USD, a record high for an art auction house. Its success was greatly attributed to high quality works, i.e., masterpieces, selling at extremely high prices (The Wall Street Journal, 2014). In terms of total auction sales, Sotheby's was close behind at 5.1 billion USD. Sales of various categories of Chinese artwork, such as 20th century and Contemporary Art, also excelled in 2013, with world record prices established for five artists.

Table 2.3
Figures from Market Insight Reports[a] based on Impressionist and Modern art auctions in Sotheby's and Christie's international auction houses.

Date	Number of auctions[b]	Auction house	Location	Repeat-sales[c]	Avg %CAR[d]	Avg holding period (yrs)[e]
Nov-10	1	Sotheby's	New York	19	10.2	13
Nov 10	1	Christie's	New York	23	8.4	12
May-11	1	Sotheby's	New York	15	11	16
May-11	1	Christie's	New York	16	11.3	15
Jun-11	1	Sotheby's	London	13	10.7	19.8
Jun-11	1	Christie's	London	15	11.4	15
Jun-11	1	Sotheby's	London	44	10.5	13.3
Jun-11	3	Christie's	London	52	8.2	13.1
Nov-12	5	Christie's & Sotheby's	New York	132	4.8	NA
May-13	5	Christie's & Sotheby's	New York	153	4.7	17
Jun-13	2	Christie's & Sotheby's	London	50	8	18.4
Jun-13	3	Christie's & Sotheby's	London	140	2.5	13.8
Nov-13	5	Christie's & Sotheby's	New York	167	4.9	18.8

[a]Source: Market Insight Reports by Beautiful Asset Advisors®, LLC, www.artasanasset.com
[b] **Number of auctions** signifies the number of physical auctions (i.e. Day Sales, Evening Sales, or combination of both) included in that month.
[c]**Repeat-sales** represent lots with prior purchase prices.
[d] **Avg %CAR** is the average of the compound annual returns across the repeat-sales in that period.
[e]**Avg holding period (yrs)** represents the average number in years that lots were held, i.e. from prior purchase date to subsequent resale of the same work.

In order to understand the information contained in our Rarity Indexes versus repeat-sales and identify how well this information captures important features of the art market today, we compare average relative rarity premiums, the building elements of our Rarity Indexes, with average compound annual returns (CAR), which form the basis of repeat-sales indexes. More specifically, we look at various average CAR values reported by Mei and Moses (Market Insight Reports, 2011-2014) for several major international Impressionist and Modern auctions (see Table 2.3) alongside the relative rarity premiums for our French Impressionist and Modern categories (see Table 2.2). Whereas the Mei and Moses combine Impressionist and Modern art into one index (IMPMOD Mei Moses World Collecting Category Index), we define a separate index for French Impressionist and Modern paintings, which highlights the differences in performance between these very distinctive genres.

In the major international auction sales which took place in Q2 and Q4, from 2010 through 2013 (with the exception of Q4 2011 and Q2 2012 due to unavailable data), the average CAR has generally declined, as depicted in Table 2.3. In contrast, the French Impressionist and Modern Rarity Indexes show an overall increase in values during the same period, which is in agreement with reports written on the subject by financial institutions and press news. In Q2 2013, the Rarity Index for Modern Paintings exceeds 50 while the index value for French Impressionists is just below 45, indicating that, on average, buyers were willing to pay nearly 50% over the mean estimate published by major international auction houses. In fact, from 2010 through 2013, the lowest value never falls below 16 for the French Impressionist category and 22 for Modern. The difference between indexes is further evidenced by their correlation. Using the average of CAR values of Table 2.3 across quarters, we find a correlation coefficient of approximately 0.17 with our Rarity Index for Modern paintings and a negative coefficient of -0.75 with our French Impressionist Index. These results, surprising at first, highlight the contrast in the information provided by each methodology, and greatly support the Rarity Index as a necessary component of the representation of the current art market.

This difference is further emphasized by the total dollar amount of realized sales (See Table 2.4 and Figure 2.3). Figure 2.3 displays a remarkable uptrend (with the exception of the financial crisis) over the period 2003 to 2013 for combined sales of paintings in our French Impressionist and Modern categories, with values exceeding 400 and 500 million USD in the most recent periods of 2012 and 2013, while repeat-sales values are declining. Worldwide, our Rarity Indexes reflect the overall strength of the art market by capturing the magnitude of *premiums* paid by the new influx of wealthy international buyers vying for the

purchase of rare, top tier artwork, with the motivation behind these purchases driven by the many benefits encapsulated in the *ownership yield.*

Table 2.4
Realized Sales, in millions USD, of Modern and French Impressionist paintings included in our dataset.

	Modern	French Impressionism	Total
Q2 03	42.09	18.57	60.66
Q4 03	65.71	51.10	116.82
Q2 04	75.98	128.96	204.95
Q4 04	67.70	102.96	170.66
Q2 05	102.03	81.71	183.75
Q4 05	96.06	95.17	191.23
Q2 06	135.75	113.89	249.65
Q4 06	161.25	97.98	259.23
Q2 07	245.13	216.76	461.89
Q4 07	295.32	171.29	466.62
Q2 08	211.86	225.86	437.72
Q4 08	113.80	54.45	168.26
Q2 09	61.41	56.75	118.16
Q4 09	100.84	47.49	148.33
Q2 10	146.55	132.77	279.33
Q4 10	123.08	44.51	167.59
Q2 11	191.58	108.22	299.81
Q4 11	159.44	58.23	217.67
Q2 12	351.51	74.46	425.97
Q4 12	410.07	107.00	517.08
Q2 13	311.07	151.01	462.08
Q4 13	335.02	94.68	429.70
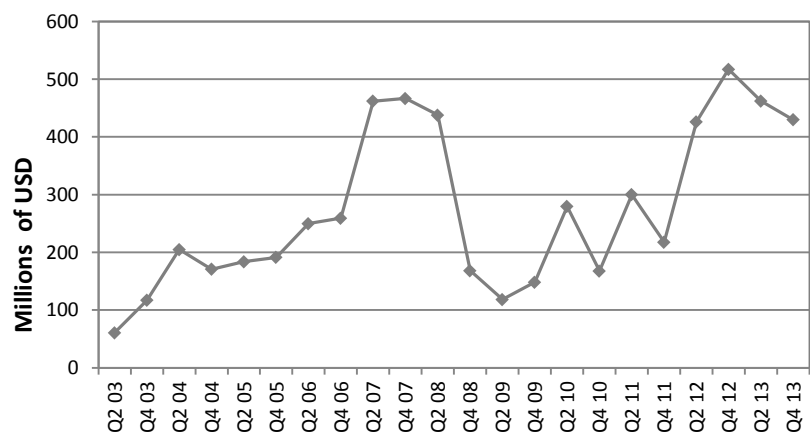
Figure 2.3. Total combined auction sales of French Impressionist and Modern paintings included in our dataset, Quarters 2 and 4 from 2003 to 2013.

6. Conclusion

In this Chapter, we argue that the existing hedonic and repeat-sales art indexes fail to capture some fundamental features of the current art market, namely the high prices buyers are willing to pay above the mean estimates published by international auction houses. Accordingly, we introduce a *rarity premium* based on auction house ex-ante estimates and realized prices, further extended to a *relative rarity premium*. We then construct Rarity Indexes by aggregation of these relative premia over homogeneous families of artwork, i.e., French Impressionist paintings, Modern paintings, and 20th century Chinese paintings. These indexes exhibit very small correlations with repeat-sales figures over the period 2003 to 2013 while signalling a very strong art market.

We further propose that the explanation of these *rarity premia* resides not only in the aesthetic yield discussed in the literature, but in a more general *ownership yield*. This term also contains the conspicuous consumption and wealth display in the acquisition of unique art pieces, together with the pure satisfaction gained from the possession of goods. It is this ownership yield which continues to be enjoyed by the proprietor once the beautiful piece of art is lent to a museum or stacked for an extended period at a free port in Geneva or Singapore.

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APPENDIX

CONSTITUENTS OF RARITY INDEX

French Impressionist artists

Frederic Bazille, Gustave Caillebotte, Mary Cassatt, Paul Cezanne, Edgar Degas, Eva Gonzales, Paul Gauguin, Armand Guillaumin, Edouard Manet, Claude Monet, Berthe Morisot, Camille Pissarro, Auguste Renoir, and Alfred Sisley.

Modern artists *(as defined by Art Market Research, one of the leading commercial art indexes, in their Modern art category; also used in Campbell (2008))*

Pierre Alechinsky, Karel Appel, Fernandez Arman, Edouard Arroyo, Frank Auerbach, Francis Bacon, Willi Baumeister, William Baziotes, Max Beckmann, Max Bill, Jules Bissier, Fernando Botero, Alberto Burri, Alexander Calder, Giuseppe Capogrossi, Corneille, Richard Diebenkorn, Jim Dine, Piero Dorazio, Jean Dubuffet, Jean Fautrier, Lucio Fontana, Sam Francis, Helen Frankenthaler, Alberto Giacometti, Arshile Gorky, Adolph Gottlieb, Hans Härtung, Patrick Heron, Eva Hesse, David Hockney, Hans Hofmann, Friedensreich Hundertwasser, Robert Indiana, Asger Jörn, Wassily Kandinsky, Paul Klee, Yves Klein, Franz Kline, Willem de Kooning, Wilfredo Lam, Peter Lanyon, Roy Lichtenstein, Richard Lindner, Morris Louis, Piero Manzoni, Giacomo Manzu, Marino Marini, Agnes Martin, Georges Mathieu, Matta, Joan Mitchell, Robert Motherwell, Ernst Wilhelm Nay, Louise Nevelson, Ben Nicholson, Jules Olitski, Victor Pasmore, Serge Poliakoff, Jackson Pollock, Arnulf Rainer, Martial Raysse, Ad Reinhardt, Bridget Riley, Jean-Paul Riopelle, Diego Rivera, James Rosenquist, Mark Rothko, David Siqueiros, Pierre Soulages, Nicolas de Stael, Rufino Tamayo, Antonio Tapies,

Wayne Thiebaud, Mark Tobey, Emilio Vedova, Bram van Velde, Maria Elena Vieira da Silva, Andy Warhol and Tom Wesselman.

Chinese painters *(a group of oil and acrylic painters from dynasties of Republic of China (1912-1949) and People's Republic of China (1949-):*

Liao Jichun, Chen Chengbo, Chang Yu, Wu Dayu, Zhao Wuji, Wang Yidong, Wu Guanzhong, Lin Fengmian, Liao Dezheng, Liu Ye, Chen Yifei, Zhang Xiaogang, Wang Guangyi, Yue Minjun, Shi Chong, Zeng Fanzhi, Hong Ruilin, Liu Haisu, Jin Shangyi, Wang Huaiqing, Yang Feiyun, Wu Zuoren, Ai Xuan, Zhu Dequn, Yan Peiming, Tang Zhigang, Luo Zhongli, Yan Wenliang, Liu Xiaodong, Ding Fang, Chang Qing, Xi Dejin, Lv Sibai, Liu Wei, Li Shan, Yang Sanlang, Li Tiefu, Fang Junbi, Wei Rong, Zhang Wanchuan, Zeng Chuanxing, Fang Lijun, Zhou Chunya, Yang Shaobin, Pan Dehai, Guo Wei, Zeng Hao, Xu Jiang, Pan Yuliang, Ling Jian, Li Guijun, Feng Zhengjie, Qin Dahu, Guo Weiguo, Su Tianci, Chen Yinpi, Chen Yanning, Shang Yang, Ding Yi and Qi Zhilong.

Chapter 3. Ownership Yield and Prime Real Estate in Alpha Cities

1. Introduction

Since the start of the millennium, the number of high net-worth individuals (HNWIs)[1] has greatly increased, from approximately 7.3 million in 2002 to 13.7 million in 2013, due to rapid growth in emerging and developing economies (Capgemini and RBS Wealth Management, 2015). As a result, there is a heightened demand for properties in prime city locations. Record prices are being paid by ultra-high net-worth individuals (UHNWIs)[2] who 'need' to maintain a residence in key places, especially at a time when barriers to live, work, and invest on a global scale are diminishing. On average, a billionaire owns four residential properties, with a combined total value of approximately 78 million USD (Wealth-X and UBS, 2014). Quality inventory of real estate in popular locations is limited and there is little space for new development, particularly in the most desirable areas of major cities such as London, New York, Hong Kong, and Singapore.

It has been suggested that high-end markets in key international cities are more related to each other than to their respective national housing markets. In a report by Douglas Elliman and Knight Frank (2014), price changes were found to be more correlated between London and Manhattan than between London and the UK housing market, or Manhattan and the US housing market. We wish to investigate this issue further by presenting a more detailed, time-varying analysis of the relationship across high-end residential property markets, in addition to exploring the relationship between prime and non-prime real estate within each metropolis.

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[1] HNWIs are currently defined as individuals who have liquid financial assets - not including their primary residence, collectibles or consumer goods - greater than one million USD.
[2] The term UHNWI became popular in 2007. UHNWIs, a sub-group of the HNWI population, are defined as individuals with 30 million USD in liquid financial assets.

We focus on real estate markets in New York, London, and Hong Kong – three cities of international importance – and contribute to the literature in several ways. After providing a brief review of the relevant literature in Section 2, we propose to recognize high-end property as a *conspicuous consumption* good and highlight the benefits embedded in its *ownership yield*, a term first introduced by Geman and Velez (2015). In Section 3, we categorize prime and non-prime property by location within each city in order to perform several empirical analyses in Section 4 with the purpose of showing differences in price changes. First, through the use of a novel 'luxury ratio', the search of structural breaks, and a comprehensive correlation analysis over the period January 2003 to December 2014, we show the extent that luxury real estate has emerged as an asset class of its own. Secondly, we focus on a single country analysis in Section 4.4, exploring the change in price levels between prime real estate in London and other metropolitan areas in the United Kingdom over the same time period. Concluding remarks are presented in Section 5.

Our dataset covers the rapid growth of these real estate markets, and their emergence and recognition as highly desirable investments by the very wealthy. These periods also have the merit of straddling the global financial crisis of 2007-2008.

2. The prime property market

2.1. The study of real estate prices

As a whole, real estate represents an enormous asset class. The size of the high-end residential market is small in comparison, and the majority of available information on this sector is in the form of reports and studies by specialists such as Knight Frank, Savills, and Rightmove, or mortgage companies

including Nationwide and Halifax. While there are no known academic studies that examine the differences between high-end residential property and general housing on a global scale, similar studies exist for commercial real estate. For example, Lim et al. (2013) look at the shift in price appreciation of prime and secondary commercial property in the UK. Several studies analyze the price behavior of residential, commercial, and industrial real estate markets across different regions, including de Wit (2010), Wilson and Zurbruegg (2002), and Lee and Stevenson (2005). Geman and Tunaru (2011) analyze the relationship of price volatility to inventory in property markets, extending the Theory of Storage to commercial real estate. In contrast to these studies, we concentrate on the high-end residential property market, while addressing regional and scarcity issues.

Since the housing market is characterized by heterogeneity (every property is unique), illiquidity, and infrequent trading, price returns are not easy to observe. This situation greatly contrasts with the liquid, transparent, stock market where reliable price returns are available on a daily basis. A major tool used to capture price change in the residential real estate market is the repeat-sales price index, first introduced by Bailey et al. (1963). There is a large body of literature related to the creation of repeat-sales indexes, including Case and Shiller (1987, 1989), Shiller (1991), Chau, et al. (2005), and Nagaraja et al. (2014).

The intuition behind the repeat-sales model is that the quality of an individual property does not change substantially over time; thus, the difference in the purchase and sale prices of the same property is regarded as an appropriate measure of price changes. Values of repeat-sales indexes are based on all available sale pairs – a sale pair consists of the sale and re-sale of the same property – over a period of time. Percentage changes in repeat-sales index

values from one period to the next represent the rate of appreciation (or depreciation) of a property market. Repeat-sales indexes including the S&P/Case-Shiller Home Price Indexes and the UK House Price Index (UK HPI) are widely recognized as benchmarks for their respective markets. The UK HPI consists of more than seven million repeat-sales, which have been paired from the UK Land Registry's dataset of more than 24 million completed sales transactions since 1995. UK mortgage providers, including Nationwide and Halifax, also publish indexes. Unlike the UK HPI, their proprietary databases are limited to transactions based on mortgage approvals.

2.2. Distinguishing features of prime property

Prime property mainly differs from the rest of the residential real estate market by price, location, and elements of exclusivity. Buyers in this niche are typically not restricted by high or low interest rates, taxes, transaction costs, or mortgage acquisition - factors which greatly affect the general housing market. However, the attraction of a wealthy buyer to a particular location is greatly influenced by factors including political and economic stability, property legislation, and favourable exchange rates. Kilpatrick (2007) studies the real estate investment behavior of the very wealthy, whose financial goals often differ from more traditional objectives associated with portfolio management. Whereas real estate holdings are the main asset and primary source of equity for the majority of home owners, residential property is a vital part of UHNWI portfolios, for purposes of both investment and luxury consumption (Paris, 2013).

Prime real estate, like collectible cars and super-yachts, can be categorized as a conspicuous consumption good. The term *conspicuous consumption*, introduced by Thorstein Veblen in 1899, represents the act of

purchasing expensive goods to display wealth, in order to enhance social standing. In his book, Theory of the Leisure Class (1899), Veblen states: "In order to gain and to hold the esteem of men, it is not sufficient merely to possess wealth or power. This one must be put in evidence, for esteem is awarded only on evidence." Exhibiting wealth or authority through expensive goods is hardly a new phenomenon. Ostentatious displays of luxury, in the form of expensive gladiator fights, chariots, and multitudes of servants, were already used to show social status and power by affluent rulers in the time of the Roman Empire. In the more recent literature, Gierl and Huettl (2010) identify three types of conspicuous consumption goods: those that are used to signal status; those that are used to establish a sense of belonging within an exclusive social circle; and items that are used to show uniqueness. A painting by an old master, flawless five-carat pink diamond, or an exclusive residence are goods that fit all three categories, while also sharing the element of scarcity.

Geman and Velez (2015) introduce the concept of *ownership yield* in the world of art, which incorporates the non-monetary benefits attached to owning an artwork. The benefits forming part of the ownership yield can be extended to other luxury assets, including real estate, as these also provide status, respect, and prestige. Additionally, in more recent years, the benefits of possession and social status have increased in importance for buyers of conspicuous consumption goods worldwide. In the case of real estate, owning several properties across city centers gives the freedom to move around the world, whether for business or pleasure, at a moment's notice. In the case of art, it is the object that is portable, whereas in the case of real estate, the physical assets (in the form of multiple dwellings) are what allow the owner to be "portable." With many UHNWIs owning their own aircraft or chartering planes, mobility has never

been easier. For example, in 2015, there were more visitors who traveled to Art Basel, an exclusive art event, by private jet than any prior year (Burns, 2015). Very wealthy individuals also have access to opportunities in several countries through programs such as the golden passport, which grants residency visas to foreigners if their investment in real estate exceeds a certain threshold.

2.3. Alpha cities

London, New York, and Hong Kong are 'alpha' cities, a term that was popularized by the Globalization and World Cities Research Network (GaWC), a think tank in England. They classify world cities as 'alpha', 'beta' or 'gamma' based on the level of global interconnection. Increasing global economic ties are a main driver of real estate investment in 'alpha' cities, and this is certainly reflected in sales of prime residential property as more and more businesses relocate or expand. In addition to the GaWC classification, London and New York rank as the top two global cities in many highly regarded reports, indexes, and other annually published rankings (see, for example, GaWC; Kotkin, 2014). Positions are based on the quantity and quality of factors such as business activity, financial services, foreign direct investment, global connectivity, human capital, and cultural experience.   Hong Kong also ranks high, due in large part to being the largest financial center in the Asia-Pacific region and the third largest in the world, following New York and London. As far as living and working are concerned, New York, London, and Hong Kong are the most expensive cities. Costs of living and renting office space for a single employee is approximately 123,000 USD per annum in Hong Kong, compared with 115,000 USD in London and 112,000 USD in New York (Savills, 2014).

The total value of residential real estate in the three alpha cities has grown tremendously in the past decade. In 2014, the estimated cumulative value of all homes in London was nearly 1.5 trillion GBP, compared with 1.12 trillion GBP in 2012 (Savills, 2015). According to Zillow, a leading real estate database for US property, the aggregate value of housing stock in New York was approximately 1.9 trillion USD at the end of 2013, an increase of 3.5 billion USD from the year before (Hopkins, 2013). The real estate market in Hong Kong, a city-state and Special Administrative Region of the People's Republic of China since 1997, has become one of the most expensive in the world. The median residential property price is nearly 15 times the gross annual median household income (Balfour, 2014). As a result, the price performance of real estate greatly impacts the economy, financial market, government budgets, and systematic risk in Hong Kong market portfolios.

The pool of buyers in the residential real estate market differs in each city. London attracts many international buyers. Badarinza and Ramadorai (2014) find that the perception of London as a safe haven, free from economic and political risk, has contributed to the influx of buyers from Southern Europe, China, the Middle East, Russia, and South Asia. In comparison to London, Hong Kong and New York property markets rely much less on international investment. A large amount of buyers in Hong Kong are from mainland China. US citizens represent the majority of sales transactions in New York, although approximately one third of buyers who purchase properties above three million USD are from abroad (Candy GPS report, 2014).

3. Data

3.1. Data sources

We use repeat-sales price indexes of monthly frequency. Since the price indexes used in this study begin at different times, we rebase them to 100 in 2003, the first year of our dataset (this is done in a standard manner; see, for example, Bollerslev et al. (2015). To combine indexes - for instance, we create the non-prime indexes for London and Hong by combining several repeat-sales indexes - we use the unweighted simple aggregate method. In terms of monthly changes, there are positive correlations (closer to one than zero) across the indexes that are aggregated.

Our data for London, provided by the UK Land Registry, is comprised of completed sales transactions for residences in the form of detached houses, semi-detached houses, terraced properties, and flats/maisonettes. Properties include both freeholds and leaseholds. We define prime London as the following two boroughs: Kensington and Chelsea, and the City of Westminster. These are the most affluent and expensive areas for housing. We define non-prime London as the remaining 30 boroughs of Greater London.

For New York, we define Manhattan, which is the most expensive of the five New York City boroughs, as prime New York. We use the Condo Market Index (CMI), a repeat-sale price index for Manhattan condominiums (or condos), to represent this prime market. Between January 2006 and August 2010, condos comprised 50.2% of all completed sales in Manhattan, according to a report by CMI. We define the rest of New York City as non-prime New York and use the

S&P/Case Shiller Home Price Index for New York to represent the non-prime segment of this real estate market.[3]

In Hong Kong, price indexes based on property prices provide an important measure, not only for real estate but of the entire economy, as argued by Chau et al. (2005). Properties in Hong Kong are very homogeneous, hence easily comparable. We define Hong Kong Island as prime. Hong Kong Island is close in size to Manhattan and home to approximately 1.2 million people. It has the highest median income and is the third most expensive place to live, following Monaco and London. The most affluent districts of Hong Kong Island include the Peak, Jardine's Lookout, Western Mid-levels, and Eastern Mid-levels. We define the regions of Kowloon Peninsula and New Territories as non-prime. Properties located in the New Territories, which is home to approximately 50 percent of Hong Kong residents, are more affordable. For prime Hong Kong and non-prime Hong Kong categories, we use repeat-sales indexes from the University of Hong Kong Real estate Index Series (HKU-REIS).

3.2. Descriptive statistics

Table 3.1 reports descriptive statistics for repeat-sales price indexes. Both the average and maximum percentage changes in index values are higher for prime properties in London, New York, and Hong Kong. This reflects greater appreciation in prime markets, compared with each city's respective non-prime market. Standard deviations are higher for prime property in the case of London and Hong Kong, indicating more variation in month-to-month changes. In the

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[3] The New York indexes overlap because there are currently no separate repeat-sale indexes available for every borough of New York City, as there is for London.

case of New York, the standard deviation is slightly higher in the non-prime category.

Table 3.1
Descriptive statistics

Alpha Cities	London	New York	Hong Kong
(A) Monthly Changes in Price Indexes: Prime			
Mean (%)	0.67	0.42	1.06
Median (%)	0.74	0.46	1.12
St Dev (%)	1.11	0.90	3.01
Maximum (%)	3.14	2.42	8.74
Minimum (%)	-2.98	-2.09	-11.30
Skewness	-0.537	-0.332	-0.967
Kurtosis	0.296	0.200	2.659
(B) Monthly Changes in Price Indexes: Non-prime			
Mean (%)	0.45	0.12	0.98
Median (%)	0.51	0.09	1.08
St Dev (%)	0.81	0.96	2.17
Maximum (%)	2.21	2.00	6.48
Minimum (%)	-2.36	-2.41	-10.34
Skewness	-1.041	-0.211	-1.020
Kurtosis	2.034	-0.903	4.269

The trajectories of repeat-sales price indexes, which reflect the impact of the global financial crisis on residential property markets, are depicted in Figure 3.1. In 2003, US house prices continued to rise until reaching a peak around 2005-2006. Non-prime repeat-sales index values are above prime index values in NY and London around this time, reflecting the buoyant housing market prior to the crisis. The US housing crisis did not severely affect the global financial and real estate markets until 2007. This was the time when the demand for mortgage-backed securities disappeared, resulting in the bankruptcy of dozens of mortgage companies (primarily specializing in subprime mortgages) and the failure of two hedge funds at Bear Stearns in July 2007. It has been shown in previous studies

(see Wilson and Zurbruegg, 2001, 2002) that major changes in the US economy, still the world's number one economy, can be a driving force of subsequent changes in the dynamics of international real estate markets.

It is clear from Figure 3.1 that the spread between the minimum and maximum values is much greater for prime markets, indicating a larger growth in prime real estate prices over the period of study. In the first half of 2008, while prices in the general housing market and also the high-end market in other parts of the UK were declining, properties in London valued at four million GBP and higher continued to grow between 0.7% and 1.2% in price (Savills, 2008). In Hong Kong, the number of sales of luxury homes in excess of 10 million HKD grew 43.9% from 2008 to 2009 (Knight Frank, 2010). This recovery in Hong Kong was mainly driven by Chinese investors from the mainland. Similarly, New York residential properties valued at more than 10 million USD quickly recovered and, in 2009, exceeded their pre-crisis highs. In 2008, real estate comprised 18% of HNWI assets - an increase of 4% from 2007 – with 45% invested in residential real estate (Capgemini and Merill Lynch, 2009).
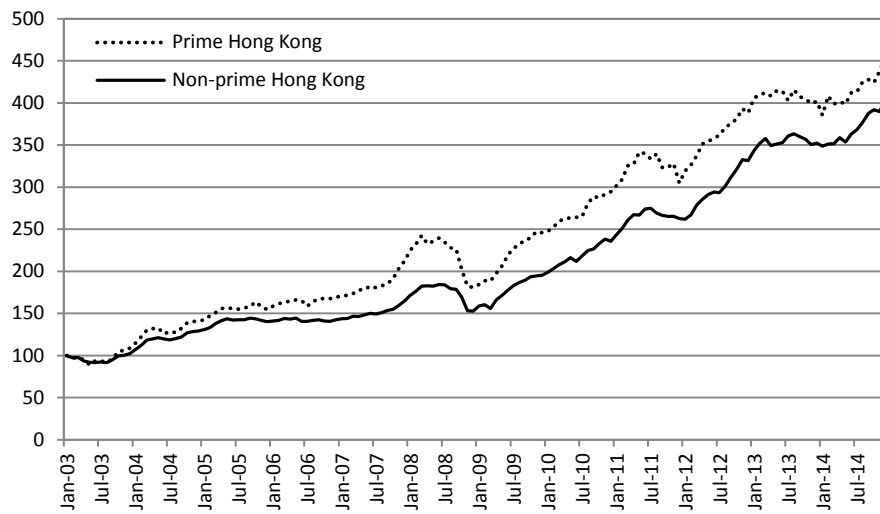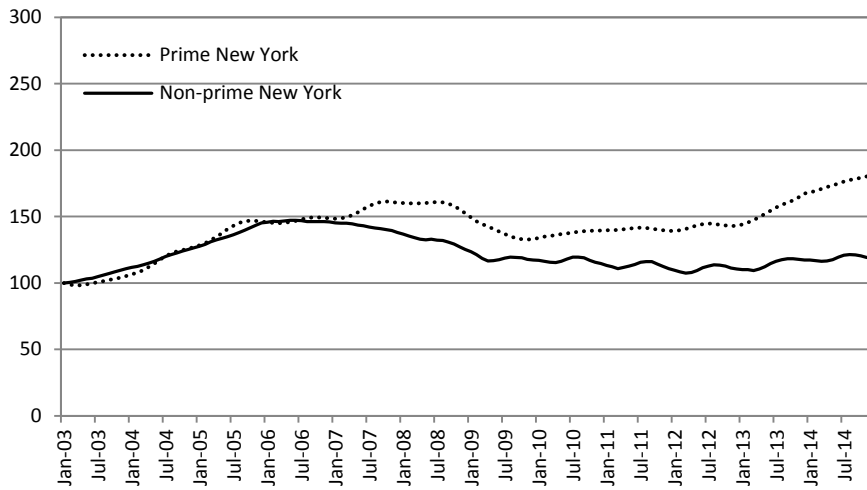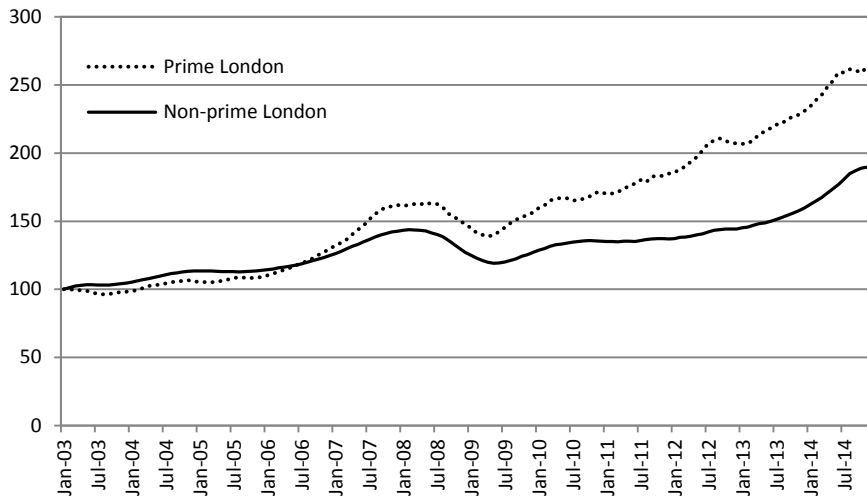
Figure 3.1. Repeat-sales price indexes

4. Empirical relationships between prime and non-prime real estate

4.1. Luxury ratios

For each city, we introduce the novel concept of 'luxury ratio', defined at date t by

$$Luxury\ Ratio_{c,t} = \frac{Prime_{c,t}}{Non\ prime_{c,t}} \qquad (1)$$

where c represents the city and t represents the month. $Prime_{c,t}$ and $Non\ prime_{c,t}$ are repeat-sales price index values, where prime and non-prime categories have already been defined for each city. By construction, the luxury ratio is independent of units. Moreover, since the underlying price indexes are all constructed under a unified methodology and are rebased to the same year, we can compare luxury ratio values for London, New York, and Hong Kong. This measure serves as a quantitative indicator; it allows one to identify changes in the market that may not be apparent by the mere consideration of individual price indexes. Whereas repeat-sales indexes measure the price movement of real estate based on aggregated price changes of sale pairs, the luxury ratio represents price level changes of one property market relative to another.

In order to interpret luxury ratio values, it is important to be aware of the trends in price indexes upon which the ratio is based. Then we can use it as a signal for changing market dynamics.

London

New York

Hong Kong
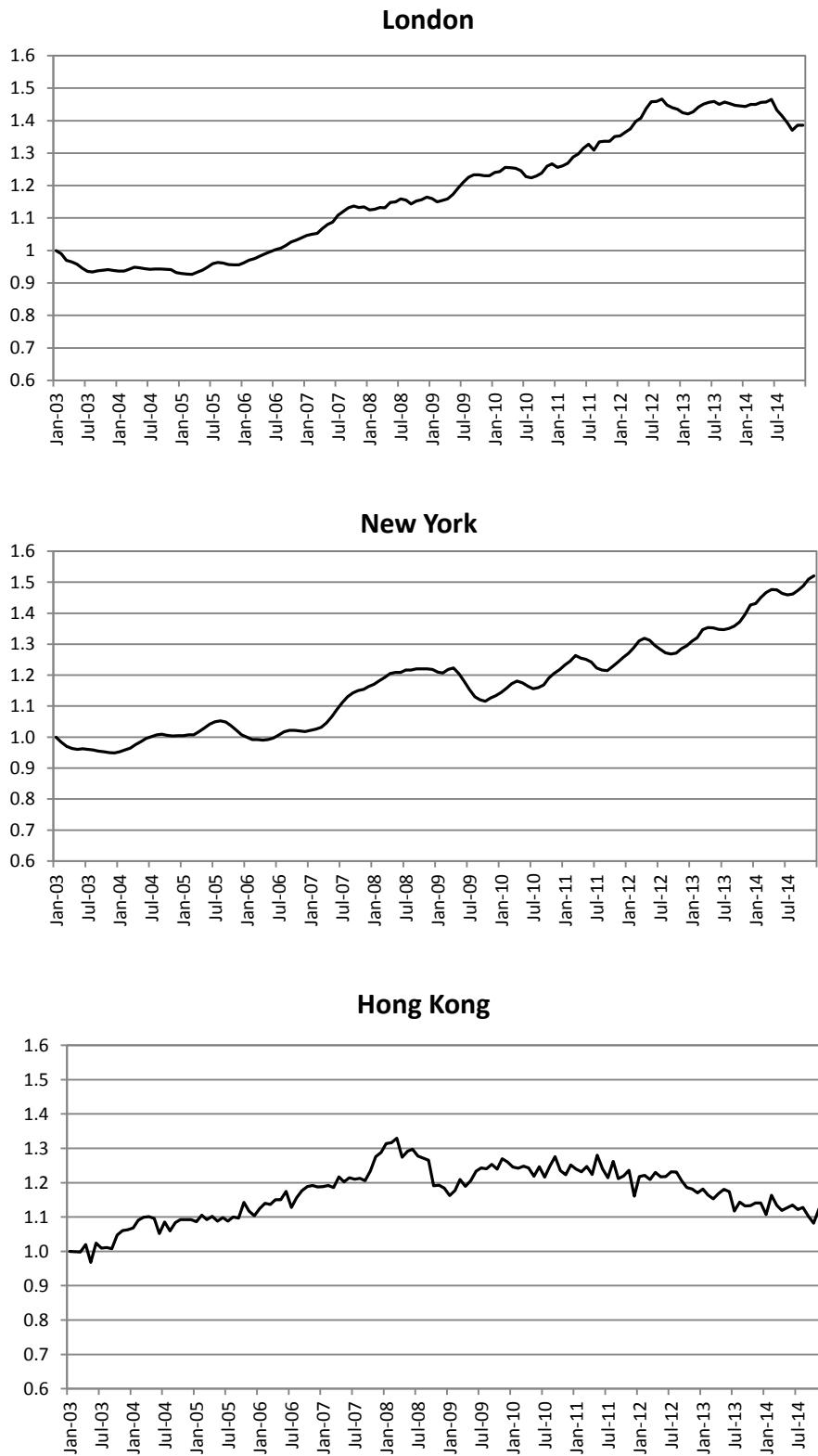
Figure 3.2. Luxury ratio indexes

Figure 3.2 depicts the trajectories for luxury ratio indexes over the period January 2003 to December 2014. In the case of New York, the prime market has remained very strong since the global financial crisis. The index peaks in December 2014 at a value of 1.52 for New York, which is higher than both London and Hong Kong, reflecting an increasing market segmentation between prime and non-prime properties.

In the case of London, we see an uptrend in the luxury ratio index until August 2012, when it plateaued at a value of 1.45. The index remains flat until mid-2014 when it begins to decline. These results could be attributed to the extension of wealthy buyers outside the traditional prime areas, due to a high demand for London real estate, combined with a severe scarcity of available properties. This unprecedented buying behavior has been pushing up prices in historically non-prime locations. For example, the number of properties selling for at least one million GBP has increased in areas of East and Southeast London such as Dalston, Streatham, and Herne Hill. If we rely only on the respective price indexes for London (see Figure 3.1), we do not see the full extent of this price behavior, since both markets are generally trending upwards (London prime falls in the second half of 2012 but continues trending upwards at the start of 2013). However, if we look at the price indexes together with the luxury ratio index, we see the shift in this relationship more clearly.

The luxury ratio index for Hong Kong increased until January 2008, when it reached a high of 1.32. It then remained mostly flat until it began a continuous decline as of 2012, depicting a convergence, rather than divergence, of price levels in more recent years. This could be explained by the growing number of affluent developments located in the Kowloon Peninsula, and reflects the popularity - especially among expatriates - of new developments with excellent

facilities, local amenities, and international schools. The luxury ratio index clearly tells us that the prime market is slowing down with respect to the non-prime market.

These values give us important signals about changes in the overall market dynamics. Over time, we can observe when market prices begin to widen or narrow, marking opportune times to buy and sell. For instance, when the ratio is high, an investor may wish to diversify her real estate portfolio within a particular city by buying non-prime real estate. Alternatively, it may be an opportune time to benefit from the sale of prime real estate holdings. Hence, together with other market information, the luxury ratio can be used as an investment signal, particularly when a market is considered to be overvalued or undervalued.

4.2. Structural break analysis

Based on the argument that the relationship among prime markets is growing at an international level, due to similarities across cities including world rankings, status as global financial centers, desirability of prime residential property to foreign investors in both emerging and established markets, and cost of living, we would expect that trends in the luxury ratio over time would be similar for New York, London, and Hong Kong. In order to test this claim, we analyze structural breaks in the luxury ratio indexes (see Figure 3.3). We use the Bai-Perron algorithm (Bai and Perron, 2003) on the logs of ratio values from January 2003 to December 2014 in order to find major break points in the data series. Logs of prices are used in order to ensure that volatility, skewness, and kurtosis are reduced, thus making normality a more acceptable assumption. According to Bai and Perron (2003), the closer a variable is to normality, the more accurate

their algorithm for estimated structural breaks. As may be expected, unit root tests (ADF, PP, and KPSS) confirm the presence of a unit root in the three log price series. When testing for normality using the Jarque-Bera test, the null hypothesis that our time series is normally distributed is rejected in all cases. However, Jarque-Bera statistics are smaller for logs of ratio values in the case of New York and Hong Kong, indicating smaller deviations from a normal distribution compared with original ratio values. In the case of London, there is no change in the value of Jarque-Bera statistic.

We first carry out a full structural break analysis to obtain a number of breakpoints, increasing from one to five. We then focus on two breaks, or the optimal three-segment partition, since this choice achieves the largest reduction in the Schwarz Bayesian Information Criterion (BIC).

Both New York and London prime categories exhibit their first structural breaks in 2007, just two months apart. The first break occurs in April 2007 for London, with a confidence interval extending from March to May 2007. For New York, the first break is in June 2007, with a confidence interval from May to July 2007. A first break in June 2009, with a confidence interval from May to August 2009, occurs in the case of Hong Kong. Second breaks are: April 2011 for London, with a confidence interval from March to May 2011; December 2012 for New York, with a confidence interval from November 2012 to January 2013; and March 2013 for Hong Kong, with a confidence interval June 2012 to June 2013. For both London and New York, the second break marks a continued uptrend in the values of luxury ratios. In the case of Hong Kong, the second break marks the beginning of a declining luxury ratio.
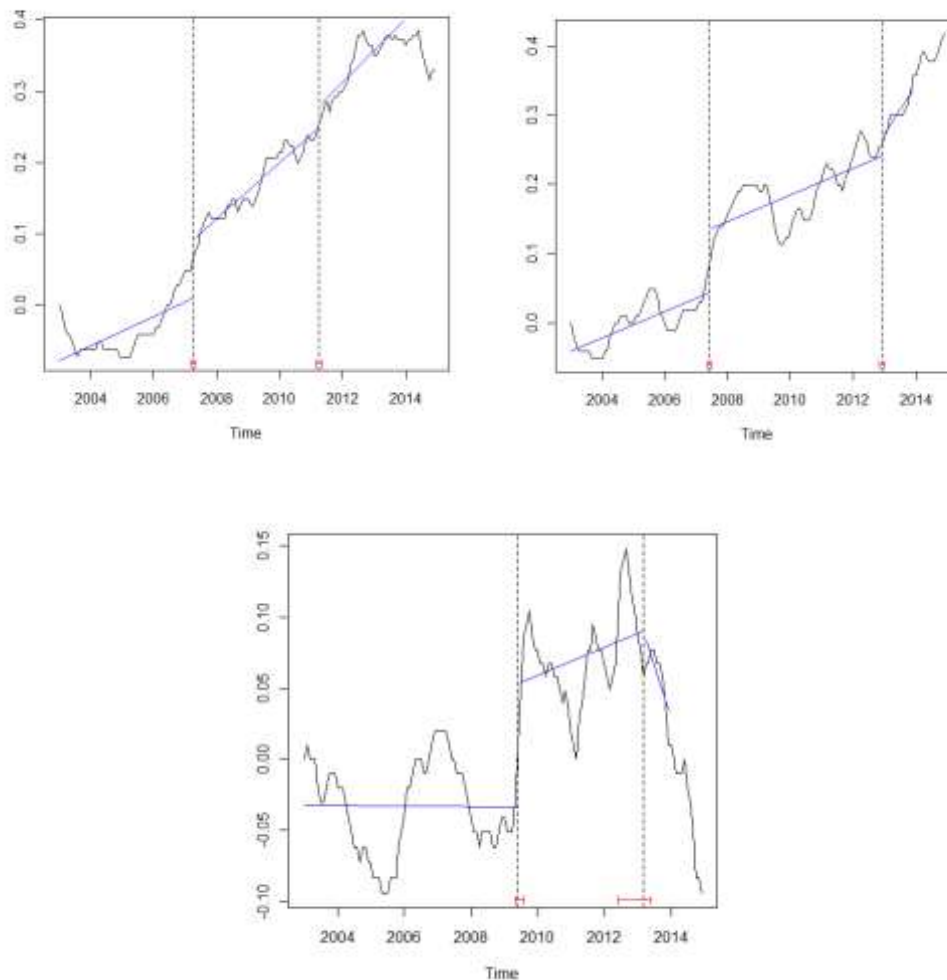
Figure 3.3. Optimal 3-segment partitions and confidence intervals for luxury ratio indexes representing London (top left), New York (top right), and Hong Kong (bottom)

Since the breaks for the three cities are different, the structural break analysis does not support our claim that the price dynamics of prime relative to non-prime markets within each city, as represented by the luxury ratio, are changing in the same way over time. Hence, there may be less similarities between London, New York, and Hong Kong than originally hypothesized. London and New York seem to have more in common, given that the spread between price levels of prime and non-prime property in both cities has grown substantially since 2007. In contrast, a declining ratio value for Hong Kong in

more recent years could be explained by the increased popularity of affluent developments in non-prime locations, as well as a slowdown in the growth of China's economy.

4.3. Correlations

We employ correlation analysis as another useful measure in exploring the changing dynamics of prime property. Table 3.2 depicts Pearson correlation coefficients, using monthly changes in repeat-sales price index values over three sub-periods: the pre-recession period of January 2003 to December 2006; the recession period from January 2007 to December 2010; and a post-recession period from January 2011 to December 2014. These periods are chosen to see if dynamics in the three cities over the same three periods coincide, which would be in agreement with our hypothesis. In the case of intra-city correlations, all coefficients are positive and statistically significant. However, compared with the first period, intra-city correlation coefficients are smaller in the third period for London, New York, and Hong Kong – suggesting that the dynamics of prime property differed more from non-prime property after the global financial crisis. With respect to inter-city relationships across prime categories, there are three cases of positive, statistically significant correlation coefficients. The first two, which occur in the sub-period covering the financial crisis, are unsurprising given that the returns of most asset classes were highly correlated during this time. However, in the third sub-period, a correlation coefficient of 0.312 exists between London prime and New York prime, with a statistical significance at the 0.05 confidence level. This result indicates a stronger relationship between these markets after the financial downturn. Overall, and contrary to our expectations, inter-city correlations are generally smaller than intra-city correlations.

Table 3.2
Correlations between prime and non-prime real estate for London (LN), New York (NY), and Hong Kong (HK), based on monthly changes in repeat-sales price indexes

Correlation Coefficients			
Intra-city	**Jan 2003 to Dec 2006**	**Jan 2007 to Dec 2010**	**Jan 2011 to Dec 2014**
LN prime, LN non-prime	0.544***	0.862***	0.316***
NY prime, NY non-prime	0.559***	0.287**	0.471***
HK prime, HK non-prime	0.744***	0.825***	0.504***
Inter-city	**Jan 2003 to Dec 2006**	**Jan 2007 to Dec 2010**	**Jan 2011 to Dec 2014**
LN prime, NY prime	-0.074	0.565***	0.312**
LN prime, HK prime	0.055	0.323**	-0.165
NY prime, HK prime	0.164	0.077	0.029

Notes: ** represents significance at the 0.05 confidence level (p-value < 0.05) and *** at the 0.01 confidence level (p-value < 0.01) of the Pearson correlation coefficient

In Figures 3.4 and 3.5, we present a total of 108 rolling correlations, using monthly changes in repeat-sales price index values for the period spanning 2003 to 2014. Figure 3.4 displays the relationship between prime and non-prime markets within each city while Figure 3.5 depicts rolling correlations across prime markets. The time window is 36 months: for example, Jan 06 in each Figure corresponds to the correlation over the period February 2003 to January 2006.
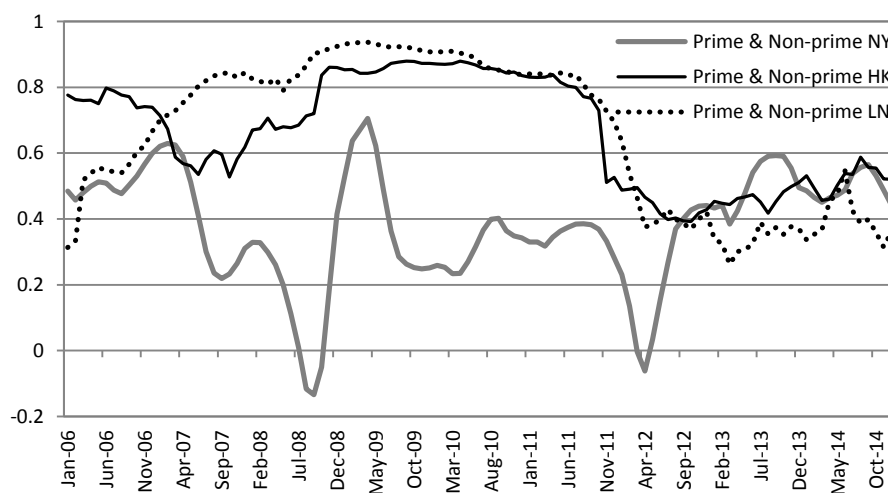
Figure 3.4. Rolling correlations between prime and non-prime real estate markets for London (LN), New York (NY), and Hong Kong (HK)
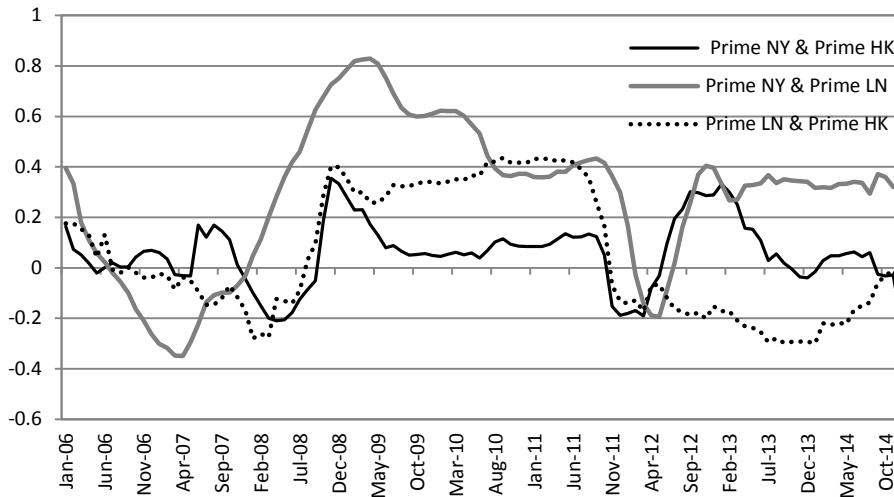
Figure 3.5. Rolling correlations across prime real estate markets in London (LN), New York (NY), and Hong Kong (HK)

The largest peaks in Figures 3.4 and 3.5 could reflect the transition from pre-recession to recession due to the global financial crisis. All assets were highly correlated during the downturn as the payment of margin calls forced heavy sales across the spectrum of investor holdings. Figure 3.4 shows similar behavior for London and Hong Kong markets. Although the correlation between prime and non-prime markets is always positive, it has declined for both cities, from levels above 0.8 to between 0.4 and 0.6 in the most recent periods. This change in relationship between prime and non-prime real estate signals a greater potential for diversifying property investments within these cities - wealthy investors do take advantage of this diverging behavior. The rolling correlations between prime and non-prime markets in New York have fluctuated around a level of about 0.4 throughout the length of our dataset, twice falling below zero.

With regard to rolling correlations across prime markets (see Figure 3.5), Hong Kong has the highest correlation with London or New York during the recession. London has displayed a stable positive correlation with New York since the end of 2012, with correlation coefficients ranging from 0.34 to 0.40.

Although there is evidence that the relationship of prime markets in certain alpha cities is stronger in more recent years, static and rolling correlations show that there is still a stronger relationship between prime and non-prime markets within each city.

4.4. The luxury ratio: comparing prime London to UK cities

Using the case of London, we look at the dynamics of prime property compared with residential real estate in other cities at a national level. For this purpose, we naturally extend the luxury ratio introduced in Equation (1) to the following

$$Luxury\ Ratio_t = \frac{Prime\ London_t}{UK\ metropolis_t} \tag{2}$$

We use average monthly prices from the UK HPI database,[4] based on a repeat-sales methodology. $Prime\ London_t$ is the average monthly price of two London boroughs: Kensington and Chelsea and the City of Westminster. $UK\ metropolis_t$ represents the average monthly price for one of four major metropolitan areas: Birmingham, Liverpool, Manchester, and Reading. We include detached and semi-detached property only since these property types are more expensive and coveted than terraced properties or apartments, and therefore best represent the luxury or conspicuous consumption aspect for buyers of prime property. For instance, in 2014, the average price of a detached house in the borough of Kensington and Chelsea was nearly 5 million GBP, while the price of an apartment in the same area was just over one million GBP. We conduct our analysis over the years 2003 through 2014 and plot the trajectories

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[4]The UK HPI calculates standard average prices by readjusting the geometric mean price from April 2000 relative to repeat-sales index changes from 1995 to present day.

of the luxury ratio indexes in Figure 3.6. Average prices based on the UK HPI repeat-sales indexes are shown in Figure 3.7.
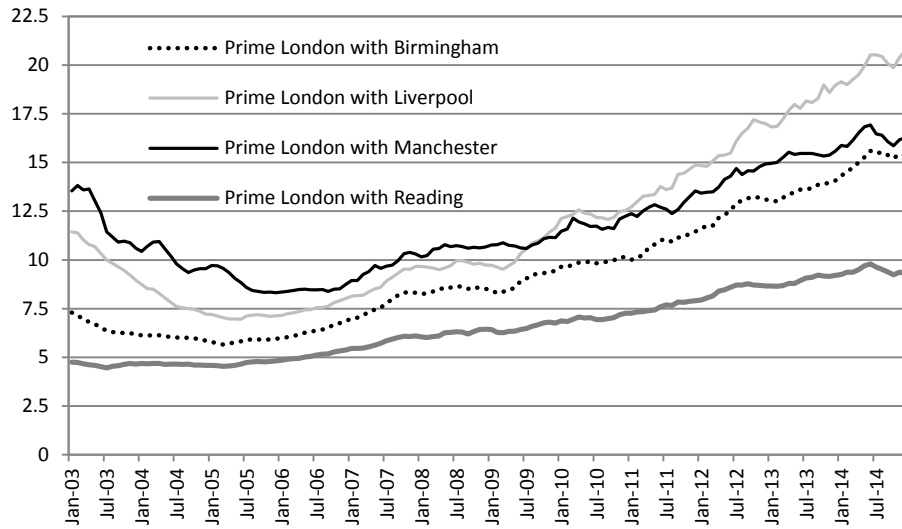
Figure 3.6. Luxury ratio indexes: prime London with respect to four major UK cities
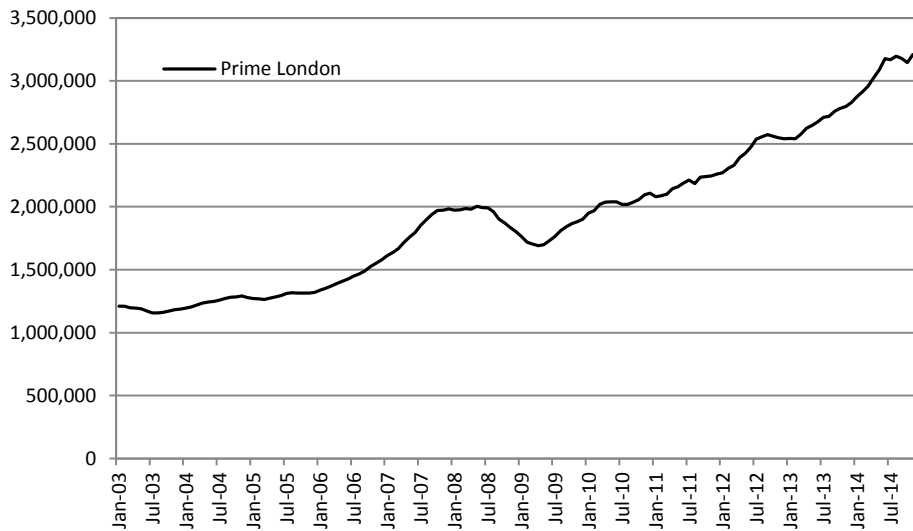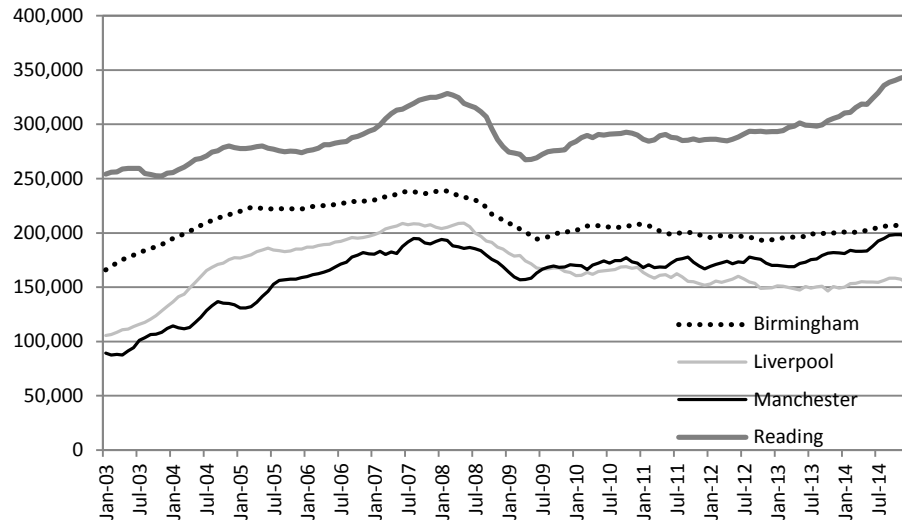
Figure 3.7. Average prices based on UK HPIs for UK cities (top) and prime London (bottom)

Although it is expected that prime London properties have experienced the largest growth of all cities within the UK, differences in luxury ratio values have been greatly magnified since the global financial crisis. The four luxury ratio indexes have been trending upwards since 2005, representing a shift in the rate of appreciation of prime London relative to other UK cities. While prime London property prices quickly recovered, resuming its upward trend by the end of 2009,

the four UK cities remained relatively flat following the downturn. These price trends are not only presented in Figure 3.7 but also reflected in Figure 3.6. Over the period January 2009 to January 2014, luxury ratio values increased from 6.4 to 9.3 in the case of Reading, 10.8 to 15.9 in the case of Manchester, 9.7 to 19.1 with respect to Liverpool, and from 8.5 to 14.3 for Birmingham. Reading and Manchester are the only UK cities which surpassed their pre-crisis price peaks, in mid-2014. Geographically, Reading is the closest to London and will be connected to central London in 2018 via the new Crossrail train, making it popular among commuters (Reading also has a very good University). Manchester is the next farthest from London, followed by Birmingham and Liverpool. A flattening of luxury ratio indexes since 2014 may be a sign of recovery for secondary cities in the UK and, hence, a signal for possible investment opportunities.

Cities including Manchester and Liverpool have undergone substantial regeneration and economic development. Many firms in the banking, and finance industries (among others) are relocating to cities outside of London, where operating costs are much less expensive. These types of development are increasing the attractiveness of residential real estate in city centers outside of London.

5. Conclusion

We argue that the price dynamics of residential real estate in the most desirable and expensive areas of London, New York, and Hong Kong, which we categorize as prime, have been diverging from other areas within the same city, defined as non-prime for the purposes of this study. To this end, we develop a 'luxury ratio' index, which tracks changes in repeat-sales index values of prime

relative to non-prime markets over time. Additionally, we conduct several empirical investigations, including rolling correlations and structural break analysis. Throughout the Chapter, we also discuss the idea that residential prime property is becoming an important element of luxury investments. Prime real estate in alpha cities is a tangible asset with many benefits encapsulated by an *ownership yield*.

Empirical results show that, although there is evidence of a positive relationship between prime real estate sectors of New York, Hong Kong, and London, correlations are stronger between prime and non-prime property within the same city. For example, the correlation between prime New York and non-prime New York is stronger than the one between prime London and prime New York. In contrast, the luxury ratio index shows a clear divergence between prime and non-prime property in all three cities - albeit at different times, as shown in the structural breaks analysis. Findings from the luxury ratio analysis support our claim, particularly in the cases of London and New York, that price movements have become more segmented in recent years.

Finally, we compare the price behavior of the prime London market with respect to other UK cities. Luxury ratios indicate that London prices have greatly diverged from secondary cities since the global financial crisis, but a flattening of the indexes since mid-2014 suggests changing market dynamics.

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Online resources

UK land registry

http://landregistry.data.gov.uk/

Manhattan Condo Index

http://streeteasy.com/market/condo_index

The Globalization and World Cities Research Network. Accessed from:

http://www.lboro.ac.uk/gawc/

The S&P/Case Shiller National Home Price Indexes

http://us.spindices.com/indices/real estate/sp-case-shiller-us-national-home-price-index

The University of Hong Kong Real estate Index Series (HKU-REIS)

hkureis.versitech.hku.hk/

Chapter 4. Expanding the Space of Real Estate Investment to Data Centers and Shopping Complexes

1. Introduction

The growth of the commercial real estate market in the past decade has led to significant changes, including a substantial increase in the number of indexes based on property returns, and the acceptance of real estate as a separate asset class. In the most recent period following the global financial downturn of 2007-2008, the importance of creating value by real estate companies through the skilful trading and operating of properties has also been acknowledged (Clayton et al. 2011). To illustrate the performance of real estate companies which reflect the maturation of the industry, we focus on two categories. The first, data centers, is a sector that has become increasingly attractive to investors due to the ever growing information technology industry. The second, shopping complexes - a term we will use throughout the paper in reference to malls, outlets, and shopping centers - also merit a revaluation, as many have undergone important transformations in response to increased competition from online retailers, changing consumer habits, and new technology. Both categories have been considered as investments that satisfy the hunt for yield, particularly in times of extremely low interest rates. Exposure to both sectors can be gained by investing in publicly listed real estate companies or real estate investment trusts (REITs).

Data centers provide the physical space for networks of computer servers, hardware for data storage, and related components used to power the internet. They can vary in size, from small networks of computer servers in office buildings to large "server farms" in industrial sized warehouses, hundreds of thousands of square feet in size. The more demand for online activities, the more

demand for data centers to accommodate the necessary infrastructure. Businesses, consumers, and individuals have become increasingly dependent upon the internet since its explosive growth and availability in the 1990s. Video streaming, social media, and online services used to purchase items, manage bank accounts, and pay bills have become a norm for individuals and households. Businesses heavily rely on the internet for data storage, hosting company websites, and cloud computing as a replacement for traditional office based operations. According to the International Telecommunication Union (ITU), the number of internet users worldwide increased from just 495 million in 2001 to more than 3 billion in 2015. In 2015, 43.8 people out of every one hundred were internet users, an increase from just eight in 2001 and 15.8 in 2005 (ITU).

The world is also being pervaded by the 'Internet of Things' (IoT) and 'connected objects', terms that refer to machine to machine technology relying on secure internet connectivity and cloud computing. Data is gathered from sensor-fitted objects (everything from home appliances and clothing to cars and medical devices), stored in the cloud, and then converted into information that is beneficial for individuals and businesses. The future of IoT implies a world where smart phones are not just the norm, but also 'smart' homes, offices, energy, and health services. Companies that provide data center space are benefiting more and more as online activity grows, the demand for cloud computing increases, and businesses transfer their IT infrastructure to larger premises.

Shopping complexes, the second focus of our study, form a large part of the retail sector. We investigate companies whose main activities involve the ownership, management, and leasing of malls, shopping centers, and outlets. Malls, defined as large enclosed spaces housing different retailers, became

popular in the 1950s. Between 1950 and 1982, the amount of retail sales (excluding car sales) from these properties increased significantly in the US (Sussman, 1983). The development of suburbs, higher economic growth, and a significant increase in the ownership of automobiles following World War II were catalysts for this change (Carter, 2009). Malls eventually extended from the suburbs to urban areas. Shopping centers – a grouping of stores in one area, typically sharing parking facilities – comprise a second type of retail real estate, and have an important role in the economies of many developed countries. In the US, consumer spending accounts for approximately seventy percent of GDP, 40 percent of which is attributed to spending at shopping centers (Clapp et al., 2014). They also account for more retail square footage than malls. Shopping centers are typically anchored by a large supermarket, drugstore, or superstore like Walmart in the US. These retailers typically sell a large range of non-discretionary goods including groceries, medicines, gasoline, and financial services, making them attractive as 'safe haven' assets, since consumers purchase such basic, necessary goods in both good times and bad (Smith and Hay, 2005). Outlets are a third type of retail space, characterized by discounted luxury brand stores in an open-air format. Income is partly driven by the tourist industry and demand for luxury retail goods (JLL, 2014).

In this Chapter, we contribute to the literature in several ways. We begin with a broad analysis of real estate sectors, followed by a more detailed study of individual companies specializing in data centers and shopping complexes, two real estate sectors that have not been studied in the recent period. In the first part of our study, we use cointegration analysis to study the co-movement of our two categories with other real estate sectors and the S&P 500. In the second part of our study, we use the Capital Asset Pricing Model (CAPM) to study the

performance of real estate companies and REITs specializing in data centers and shopping complexes relative to the broader stock market. Many studies use benchmark indexes for their empirical investigations, or average results across real estate companies. However, since the nature of real estate firms and REITs is such that performance is primarily based on the quality of property management and strategic decisions made by the company, rather than simply the number or value of property acquisitions, we present results for each individual firm. Our results may better inform investors who have an interest in these sectors.

The rest of Chapter 4 is organized as follows. After an overview of investing in real estate through publicly listed securities in Section 2, we present recent developments in the categories of data centers and shopping complexes in Section 3. Data, methodology, and results for the cointegration analysis are then presented in Section 4, followed by a CAPM analysis in Section 5. Empirical investigations are followed by a discussion in Section 6 on the future of alternative power solutions for data centers, and the positive impact of these developments on investment. We end with concluding remarks in Section 7.

2. Investing in securitized real estate

A popular means of gaining exposure to real estate is to invest in publicly listed real estate companies, particularly in real estate investment trusts (REITs). REITs have become a liquid means of investing in sophisticated portfolios of commercial real estate and create an important connection between equity markets and property markets. There is a large body of literature on REITs from an investment perspective. See, for example, Corgel et al. (1995) and Brounen and Koning (2013) for a review of the industry.

A REIT is a company that generates income from real estate which they own or finance. By law, at least 75% of REITs' gross income must be derived from real estate and 90 percent of all taxable income must be paid out to shareholders in the form of dividends. Shareholders benefit from both the capital appreciation of shares and dividends received from the rental and sale of properties in the REIT portfolio. Publicly listed REITs offer the advantage of immediate entry into the market, greater accessibility in terms of cost, and the liquidity and transparency of an exchange-traded instrument.

The US has the most mature REIT market in the world. It first introduced REIT legislation in 1960; in 1965, the first REIT was listed on the New York Stock Exchange (NYSE). Since then, other countries have developed similar real estate legislation in order to advance their own national real estate markets. Of the additional countries included in our study, REIT legislation in Australia originated in 1971, followed by Canada in 1994, Singapore in 1999, Japan in 2000, Hong Kong in 2003, and the United Kingdom in 2007. For some countries, the first REITs were listed on a major exchange several years following legislation For instance, the first REIT was not listed on the Singapore Stock Exchange until 2002. The activities of REITs across countries can also very greatly. In the US, real estate companies typically diversify within their own borders, with a focus on a single property type. Smaller real estate markets in European and Asian regions restrict geographical diversification; hence, diversification generally takes place across different property types (Serrano and Hoesli, 2009).

Institutional investors including pension funds, insurance companies, and hedge funds are major investors in REITs. Ciochetti et al. (2002) show, from 1993 to 1998, that such institutions prefer liquid, listed REITs to illiquid real estate

investments. Between 1993 and 2009, total ownership of shares in REITs by institutional investors grew by nearly 40 percent (Feng et al., 2011). Since the modern REIT era began in 1993, the size of the global industry has grown from 26 billion USD to more than one trillion USD. The global ratings agency Standard & Poor's added a new 'real estate' Global Industry Classification Standard (GICS) sector in September 2016, separating real estate from its previous inclusion in the 'financials' category for the first time. This development further increases the visibility of real estate companies, including shopping complexes and data centers.

Most of the largest providers of data centers and shopping complexes are REITs. Companies specializing in data centers were still relatively new in the mid-2000s. Initially, strong price returns and yields of data center REITs were easily blurred since they were often grouped with other commercial real estate segments, including office, industrial, or specialty categories. However, in recent years, data centers have been increasingly recognized as a separate real estate sector. A REIT-based data center price index has been available through the FTSE/EPRA NAREIT series since December 2015. Major commercial real estate brokers, including CBRE group, Jones Lang La Salle, and Cushman & Wakefield now have teams dedicated solely to the leasing and sales of data center facilities (Wall Street Journal, 2012). With regards to shopping complexes, retail REITs have existed for decades and there are many benchmark indexes that track the performance of retail REITs, including the FTSE EPRA/NAREIT US index since 2007 and the MSCI World Retail REIT index since 2006. Retail REITs have been outperforming office and industrial REIT sectors for the past several years.

There are many studies covering REITs and real-estate companies in the 1990s and 2000s, a time period spanning the US subprime mortgage crisis and ensuing global financial crisis from 2007 to 2009 (See, for example, Feng, et al., 2011; and Lieser and Groh, 2011). However, shopping complexes have not been addressed from an investment standpoint in the period following the global financial crisis. With respect to data centers, the existing literature essentially has a technical approach, although Newell and Peng (2006) provide a financial analysis of non-traditional real estate sectors, including self-storage, healthcare, and communication towers.

3. Data centers and shopping complexes: recent strategies

Acquiring the best possible facilities, procuring quality tenants, and implementing effective management are central to the prosperity of real estate companies and REITs. Successful strategies result in increased competitiveness, more income, and greater investor confidence in the long-run. Recent strategies employed by data centers and shopping complexes, such as geographical diversification, redevelopment of existing properties, and incorporation of technology, have helped to raise the profile of many companies and attract new investment.

Geographical diversification, in terms of both tenants and acquisition or construction of facilities, has become increasingly important. QTS Realty Trust owns data centers in the US, Canada, Europe, and Asia. Within the US, it has facilities in the New York metropolitan area and Chicago, both Tier 1 data center markets. The largest US data center REIT in terms of market capitalization, Equinix, owns more than 145 data centers across the world. In 2016 deals, Equinix acquired 40 data centers in Europe. It also owns facilities in the Middle

East, Africa and Asia-Pacific regions. Globalization has also had a profound impact on the retail industry. Many firms specializing in malls, outlets, and shopping centers have expanded abroad, either directly by buying property or indirectly by forming partnerships with foreign companies in order to avert risks that may be associated with government legislation, currency, and taxes. While the majority of its premium outlet centers are located in the US, Simon Property Group (SPG) – the largest retail REIT in our sample – has built outlet centers in Japan, Korea, Malaysia and Mexico, in addition to having retail exposure in Europe and China. Recently, Kimco Realty (KIM) – the largest US REIT specializing in shopping centers - has acquired shopping centers in Canada, Mexico and Latin America, where it owns more than 85 properties. Several REITs, such as KIM, are taking advantage of markets with growing middle class populations, where consumer demand for retail goods is growing at a fast pace (Thomas, 2012). The average person's income in Latin America, for example, has grown more than sixty percent since 2001, while unemployment has declined.

Many companies are redeveloping or restructuring existing properties as a way of improving portfolios and profitability. Mall owners are buying out leases of traditional department stores with declining revenues in favour of newer retailers that attract more customers, hence creating an updated mall infrastructure where department stores are no longer the primary anchors. Outmoded retailers are being replaced by supermarkets, low-cost clothing stores, and services such as fitness centers, restaurants, and entertainment venues. Simon Property Group and General Growth Properties are examples of REITs who have replaced dozens of weak-income department stores with new tenants. It has also become popular to divide large spaces that were once occupied by

outdated department stores into smaller spaces that can be rented to more 'productive tenants' that not only pay higher rent per square foot but also increase total mall sales by attracting more shoppers.

Another trend seen within the retail sector is a focus on high-end malls. Simon Property Group and General Growth Properties have recently been divesting lower performing properties in order to focus their attention on 'A' malls. These shopping destinations are typically located in heavily populated, affluent areas, and attract high-end retailers and consumers. They are also considered to be more immune against the threat of online retailers (Pleven, 2016). Data centers are transitioning from retail to wholesale colocation, catering to large global customers such as Microsoft and Facebook who require large capacity in order to provide services on a global scale. Consumers of enormous amounts of electricity and water, data centers are also increasing investment in renewable energy sources, in order to reduce operational costs and attract clients who demand long term sustainability. The trend of buying existing buildings, such as a former Toronto printing press by DuPont Fabros Technology or warehouse by CyrusOne, is also saving firms time and money, compared to building a brand new data center.

Updating technology infrastructure is vital to both sectors. With respect to data centers, cloud computing is growing as more and more individuals and businesses are replacing physical storage with cloud storage. Global data center companies including Iomart, QTS Realty Trust, and DuPont Fabros technologies are catering more for this technology. In 2014, Iomart bought ServerSpace Ltd., a cloud hosting provider based in London, and also acquired SystemsUp in 2015, which specializes in public cloud solutions. In the first quarter of 2016, DuPont Fabros Technology secured leases with many large public cloud providers. QTS

also has connections with many of the largest public cloud providers. With the advent of the IoT and online retail, shopping complexes also continue to reinvent themselves in order to stay relevant. There now exist mobile phone applications to help consumers navigate mall parking lots and shopping spaces, and software to analyze foot traffic for the benefit of mall landlords, who can then use this information to negotiate leases with their tenants. Jibestream, Sensity, and Retailcommon are three companies that build navigation, security, and smart energy technology specifically for shopping complexes, making the internet as relevant for physical retailers as for online retailers. Other companies, including Shoppertrak, offer cloud based solutions to help retailers scrutinize the movements and shopping patterns of consumers, in order to identify marketing opportunities and shortcomings of existing strategies.

4. Cointegration analysis

Using securitized financial instruments, primarily in the form of REIT price indexes, we analyze short-term and long-term relationships through Engle-Granger cointegration and other empirical analyses over the period 2009 to mid-2016. Cointegration testing is used to explore long-term relationships amongst several sub-sectors of commercial real estate and the S&P 500 index. We wish to know if the two targets of our study, data centers and shopping complexes, have more in common with other commercial real estate sectors versus an equity index that represents the broader movements of the US market. Results will have implications regarding their potential for diversifying portfolios.

Tarbert (1998) uses cointegration to analyze the relationship between commercial and real estate sectors, while Chiang et al. (2013) study the time-varying links of REITs and the stock market in four Asian markets over the period

2005 to 2009. They find that the correlation between REIT and stock markets greatly increased in several Asian countries following the global financial crisis. In order to investigate the recent return performance of data centers and shopping complexes, our period of study excludes the sharp fall across asset classes caused by the US sub-prime mortgage crisis of 2007-2008.

4.1. Data

We use the closing prices of daily time series over the period 01 October 2009 through 31 August 2016 for the Engle-Granger cointegration analysis, excluding the sharp downturn experienced across asset classes during the global financial crisis. All series are denominated in US Dollars. In this section, we also provide descriptive statistics, including static and rolling correlations, to compare the price return performance across sectors.

Since a benchmark index for data centers, published by the FTSE EPRA/NAREIT, has only been available since 21 December 2015, we create a cap-weighted price index as of 2009 with the same six constituents as the current benchmark index (See Figure 4.1). We classically follow the methodology of many S&P, FTSE, and MSCI price indexes, and define our index as

$$Index_t = \frac{\sum_{i=1}^{N} P_{it} Q_{it}}{\sum_{i=1}^{N} P_{i0} Q_{i0}} \tag{1}$$

where the denominator represents the base value. Over time, we adapt (1) to changes in the number of shares and constituents in order to preserve the level of the index.

$$Base\ Value_t = Base\ Value_{t-1} \frac{\sum_{i=1}^{N} P_{it} Q_{it}}{\sum_{i=1}^{N} P_{it-1} Q_{it-1}} \tag{2}$$

The inception of our index is 01 October 2009, a date when DuPont Fabros Technology, Inc., Equinix, Inc., and Digital Realty Trust, Inc. were all trading. Three additional data center REITs – Coresite Realty Corporation, CyrusOne, Inc., and QTS Realty Trust, Inc. – were added between 2010 and 2013.

Price Index for Data Centers
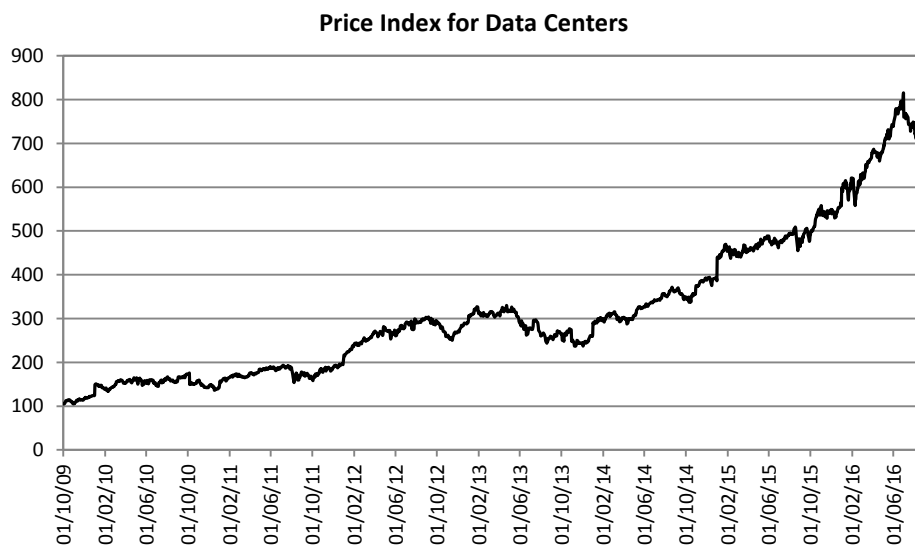
Figure 4.1. Price Index (USD) for Data Centers from 01 October 2009 to 31 August 2016

The industrial, office, and retail real estate markets in the US are represented by the FTSE EPRA/NAREIT US REIT price indexes (See Figure 4.2). The retail REIT index is used as a proxy for shopping complexes.
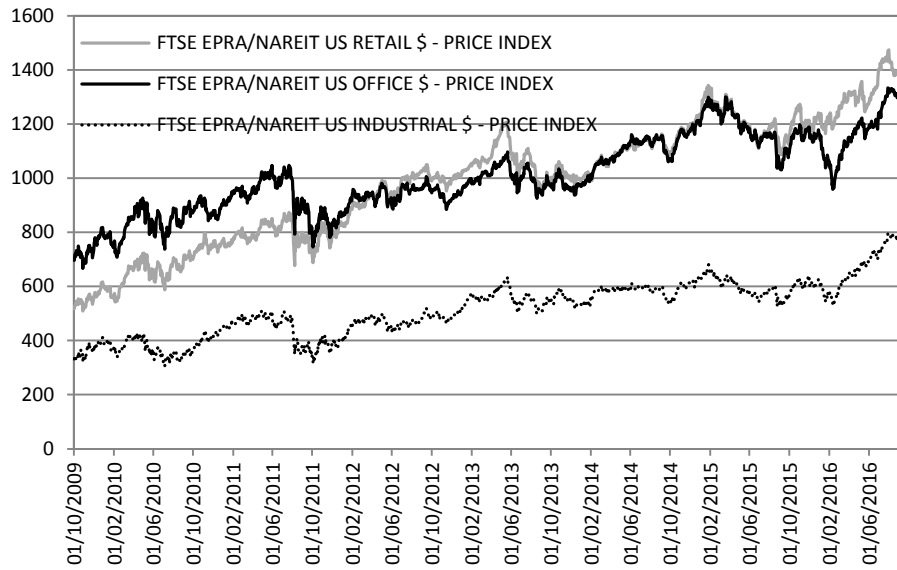
Figure 4.2. FTSE EPRA/NAREIT US REIT price indexes (in USD) from 01 October 2009 to 31 August 2016

In order to compare the price return performance of commercial real estate markets to traditional assets, we use the S&P Composite 500 index and the US Benchmark 10-year government price index from Datastream (See Figure 4.3).
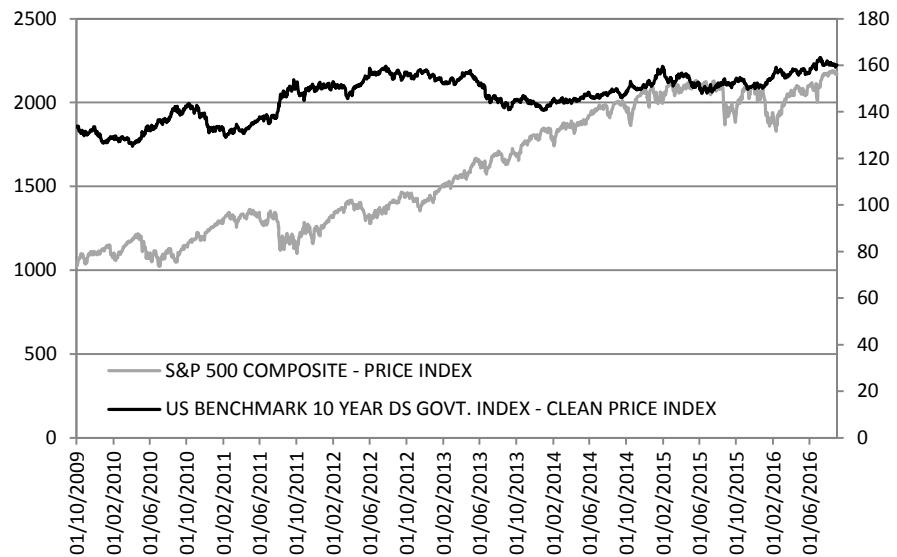
Figure 4.3. S&P 500 Index (left axis) and US bond benchmark series (right axis) from 01 October 2009 to 31 August 2016

4.2. Descriptive statistics

Table 4.1 presents descriptive statistics for the time series used in our study. Data centers have the highest compound annual growth and mean return over the study period, as compared with other commercial real estate sectors, the S&P 500, and US bonds. Sharpe and Sortino ratios for data centers are only second to bonds (the larger the value for the ratios, the more attractive the asset). Price returns from data centers have far surpassed those of other commercial real estate categories and the S&P 500 during this time. Following data centers, retail has the second highest compound annual growth percentage. Of the four real estate categories, it also has the second highest Sharpe and Sortino ratios, as well as the lowest annualized volatility.

Table 4.1
Compound annual growth figures and descriptive statistics for daily returns for four commercial real estate sectors, the S&P 500 and the US bond market (represented by the Benchmark 10-year government) price index over the period 01/10/2009 to 31/08/2016

	Data centers	Industrial	Office	Retail	S&P 500	Bonds
Compound Annual Growth (%)	31.56	13.03	9.53	15.25	11.38	2.62
Mean (%)	0.11	0.05	0.03	0.05	0.04	0.01
Median(%)	0.05	0.05	0.02	0.05	0.03	0.02
Maximum (%)	18.33	9.43	9.32	10.39	4.63	1.86
Minimum (%)	-16.63	-12.61	-10.06	-9.51	-6.90	-1.93
Std. Dev. (%)	1.58	1.68	1.33	1.31	0.98	0.45
Annualized volatility (%)	25.08	26.67	21.09	20.82	15.50	7.22
Skewness	0.79	-0.33	-0.22	-0.08	-0.44	-0.142
Kurtosis	26.43	7.77	8.49	8.91	7.21	3.91
Sharpe ratio	3.07	0.98	1.09	1.58	1.80	2.34
Sortino ratio	4.26	1.26	1.43	2.08	2.27	3.56

A correlation matrix for the full length of our study is shown in Table 4.2. 36-month rolling correlations are presented in Figures 4.4 and 4.5. All sectors are positively correlated (with correlations higher than 0.5) with the S&P 500 over the full length of our study. In 2001, REITs were first included in S&P indexes and by June 2016, there were 27 REITs in the S&P 500; hence, these correlation

coefficients are not surprising. However, rolling correlations show that the correlation coefficients of data centers with the S&P 500 on the one hand, and office, industrial and retail sectors on the other hand have clearly declined in more recent years. Retail is more highly correlated with office and industrial real estate than data centers, but its correlation with the S&P 500 has also declined substantially, from 0.85 in 2013 to 0.6 in 2016.

Table 4.2

Correlation Coefficients over period 01/10/2009 to 31/08/2016

	Data centers	Industrial	Office	Retail	S&P 500	Bonds
Data centers	1.000					
Industrial	0.589	1.000				
Office	0.630	0.898	1.000			
Retail	0.613	0.888	0.941	1.000		
S&P 500	0.579	0.764	0.776	0.755	1.000	
Bonds	-0.195	-0.278	-0.270	-0.227	-0.478	1.000
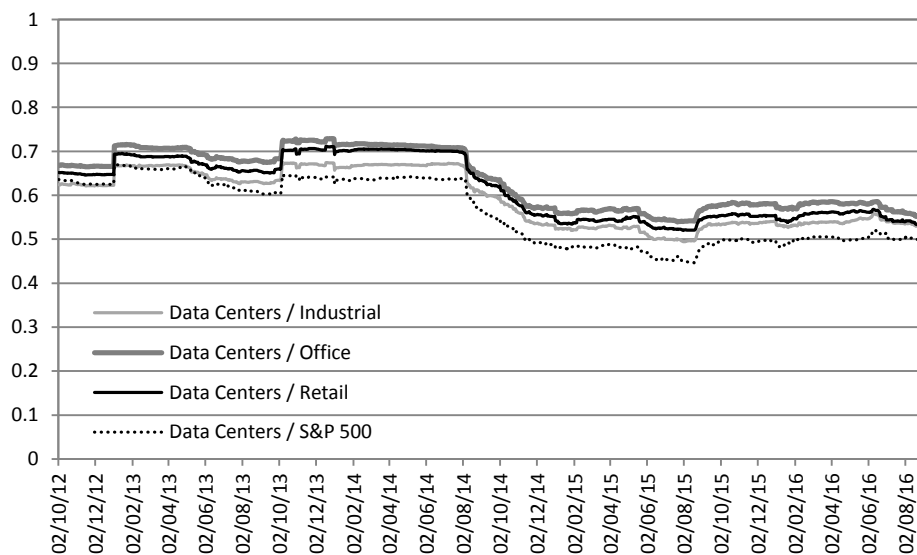
Figure 4.4. 36-month rolling correlations of data centers with industrial real estate, office real estate, retail real estate, and the S&P 500.
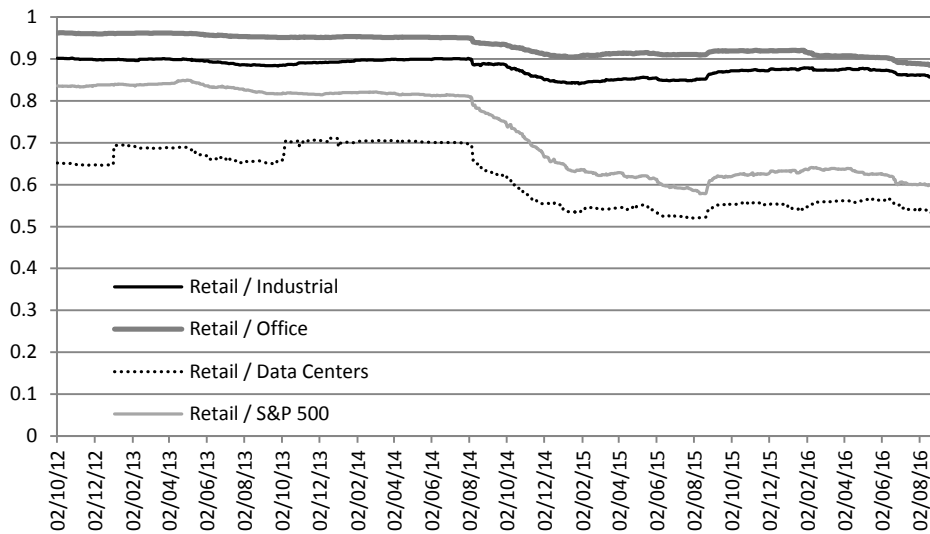
Figure 4.5. 36-month rolling correlations of retail real estate with industrial real estate, office real estate, data centers, and the S&P 500.

4.3. Methodology and results

In order to identify the existence of long-run relationships between our time series, we use the cointegration test developed by Engle and Granger (1987). Natural logarithms of the price indexes described in the previous data section are used for this analysis. We test for cointegration over the period 01 October 2009 to 31 August 2016. Cointegration is a more robust measure than correlation of the co-movement between two time series, and also allows us to differentiate between short and long term price variations. Since the regression coefficients are affected by which variable is chosen as the dependent variable, we run each test twice. Variables are cointegrated only if the residuals of both regressions are stationary.

Before proceeding with the cointegration analysis, we test each time series for stationarity using the Augmented Dickey-Fuller (1979) tests (See Table 4.3). We find that all of our times series are non-stationary at levels and

stationary after taking first differences, pre-conditions for cointegration testing and the second step of the Engle Granger approach, the Error Correction Model. To test the robustness of these results, we also perform the Phillips-Perron (1988) and Kwiatkowski-Phillips-Schmidt-Shin (1992), or KPSS, unit root tests. Both tests confirm stationarity of all variables after taking first differences at a one percent significance level.

Table 4.3
Augmented Dickey Fuller (ADF) unit root tests

Log prices (log levels)		
Variable	**ADF**	**lag**
Data centers	-0.82	0
Industrial	-1.58	2
Office	-2.11	2
Retail	-1.88	3
S&P 500	-1.19	0
Log returns (log first differences)		
Variable	**ADF**	**lag**
Data centers	-44.31***	0
Industrial	-29.58***	1
Office	-29.51***	1
Retail	-25.79***	2
S&P 500	-44.76***	0

Notes: Null hypothesis: variable has a unit root; alternative hypothesis: variable is stationary (no unit root). *, **, *** represent rejection of the null hypothesis at the 10%, 5%, and 1% levels respectively.

Table 4.4 shows that cointegration only exists in the case of office real estate and the S&P 500[5]. The absence of long term relationships between data centers and retail with office real estate, industrial real estate, and the S&P 500 have important implications for investment and portfolio diversification. Our results are in line with other authors who conclude that investing across different property types is a better way of diversification than investing in the same property type across different regions (Hamelink et al., 2000). Decreasing

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[5] Since our focus is on data centers and retail categories, we do not include our estimation of the Error correction model for the cointegrated pair of office real estate and the S&P 500.

correlations combined with no cointegration with other market segments over our period of study gives data centers greater potential as a portfolio diversifier (in a portfolio comprised of the S&P 500 and other real estate sectors). Given our results, a similar case could be argued for retail real estate (used as a proxy for shopping complexes).

Table 4. 4
Results for Engle and Granger Cointegration Test

REIT indices with S&P 500		Unit Root Test in Residuals	
Dependent variable	Independent Variable	ADF	lag length
Data centers	S&P 500	-1.51	0
S&P 500	Data centers	-1.71	0
Industrial	S&P 500	-3.10*	2
S&P 500	Industrial	-2.88	2
Office	S&P 500	-3.77**	2
S&P 500	Office	-3.30*	2
Retail	S&P 500	-2.69	0
S&P 500	Retail	-2.23	0
REIT Indices		Unit Root Test in Residuals	
Dependent variable	Independent Variable	ADF	lag length
Data centers	Industrial	-2.75	0
Industrial	Data centers	-3.06*	2
Data centers	Office	-3.04	0
Office	Data centers	-3.58**	2
Data centers	Retail	-2.50	0
Retail	Data centers	-3.00	0
Industrial	Office	-2.26	0
Office	Industrial	-2.70	0
Industrial	Retail	-2.46	0
Retail	Industrial	-2.52	0
Office	Retail	-2.67	0
Retail	Office	-2.31	0

Note: MacKinnon (1991) critical vlaues are used for the ADF test. The lag length is selected with the Schwarz Bayesian Information Criterion (SIC). *, **, *** represents the rejection of the Null hypothesis (residual has a unit root) at the 10%, 5%, and 1% levels respectively.

5. CAPM analysis

We use the standard Lintner-Sharpe Capital Asset Pricing Model (CAPM) to measure the performance of publicly listed REITs and companies (Lintner, 1965; Sharpe, 1964). Although there is much debate about the validity of the CAPM, as discussed extensively in Fama and French (2004) and MacKinley (1995), this model continues to be widely used in all economic sectors, since it offers a very intuitive way of considering the trade-offs between risk and return.

Brounen and Koning (2013) use the CAPM to study REITs. They find that standard asset pricing models have become more effective in explaining the performance of REITs as these markets have developed. Chen (2003) finds that the CAPM beta continues to be a very effective estimate of risk and return. Bartholdy and Peare (2005) compare the performance of the Fama-French three-factor model with the standard Lintner-Sharpe CAPM. Their results, based on five years of monthly data, show that the inclusion of two additional factors does not justify a minimal gain in explanatory power. Further empirical support for the relevance of the CAPM is provided by Da et al. (2012).

5.1. Methodology

The CAPM effectively quantifies a linear relationship between the expected return on a security and the expected return of the market portfolio. The beta is a measure of systematic, or market, risk and determines the sensitivity of an asset's return to changes in the market.

$$E[R_i] - R_f \ = \ \beta_i \big[E[R_m] - R_f \big] \tag{3}$$

In (3), R_i represents the return on asset i, R_m is the return on the world market portfolio, and R_f is the risk-free return. The beta, β_i, is calculated as the ratio of

covariance of the security's return with the market return and the variance of the market return

$$\beta_i = \frac{Cov(R_i, R_m)}{Var(R_m)} \tag{4}$$

An asset with a β_i larger than one moves strongly with the market. Conversely, a β_i smaller than one indicates weak movement with the market.

The empirical version of the CAPM is a one-factor model where the "market" is the state variable (Bartholdy and Peare, 2005). Using historical price returns, since the relationship in (3) relies on unobserved expectations, we can rewrite (3) as a linear regression in order to estimate β_{it} (See, for example, Grinblatt and Titman, 1998; Verbeek, 2008).

$$R_{it} - R_f = \alpha_{it} + \beta_{it}\left[R_{mt} - R_f\right] + \varepsilon_{it} \tag{5}$$

Equation (5) is a graphical representation of the CAPM, known as the Security Market Line (SML), where R_{it} and R_{mt} are the respective observed returns for asset i and the market portfolio at time t. The SML depicts a security's expected return as a function of systematic risk. Beta values lie on the horizontal axis of the SML while the vertical axis is comprised of expected returns, represented by the average of annualized monthly returns over the period of study. The risk-free rate of return is the intersection of the SML with the vertical axis. Alpha,α_{it} , represents the extra return above the market's return at a given level of risk, or a firm's outperformance of the market. Securities that lie above the SML are very desirable to hedge funds and asset managers of all kinds since their return is higher than the market at a given beta.

5.2. Data

We use monthly total return data for six data center REITs, five data center related companies and thirty retail REITs whose primary activities involve the owning, leasing and management of malls, shopping centers, and outlets. All of our data is sourced from Thomson Reuters Datastream. Our study runs from October 2009 to August 2016, a period following the global financial crisis, which avoids major structural breaks in the time series. Tables 4.5 and 4.6 present information about each company, including market capitalizations as of August 2016. For the estimation of beta within a CAPM framework, the usual recommendation is to use five years of monthly data (Shalit and Yitzhaki, 2002; Bartholdy and Peare, 2005). Given the sensitivity of beta to extreme observations, longer estimation periods tend to result in data mining or atypical outcomes. Using data of a greater frequency (for example, weekly or daily) increases noise, negatively affecting the efficiency of the estimates.

Of the firms in our sample, twenty-six are based in the US and the remainder are from the United Kingdom, Japan, Hong Kong, Singapore, Australia, and Canada. All companies are publicly-listed on major international stock exchanges. Prices for international companies are converted into US dollars in order to compare performance across our sample. In the CAPM analysis, we use the one-month overnight index swap (OIS) in USD for the risk free rate and the MSCI World Index for developed countries as the benchmark for broader market performance.

In the case of data centers, we include both REITs and non-REITs since there are very few REITs in this category that have been listed for three years or more. In the case of shopping complexes, the oldest firm in our sample was first

listed in 1973. Since the development of mobile devices such as the smart phone and iPad that allow information to be exchanged through the internet, data centers have been central to telecommunications infrastructure, which is why we include Vocus Communications and SuneVision Holdings in our sample. In addition to specializing in telecommunications, these two companies also own and manage data centers. In 2016, Vocus acquired NextGen, the fourth largest data center business in Australia.

Microcaps, companies whose market capitalization is below 300 million USD, are excluded from the study since these companies are associated with greater volatility and less liquidity than companies with larger market capitalizations. We only include companies that have been trading for at least three years in order to have an adequate number of monthly observations. Although there are several European countries with well-established REIT legislation, we only include the United Kingdom, the most traded European retail real-estate market in terms of transactions.

Table 4.5
Global Retail REITs (malls, outlets, and shopping centers**)**

US based Companies	Country	Ticker	Exchange	Year	Market Cap
Cedar Realty Trust, Inc.	US	CDR	NYSE	1986	629
Ramco-Gershenson Properties Trust	US	RPT	NYSE	1988	1,532
Pennsylvania Real Estate Investment Trust	US	PEI	NYSE	1973	1,726
CBL & Associates Properties, Inc.	US	CBL	NYSE	1993	2,280
Kite Realty Group Trust	US	KRG	NYSE	2004	2,375
Retail Opportunity Investments Corp.	US	ROIC	NASDAQ	2007	2,388
Acadia Realty Trust	US	AKR	NYSE	1993	2,928
Tanger Factory Outlet Centers Inc.	US	SKT	NYSE	1993	3,819
Retail Properties of America Inc.	US	RPAI	NYSE	2012	3,972
Taubman Centers Inc.	US	TCO	NYSE	1992	4,623
Weingarten Realty Investors	US	WRI	NYSE	1985	5,228
Regency Centers Corp.	US	REG	NYSE	1993	8,255
Brixmor Property Group Inc.	US	BRX	NYSE	2013	8,485
Federal Realty Investment Trust	US	FRT	NYSE	1973	11,332
Macerich Co.	US	MAC	NYSE	1994	11,707
Kimco Realty Corp.	US	KIM	NYSE	1991	12,296
General Growth properties Inc.	US	GGP	NYSE	1993	25,536
Simon Property Group Inc.	US	SPG	NYSE	1993	66,612
Non US based Companies	**Country**	**Ticker**	**Exchange**	**Year**	**Market Cap**
Plaza Retail REIT	Canada	PLZ	TSE	1999	381
Lippo Malls Indonesia Retail Trust	Singapore	LIPO	SGX	2007	772
CapitaRetail China Trust	Singapore	CRCT	SGX	2006	1,021
Shopping Centers Australasia Property Group	Australia	SCP	ASX	2012	1,269
Charter Hall Retail REIT	Australia	CQR	ASX	1996	1,338
Frontier Real Estate Investment Corp.	Japan	FRON	TYO	2004	2,511
Smart REIT	Canada	SRU	TSE	1998	3,627
Capitaland mall trust	Singapore	CAPI	SGX	2002	5,621
Hammerson plc	UK	HMSO	LON	1964	5,934
Japan Retail Fund Investment Corporation	Japan	JRFI	TYO	2002	6,044
RioCan REIT	Canada	REI	TSE	1994	6,967
Vicinity Centers Re Ltd	Australia	VCX	ASX	2011	10,051

Notes:
Market Cap is market capitalization in millions USD.
Year represents the year when the company became publicly listed on a major stock exchange.

Table 4. 6
Global Data Centers

| US based Company	Country	Ticker	Exchange	Year	Market Cap
Interxion Holding N.V.[a]	US	INXN	NYSE	2011	2,534
QTS Realty Trust Inc.	US	QTS	NYSE	2013	2,566
DuPont Fabros Technology Inc.	US	DFT	NYSE	2007	3,276
Coresite Realty Corp.	US	COR	NYSE	2010	3,706
CyrusOne Inc.	US	CONE	NASDAQ	2013	4,128
Digital Realty Trust Inc.	US	DLR	NYSE	2004	14,709
Equinix Inc.	US	EQIX	NASDAQ	2000	25,922
Non US based Company	**Country**	**Ticker**	**Exchange**	**Year**	**Market Cap**
Iomart Group plc[a]	UK	IOM	LON	2000	414
Nextdc Ltd.[a]	Australia	NXT	ASX	2010	738
SUNeVision Holdings Ltd.[a]	Hong Kong	SUNE	HKG	2000	952
Vocus Communications Ltd.[a]	Australia	VOC	ASX	1999	4946

Note: [a] represents non-REIT companies (EQIX converted to an REIT in 2015).
Market Cap is market capitalization in millions USD.
Year represents the year when the company became publicly listed on a major stock exchange.

5.3. Results

The results of our SML plots are depicted in Figures 4.6, 4.7, and 4.8. On average, data centers outperform the market more than retail REITs. The average alpha – the difference between the market return represented by the SML and the realized return of each firm – of data center companies is a remarkable 16.29%, compared with 9.58% for US retail REITs and a much lower 2.93% for International retail REITs. Systematic risk, as measured by beta with respect to the MSCI World index, is similar in all three categories, with average betas ranging from 0.76 for international retail REITs to 0.85 and 0.87 for US retail REITs and data centers respectively. In the CAPM framework, the returns of assets with betas less than one are less sensitive to fluctuations in market returns, thus making them more attractive for portfolio diversification.
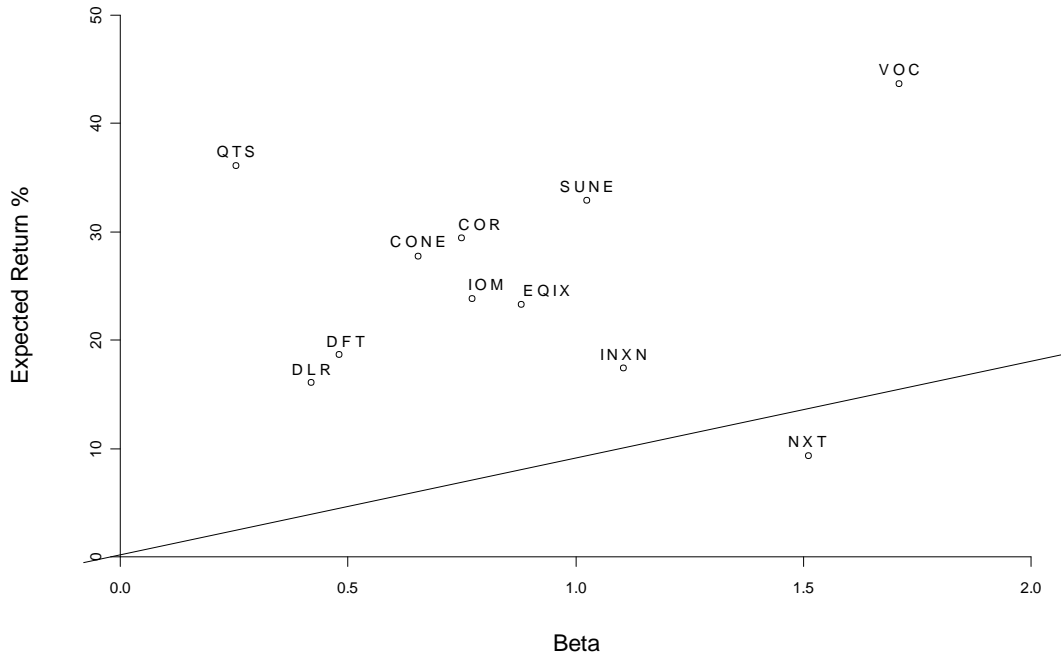
Figure 4.6. SML plot for data center companies (REITs and non-REITs), October 2009 to August 2016
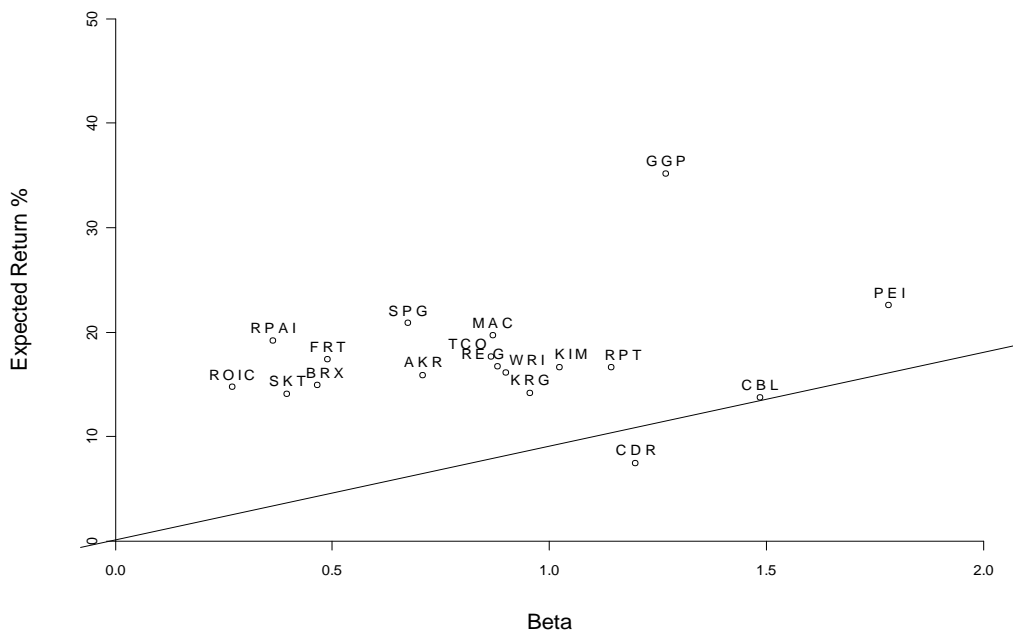
Figure 4.7. SML plot for US retail REITs, October 2009 to August 2016
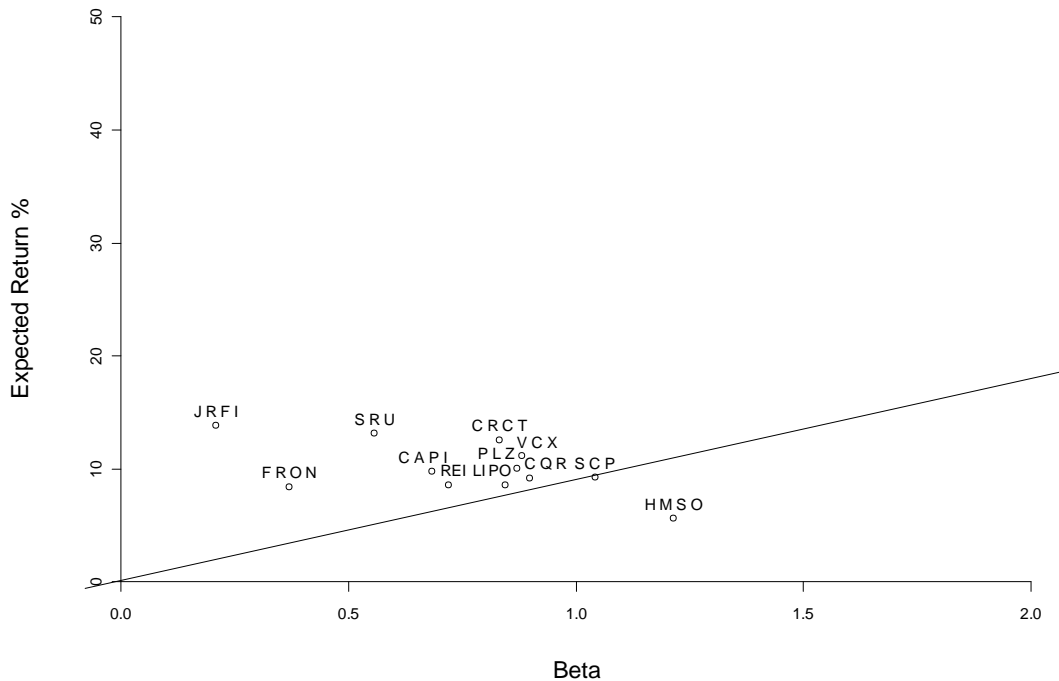
Figure 4.8. SML plot for international REITs, October 2009 to August 2016

Values for the alpha, beta, and mean return of each company over the period October 2009 through August 2016 are presented in Tables 4.7, 4.8, and 4.9. In the case of data centers, the six US REITs and United Kingdom company IOM perform very well in terms of risk/reward tradeoff (i.e., betas are less than one and alphas are positive). QTS, the smallest of the US REITs in terms of market capitalization, is an outstanding performer, with an alpha of nearly 35% over the equity benchmark. This company's investment appeal includes low operating costs and federal government approvals which allow QTS to lease space to high profile tenants. Of other top performers, DFT has recently expanded to Toronto, and DLR is opening a second data center in Singapore. Overall, continuous global expansion, investment in infrastructure for long-term cost efficiency, and catering to the needs of wholesale clients including IBM,

Amazon, UBER, Fortune 100 companies, and telecommunication companies (such as CenturyLink and AT&T) make the US data center REITs particularly attractive. NXT exhibits a negative alpha. VOC exhibits the highest alpha, although the activities of VOC are not entirely related to data centers. Overall, in terms of beta, non-REITs are more risky and REITs are less risky than the broader stock market.

Table 4.7
Estimation results of the CAPM model for data center companies, with the MSCI World Index for developed countries as the market proxy

Company	Alpha (%)	Beta	Mean return (%)
IOM[a]	16.77	0.77***	23.67
SUNE[a]	23.62*	1.02***	32.79
VOC[a]	28.23*	1.71***	43.51
NXT[a]	-2.46	1.51***	9.20
INXN[a]	9.05	1.10***	17.27
EQIX	15.28*	0.88***	23.15
CONE	22.35*	0.65***	27.62
COR	22.63**	0.75***	29.27
QTS	34.70**	0.25	35.93
DLR	12.17	0.42**	15.92
DFT	14.18	0.48**	18.48

Notes: [a] represents a non-REIT company.
***, **, * indicates significance at the 1%, 5% and 10% levels respectively. Rejection of the null hypothesis indicates that Alpha and Beta are significantly different from zero.

With regards to US retail REITs, RPAI, SPG, and BRX exhibit the highest alphas among the companies with betas less than one. BRX is a relatively new REIT, established in 2011 and made public in 2013. It is now the second largest owner of shopping centers in the US, following KIM. SPG is the largest REIT in our sample, with high-end malls and outlets in the US and abroad. Other companies should also be considered, given their development since the global financial crisis. GGP filed for bankruptcy in 2009 but, following a deal involving a

sizeable equity investment, has since transformed into the leading owner of malls in the US It exhibits the highest alpha of all retail REITs, although its systematic risk is higher than the market benchmark. CDR, the smallest company in our study in terms of market capitalization, could be considered the worst performer. However, in recent years, CDR has been in the process of a massive portfolio redevelopment, which has entailed divesting lower quality properties in secondary markets and focusing on shopping centers anchored by supermarkets in prime northeastern US locations such as Washington D.C. and Boston.

Table 4.8
Estimation results of the CAPM model for US retail REITs, with the MSCI World Index for developed countries as the market proxy

Company	Alpha (%)	Beta	Mean return (%)
AKR	9.44	0.71***	15.77
BRX	12.48	0.46	14.74
CBL	0.33	1.48***	13.60
CDR	-3.39	1.20***	7.32
FRT	12.87***	0.49***	17.24
GGP	23.72	1.27***	35.07
KIM	7.37	1.02***	16.52
KRG	5.52	0.96***	14.07
MAC	11.75	0.87***	19.54
PEI	6.51	1.78***	22.44
RPT	6.28	1.14***	16.49
REG	8.70	0.88***	16.57
ROIC	12.20***	0.27**	14.61
RPAI	15.81**	0.36*	19.09
SPG	14.70***	0.67***	20.74
SKT	10.44**	0.39***	13.97
TCO	9.84	0.86***	17.57
WRI	7.93	0.90***	15.98

Notes: ***, **, * indicates significance at the 1%, 5% and 10% levels respectively. Rejection of the null hypothesis indicates that Alpha and Beta are significantly different from zero.

In the case of international retail REITs, the two Japanese REITs have favourable risk/return trade-offs, with the largest alpha, 11.83%, belonging to JRFI. Japanese REITs are popular with investors due to several factors, including the strength of Japan's real estate industry, high demand for hotels and retail goods by foreigners traveling to Japan, and interest rates close to zero (Narioka, 2016). After Japan, Singapore accounts for the largest share of the REIT market in Asia. The Singapore based REITs also have favourable risk/reward payoffs. Tighter regulations, which have increased market transparency, and new tax-friendly policies have increased their attractiveness for foreign investors. SRU, a Canadian REIT specializing in shopping centers, has the second highest alpha. The company is focused on developing a portfolio of well-located properties in Canada, anchored by strong retailers such as Walmart. The worst performer of this category is HMSO, a UK-based REIT which owns and manages shopping centers and outlets across Europe.

Table 4. 9
Estimation results of the CAPM model for international retail REITs, with the MSCI World Index for developed countries as the market proxy

Company	Alpha (%)	Beta	Mean return (%)
JRFI	11.83	0.21	13.68
FRON	5.02	0.37**	8.31
HMSO	-5.38	1.21***	5.47
LIPO	0.94	0.84***	8.48
CRCT	5.02	0.83***	12.44
CAPI	3.52	0.68***	9.63
PLZ	2.17	0.87***	9.94
REI	2.03	0.72***	8.47
SRU	8.03	0.56***	13.01
CQR	1.06	0.90***	9.08
VCX	1.77	0.88***	11.02
SCP	-0.85	1.04***	9.10

Notes: ***, **, * indicates significance at the 1%, 5% and 10% levels respectively. Rejection of the null hypothesis indicates that Alpha and Beta are significantly different from zero.

6. Data centers and energy

Lastly, we turn to data centers in order to address energy consumption, and how developments in this area could affect future investment appeal for this real estate sector. Data centers consume enormous amounts of electricity. Thirty to fifty percent of operational costs are from electricity alone (Guo and Fang, 2013). Large companies such as Google and Microsoft pay millions of dollars every year in electricity usage. Data centers use approximately forty times more energy (primarily for servers, storage, network equipment, and infrastructure) than traditional office buildings, similar to the amount used by an aggregate 5.8 million average US households (Choo et al. 2014).

The total amount of electricity used by data centers more than doubled between 2000 and 2005 (Koomey, 2008). In 2011, data centers used an estimated 1.5 percent of worldwide electricity consumption (Wierman, 2014). According to a Data Center Efficiency Assessment (2014), data centers in the US consumed approximately 91 billion kilowatt hours of electricity in 2013. A rise of 47 billion kilowatt hours annually is forecasted by the year 2020, which will cost businesses tens of billions USD per year (Data Center Efficiency Assessment, 2014). Hence, being close to a power source is extremely advantageous in terms of operational and cost efficiency. CyrusOne owns two data centers in San Antonio, Texas, because of its proximity to several electrical substations, providing its facilities with a stable power grid. The location also has the merit of being protected from natural disasters.

In the case of electric failure on the main grid, data centers have backup power supply units. However, since their main objective is to provide reliable, uninterrupted access to data at all times, they are ideal candidates for microgrids.

Microgrids are miniature versions of an electric grid. Unlike major grid systems, which provide electricity to large geographic areas (for example, to several states in the US or several countries across Europe) via thousands of interconnecting power lines, a microgrid is local in nature, servicing a much smaller area. Current microgrid users include college campuses, military bases, and communities, which use microgrids to service facilities such as hospitals and police stations in the case of power failure. The primary motivation for the use of microgrids is power efficiency. Like data centers, many businesses and public service providers rely on an uninterrupted power supply for their operation. Microgrids can use many energy sources, including utility grid energy, renewable energy, and fuel-based generation. In a microgrid, electricity also travels over much shorter distances, resulting in minimal losses in power compared with larger grids. Mainstream grids are more susceptible to weather events, and superstorms like hurricane Sandy in 2012, which are occurring with greater frequency. A single damaged line can create a domino effect, causing power outages within a radius of many miles. Microgrids have the merit of isolating themselves from the main grid, and thus function without being exposed to the same failures.

Relying on a local microgrid not only saves the cost of high electricity bills for the data center but also allows them to sell surplus power back to the main grid when prices are favorable. The use of renewables in microgrids is also an attractive feature for both data center tenants and investors, especially for the long term, as renewable technologies become more and more cost efficient. When choosing a data center provider, tenants increasingly consider sustainability from both a cost and environmental perspective. Companies including Digital Realty Trust (DLR) and Equinix (EQIX) use more renewable

energy than their competitors, according to the Environmental Protection Agency. DLR has also been commended for being a socially responsible company and is a member of the iShares MSCI KLD 400 Social Index Fund. Members of the fund must be publicly listed companies that have proved to be environmentally aware with commendable governance practices.

We illustrate additional earnings for a prototypical data center in the case of a spike in electricity prices. Usually, a data center uses one third of its power for computing, one third for processing, and another third for cooling. This means that the total computing load is two thirds of the total. In practice, 25% of the computing power can be shifted with no damage to the system from its regular use. Moreover, data centers usually run between 20 to 50 MW capacity. If we take as an example that spikes at 1000 US dollars per Megawatt hour take place 12 days a year, the data center could generate an additional 1.2 million (0.25 x 40 x 12 x 10 x 1000) US dollars per year, assuming ten peak hours per day and 40 MW capacity. This number will only increase as more renewable and not permanent sources of electricity like wind or solar appear in the power mix and benefit from 'reserve capacity.'

7. Conclusion

We analyze the recent performance of two popular real estate sectors in this Chapter: data centers and shopping complexes. In recent years, both have been attractive for their high yields, capital appreciation, and diversification potential amidst a climate of low interest rates and market volatility.

As a first step, we study short-term and long-term relationships between the S&P 500 and several commercial real estate categories through Engle-Granger cointegration over the period 2009 to mid-2016. An existing US retail

REIT index is used to proxy shopping complexes. To represent data centers, we build a cap-weighted price index based on six US data center REITs. There is no evidence of cointegration between data centers and the S&P 500, nor between retail and the S&P 500, suggesting that both real estate classes are attractive for portfolio diversification.

In the second part of our study, we focus on individual firms, and perform a CAPM analysis on 41 companies across the US, Canada, UK, Australia, and several Asian countries. Data centers, on average, outperform shopping complexes, while US shopping complexes outperform those of similar international firms.

Finally, we discuss the future outlook of data centers, with respect to alternative power solutions to the main grid and the positive effect of these developments on clients and investors. We present a scenario in which additional revenue can be made by selling excess capacity to the main grid.

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Chapter 5. Conclusion

1. Final comments

The emphasis of this thesis is on the empirical analysis of real, alternative assets that have become increasingly attractive to investors, particularly in more recent years following the global financial crisis of 2007 to 2009. In Chapter 1, we provided an overview of three asset classes: art, residential real estate, and commercial real estate. Two main features have been highly influential in the growing popularity of these assets. First, a long period of near zero interest rates has driven investors to search for yield in other places. The second has been a growing population of high net worth individuals (HNWIs) and ultra-high net worth individuals (UHNWIs). Despite differing opinions, art and other collectibles are clearly contributing to a greater proportion of global investment portfolios. Apartments, condominiums, and single family homes - particularly in global financial centers such as New York and Hong Kong - are being acquired by investors as safe haven assets. There has also been more 'flipping' activity, for profit-taking in the short term. In the case of commercial real estate, many firms are continually improving management practices, infrastructure, and diversification strategies in order to increase profit margins and investment appeal in response to losses from the bursting of the housing bubble.

Chapters 2, 3, and 4 address art and real estate from a financial standpoint, including a discussion regarding the index methodologies that are currently available for these alternative asset classes. These markets are characterized by illiquidity, opacity, and heterogeneity. After highlighting some of the shortfalls of existing measures, we introduce new tools allowing investors and industry participants to gauge the performance of real assets. We also illustrate

the benefits of portfolio diversification through several empirical analyses. Each chapter contributes to the existing literature in several ways.

2. Main contributions

In Chapter 2, we address three genres of paintings popular with investors over the period 2003 to 2013, a very strong period for the art market. During this time, particularly following 2008, prices paid by buyers were much greater than the pre-auction estimates published by international auction houses. We argue that hedonic and repeat-sales indexes fail to capture some fundamental features of the art market. Our contributions include the creation of a 'Rarity Index' and the identification of several non-monetary benefits, which explain high prices paid for art at auction. The Rarity Index is based on rarity premia, each premium being defined as the difference between the average pre-sale estimate and the final price paid by a buyer. Unlike the repeat-sales methodology, all types of sales are included. The Rarity Index not only reflects the strong performance of the art market in recent years, but also serves as a tool for investors to gauge the performance of a particular genre and identify periods when art may be undervalued or overvalued based on average premia being paid. We further propose that high rarity premia paid by buyers are not only explained by the aesthetic yield discussed in the literature, but by a more general 'ownership yield', which includes the many benefits that accrue to the owner of artwork, such as the satisfaction gained from the possession of a rare good.

The focus of Chapter 3 is prime real estate in New York, London, and Hong Kong – all global financial centers and important socio-cultural destinations. For each city, we define prime real estate as residential housing in the most desirable locations and non-prime as the remainder of housing stock within a

particular city. Our goals are twofold. We first claim that, within each city, monthly price changes of prime real estate have diverged from non-prime housing over the years 2003 to 2014. Secondly, we argue that similarities in monthly price changes across prime markets in London, New York, and Hong Kong have increased over the same period. In addition to the use of statistical and structural break analyses to illustrate these developments, we create an index based on a 'luxury ratio', which tracks changes in repeat-sales index values of prime relative to non-prime markets over time. We find that positive correlations of prime and non-prime real estate sectors within each city remain higher than correlations across prime markets in different cities. However, there is also evidence confirming a growing relationship among prime markets through the luxury ratio index, which shows a clear divergence between prime and non-prime property in all three cities. Results support our claim, especially for London and New York, that the gap in price movements between prime and non-prime markets has grown substantially in the years following the global financial crisis. Our findings also support the existence of an 'ownership yield', explained by a growing number of wealthy individuals whose motivations for purchasing an exclusive residence include status, prestige, and mobility.

In Chapter 4, we address data centers and shopping complexes – companies specializing in shopping centers, malls, and outlets. In the recent situation of low interest rates and market uncertainty, both commercial property sectors have been popular because of high yields, capital appreciation, and diversification benefits. As a first step, we use US REIT indexes to study relationships between the S&P 500 and several commercial real estate categories from 2009 to mid-2016 using correlation and cointegration analyses. Using the Engle-Granger methodology, we find no cointegrating relationship

between data centers and the S&P 500, or retail and the S&P 500, indicating that data centers and shopping complexes are attractive investments and beneficial in building a diversified portfolio. In the second part of this Chapter, we perform a CAPM analysis on 41 companies based in North America, Asia, and Europe. On average, we find that data centers outperform shopping complexes, while shopping complexes in the US outperform similar firms abroad. In the final part of Chapter 4, we discuss implications for investors with respect to alternative energy sources for data centers.

We contribute to the literature in several ways. In the case of data centers, most literature is from a technical, rather than investment, standpoint. Moreover, companies specializing in data centers only began to emerge in the mid-2000s and many have only been publicly listed since the 2010s. Our research looks at data centers from an investment standpoint and includes all listed data center REITs in the US in addition to several international companies specializing in this sector. With respect to shopping complexes, there is no literature studying the performance of the companies included in our investigation following the global financial crisis. Since 2009, many of these firms have reacted to the adverse consequences of the housing bubble by updating property portfolios and improving management practices in order to attract desirable (profit making) tenants and new investment. Furthermore, we report results for each firm, as opposed to results based on benchmark indexes or averages of companies in order to better inform investors and market participants.

3. Ideas for future research

Moving forward from this thesis, future research could address the lack of timely indexes and information for real assets such as art. Better analytical tools

would help investors understand price performance over time and be aware of risks (liquidity, heterogeneity, opacity, etc.) inherent in these alternative asset classes. Indexes that take into account all sales, such as the Rarity Index presented in Chapter 2, could be created for more genres of fine art, as well as other collectibles sold primarily at auction, including coins, gemstones, and jewelry. If there is sufficient data available (combining auction sales with private data, for example), indexes could be created with a monthly frequency, rather than quarterly or annually, which is generally the case now. Indexes could also be broken down into price brackets to provide more detailed information about the market. Additionally, "buy-ins", objects that fail to sell at auction, could be addressed more carefully and their effect on auction performance incorporated into an index or other market indicator.

In the case of real estate, the luxury ratio introduced in Chapter 3 could be extended to other regions and cities. To complement analyses of real estate in alpha cities, both residential and commercial real estate in secondary cities could be studied in greater depth. Secondary cities are often considered "hedge cities" by wealthy foreign investors since they are characterized by political and economic stability relative to their own countries. Moreover, these property markets are less expensive than popular global cities such as New York and Hong Kong. Examples include: Vancouver in Canada; Charlotte, Phoenix, and Seattle in the US; and Manchester and Reading in the UK A comparative study could serve as a very useful information source for both domestic and foreign investors who wish to invest in secondary cities but may not be familiar with the real estate market in a particular country.

To extend the research presented in Chapter 4, the performance of emerging real estate sectors, including self-storage centers, retirement homes,

and university housing, could be studied using econometric analyses and the CAPM or other framework. In the past decade, more real estate companies and REITs specializing in these property types have attracted the attention of investors.