An Econometric Analysis and Forecast of the Central London Office Market:

Single Model versus Aggregate Submarket Models

By

Matthew E. Waisnor

B.S. Finance 2006

Pennsylvania State University

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

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Signature of Author_____

Center for Real Estate
July 30, 2013

Certified by_____

William C. Wheaton
Professor, Department of Economics
Thesis Supervisor

Accepted by_____

David Geltner
Chairman, Interdepartmental Degree Program in Real Estate Development

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Abstract

This paper examines and projects fundamental characteristics of the London Office rental market which is facing supply and demand issues in upcoming years despite being considered one of the few safe haven places for real estate investors during the recent worldwide financial uncertainty. The paper divides the Central London market into four submarkets: Docklands, Midtown, City, and West End. The key issue the paper will examine, aside from projecting future market fundamentals for a 10 year period, is whether on an econometric analysis level it is better statistically to analyze the market utilizing one singular model or to model each submarket separately then sum the outputs.

First, the paper will discuss the history and development of the economic model, then discuss what papers have analyzed the London office market utilizing econometric models, and finally what previous studies have examined submarkets utilizing econometric models. Next, the paper will analyze what's occurred from 1986-2012 and try to offer some explanation of why the markets have behaved the way they have on a submarket and aggregate level. Next, the paper will present the model utilized to project the conditions for 10 years and examine back tests for the previous five years (2008-2012) to examine how well the model would have predicted the actual events of the time period.

This study derives three main econometric equations for each submarket and Central London as a whole. The rental equation is explained by a lag of one year of rent and the current quarter's vacancy. The demand equation is explained by a 1 year lag in occupied stock, the current level of government service employment, the current level of fire, insurance, and real estate employment, and a four year lagged vacancy. The supply equation is explained by a 1 quarter lag in yield, a 1 year lag in yield, the current bond rate, the current real rental rate, a 1 quarter lag in real rental rate, and the spread between 10 year government bonds and corporate bond rates. The model is utilized both on each submarket and on the Central London market as a whole.

Finally, the paper examines the differences in aggregating the submarkets versus modeling Central London in one model. This is done by comparing the models outputs for the previous 5 year back test and also for the 10 year projections.

Thesis Supervisor: William C. Wheaton
Title: Professor of Economics

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To my brother Christopher, who was always there for me during my time at MIT (and all other times) and is the best friend anyone could ever have.

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Chapter 1: Introduction

Central London is one of the most developed and analyzed office markets in the world. Since the financial collapse of 2008 there has been an influx of capital from other areas of the world, in particular from the Middle East and Asia to London's residential and commercial real estate markets.[1] From a real estate investor's point of view, London is seen as a place where there is relatively low amount of risk in real estate in turbulent times. This is similar to the influx of capital to New York City[2] and other "core" cities that have attributes of low yields, low risk, and a way to invest with expectations of inflation in an area of financial depression. [3]

Since the financial collapse of 2008, speculative development within the London office market has continued at previous rates despite such poor economic conditions. Absorption rates have not been able to keep with the new supply and as a result vacancy rates have risen and rental rates have remained stagnant or even declined, particularly in real terms.[4] There have been several new buildings including the iconic Shard, which was developed utilizing Middle Eastern capital, and Cannon Place, which was developed by Hines, which have had difficulties in finding tenants since their completion despite their prime locations and modern construction qualities.

The worldwide economic collapse in 2008 also had the residual effect of severely hurting the financial services industry.[5] With London being the financial capital of Europe, if not the world, this has had an adverse effect on attracting the types of tenants these new buildings were designed for. Additionally, the uncertainty with the LIBOR scandal where financial institutions were controlling

[1] According to the CBRE 1st quarter 2013 Central London Property Review, the 1st quarter of 2013 saw foreign investment account for 61% of all transactions in the London office market with 23% of that being from Asian investors and 15% from Middle Eastern sources.
[2] For reference, New York's office market contains approximately double the square footage of London's
[3] Average yields in the London Office market were 4.9% in the 1st quarter 2013.
[4] This will be examined further in Chapter 3
[5] London lost about 50,000 Finance, Insurance, and Real Estate jobs between 2001 to 2003 and around 85,000 of these jobs from 2007-2010 according to the Office of National Statistics (UK)

this rate and facing significant fines has made the financial companies that are left hesitant to sign any lengthy, high priced lease.[6]

Utilizing a dynamic econometric model, this paper attempts to answer the question of what will happen in the next 10 years both to the Central London office market[7] as a whole but also to the four main submarkets[8]. Utilizing a structural econometric model, the paper will present separate rent, demand (absorption), and supply (construction) equations for the four submarkets and Central London as a whole to project future trends in these categories as well as several other key attributes of the office market. Following the preparation and analysis of the equations, the paper will try and answer a key question within the structure of the econometric model: should a large market, such as London, be modeled as one large market or rather on a submarket level and aggregated.

In conclusion, this paper projects decreases in vacancies for an approximate 5 year period while the projected supply is being built, following Central London will enter a period of increasing vacancy and decreasing rental rates as the market will be oversupplied. Real Rents will essentially reach the same price per square foot at the end of the 10 year projection as where they started exhibiting similar trends as previous cycles. When examining if the Central London office market should be modeled as one market or as separate submarkets and then summed, the results yields inconclusive evidence to support either methodology as both depict similar results either both being accurate in their representations or missing by the same approximation. Overall, both methods yield similar results and both are valuable for their own characteristics when projecting space market conditions.

[6] This issue was still being dealt with at the time of this publication as in July 2013 the U.K Serious Fraud Office charged two former bankers of RP Martin Holdings Ltd. With conspiracy to fraud related to the LIBOR rate.
[7] For the duration of this paper Central London Office Market will consist of the four main submarkets: Docklands, Midtown, City, and West End
[8] Docklands, Midtown, City, and West End

Thesis Outline

The thesis is comprised of six total chapters.

Chapter 1 introduces market conditions within the London office market, introduces the model and methodology applied, and discusses the submarket versus single model approaches to modeling the market. Chapter 2 examines the historical development of the model utilized in this thesis, the history of studies within the London office market, and summarizes any studies that have examined submarkets within real estate markets. Chapter 3 will introduce the historical and current market conditions within Central London and it's submarkets to the reader to provide context prior to the introduction of the model and projections. Chapter 4 describes the equations for the Central London market as a whole and the four submarkets. It also provides 5 year back tests and 10 year projections for each of the markets based on the utilized equations. Chapter 5 aggregates the four submarket models and compares this with the single model analysis. This is done by comparing the two methods against 5 year back tests and also compares the 10 year projections for each. It also includes a section comparing the coefficients of the equations for the submarkets modeled separately and Central London as a single model. Chapter 6 concludes the thesis with a summary of the findings and the conclusion of the thesis.

Chapter 2: Literature Review

2.1 Studies on Supply and Demand Fundamentals within Office Markets

Relating the changes and fluctuations between vacancy rates and rental rates has long been established in the modeling of office as well as other commercial real estate markets with similar fundamentals. The adjustment made between a change in vacancy and the corresponding inverse relationship with rental rates was first rooted in the 1953. Blank et al. This study was the first credited with explaining the reverse symmetrical relationship between rental and vacancy rates. The data used in this study was the first to explain the relationship between rental and vacancy rates by utilizing data from six cities between 1932 and 1937. The relationship between the two has been tested and improved repeatedly in many more structured studies.

Rosen (1984) proposed a new model for forecasting office markets with more complicated equations and models while examining the San Francisco office market. The main variables utilized in this study were the flow of new office construction, rent for office space, vacancy rate, and stock office space with the analysis essentially being a supply and demand function utilizing the empirical data. He connected three equations and the functions that make the previously stated function. (1) the desired stock equation is a function of employment in the key service producing industries and rental rates, (2) the change in net office rents is a function of the difference between actual and optimal vacancy rates and the change in overall price level, and (3) the supply of new office space is a function of expected rents, construction costs, interest rates, and how taxes effect commercial properties. The results of the study concluded that his equation for new office space was not statistically significant and only lagged vacancy is significant when explaining supply. However, his equations for the desired office supply and change in office rents did contain statistically significant results.

Examining 14 metropolitan United State office markets, Hekman (1985) utilized a 2 equation model where rent is determined by vacancy and other variables, and quantity supplied is a function of rent and other variables. The results indicated that the rental rate for buildings under construction is a strong function of current market conditions including vacancy rates within the city but also suburban office markets. The study also linked construction of office supply being strongly connected to real rents and long term office employment.

Schilling et al. (1987) utilized the aggregate data from 17 United States cities to try and estimate the change in natural vacancy rates. However, this study did not reveal any significant results. The expense function utilized in the analysis only yielded statistically relevant results for four of the cities and for 11 of the cities in vacancy at a very low significance level. Overall, conclusions about the natural vacancy were not seen as realistic.

Wheaton (1987) established an econometric forecast model utilizing three behavioral equations and three identities. The supply equation connected building permits to real rent, vacancy, stock of office space, employment growth, construction rates, and interest rates. The demand equation related office employment growth rate, office employment, and real rents to absorption levels. The third equation built on previously mentioned studies relating real rents to vacancy levels. This model projected that the US Office markets would remain soft or tight for upcoming years and was later proved to be an accurate method in projecting commercial real estate fundamentals.

Torto and Wheaton (1987) expanded on this study and provided statistical evidence that the change in office rents is determined by the difference between structural and actual vacancy rates. This study was different from other studies utilized in the past in that they assumed structural vacancy could rise linearly over time instead of the previous assumption that structural vacancy would remain relatively constant over time.

Hendershott (1996) developed a model of rent adjustment by creating an equation for long run equilibrium gross rent g* which states $g^*(1-V_n)=C+exp$ where exp are operating expenses. The Sydney office market was utilized for g*. Gross rent is then adjusted based on the differences between gross rent and g* by the natural vacancy rent-actual vacancy rate. The conclusions indicated that a rent below (above) long run equilibrium would result in a rental increase (decrease) so this variable is adjusting for long equilibrium.

Grenadier (1995) utilized semiannual data 20 cities for the time period covering 1960-91 and analyzed office vacancy rate directly. This paper reinforced the conclusions in Wheaton and Torto and additionally estimated a wide range in a cities natural vacancy rates.

Wheaton et al. (1997) examined and forecasted the London office market using the structural econometric model mentioned previously on data within London between 1970-1995. The paper concluded that office construction is well explained when using a traditional model but only when the previous rental rates are explained by and accounted for with a structural model. Additionally, the paper concluded that movements in supply and demand were well explained simply by office employment. The amount of space demanded per worker displays a typical demand schedule with respect to rental rates, and rents react sharply to vacancy rates and leasing. In the following section we will further explore this paper as it has important implications on this thesis as it relates to the cyclic nature of the London office market as a whole.

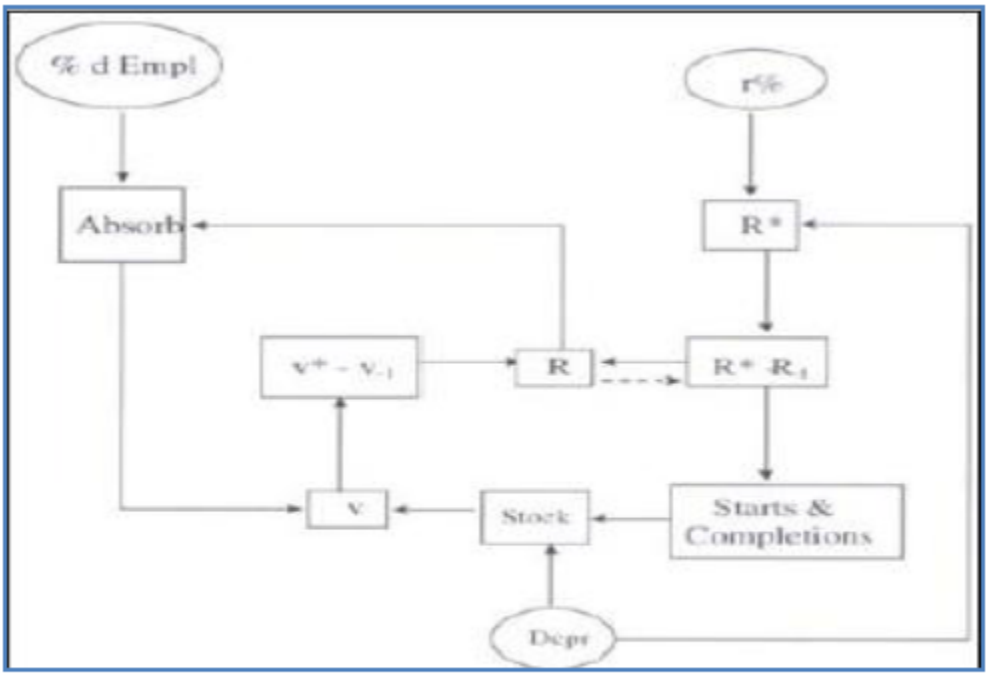

Fig 1 Hendershott et al. (1999)

Hendershott et al. (1999) developed the chart (FIGURE) which shows the rental adjustment connected with supply and demand through vacancy rate. This model concluded that the Greater London office market were positively affected by FIRE employment and one lagged year rents and negatively affected by office supply.

Ho (2003) used a 2 stage least squares regression for rent and demand to forecast the Hong Kong Office Market. The study showed that the demand for office space is related to office employment but inversely related to rent. Additionally, office rents are positively related to office employment but inversely related to office stock. Finally, the study concluded that the elasticity of absorption with respect to rent is very inelastic.

2.2 Studies on the London Office Market

Historically, there have been significant modeling and statistical studies on the London office market, particularly within the last 20 years. Wheaton (1995) explored the cyclical behavior of the London office market by examining time series data over a 20 year period. The study revealed two large cyclical swings despite only one building boom in the middle of the time series. It also exhibited that London had the fundamental characteristic of office space being scattered throughout the city in smaller buildings rather than concentrated in large buildings in one specific CBD like as seen in the United States. Another key revelation in the paper is the fact that the longer term nature of leases within London, compared to the United States, tends to hinder the adjustment of supply to changing demand fundamentals and creates a longer lag period for new supply. The conclusion of the paper had three forecasts.

The first forecast, called the "base" forecast, utilized the previous data to forecast market conditions going forward. The conclusion using these parameters concluded that the crash of the early 1990s would lead to new absorption, falling vacancy, and increased rental rates. These new parameters would lead to new construction and significant land residuals in the projections. The second forecast examined a negative economic shock in the London market. The model responded with a quick and sharp drop in absorption with a rather quick recovery due to a large drop in rental rates. These rents eventually recover as there is no new supply being forced onto the market. Finally, the final forecast examines the impact of a positive employment shock to the London economy. The conclusion of this forecast indicates a large increase in rental rates, contraction of absorption, and no new supply due to the length of time (2 years) for supply to react to such a large increase in demand. By the time the supply arrives, the vacancy rises and rental rates fall dramatically. The overall conclusion of the paper indicates that the volatility within the London office market is largely

explained by employment in the city's office sectors. Also, the model indicated that commercial property within London is able to be forecasted is dependent on the forecasting of economic growth.

Hendershott et, al (1999) utilized a dynamic model to project rental rates and vacancy within the London office market. Conclusions within the paper included that real rents respond to the mean reversion characteristics of actual rent levels and between natural and actual vacancy rates. When the model set employment growth at the long term trends and interest rates at a fixed rate, the cyclical natures of rental and vacancy rates disappeared. In essence, the rise in employment and decline in real interest rates triggered a development boom. Thereafter, when the new supply coming online coincided with a decline in employment, the result was a sharp rise in vacancy with rents and values of properties sharply declining. Within the model, the vacancy rates only took about 6 years to return to their previous levels with is quite fast. The characteristics of London differed from that of many US cities as vacancy within these cities stayed at double digit levels while building within London stopped once vacancy rose. This explained much of the boom then bust period of London within the 1980s and 1990s.

Farrelly and Sanderson (2005) studied both the linear and non-linear aspects of the London office market and how to model regime shifts within it. The conclusion of the paper indicated that an STR model was an improved fit over the linear model although it could not model outliers in the study.

As mentioned previously, an important fundamental of the London office market is the long term nature (10-15 years) of the leases that encumber office properties and slows down the rental adjustment process. Englund et al (2008) studied "hidden vacancies" in the Stockholm office market which occur due to slow rental adjustments and when space occupancy does not match current demand. The model utilized in the paper indicated when there is an increase in demand for

space this increase initially supports a large decrease in vacancies. Following, rents rise to match the space demand and the decline in vacancy reverses. Due to the long term nature of the leases signed, a larger than normal rent increase is needed to restrict the demand for these new leases. Eventually, new supply is delivered and the leases roll over at these overshot rents and bring the market back to equilibrium.

Hendershott et. Al (2009) expanded on their previous study by utilizing a longer data set and tested the responses of rent and vacancy to employment and supply shocks depending on the impact of the shock within the real estate cycle. The study tested whether the shocks to employment and supply are positive or negative and where they occur in relation to where current vacancy rates stand will impact the change in rental rates and how vacancy changes to these shocks. The conclusion of the paper indicated an asymmetric response to rental rates.

2.3 Studies on Real Estate Submarkets

Bourassa et al. (2002) compared whether housing submarkets matter and if they do, how they should defined by analyzing housing data in Auckerman, New Zealand. The main hypothesis of the paper tested submarkets organized based on contiguous geographical constraints versus statistically generated submarkets based on statistically similar dwelling units but not based on contiguous geography. The paper concluded that not only housing submarkets matter, the geographic location of the submarkets is better in organizing them rather than by statistical trends. On the other hand, statistical analysis for defining submarkets may be useful for combining submarkets for a larger analysis of a city.

Chen et al (2007) examined forecasting assumptions based on different submarket assumptions and the accuracy of these assumptions in hedonic pricing models based on housing sales data in metropolitan Knoxville, Tennessee. The conclusion of the paper indicated that the forecasting

accuracy of the hedonic price model improves when there is an expert knowledge (such as an appraiser or real estate agent) of the defined market, school district and combining information conveyed in different modeling strategies are used to define housing markets. Compared to models that use systematic clustering to define submarkets, this technique yields superior statistical results. This result implied that submarkets defined with expert knowledge and school quality yield better for housing market segmentation than boundaries drawn with clustering or predefined geographic units.

Leishman et al. (2012) moved away from how submarkets should be defined and instead evaluated how to best model submarkets once they have defined. It specifically examined the multilevel strategies to modeling spatial housing submarkets. First, the analysis set up a simple city wide hedonic model with a simple distance variable to establish a benchmark approach. Similarly to previously discussed papers, the conclusion of this first test was that submarkets defined by real estate experts yields statically superior results to the benchmark. The overall conclusion of the paper implies that submarket boundaries should be subject to modification over time and be able to capture the fluidity in submarket dimensions and a multi-level model captures this fluidity the best.

Chapter 3. London Office Market Analysis

3.1 Introduction – Overall Trends

The city of London is the capital of the United Kingdom and has long been considered the financial capital of the world.[9] The pound is still one of the strongest currencies in the world despite turbulent times in the economic health of the United Kingdom and European Union.[10] The city of London contains approximately 8.2 million people with the metropolitan area containing about 15 million people making it the largest in the European Union. Historically, Central London has exhibited some of the highest residential and commercial real estate prices in the world due to its high demand and limited supply.

Central London is divided into five main submarkets: West End, Midtown, South Bank, Docklands, and City.[11] We should note that the South Bank has not been included in the analysis for this paper due to the small size and lack of data for the area.[12] Therefore this paper will analyze the four other previously mentioned submarkets as well as Central London as a whole.

In terms of geography, the West End is the located in the western portion of Central London with Hyde Park bordering it to the west, Regent's Park to the north, and the Thames River to the south. St James Park and Green Park are also key parts of the West End submarket. Moving east, the Midtown submarket is a transition zone between the City and West End submarkets. Midtown exhibits physical characteristics of both the West End, which contains older, smaller properties and the City submarket which is the financial center of London and contains a majority of large office product. The City submarket is to the east of the Midtown submarket and is constrained by the

[9] Although this was changing as of the date of this paper due to the large financial job loss during the recent recession.
[10] As of July 2013 the British £ was trading as £1.51 = $1.00, which was down from a peak of £2.10 = $1.00 in early 2008 prior to the recession.
[11] The East London submarket does not contain many high grade investment office properties and is becoming a more established submarket since the London Olympics of 2012 where the majority of the events were located in East London.
[12] The South Bank expects to demand higher rental rates in the upcoming years due to the recent delivery of *The Shard*, a 95 story mixed use tower which is now the tallest in the European Union.

River Thames to the south. An important feature of the City submarket is the Bank of England which is located in the center. Lastly, the Docklands submarket is located to the southeast of all these submarkets and stands on its own. Developed in the late 1980s/early 1990s, the Docklands submarket is constrained by large river inlets and is surrounded by water on three sides. The following map depicts the submarket locations within Central London:

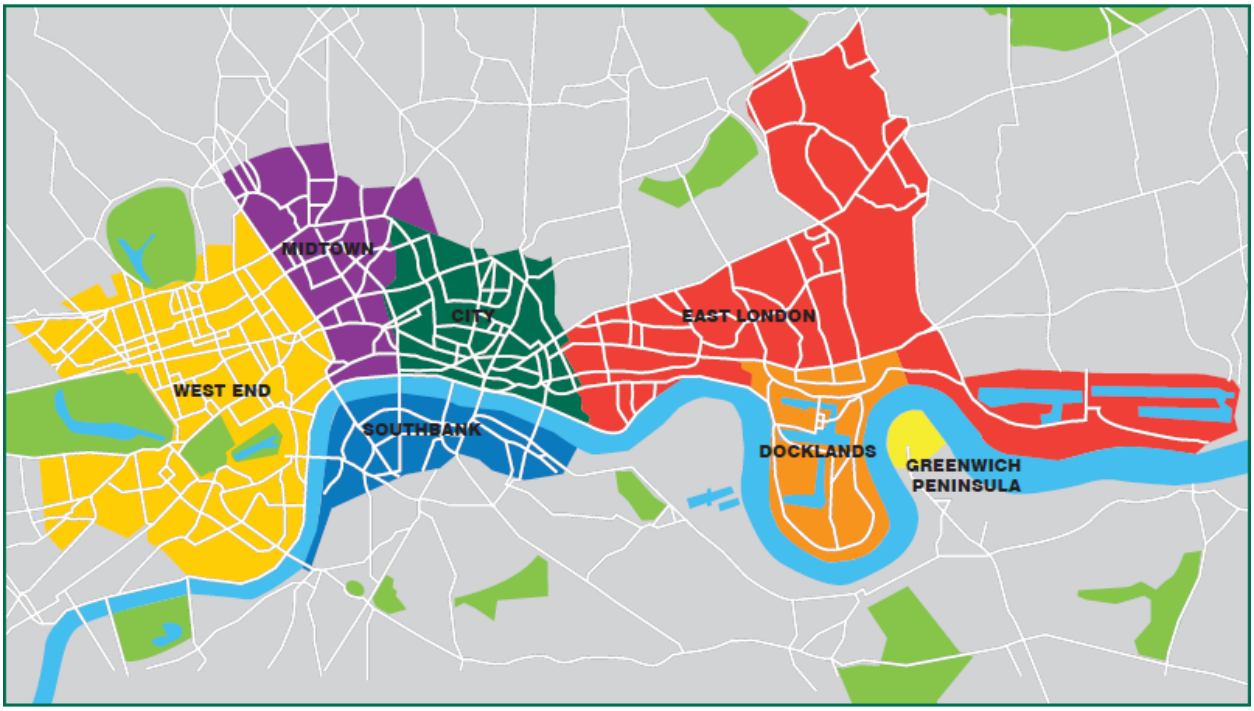

Figure 2 Source: CBRE

3.2 Key Metrics of the London Office Market

3.2.1 Supply of Office Space

Within Central London as whole since 1986 there have been three periods of significant office growth. The growth of the late 1980's and early 1990's is explained by the development of the

Docklands submarket which brought on 635,000 square meters of development into the southeastern portion of London.[13]

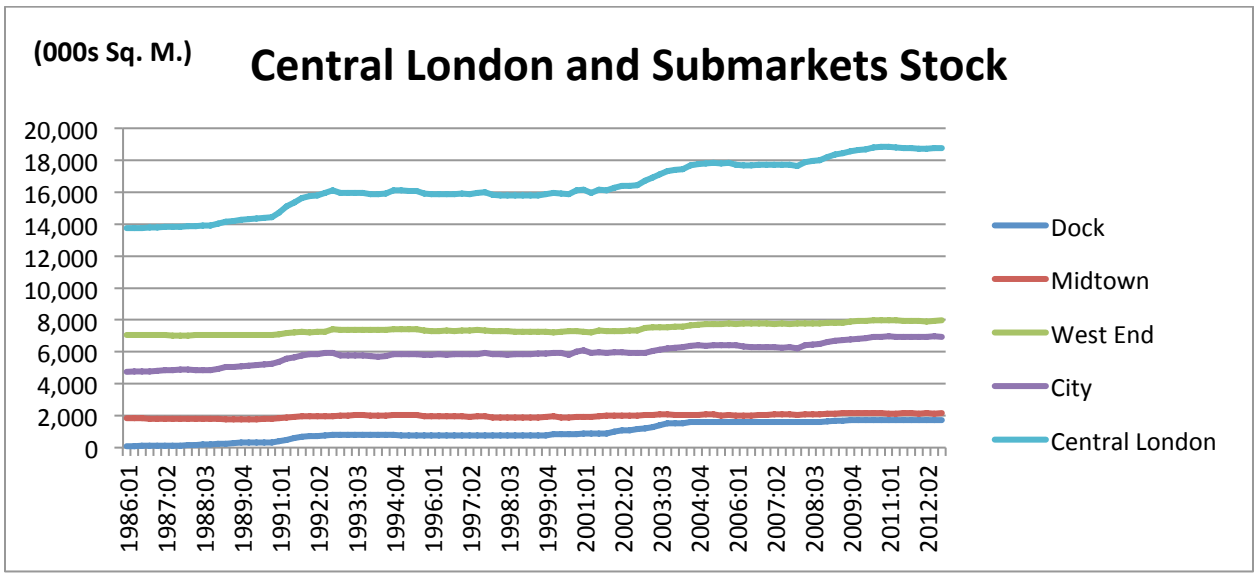

Figure 3 Source: CBRE

As shown in the chart above, there was significant supply added in circa 1990 in the aggregate Central London submarket due largely to the addition of the Docklands submarket in the Canary Wharf area of London.[14] There were also two additional "boom" periods in the early 2000s for supply in Central London, as a response to the technology and internet boom and in 2007-2008 as a result of the real estate bubble just previous to the financial collapse of 2008. In both instances the additional inventory was not delivered until the economic conditions had severely deteriorated.[15] As shown, the Dockland's submarket slowly constructed from 1986-1990 and delivered approximately 800,000 square meters to the Canary Wharf area in 1990. Following this, there were no additional buildings built in the submarket until the year 2000 which saw the inventory double to 1,600,000

[13] Main construction of the submarket began in 1988 with the first building completed in 1991. At the time of completion, the London and worldwide commercial Real Estate markets had collapsed and the developers filed for bankruptcy.
[14] The City and Midtown submarkets also had large supply deliveries at this time.
[15] Vacancies in Central London were around 11% in 1992 and 2004 when the new inventory was delivered.

square meters by the year 2005.[16] There were smaller additions to the submarket around the year 2008 but not at the level of the two previous development periods. The Midtown submarket has only added approximately 200,000 square meters of office space in the time period of this analysis and even saw a period of slight decline in overall space between 1994 and 2001 due to deteriorated buildings or land that was held for development due to poor economic conditions. Following, the submarket increased the stock of space to about 2,150,000 square meters of space by the end of 2012. The City submarket increased the substantially from 1986 to 2012, adding nearly 2,200,000 square meters of space. This is mainly due to new developments at increased densities as this area of London is considered to be the financial capital of the city and has long been the center of office development. The West End added approximately 1,000,000 square meters of office space between 1986-2012 with a steady increase throughout this time period.[17]

3.2.2 Completions

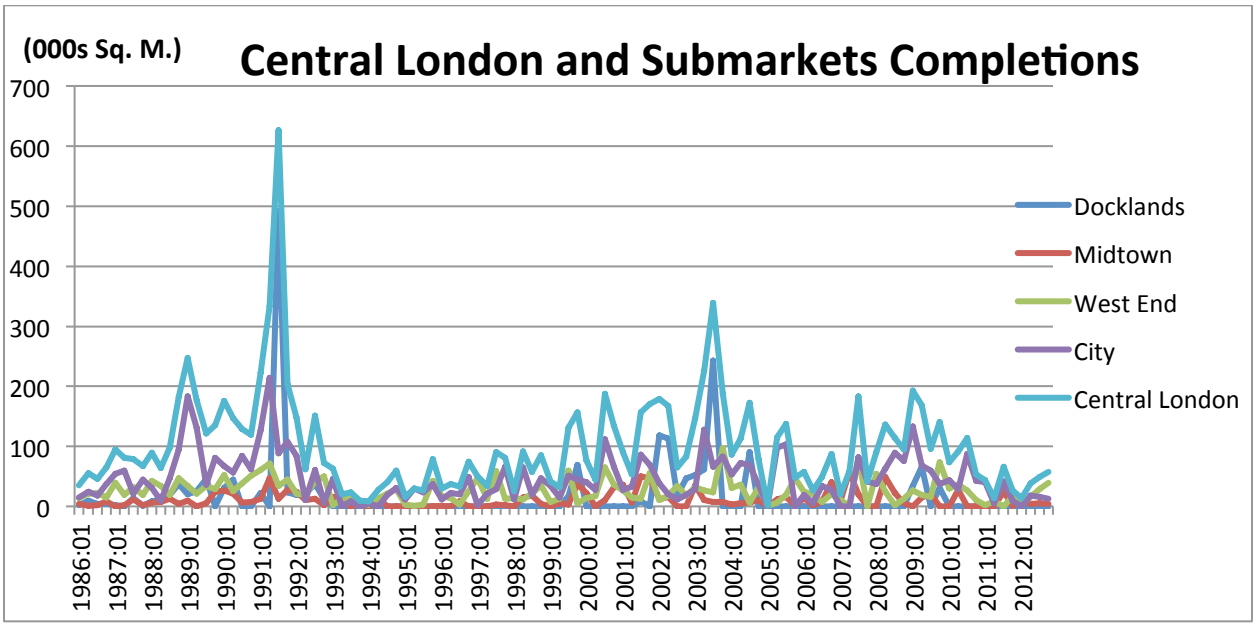

Figure 4 Source: CBRE

[16] As of July 2013, Canary Wharf Limited Group owns approximately 60% of the inventory in this submarket.
[17] According to CBRE, the West End submarket is the second highest priced submarket in the world trailing only Hong Kong's CBD as of July 2013.

Aside from the additional of the Docklands submarket at Canary Wharf in 1990, London as a whole has exhibited a steady trend of completions averaging 47,000 square meters per quarter during the time analyzed. The two large construction periods for Central London as a whole were around 1990 and in the mid-2000s. The Docklands delivered nearly 500,000 square meters of space in 1990 and didn't deliver any more inventory until 2000 as it took approximately 10 years for the vacant space to be absorbed within the submarket.[18] There was another development period between 2000 and 2005 with another 820,000 square meters delivered in the Docklands submarket or 39,000 square meters per quarter during that time period. The Midtown submarket has had ranging completions over the time period analyzed ranging from a high of 50,000 square meters completed in 2007 to a few time periods where there was no additional stock added to the inventory. Over the time period there was a total of 316,000 square meters added to the submarket with an average of about 3,000 square meters per quarter. This is similarly true for the West End submarket as it also lacks available land for development. The City delivered 930,000 square meters in inventory in the 1989-1991 time period as a response to the completion of the Docklands submarket.[19] Developers wanted to remain competitive in the City by adding direct competition to the Docklands office market. Since then, the submarket has averaged 14,000 square meters per quarter. In 2003 there was nearly 95,000 square meters of development added to the West End submarket. Overall, the West End has added 8,000 square meters per quarter or a total of about 905,000 square meters from 1986-2012.

[18] As noted before, the timing for the development of the Docklands submarket could not have come at a worse time.
[19] At the time, developers in the City and Midtown submarkets thought that if they just built more space within the City then the Docklands would never succeed. This was partially true as absorption of the new space within the Docklands took approximately 10 years. However, the influx of supply from all submarkets at the time worsened an already rough real office market.

3.2.3 Vacancy

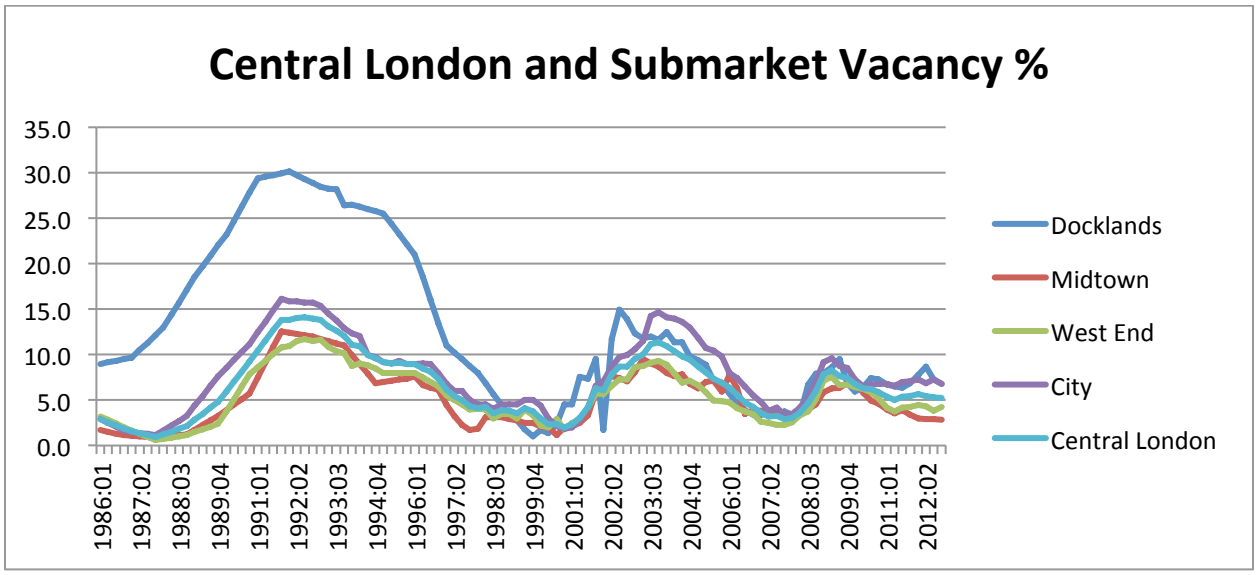

Figure 5 Source: CBRE

Central London as a whole has depicted a very cyclical nature for vacancies (as well as rents) as explained by Wheaton.[20] The vacancy peaked in 1992 within Central London as a response to the inclusion of the entirely new Docklands submarket as well as significant additions to the City and Midtown submarkets. This time period also saw significant increases in vacancy in all submarkets as a response to the additional inventory but also due to the poor economic conditions exhibited following real estate crash of the early 1990s[21]. Following, vacancy decreased significantly as the market absorbed this space and reached a low of 1.96% in the 4th quarter of 2000. After the economic trouble of this time period[22], the vacancy rate rose to 11% in 2004. Another period of increased vacancy followed this until the economic collapse of 2008 which saw a 5% increase in vacancy in just a one year period. Since then, during the time period this paper analyzed, the vacancy decreased to a current rate of approximately 5% within Central London. Following the

[20] See explanation of the *Cyclical Nature of the London Office Market* by Wheaton in Chapter 2.
[21] According to the UK Office of Statistics, Central London lost around 90,000 jobs and saw interest rates on 5-year swaps reach 11.6%.
[22] The early 2000s was also a time of economic depression following the "tech" bubble.

delivery of the Docklands submarket in 1991, the submarket exhibited a 30% vacancy rate. It took around 10 years for the market to stabilize and reached a 5% submarket vacancy in 1998. This number reached a low of 1% in 2000 but increased to a peak of around 15% in 2002. Since then, the market has depicted solid market fundamentals.[23] The Midtown submarket peaked with a vacancy of around 12% in 1991, exhibiting similar fundamentals to the other submarkets. Following this peak, the next decade saw significant declines in vacancies with a low of around 1% in 2000. The next 10 years showed an average of 5.35% with some peaks and valleys but no significant trends. This is similar to the overall vacancy average of 5.25% from 1986-2012. The City has shown vacancy trends similar to the West End but with even more dramatic peaks and valleys. In 1991 the submarket exhibited a vacancy of 16%, and then reached a low of around 3% in 2001. Following, a dramatic rise in vacancy occurred over the next several years to a peak of 15% in 2004. Another downward trend occurred after to a low of 4% in 2007 but after the economic collapse in 2008 the vacancy rose to 10%. Since then, the vacancy has dropped to around 6% and has remained constant until the end of 2012. The West End general depicts cyclical trends that echo the health of the overall economy. It peaked in 1992 at 12% and followed by a low of 2% in 2000. In difference to the Midtown submarket, it showed a very cyclical trend in the 2000s peaking at 9% in 2003 and reaching a low of 2% in 2008. Since then it has even showed another cycle, peaking at 7% in 2009 but lowering to 4% at the end of 2012. An overall view of all the submarkets depicts that they all depict very similar trends in terms of their cyclical nature. The one exception is the Docklands submarket in the early 1990s but this is not surprising because it was a newly delivered submarket.

[23] Current vacancy is around 5% in the Docklands submarket.

3.2.4 Real Rents

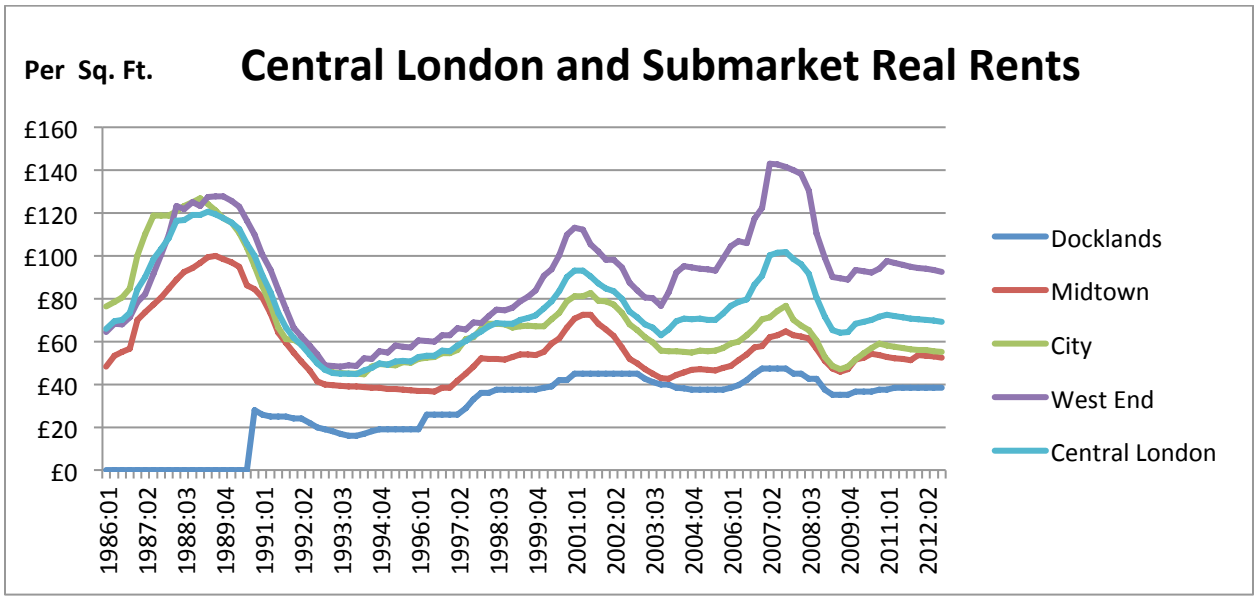

Figure 6 Source: CBRE

Central London on a weighted aggregate level has shown a very cyclical nature over the previous 27 years in terms of real rents. The average peaked at about £120 per square foot in 1989 but this saw a dramatic decrease with the inclusion of the Docklands submarket as well as more completions in both the City and Midtown markets.[24] Real rents never reached that level again even in the boom period of the 2000s prior to the financial crash of 2008.[25] In general, the Central London aggregate market mirrored the City data until the late 1990s where it appears that the separation between the West End and the other 3 submarkets heavily influenced the average for Central London. Upon the introduction of the Docklands submarket in 1990 there was an initial lag as the newly built space took some time to absorb. The 1990s saw gradual increases until the peak of £45 per square foot in 2001. Since then, the rents have remained approximate to this ending 2012 at £38.50 per square foot within the Docklands submarket. The Midtown submarket exhibits a cyclical nature in real

[24] The City and Midtown submarket added an additional 1,200,000 square meters of space between 1989 and 1992.
[25] In terms of real rents, the Central London office market has never recovered from the downward cycle in 1990.

rents but an overall downward trend which reinforces the strength of the other submarkets in relation to the Midtown submarket.[26] The City submarket shows similar trends as the Midtown submarket with similar cyclical rental rates trends (albeit at higher £ per square foot in comparison to the Midtown submarket) and decreasing rates in real terms. The City submarket peaked at £127 per square foot in real terms in 1989 while also exhibiting the highest levels of real rents outside of the West End submarket during this period. The West End, in contrast to the other submarkets, depicts dramatic increases in real rents prior to the economic crash in 2008. West End real rents peaked at $140/SF in 2007. This is also the time where the gap between the West End and the other submarkets reached its greatest difference. When examining the submarkets real rental rates, it shows that the submarkets move together as the market cycles. Another interesting characteristic of both the real rental rates, as mentioned previously, is the dramatic difference between the West End and the other submarkets. The gap between the West End and the other submarkets appears to be widening and is at its largest difference in the time analyzed within this study.

[26] The Midtown submarket consists of approximately 10% of the inventory within Central London while the West End and City submarket comprise of 40% and 35% respectively.

3.2.5 Net Absorption

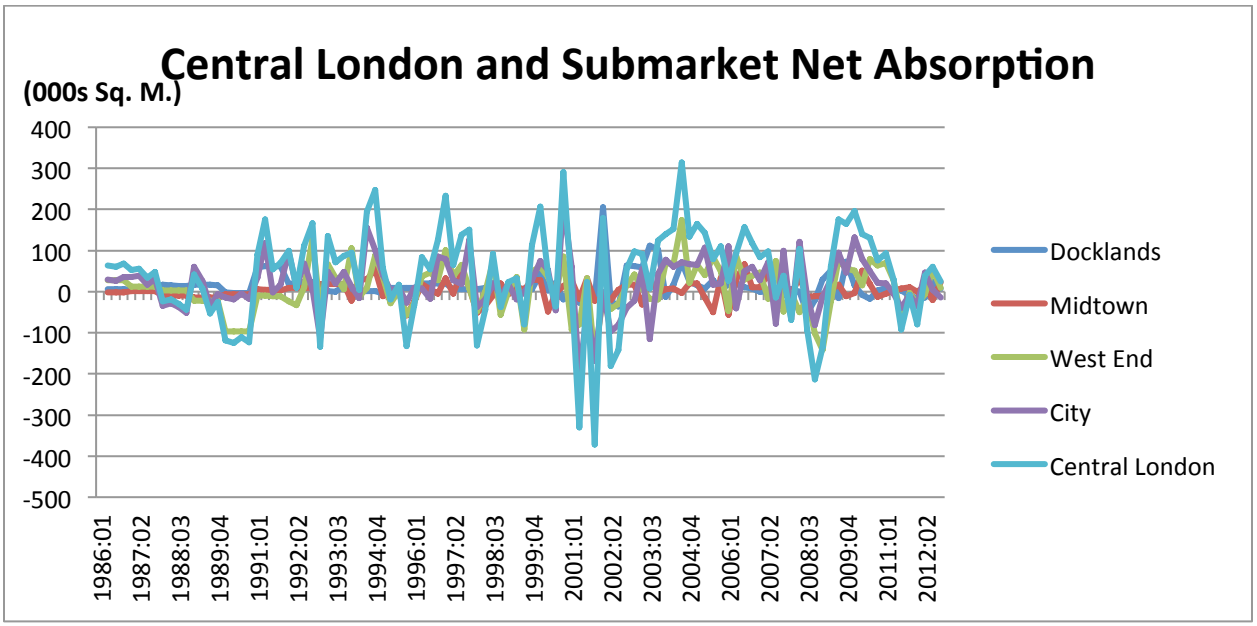

Figure 7 Source: CBRE

Central London and the submarkets depict very similar trends in terms of absorption in that there is typically large positive absorption in upward economic and real estate cycles and when the cycle turns downward there are typically large amounts of negative absorption.[27] Central London saw the greatest negative net absorption period following the technology bubble bursting in the early 2000s and saw another large negative absorption following the economic crash in 2008. [28] Central London averaged positive net absorption of 42,000 square meters per quarter despite some large negative periods. Throughout the 1990s the Docklands exhibited consistent positive absorption as a result of there being significant available space following the construction of the submarket in the late 1980s. The only period of negative absorption in the submarket was following the economic recession in 2008. Through the time period analyzed, the Docklands averaged about 14,000 square meters of

[27] This is typically the case in most commercial real estate markets.
[28] These two periods exhibited 7.5% and 5% increase in vacancies respectively.

positive absorption per quarter. The Midtown submarket is different than the other submarkets in terms of net absorption as there appears to be no exaggerated cyclical trends in the absorption of the market. In fact, there was a large amount of negative absorption in 2004-2006 which is unlike any of the other submarkets. There was also a period of positive absorption following the economic crash of 2008 which is most likely an indication that tenants left the more expensive City and West End submarkets for lower rental rates within the Midtown submarket.[29] Midtown averaged about 2,000 square meters absorbed per quarter for the period analyzed which is the lowest of the four submarkets examined within this study. The City submarket was hit the hardest with negative absorption following the previously mentioned technology bubble bursting in the early 2000s where tenants flooded out of the City submarket.[30] Following this, there was a long period of positive net absorption in the mid-2000s but this was halted by the economic crash of 2008 and there have been various results since then from quarter to quarter. The West End submarket contains some characteristics of each of the submarkets in its absorption trends. Similar to the Midtown submarket, it is very random from quarter to quarter. However, similar to the City submarket it was hit hard in the poor economic times of the early 2000s and following the economic crash of 2008. During the time period analyzed the City averaged about 17,000 square meters absorbed per quarter.

3.2.6 Market Indicators

Within the model, capitalization rates[31], government bond rates[32], and the spread between corporate bond rates and 10 year government bonds were utilized for Central London as a whole for each submarket as this kind of data is unavailable on a submarket by submarket basis.

[29] During the 27 periods of data the Midtown submarket averaged £40.56 per square foot in nominal rents while the City and West End averaged £48.91 and £66.09 per square foot respectively.
[30] During this time the City's rent went from £62.75 per square foot to £43.50 per square foot and vacancy went from 2.8% to 14.6%.
[31] A capitalization rate is the ratio of net operating income to property value in commercial real estate.

3.2.6.1 Yields

Similar to other fundamentals of the Central London office market, capitalization rates depict a very cyclical trend that mirror broader economic indicators. Each peak in capitalization rates, which are just below 7%, occurs following an economic crash and coinciding downward real estate cycle.

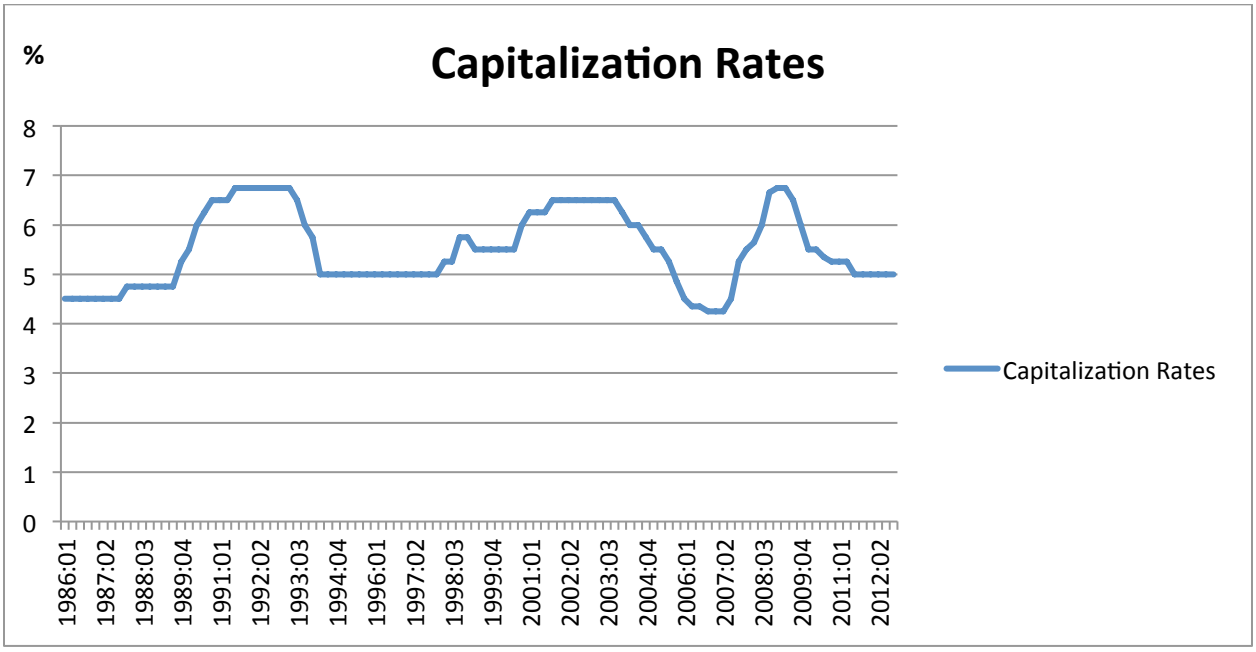

Figure 8 Source: CBRE

3.2.6.2 10 Year Government Bond Rates

The overall downward trend in 10 year bond rates from a peak of 12% in 1990 to a low of under 2% in 2012 is not surprising considering the worldwide trend.[33] It is noted that this rate is expected to rise to the levels of 2000-2008 when economic conditions improve on a worldwide scale.[34]

[32] The rate used in this paper is the 10 year UK government bond.
[33] Bond yields were at the lowest rates on a worldwide level for the previous five years in recorded history.
[34] As of July 2013 yields had raised from 1.3% to 2.5% on 10 year UK Bonds.

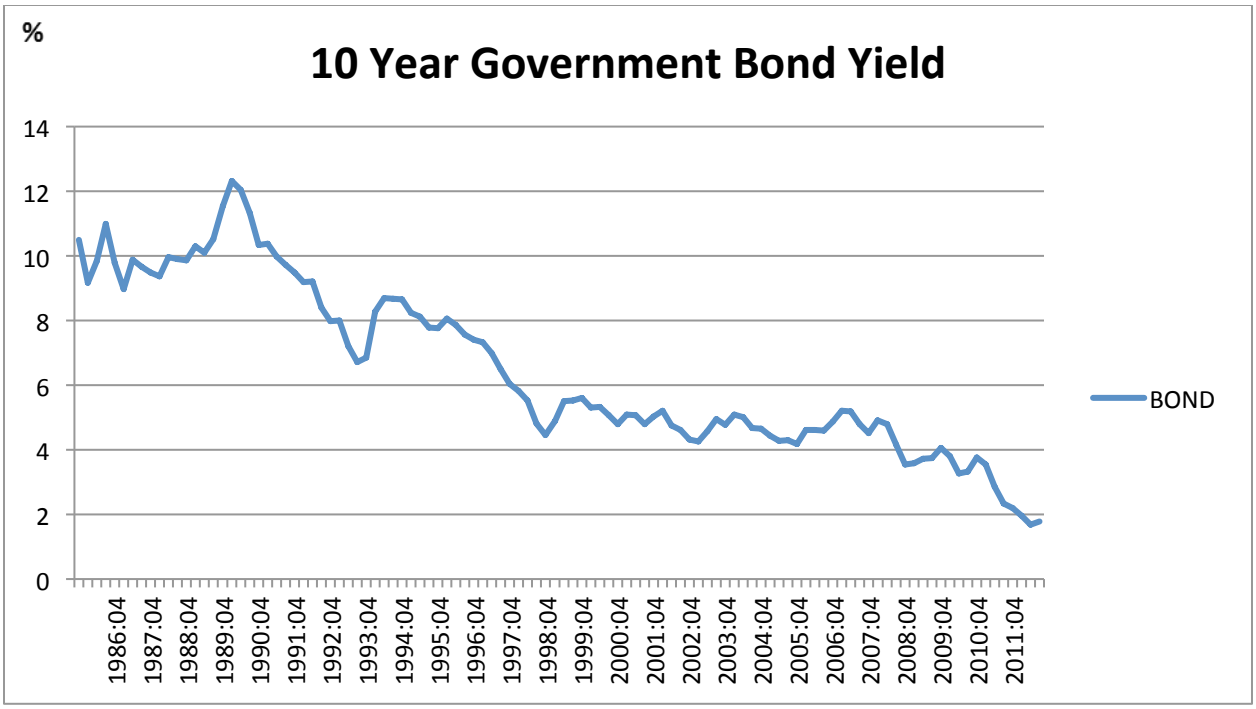

Figure 9 Source: CBRE

3.2.6.3 Spread

Also utilized as data within the supply equation is the spread between corporate bonds and 10 year UK Government Bonds, which is a very relevant and interesting statistic. This data point peaked following the economic crash of 2008 which is an indication that the yields on corporate bonds were so high due to the uncertainty of corporations following the collapse of Lehman Brothers.[35]

[35] On August 22, 2008 Lehman Brother's stock on the New York Stock Exchange fell 45% and they filed for bankruptcy one month later. At the time the company held $600 billion in assets.

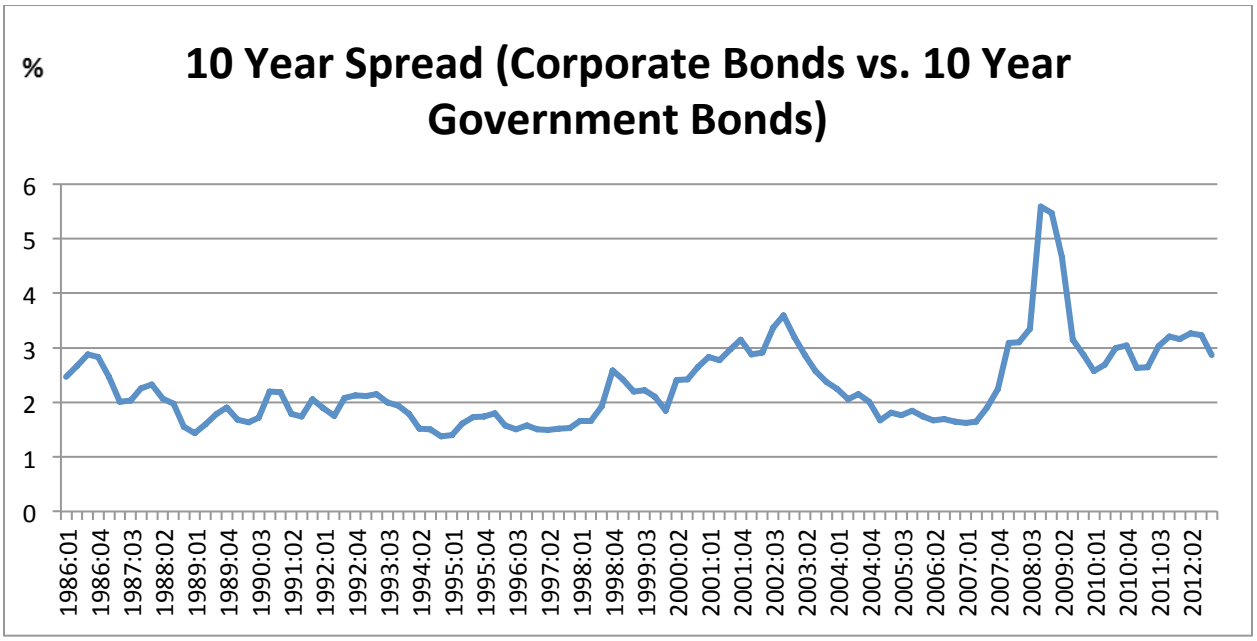

Figure 10 Source: CBRE

Chapter 4: The Econometric Model for Central London and Submarkets

4.1 Data Used in Study

4.1.1 Sources of Data

The data utilized in the model comes from CBRE – London. The analyzed period of the data is from 1986 through the end of 2012. There are some important features of the data that need to be mentioned prior to presenting the equations, 10 year projections, and back tests from 2008-2012.

4.1.2 Stock

For the stock in the data set, there is data for the Midtown, City, and West End submarkets for the time period covered in the analysis. However, for the Docklands submarket, this submarket had very minimal office product from 1986-1990 and was only heavily developed beginning in 1989. For the Central London market, the stock is the sum of all the submarkets for each quarter.

4.1.3 Vacancy and Rent

For all the submarkets the data is simply utilized as it was presented to project the conditions going forward. However, for the aggregate Central London projections, each submarket is given a weight by their stock in comparison to the aggregate stock of Central London and summed to reach a weighted Central London projection.[36] [37]

4.1.4 Completions

The projected completions for each submarket are projected in the following chart:

[36] Weighted vacancy is computed as : vac = vac_city*(stk_city/stk)+vac_dock*(stk_dock/stk)+vac_mtown*(stk_mtown/stk)+vac_we*(stk_we/stk) and t

[37] Weighted rent is computed as: rent = rent_city*(stk_city/stk)+rent_dock*(stk_dock/stk)+rent_mtown*(stk_mtown/stk)+rent_we*(stk_we/stk)

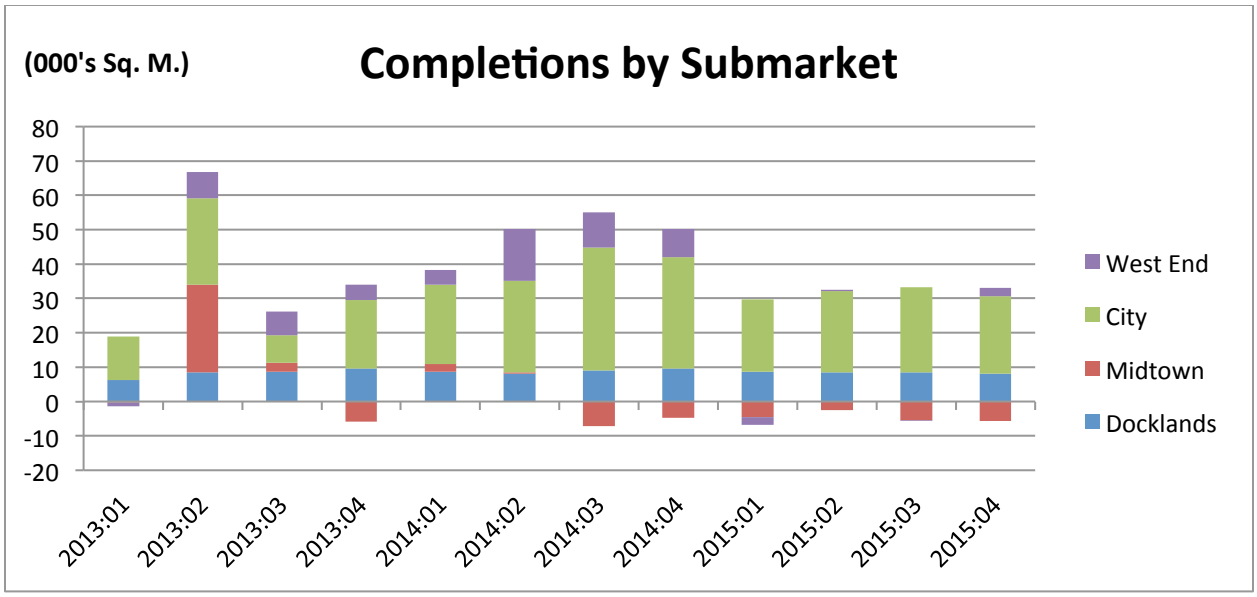

Figure 11 Source: CBRE

For the next three years the City submarket is projected to have the most completions averaging about 23,000 square meters added per quarter. The Midtown submarket is expected to add the least with several quarters of negative completions.

4.1.5 Back Tests

The back test portion of the analysis utilizes the data from 1986-2006 and projects what would have occurred from 2007-2012. The equations, therefore, would be slightly different as it does not utilize the data from 2007-2012 when creating the equations.

4.2 Econometric Models

4.2.1 Models Utilized

After considering several different equations for rent, demand, and supply, the following equations were utilized in modeling Central London on aggregate and the submarkets:

Rent = α_0+ α_1RRENT$_{t-1}$ + α_2VAC[38]

Demand = α_0+ α_1OSTK$_{t-4}$ + α_2GSERV+ α_3FIRE+ α_4VAC$_{t-4}$[39]

Supply = α_0+ α_1COMP$_{t-1}$ + α_2COMP$_{t-2}$ + α_3COMP$_{t-3}$+ α_4COMP$_{t-4}$+ α_5COMP$_{t-5}$+α_6COMP$_{t-6}$+α_7COMP$_{t-7}$+α_8COMP$_{t-8}$+α_9RRENT$_{t-8}$

4.3 Central London – Single Model

Modeling Central London in one singular model, rather than summing the outputs of the individual submarkets, yields very interesting results for a 10 year projection and also is a reasonable statistical fit on a back test versus what occurred between 2008 and 2012.

4.3.1 Rent Equation

The rent equation for Central London yields the correct signs for both rent and vacancy and is statistically significant as presented in the following equation and summary of the data:

Rent = 13.35+ .9RRENT$_{t-1}$ - .89VAC (1)

	Regression Statistics
Centered R Squared	0.980871
Uncentered R Squared	0.998798
Standard Error	2.752083791
Observations	108

	Coeff.	**Std. Error**	**T-Stat**	**Signif.**
Intercept	13.35263101	1.5685032	8.51298	0
RRENT $_{t-1}$	0.9011989	0.0155953	57.78654	0
VAC	-0.88869299	0.0869769	-10.2176	0

[38] Other rent equations considered were: **(1) Rent = α_0+ α_1DRRENT$_{t-1}$ + α_2RRENT$_{t-1}$ +α_3VAC and (2) Rent = α_0+ α_1RRENT$_{t-1}$ + α_2RRENT$_{t-1}$ +α_3VAC+ α_4OFFEMP+ α_5STK**

[39] The other main demand equation considered was **Demand = α_0+ α_1OSTK$_{t-4}$ + α_2GFIRE+ α_{3SERV}+ α_4VAC$_{t-4}$**[39]

4.3.2 Model Projections – Central London Single Model

The following charts project the 10 year real rent projections for a 10 year period:

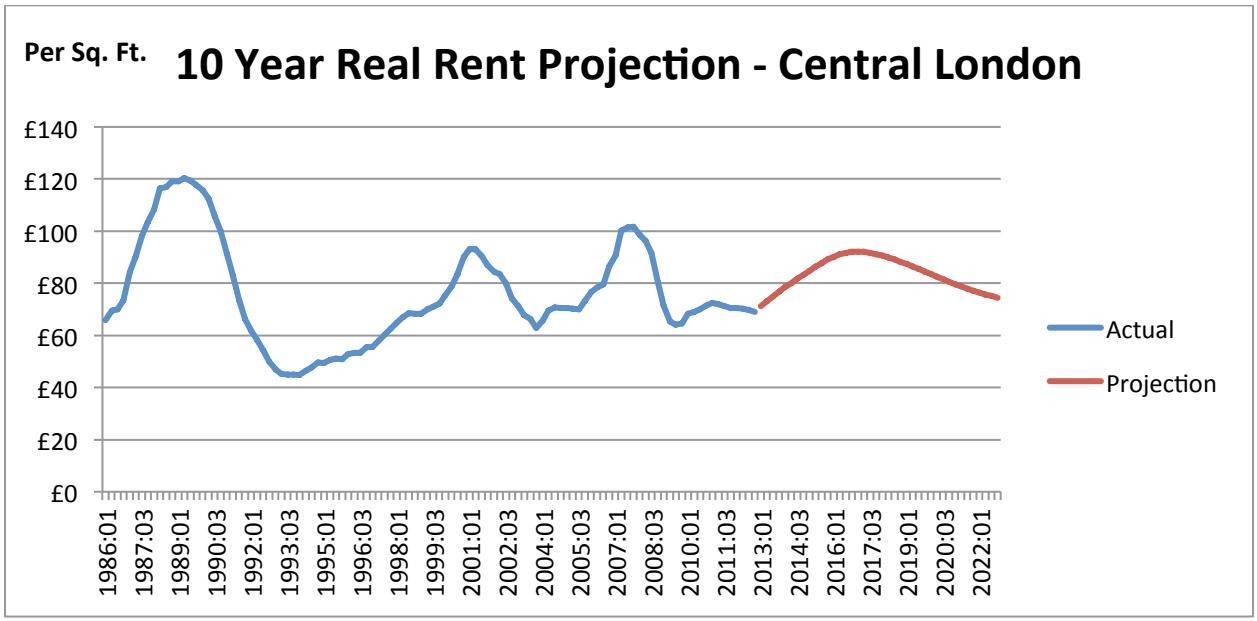

Figure 12 Source: CBRE and Author

The model projects real rents to have a steady increase in the first 5 years of the projections and reach a maximum of £92.16 per square foot in the 1st quarter of 2017 in real terms. However, due to an increase in supply into the market during this time, the rents are then projected to decrease dramatically and on a real level return to about the level at the start of the analysis. Overall, real rents are projected to start at £71.70 per square foot in the 1st quarter of 2013 and ending at £74.47 per square foot in the 4th quarter of 2022 for the 10 year projection. This is a £2.77 increase or 3.86% for an annual increase of only .0386% per year.

4.3.3 Real Rent Back Test 2008-2012 – Central London Single Model

When comparing what occurred between 2008-2012, following the financial crash of 2008, the model would have predicted the following real rent rates in comparison to what actually occurred in the four Central London submarkets:

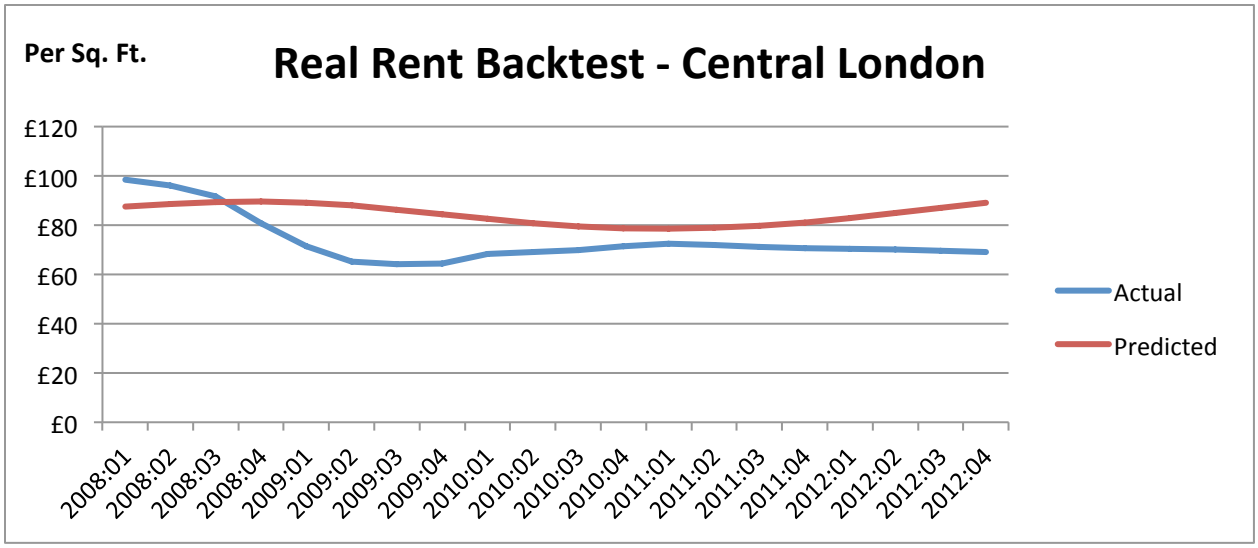

Figure 13 Source: CBRE and Author

The real rents displayed a 32% decrease from the first quarter of 2008 till the lowest point in the 3rd quarter of 2009 for the actual data. The model could not entirely capture this decrease and projected rental rates that were 26% higher. The one weakness in the dynamic model is capturing a "black swan" event such as what occurred in 2008.[40] Overall, the model predicted real rents averaging £84.35 per square foot for the time period versus the £73.83 per square foot average of what actually occurred.

4.3.4 Absorption Equation

The absorption (demand) for Central London yields the following equation and statistical data:

Demand = -107.49+ -.05OSTK$_{t-4}$ + 1164.08GSERV+ 2.54FIRE+ 18.56VAC$_{t-4}$(2)

[40] *Investopedia* defines a black swan event as an event or occurrence that deviates beyond what is normally expected of a situation and that would be extremely difficult to predict. The 2008 financial crash was considered to be one of those events.

	Regression Statistics
Centered R Squared	0.601079
Uncentered R Squared	0.691813
Standard Error	49.41639244
Observations	108

	Coeff	Std. Error	T-Stat	Signif
Intercept	-107.489766	56.387361	-1.90627	0.059515
$OCCSTK_{t-4}$	-0.054647	0.012497	-4.37281	3.04E-05
GSERV	1164.084631	149.23801	7.80019	0
FIRE	2.541489	0.517991	4.90644	3.65E-06
VAC_{t-4}	18.557712	1.837787	10.09786	0

4.3.5 Model Projections: Central London One Model

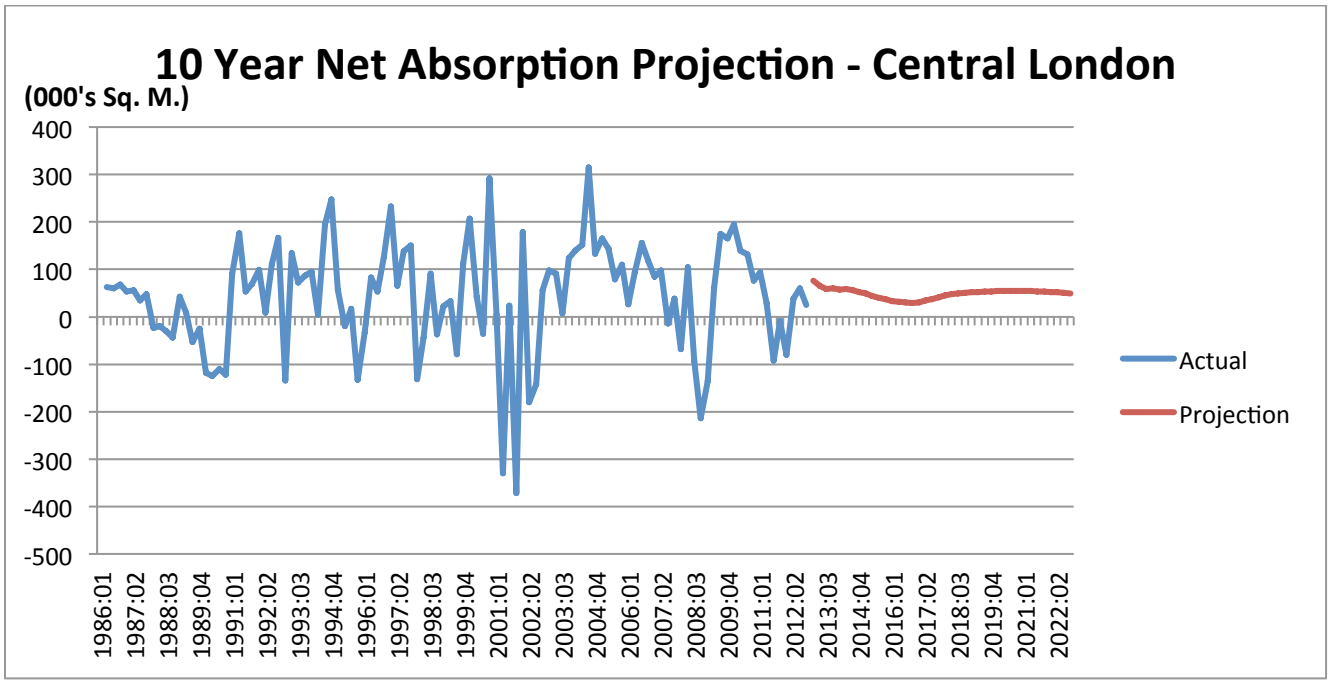

Figure 14 Source: CBRE and Author

The model projects a very level net absorption level of 49,000 square meters absorbed per quarter with a peak of 76,000 square meters absorbed in the first quarter of 2013.

4.3.6 Absorption Back Test 2008-2012: Central London One Model

The single model absorption back test for Central London shows a very close picture to what actually happened in terms of overall trends. It appears that the data lags in terms of peaks and valleys by about 2 quarters but in general the back test shows that the model would have been generally accurate in the direction of net absorption over the 5 year period but not as accurate in the overall average. The model predicted an average absorption of about 70,000 square meters absorbed per quarter while the market actually exhibited absorption of about 30,000 square meters absorbed per quarter.

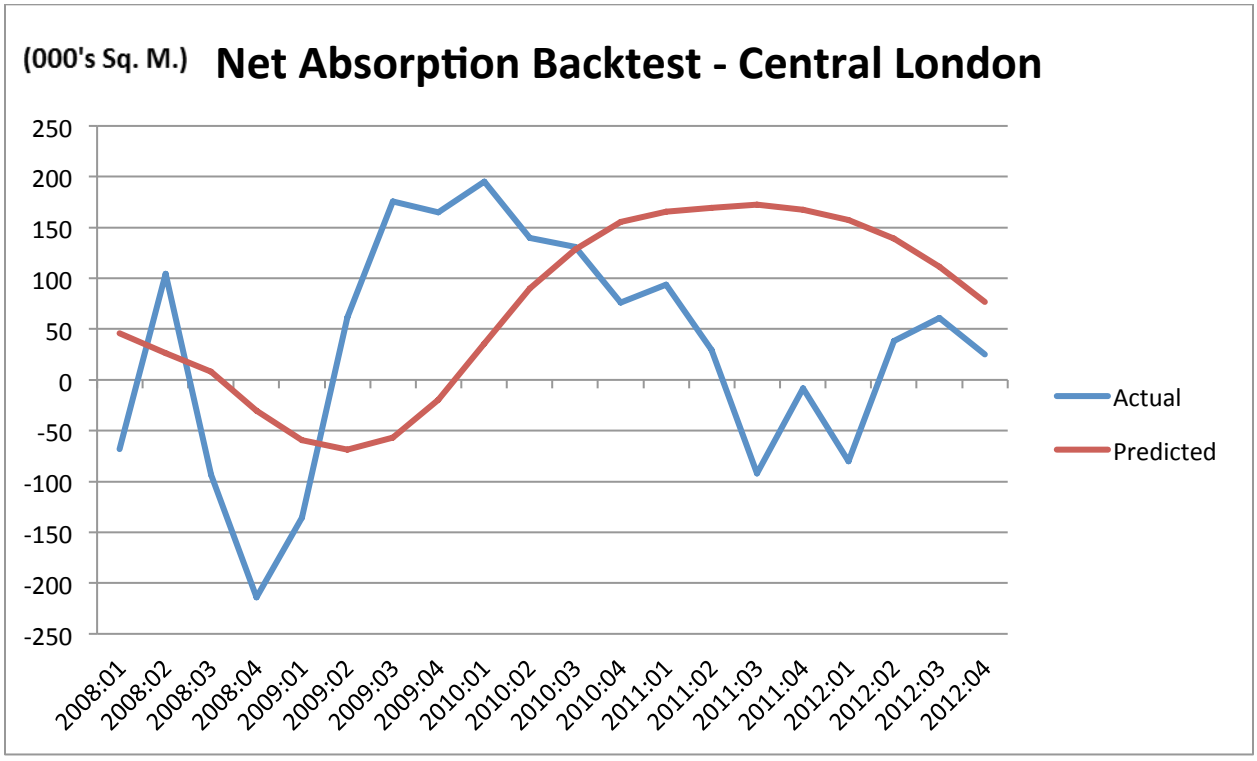

Figure 15Source: CBRE and Author

4.3.7 Supply Equation

The supply for Central London yields the following equation and statistical data:

$$\text{Supply} = -141.85 + .11\text{COMP}_{t-1} - .05\text{COMP}_{t-2} + .14\text{COMP}_{t-3} - .04\text{COMP}_{t-4} - .08\text{COMP}_{t-5} + .07\text{COMP}_{t-6} - .25\text{COMP}_{t-7} + .02\text{COMP}_{t-8} + 2.58\text{RRENT}_{t-8} \quad (3)$$

	Regression Statistics
Centered R Squared	0.369447
Uncentered R Squared	0.485392
Standard Error	87.62320987
Observations	108

	Coeff	Std. Error	T-Stat	Signif
Intercept	-141.8463230	41.5438106	-3.41438	0.00096452
COMP_{t-1}	0.1108014	0.1043816	1.06150	0.29133329
COMP_{t-2}	-0.0536860	0.1015440	-0.52870	0.59833196
COMP_{t-3}	0.1422771	0.1000088	1.42265	0.15833457
COMP_{t-4}	-0.0443546	0.1008496	-0.43981	0.66114152
COMP_{t-5}	-0.0838433	0.1003177	-0.43981	0.40551812
COMP_{t-6}	0.0665461	0.0973728	0.68342	0.49611975
COMP_{t-7}	-0.2517207	0.0973799	-2.58493	0.01136671
COMP_{t-8}	0.0237018	0.0973799	0.24410	0.80771482
RRENT_{t-8}	2.5782791	0.6061745	4.25336	0.00005188

4.3.8 Completions Projections: Central London Single Model

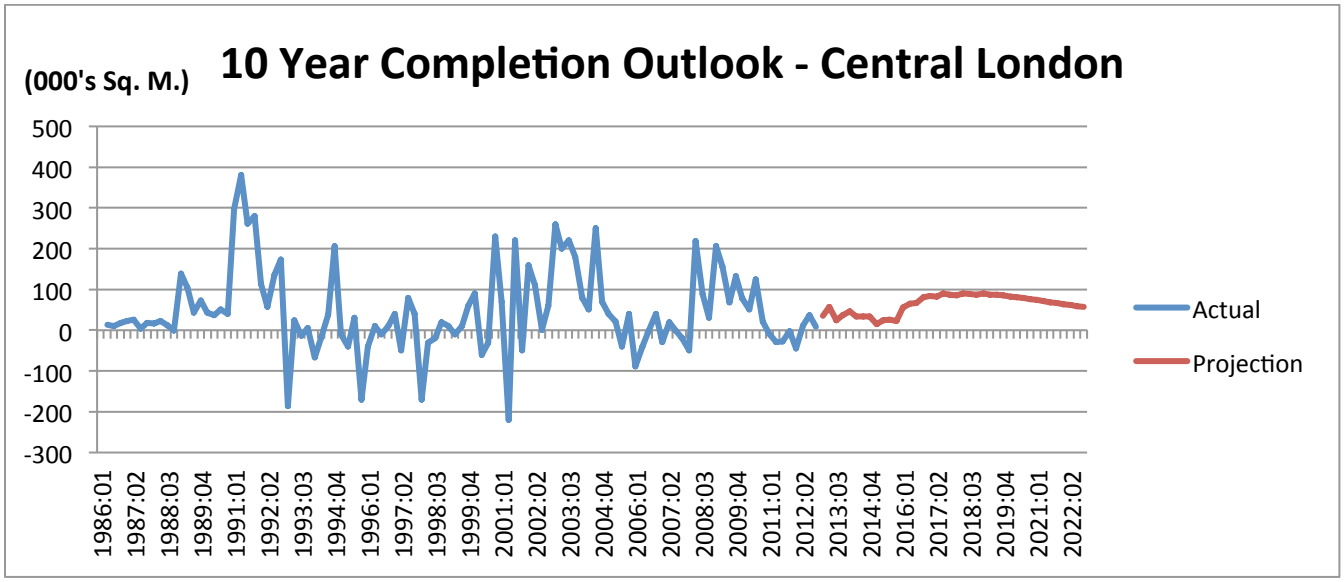

Figure 16 Source: CBRE and Author

For the 10 year projection the model expects 63,000 square meters of space delivered per quarter which is very close to what happened in the previous 5 years for the four main submarkets of Central London. The projection is expected to begin slowly then increase to high in the 1st quarter of 2019 but then fall slowly as new supply is delivered into the market and speculative development slows down with myopic expectations.

4.3.9 Completions Back Test 2008-2012: Central London Single Model

When computing the back test for completions in Central London, the actual data shows a large negative completion trend during the economic turmoil of 2008.[41] The model does not capture this but does average about 54,000 square meters per quarter completed during the time period which compares favorably with what actually occurred (68,000 square meters per quarter).

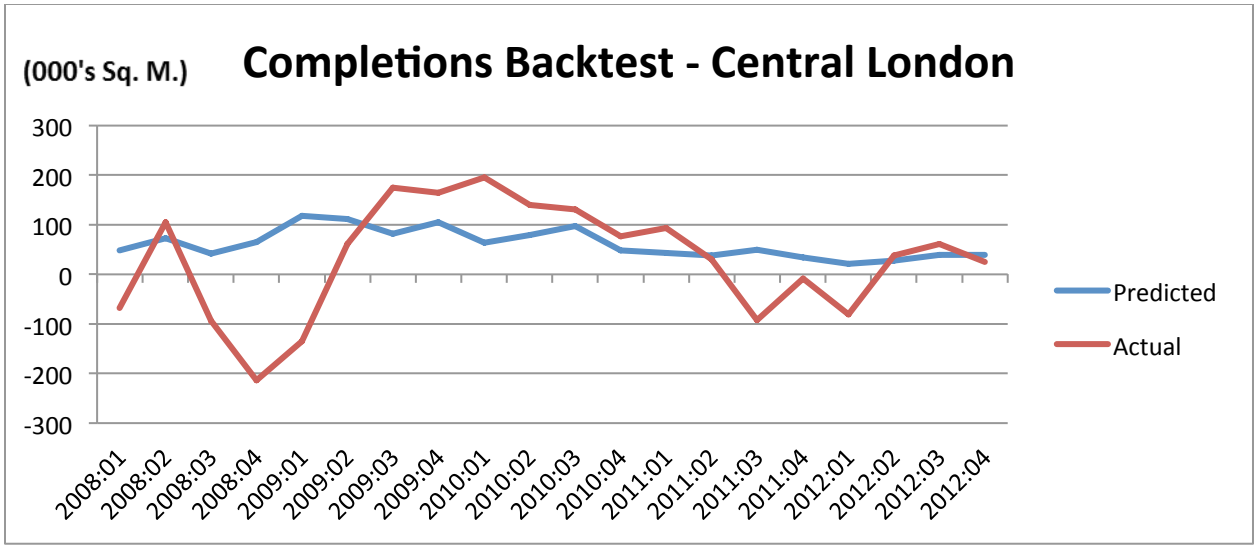

Figure 17Source: CBRE and Author

[41] During this time period development essentially stopped and the data shows negative completions as the result of buildings becoming obsolete.

4.4 Docklands

The Docklands submarket is the only submarket in this paper that does not yield statistically significant results. This is mainly due to the lack of data prior to 1990 and the 10 year absorption period that took place in the 1990s. However, it has been included in this paper due to the important fundamental characteristics of the submarket.[42] The rent equation and statistical data are presented as follows.

4.4.1 Rent Equation

Rent = 2.48+ .95RRENT$_{t-1}$ - .01VAC (4)

	Regression Statistics
Centered R Squared	0.934078
Uncentered R Squared	0.986175
Standard Error	4.912000214
Observations	108

	Coeff	**Std. Error**	**T-Stat**	**Signif**
Intercept	2.47575946	1.6104357	1.53732	0.127251
RRENT $_{t-1}$	0.946935911	0.0278884	33.95444	0
VAC	-0.014892915	0.0607738	-0.24505	0.806897

4.4.2 Real Rent Model Projections: Docklands

One of the main weaknesses of the Docklands model is the real rent projections. The real rent projections depict a sharp increase for the 10 year projection with no decrease or even leveling. Intuitively it would seem that this market would be largely affected by what occurs in the other submarkets, particularly the City submarket which is its main competition.[43]

[42] The Docklands submarket provides direct competition to the City albeit at discounted rental rates.
[43] The City at the end of the 4th quarter 2012 averaged £55.00 per square foot while the Docklands only averages £38.50 per square foot.

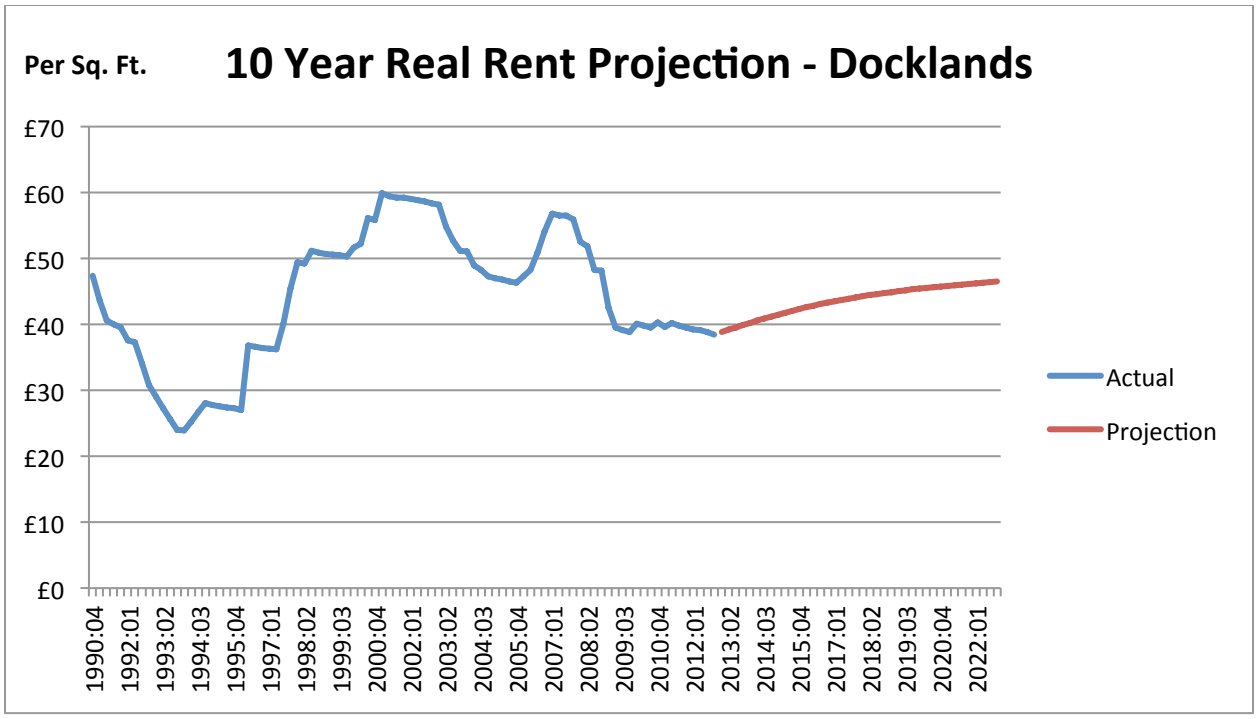

Figure 18 Source: CBRE and Author

4.4.3 Real Rent Back Test 2008-2012: Docklands

Similar to the Central London market as a whole, the Docklands depicted a sharp decrease in real rental rates following the economic recession. The model for the Docklands submarket would not have captured this decrease but does exhibit the level nature of the submarket following the decrease which actually occurred. The real rents actually averaged £41.77 per square foot and the model predicted real rents of £47.29 per square foot.

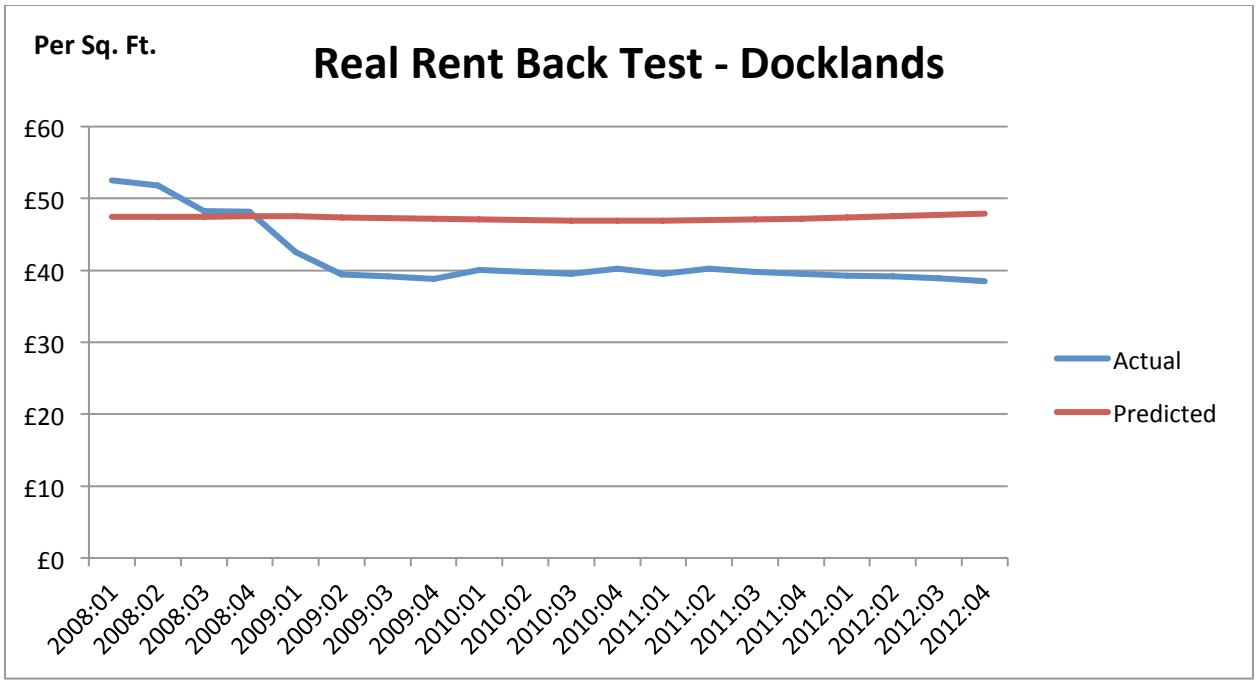

Figure 19 Source: CBRE and Author

4.4.4 Absorption Equation: Docklands

The absorption (demand) equation and relevant statistical data for the Docklands submarket is as follows:

Demand = 141.34+ .01OSTK$_{t-4}$ – 264.48GSERV- .38FIRE- .56VAC$_{t-4}$(5)

	Regression Statistics
Centered R Squared	0.292062
Uncentered R Squared	0.566232
Standard Error	15.72267006
Observations	108

	Coeff	Std. Error	T-Stat	Signif
Intercept	141.3439222	34.967375	4.04217	0.000105
OCCSTK$_{t-4}$	0.0132994	0.0056785	2.34204	0.021181
GSERV	-264.4795464	8.8383267	-5.41541	4.3E-07
FIRE	-0.3815262	0.1083759	-5.38805	0.000653
VAC$_{t-4}$	-0.5631376	0.3015223	10.09786	0.064769

4.4.5 10 Year Net Absorption Projection: Docklands

The model predicts a 10 year average of 18,000 square meters absorbed per quarter which is similar to what the model projected for the 5 year back test.

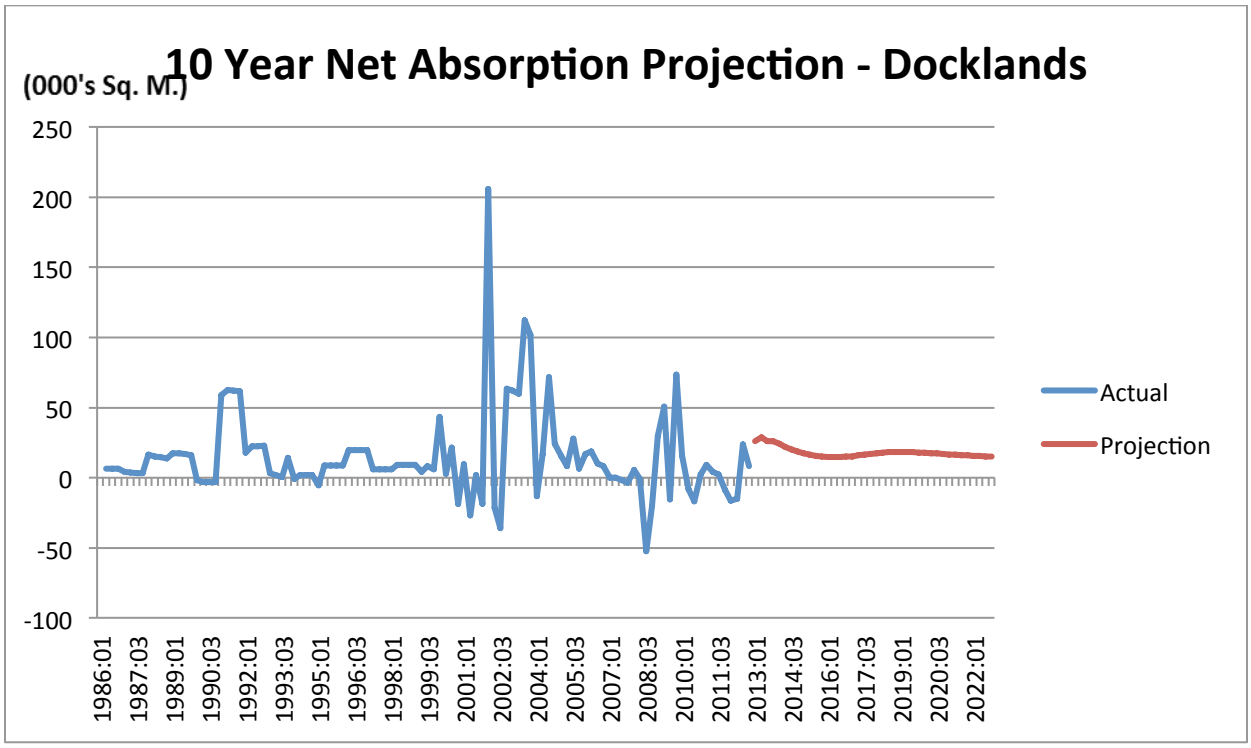

Figure 20 Source: CBRE and Author

4.4.6 Net Absorption Back Test 2008-2012: Docklands

Net absorption for the Docklands submarket went through a very turbulent time during the 5 year period from 2008-2012. The model would have predicted a more stable environment with the submarket absorbing 3,500 square meters per quarter and the model predicting 15,000 square meters absorbed per quarter.

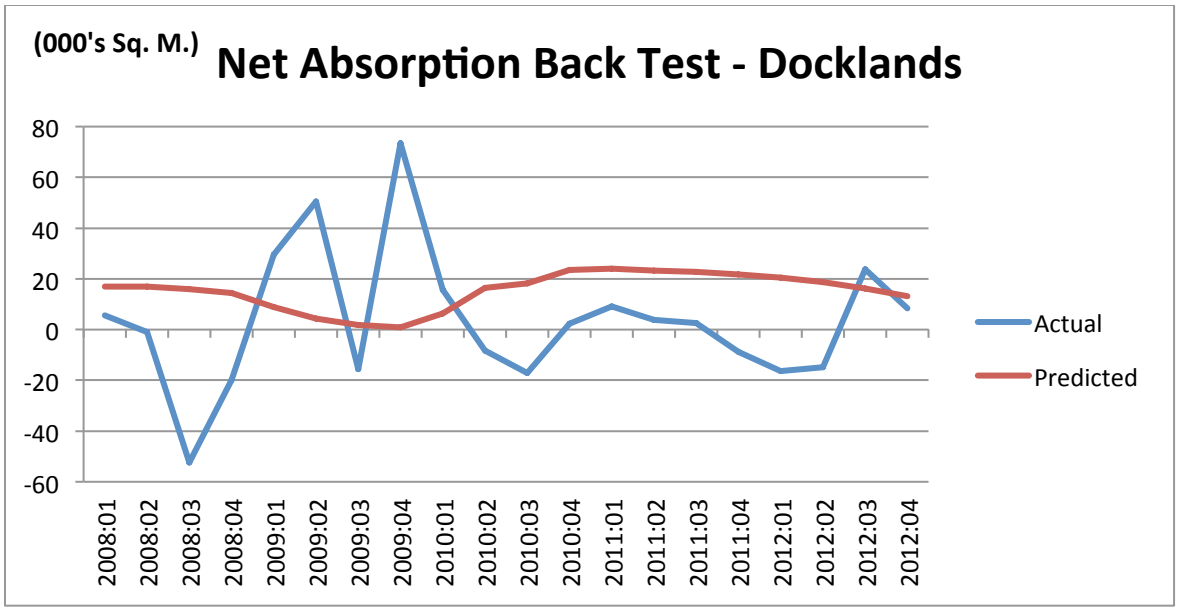

Figure 21 Source: CBRE and Author

4.4.7 Supply Equation

Supply = 8.11+ .51COMP$_{t-1}$ - .06COMP$_{t-2}$ + .19COMP$_{t-3}$ - .04COMP$_{t-4}$ - .02COMP$_{t-5}$ + .23COMP$_{t-6}$ - .08COMP$_{t-7}$ - .15COMP$_{t-8}$- .05RRENT$_{t-8}$(6)

	Regression Statistics
Centered R Squared	0.360423
Uncentered R Squared	0.492366
Standard Error	26.386180989
Observations	108

	Coeff	Std. Error	T-Stat	Signif
Intercept	8.119602804	5.930729518	-3.41438	0.17442166
COMP$_{t-1}$	0.515159448	0.104917154	1.06150	0.00000410
COMP$_{t-2}$	-0.061367629	0.117809333	-0.52870	0.60372566
COMP$_{t-3}$	0.192086755	0.115558304	1.42265	0.09998103
COMP$_{t-4}$	-0.048106054	0.117248786	-0.43981	0.68257894
COMP$_{t-5}$	-0.048106054	0.117250527	-0.43981	0.87476623
COMP$_{t-6}$	0.233045690	0.115651339	0.68342	0.04691462
COMP$_{t-7}$	-0.076932808	0.115651339	-2.58493	0.51719752
COMP$_{t-8}$	-0.146429238	0.105060276	0.24410	0.16685936
RRENT $_{t-8}$	-0.045680251	0.138963733	4.25336	0.74313905

4.4.8 10 Year Completion Projection: Docklands

The 10 year projection for the Docklands projects completions of 13,000 square meters per quarter which is around the average of the previous 27 years.[44]

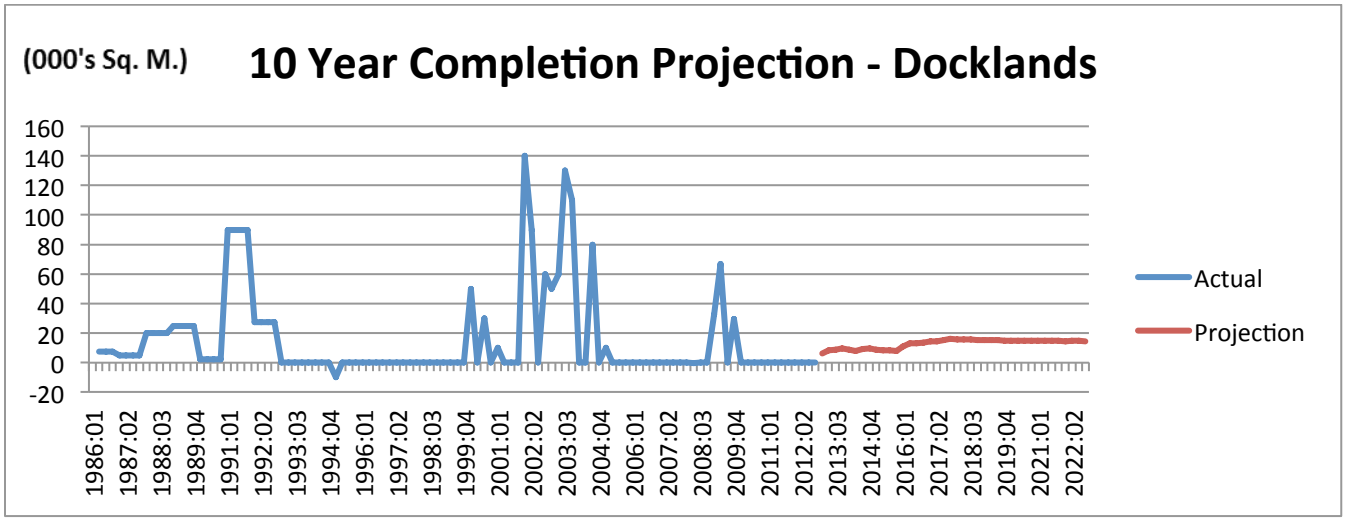

Figure 22 Source: CBRE and Author

4.4.9 Completions Back Test 2008-2013: Docklands

The back test for completions for the Docklands submarket would have predicted almost exactly what actually happened. This is most likely due to the small amount of completions within the market over the 5 year period.

[44] The actual average was 15,000 square meters per quarter.

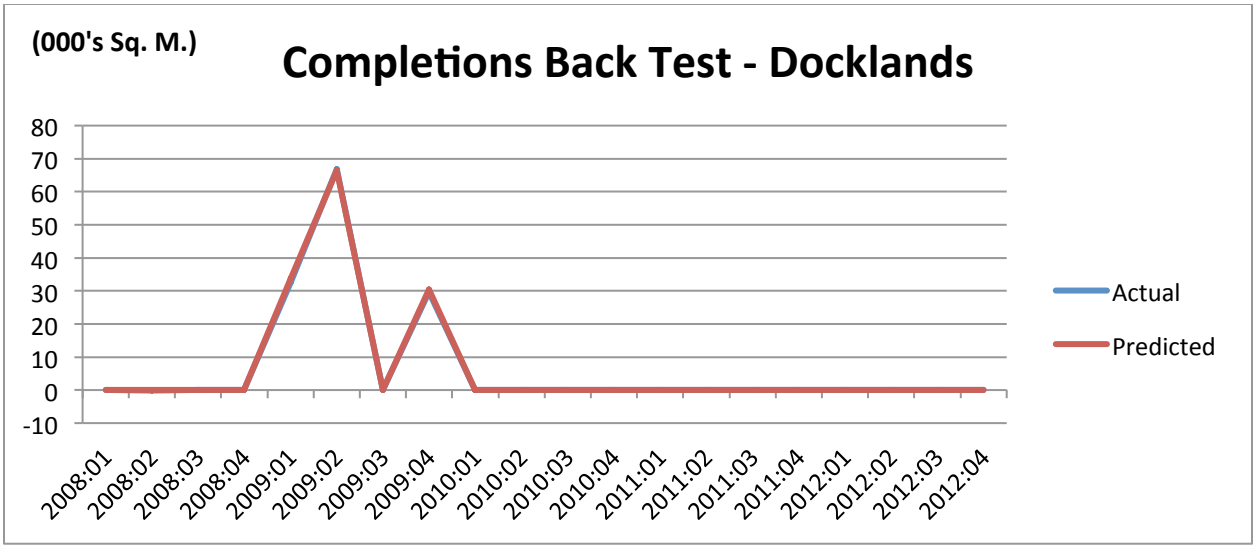

Figure 23 Source: CBRE and Author

4.5 Midtown

The midtown submarket is considered to be the third strongest submarket in Central London as both the City and West End demand higher rental rates and attract more lucrative tenants. However, the model depicts an initial positive trend for Midtown when modeled on its own as demand for space will outpace supply until the middle of the 10 year projection.

4.5.1 Rent Equation

The rental equation yields the right signs for both real rents and vacancy with highly statistical relevant results as depicted in the following equation and data:

Rent = 8.1+ .93RRENT$_{t-1}$ - .74VAC (7)

	Regression Statistics
Centered R Squared	0.981093
Uncentered R Squared	0.998556
Standard Error	2.286911597
Observations	108

	Coeff	Std. Error	T-Stat	Signif
Intercept	8.097773566	1.0676298	7.58481	0
RRENT $_{t-1}$	0.927619121	0.0145122	63.92	0
VAC	-0.743730726	0.0757433	-9.81909	0

4.5.2 10 Year Real Rent Projections: Midtown

The Midtown submarket projects a large increase initially for a 4 year period at the start of the 10 year projection that would increase real rents to £73.50 per square foot in the 4th quarter of 2017. However, with the delivery of more space into the submarket the increase is expected to be offset by a decrease back to the original level in real terms by the end of the analysis. [45] Overall, the Midtown submarket is projected to have a similar, albeit longer cycle in the next ten years similar to the early 1990s and early 2000s.

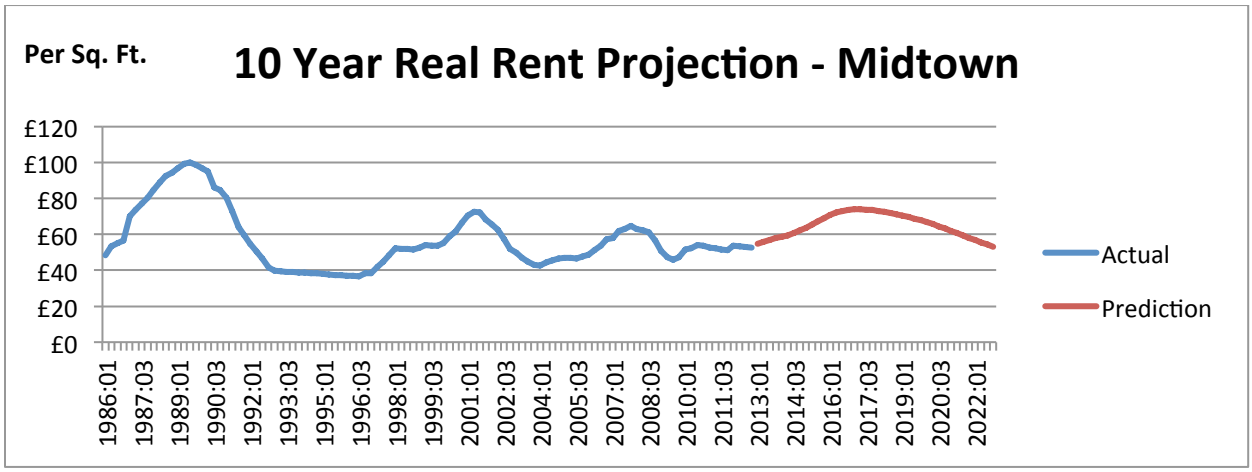

Figure 24 Source: CBRE and Author

[45] Real Rents are projected to begin at £54.71 in the 1st quarter of 2013 and end at £53.11 per square foot at the 4th quarter of 2022 which is a slight decrease.

4.5.3 2008-2012 Back Test Real Rents: Midtown

Unlike the Central London singular model and the Docklands submarket, the model on a back test for rental conditions actually expected a lower than actual rental rate, particularly for the period from mid-2009 to the end of 2012. The model did not predict that the Midtown submarket would attract as many tenants as it did as a result of tenants seeking lower priced space following the economic recession. The model predicted real rents averaging £46.16 per square foot while the submarket actually exhibited rents of £53.35 per square foot.[46]

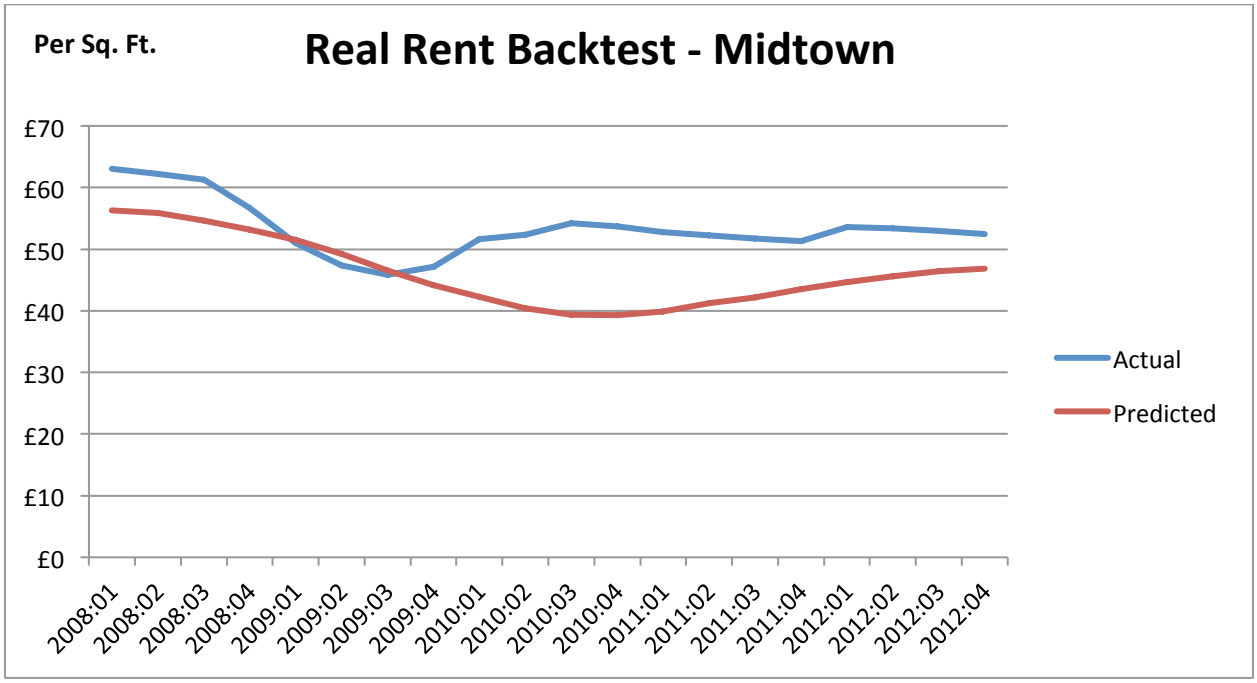

Figure 25 Source: CBRE and Author

4.5.4 Absorption Equation

The absorption equation and statistical data are presented as follows:

Demand = 117.58- .16OSTK$_{t-4}$ + 129.11GSERV+ .49FIRE+ 2.64VAC$_{t-4}$ (8)

[46] Some tenants during this period opted for cheaper rents in the Midtown submarket rather than the City and West End because of the financial crisis.

	Regression Statistics
Centered R Squared	0.626249
Uncentered R Squared	0.648053
Standard Error	6.845862521
Observations	108

	Coeff	Std. Error	T-Stat	Signif
Intercept	117.5760575	19.227828	6.11489	0
$OCCSTK_{t-4}$	-0.1564713	0.0186257	-8.40083	0
GSERV	129.1111029	20.365326	6.33975	0
FIRE	0.4925847	0.0540064	9.12086	0
VAC_{t-4}	2.639473	0.2376297	11.10751	0

4.5.5 10 Year Net Absorption Projection: Midtown Submarket

The model predicts a period of negative absorption in the market for the first 5 years of the analysis. This is not surprising given the projection of large rental increases. Also not surprising is the increase in absorption following this, as this would coincide with the peak and decrease in rental rates. Overall, the market averages 3,000 square meters per quarter for the 10 year projection which puts it along the lines with the previous 5 years of actual data.

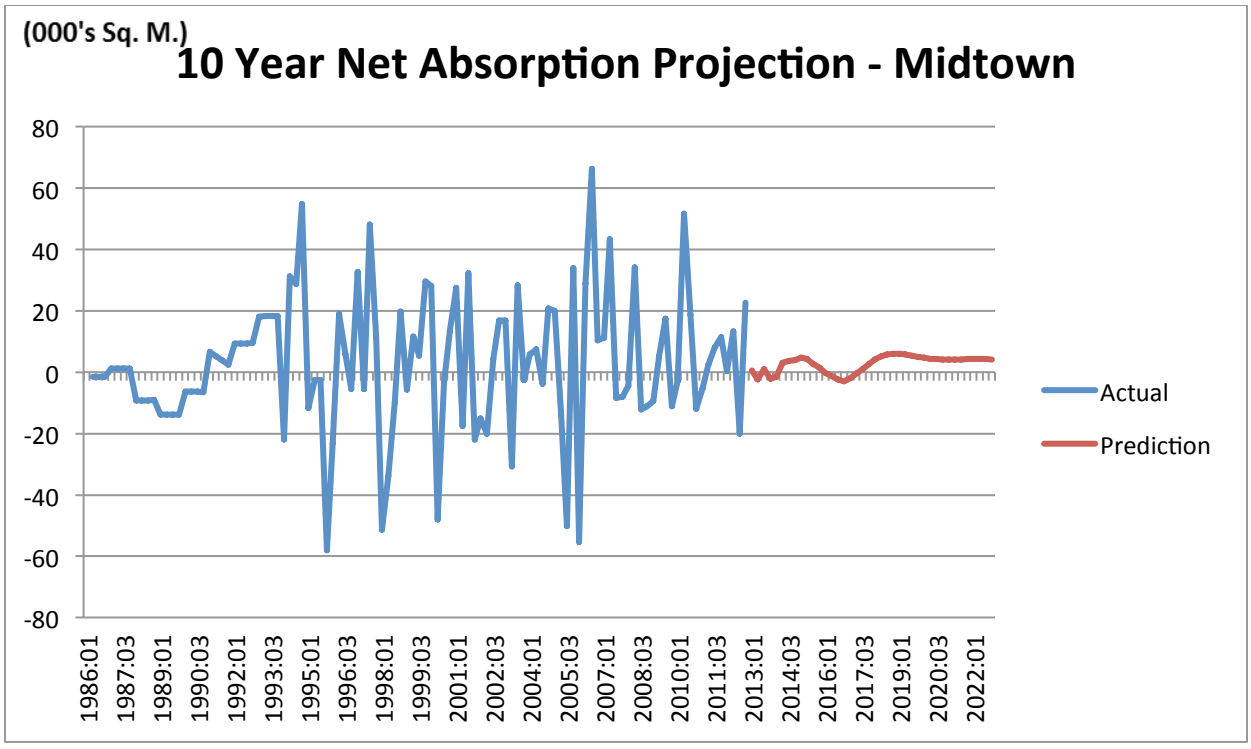

Figure 26 Source: CBRE and Author

4.5.6 Net Absorption Back Test 2008-2012: Midtown Submarket

The absorption back test for the Midtown submarket depicted a very close representation of what actually occurred. The submarket absorbed about 5,000 square meters per quarter while the back test expected absorption of about 7,000 square meters per quarter. In general, the model would have pretty accurately predicted the actual net absorption within the Midtown submarket.

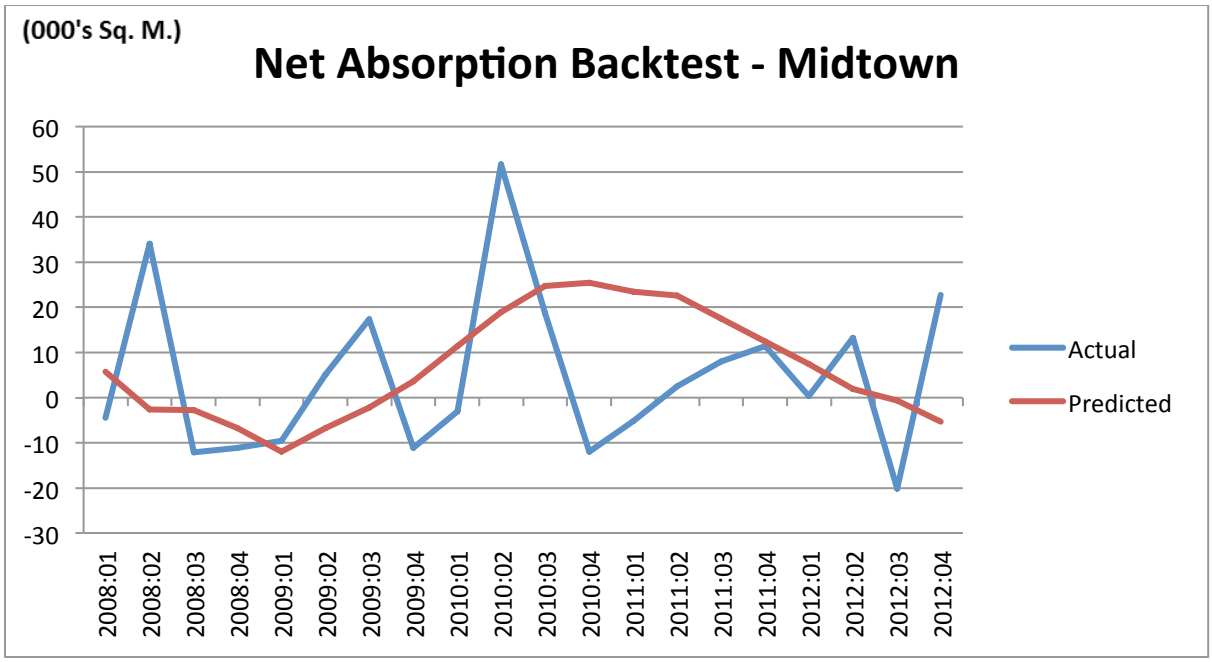

Figure 27 Source: CBRE and Author

4.5.7 Supply Equation

The supply equation for the Midtown submarket depicts statistically relevant data as presented in the following equation and data:

Supply = -21.67+ .06COMP$_{t-1}$ - .10COMP$_{t-2}$ - .06COMP$_{t-3}$ + .02COMP$_{t-4}$ - .07COMP$_{t-5}$ - .02COMP$_{t-6}$ - .01COMP$_{t-7}$ + .01COMP$_{t-8}$ + 0.44RRENT$_{t-8}$(9)

	Regression Statistics
Centered R Squared	0.136283
Uncentered R Squared	0.158274
Standard Error	20.381463667
Observations	108

	Coeff	Std. Error	T-Stat	Signif
Intercept	-21.66766397	8.19589511	-2.64372	0.00967326
$COMP_{t-1}$	0.06039592	0.10548053	0.57258	0.56835756
$COMP_{t-2}$	-0.10429872	0.10625485	-0.98159	0.32893313
$COMP_{t-3}$	-0.06081820	0.10606914	-0.57338	0.56781563
$COMP_{t-4}$	0.01700801	0.10562278	0.16103	0.87243385
$COMP_{t-5}$	-0.06933594	0.10459502	-0.6629	0.50908943
$COMP_{t-6}$	-0.01701549	0.10455838	-0.16274	0.87109057
$COMP_{t-7}$	-0.01009536	0.10417526	-0.09691	0.92301539
$COMP_{t-8}$	0.10703919	0.10246717	1.04462	0.29899657
$RRENT_{t-8}$	0.44146303	0.14606143	3.02245	0.00326538

4.5.8 10 Year Completion Projections: Midtown Submarket

The model predicts a lag in completions within the submarket until 2016 when the completions are expected to pick to 8,000 square meters completed per quarter with an overall average of 5,500 square meters per quarter for the 10 year projection which is slightly above the 4,000 square meters per quarter average for the previous 5 years.

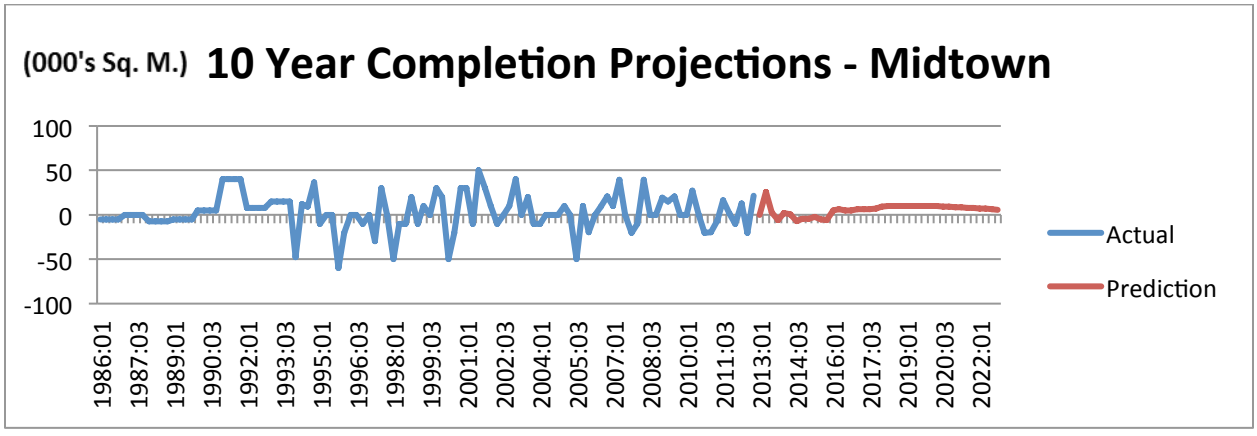

Figure 28 Source: CBRE and Author

4.5.9 Completions Back Test 2008-2012: Midtown Submarket

The back test for completions within the Midtown submarket is very comparable to what actually occurred. The submarket averaged 4,000 square meters of completions per quarter and the model would have predicted 9,000 square meters of completions per quarter.

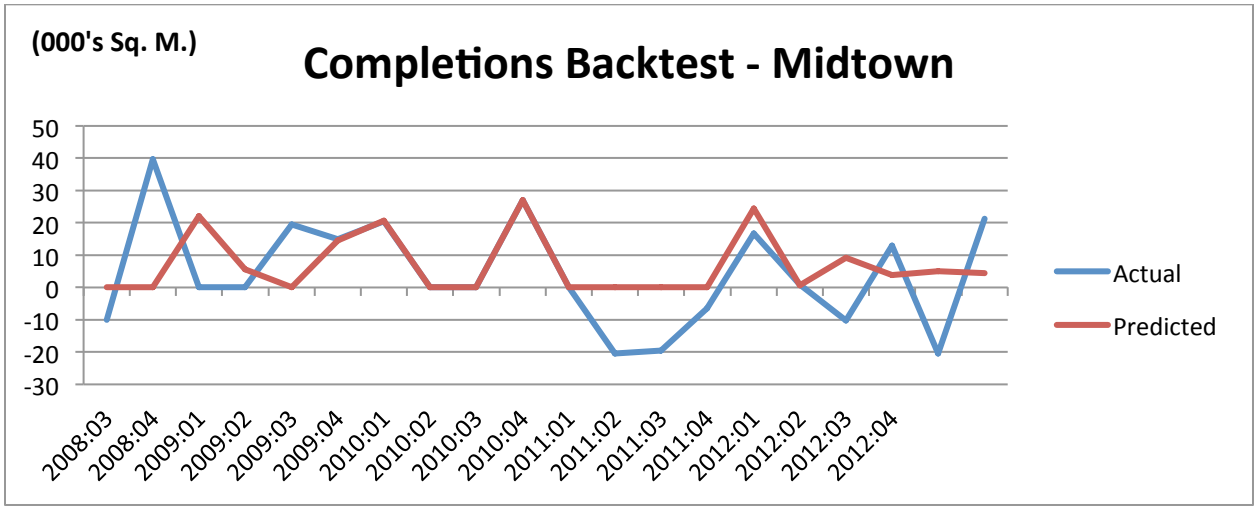

Figure 29 Source: CBRE and Author

4.6 City

4.6.1 Rent Equation

The rental equation for the City submarket yields the right signs for real rents and vacancy and also is very statistically relevant as depicted in the following equation and data:

Rent = 9.07+ .94RRENT$_{t-1}$ - .64VAC (10)

	Regression Statistics
Centered R Squared	0.983331
Uncentered R Squared	0.998487
Standard Error	2.87521661
Observations	108

	Coeff	Std. Error	T-Stat	Signif
Intercept	9.069669498	1.3489523	6.72349	0
RRENT $_{t-1}$	0.93853239	0.0139042	67.49972	0
VAC	-0.642393304	0.075119	-8.55167	0

4.6.2 10 Year Real Rent Projection: City Submarket

The model projects a dramatic increase in rents for the first 6 years of the analysis, peaking at £74.53 per square foot in the 4th quarter of 2018. Following, the model projects a decrease for the remainder of the 10 year projections.

Real rents are projected to begin at £56.50 per square meter in the first quarter of 2013 and end at £65.60 by the 4th quarter 2022 which is a 16% increase.[47]

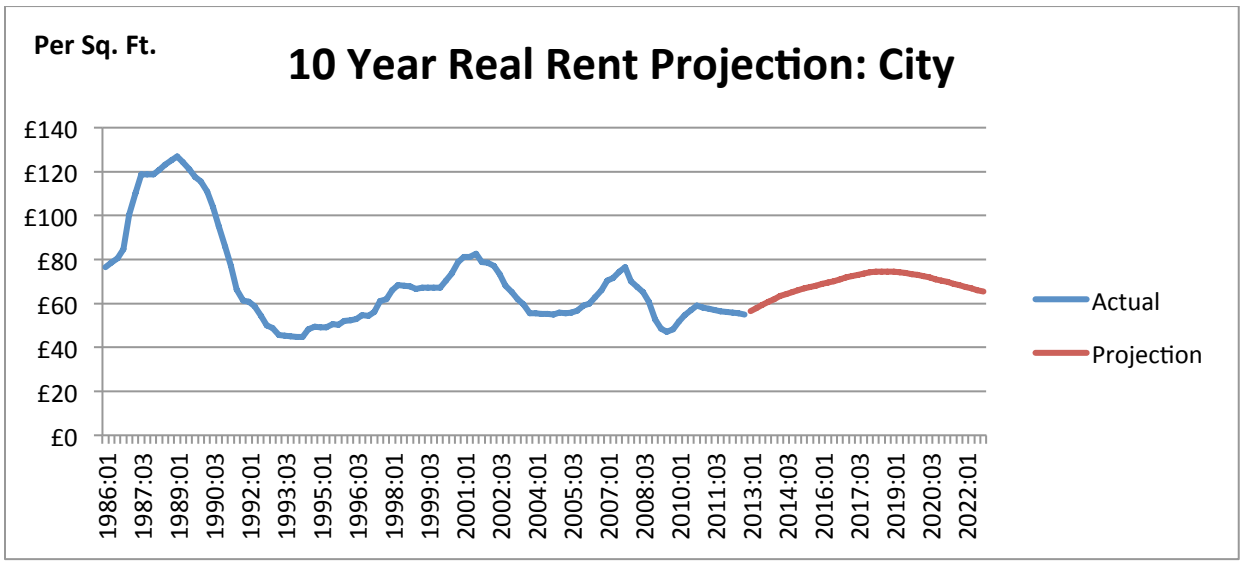

Figure 30 Source: CBRE and Author

[47] The City submarket projects the largest increase in real rents of the submarkets analyzed in this study.

4.6.3 Real Rent Back Test 2008-2012: City Submarket

The model, on the back test, would have initially predicted a higher rental rate than what actually occurred as it would not have been able to capture the severity of the financial crash of 2008. However, it also would not have captured the recovery which took place in 2010 and would have been off by approximately £10 per square foot until it almost fully recovered to the actual level the last quarter of 2012. That being said, the model did average £54.76 per square foot for the 5 year period which is very comparable to the £59.42 per square foot which was the actual average over the time period. [48]

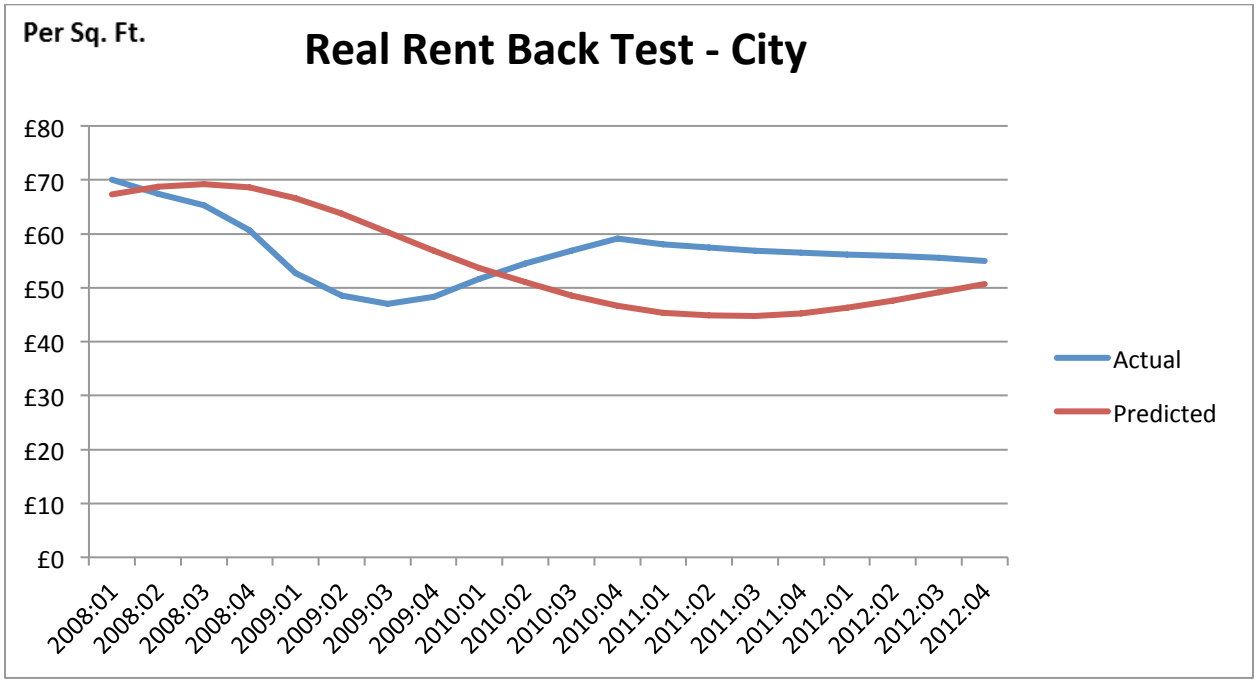

Figure 31 Source: CBRE and Author

[48] The real data was also very comparable with the model predicting £55.75 per square foot while the submarket actually exhibited an average of £56.67 per square foot.

4.6.4 Absorption Equation

The absorption equation and relevant data for the City submarket are presented as follows:

Demand = -35.03 - .08$OSTK_{t-4}$ + 606.37GSERV+ 1.23FIRE+ 2.56VAC_{t-4} (11)

	Regression Statistics
Centered R Squared	0.557402
Uncentered R Squared	0.634861
Standard Error	25.54117286
Observations	108

	Coeff	Std. Error	T-Stat	Signif
Intercept	-35.0309977	27.473713	-1.27507	0.205268
$OCCSTK_{t-4}$	-0.07646	0.0124279	-6.15228	2E-08
GSERV	606.3749032	77.644235	7.80966	0
FIRE	1.2348552	0.19454	6.34757	2E-08
VAC_{t-4}	6.5571807	0.7192676	9.11647	0

4.6.5 10 Year Net Absorption Projection: City Submarket

The model projects absorption of about 16,000 square meters absorbed per quarter for the 10 year projection which is in line with the previous 5 years of data.

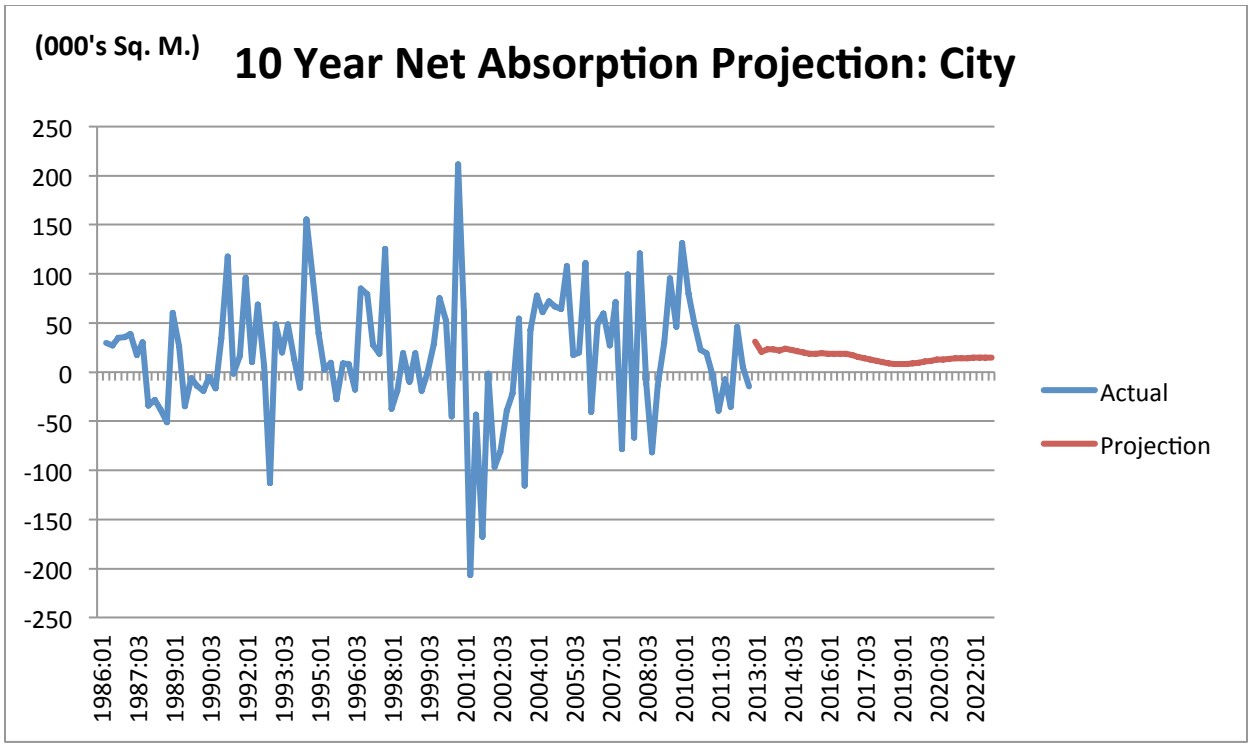

Figure 32 Source: CBRE and Author

4.6.6 Net Absorption Back Test 2008-2012: City Submarket

The city submarket's back test for absorption shows a large lag behind the actual data and also predicted a much favorable outcome than what actually occurred.[49] For the 5 year period the model predicted absorption of about 31,000 square meters absorbed per quarter while the submarket actually only absorbed 18,500 square meters per quarter.

[49] The model could not account for the financial jobs lost during this time period in Central London of which the City was hit the hardest as it is the submarket with the most financial tenants.

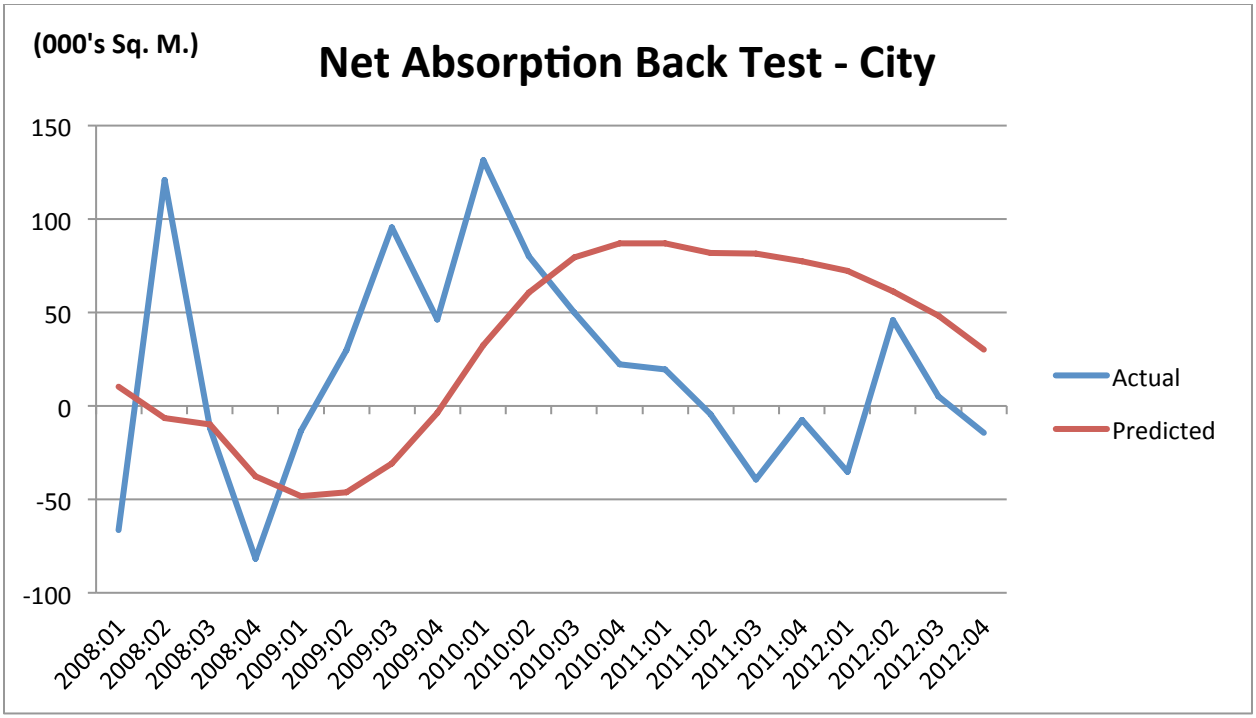

Figure 33 Source: CBRE and Author

4.6.7 Supply Equation

The supply equation yields high r squared regression statistics and is presented in the following equation and chart:

Supply = -44.31+ .02COMP$_{t-1}$ - .11COMP$_{t-2}$ + .21COMP$_{t-3}$ - .06COMP$_{t-4}$ + .11COMP$_{t-5}$ - .16COMP$_{t-6}$ - .18COMP$_{t-7}$ - .15COMP$_{t-8}$+ 1.02RRENT$_{t-8}$(12)

	Regression Statistics
Centered R Squared	0.264539
Uncentered R Squared	0.343557
Standard Error	54.004405635
Observations	108

	Coeff	Std. Error	T-Stat	Signif
Intercept	-44.31150559	19.43371915	-2.28014	0.02498887
$COMP_{t-1}$	0.02307979	0.10496201	0.21989	0.82646263
$COMP_{t-2}$	-0.11157996	0.10297720	-1.08354	0.28149534
$COMP_{t-3}$	0.21926498	0.10127488	2.16505	0.03305974
$COMP_{t-4}$	-0.06291187	0.10244781	-0.61409	0.54072443
$COMP_{t-5}$	0.10651450	0.10235936	1.04059	0.30088281
$COMP_{t-6}$	-0.15549178	0.09873831	-1.57479	0.11885394
$COMP_{t-7}$	-0.17748267	0.09998446	-1.77510	0.07929973
$COMP_{t-8}$	-0.14697001	0.10054198	-1.46178	0.14732418
$RRENT_{t-8}$	1.02055258	0.29507295	3.45864	0.00083509

4.6.8 10 Year Completions Projection: City Submarket

The 10 year prediction for the city submarket shows an average of 21,500 square meters delivered per year with a peak of 25,000 square meters in 2nd quarter of 2014 and a low of 8,000 square meters in the third quarter of 2013.

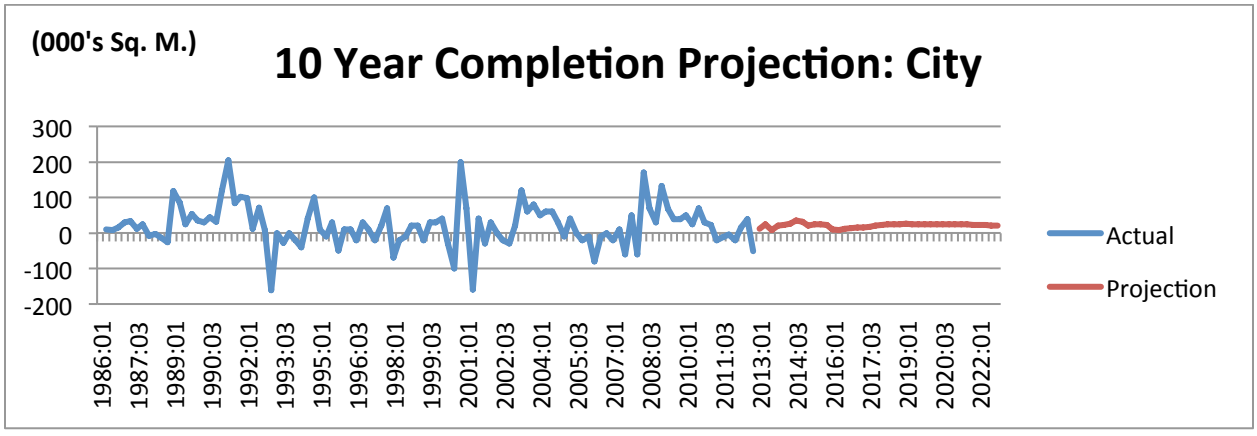

Figure 34 Source: CBRE and Author

4.6.9 Completions Back Test 2008-2012: City Submarket

As shown in the chart below, the back test for the City submarket for completions is a very accurate depiction of what actually occurred as the back test almost mirrors the actual completions albeit at slightly higher rates for the duration of the 5 years. For averages, the model projected about 45,000 square meters completed per quarter while the submarket actually completed 32,000 square meters per quarter.

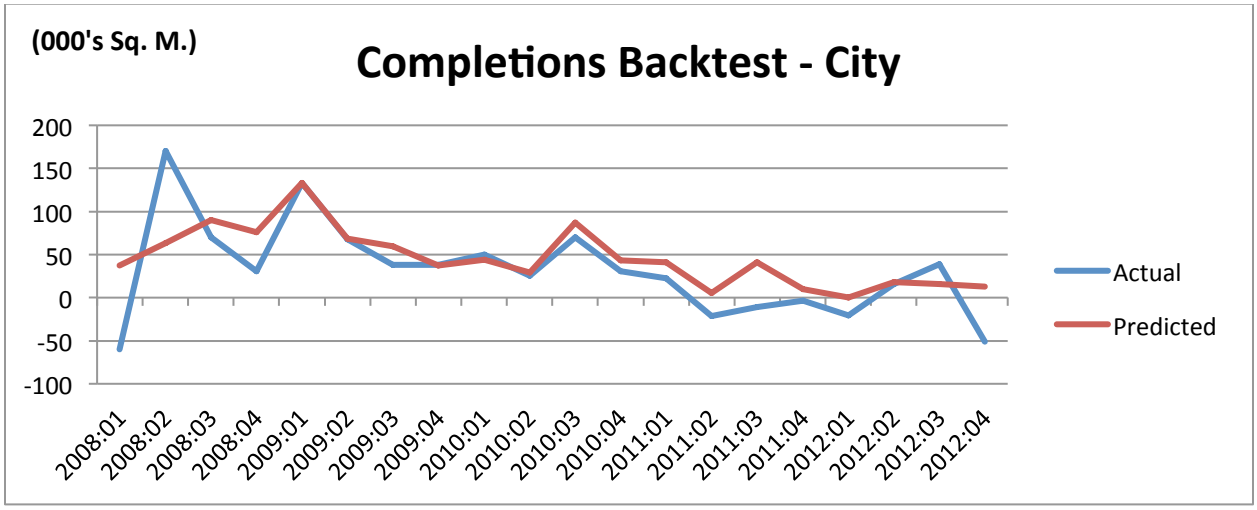

Figure 35 Source: CBRE and Author

4.7 West End

4.7.1 Rent Equation

The West End rental equation shows the right sign for real rents and vacancy with very high r squared. The equation and data is presented as follows:

Rent = 17.44+ .99RRENT$_{t-1}$ - 1.33VAC (13)

	Regression Statistics
Centered R Squared	0.971025
Uncentered R Squared	0.998029
Standard Error	4.200662832
Observations	108

	Coeff	Std. Error	T-Stat	Signif
Intercept	17.44386875	2.3398268	7.4552	0
RRENT $_{t-1}$	0.88934427	0.0192946	46.09284	0
VAC	-1.33054368	0.1606698	-8.28123	0

4.7.2 Real Rent Projections: West End Submarket

In nominal terms, the model predicts an increase to around £120 per square foot by 2017 which would return it to the level prior to the economic crash in 2008. However, in real terms this would actually be a decrease. In general, the real rent level in 2007 is probably something that will not occur in the West End submarket in the next 10 years.[50] Real rents are projected to begin 2013 at £94.37 per square foot and end the 10 year projection in 2022 at £92.93 per square foot.

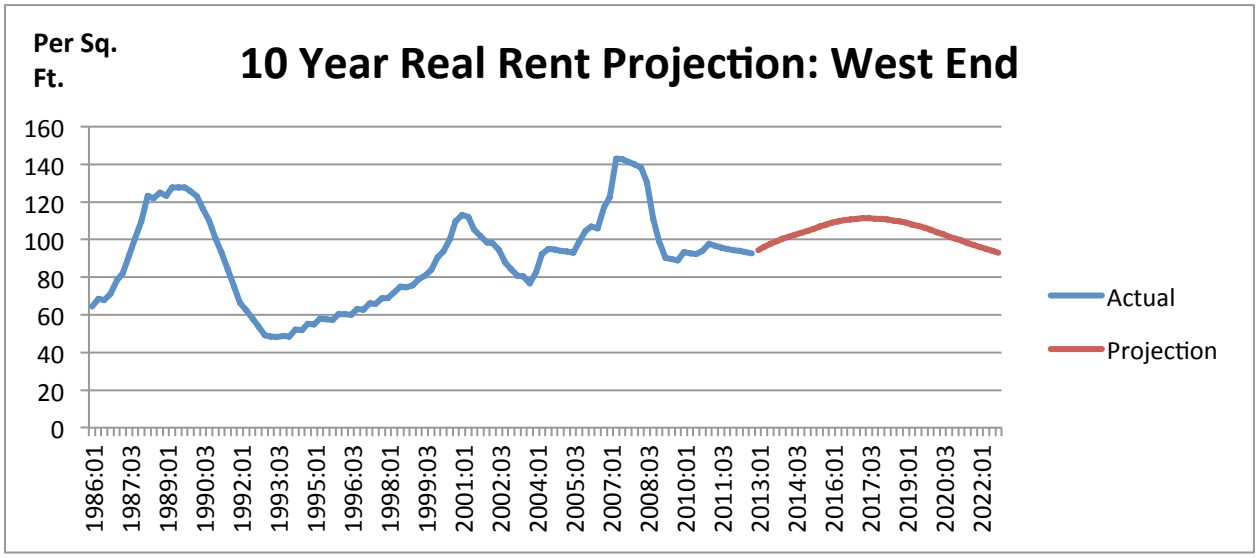

Figure 36 Source: CBRE and Author

[50] The Real Rent level in the West End in 2007 and 2008 was the highest in the world at the time.

4.7.3 Real Rent Back Test 2008-2012: West End Submarket

The model did not anticipate the overall decrease in rent that occurred from 2008 to the beginning of 2009.[51] However, by 2011 the model was in line with what actually occurred. For 2012 the model predicted a slight increase in rental rates but prime rents in the West End stayed at £95 per square foot.[52] For the back test period, real rents averaged £100.91 per square foot while the model would have predicted £107.58 per square foot.

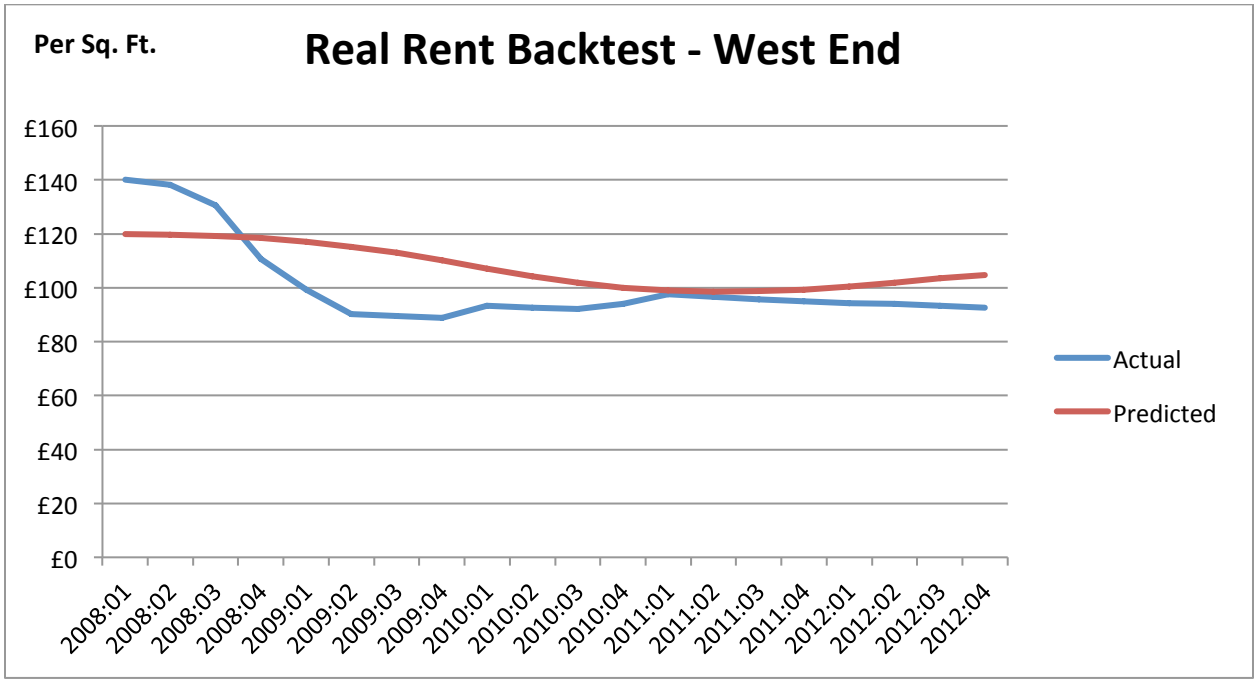

Figure 37 Source: CBRE and Author

4.7.4 Absorption Equation

Demand = 117.58- .16OSTK$_{t-4}$ + 129.11GSERV+ .49FIRE+ 2.64VAC$_{t-4}$ (14)

[51] As a comparison, the Financial Times Stock Index fell 30% in three months during this time period.
[52] Prime rents are defined as the top 3%-5% leases in a submarket.

	Regression Statistics
Centered R Squared	0.664129
Uncentered R Squared	0.674976
Standard Error	22.60899222
Observations	108

	Coeff	Std. Error	T-Stat	Signif
Intercept	154.7036951	109.18288	1.41692	0.159645
$OCCSTK_{t-4}$	-0.0605522	0.0227785	-2.65831	0.009159
GSERV	675.4500343	66.578855	10.14511	0
FIRE	0.6920252	0.1850568	3.73953	0.000309
VAC_{t-4}	6.2069686	0.9935372	6.24734	0

4.7.5 10 Year Net Absorption Projection: West End Submarket

The model projects an average absorption of 9,000 square meters per quarter which is above the 5 year recent trend but is close to the average of the data utilized in this analysis since 1986.

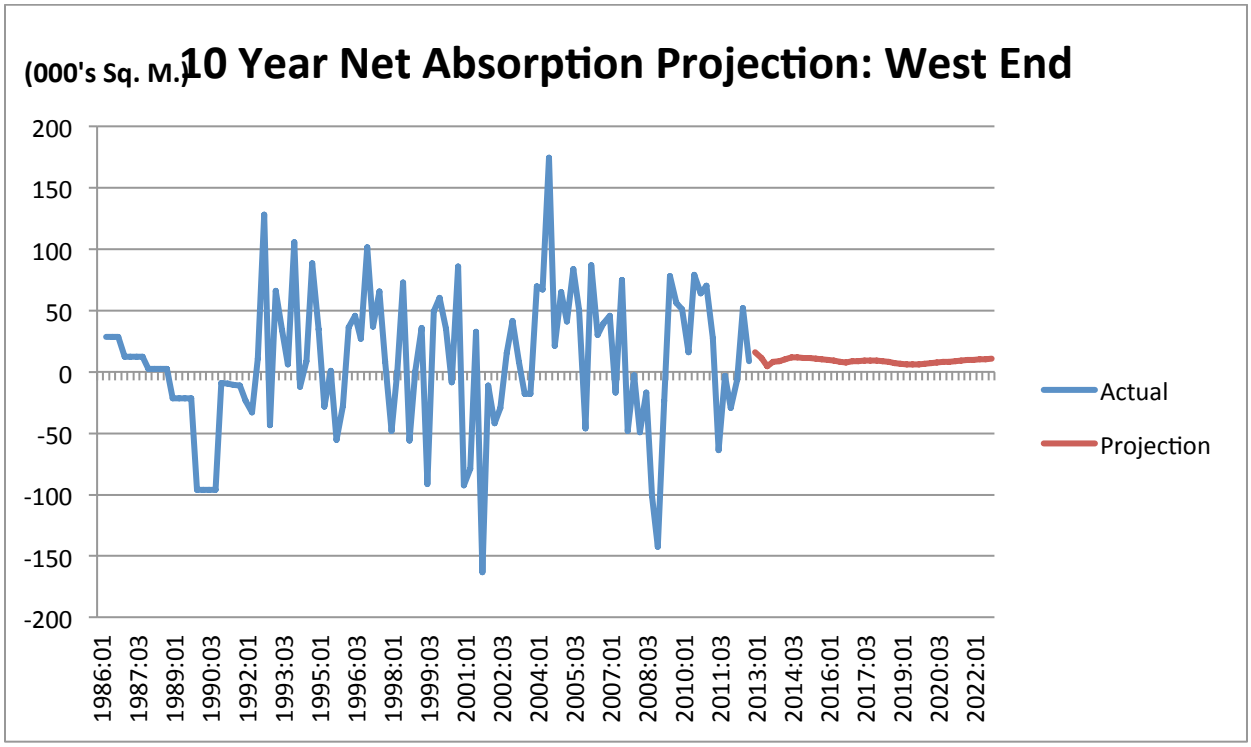

Figure 38 Source: CBRE and Author

4.7.6 Net Absorption Back Test 2008-2012: West End Submarket

The model predicted an average absorption of 20,000 square meters per quarter while the actual data depicted a much lower net absorption level of 3,000 per quarter due to several periods of high negative absorption levels.

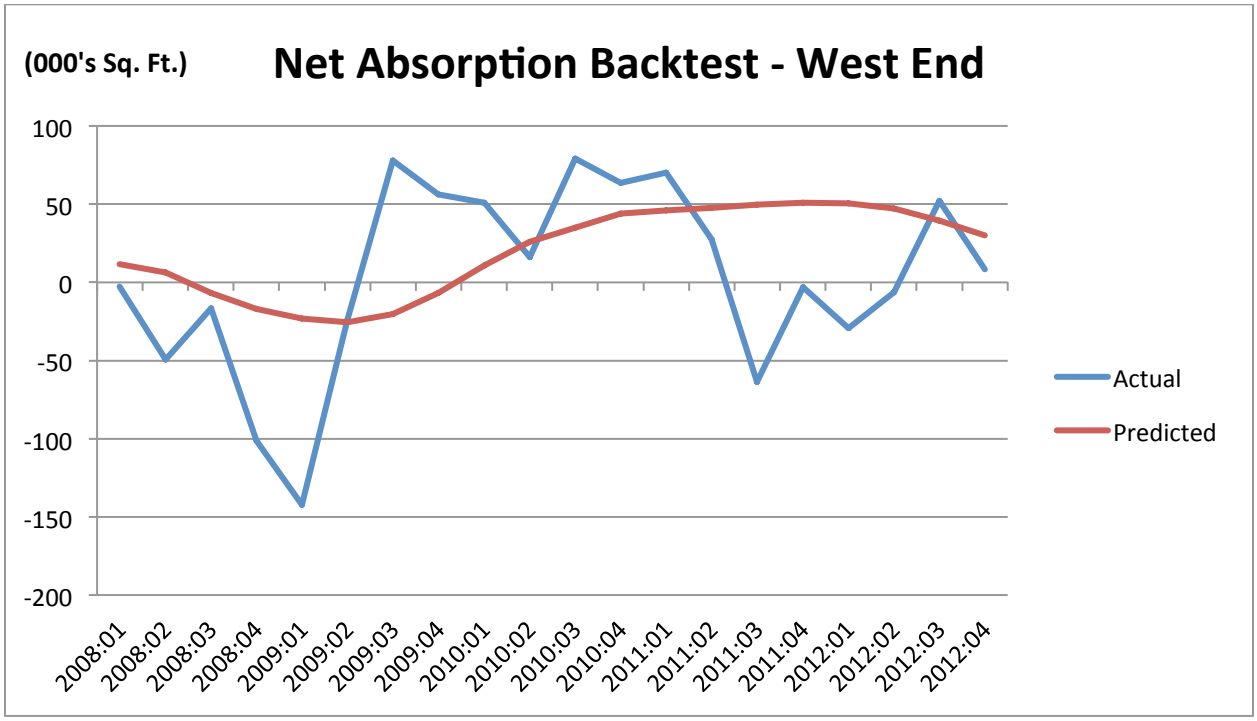

Figure 39 Source: CBRE and Author

4.7.7 Supply Equation

Supply = -33.82- .16COMP$_{t-1}$ - .07COMP$_{t-2}$ - .02COMP$_{t-3}$ + .00COMP$_{t-4}$ - .07COMP$_{t-5}$ + .11COMP$_{t-6}$ + .08COMP$_{t-7}$ - .01COMP$_{t-8}$ + 0.5RRENT$_{t-8}$(15)

	Regression Statistics
Centered R Squared	0.129247
Uncentered R Squared	0.184188
Standard Error	36.216596716
Observations	108

	Coeff	Std. Error	T-Stat	Signif
Intercept	-33.82227994	14.04175562	-2.40869	0.01804806
COMP$_{t-1}$	-0.15793075	0.10439164	-1.51287	0.13381701
COMP$_{t-2}$	-0.06798650	0.10387287	-0.65452	0.51444832
COMP$_{t-3}$	-0.01540134	0.10154324	-0.15167	0.87978456
COMP$_{t-4}$	0.00049439	0.10044994	0.00492	0.99608388
COMP$_{t-5}$	-0.06812061	0.09994599	-0.68157	0.49725834
COMP$_{t-6}$	0.10726944	0.10025854	1.06993	0.28751271
COMP$_{t-7}$	0.07662447	0.10088166	0.75955	0.44950972
COMP$_{t-8}$	-0.01050477	0.10126610	-0.10373	0.91761096
RRENT $_{t-8}$	0.49827092	0.15975686	3.11893	0.00243827

4.7.8 10 Year Completion Projection: West End Submarket

The model projects an average completion projection of 13,000 square meters per quarter which is close to the previous 5 year average of 11,000 square meters per quarter.

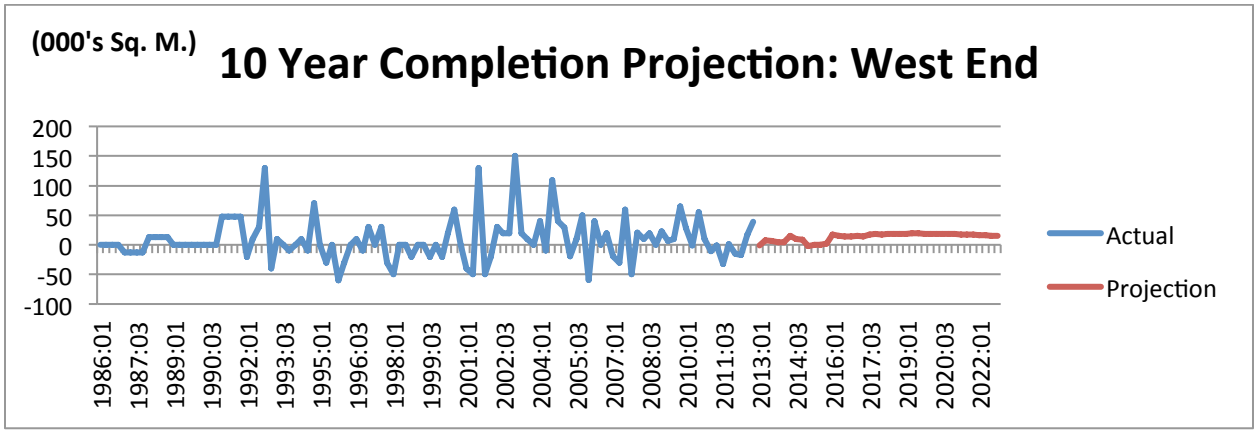

Figure 40 Source: CBRE and Author

4.7.9 Completions Back Test 2008-2012: West End Submarket

The West End model for completions very closely mirrors what actually occurred but did, similar to other submarket models, project higher completions. The submarket actually delivered 11,000 square meters of space per quarter while the back test predicted an average of 22,000 square meters of space per quarter.

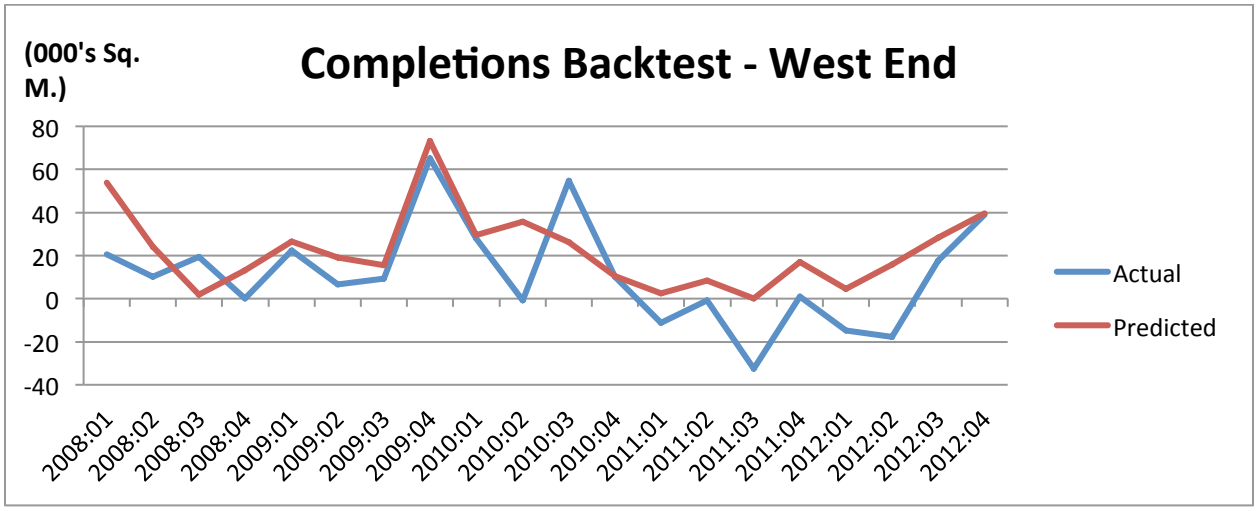

Figure 41 Source: CBRE and Author

Chapter 5: Comparing Single Model versus Aggregate Submarket Models

To determine whether a single model or the summation of the submarket models is a better modeling technique, the outputs of the single model versus the submarkets are compared through back tests and projections of modeling Central London. The following charts and data show 5 year back tests and 10 year projections for the fundamental characteristics of the Central London office market modeled as one market and the sums of the four separate submarkets.

5.1 Real Rents

5.1.1 Back Test 2008-2012

When comparing the actual data to the single model and separate models, it appears that both models follow similar trends but with a reasonable difference in rents per square foot. Also, it should be noted, the models projected much lower rental rates than the actual data prior to the financial collapse in mid-2008. The real rents on a back test are modeled better separately than as a single model. The actual data averaged £73.84 per square foot while the single model projected rents averaging £84.35 and the single separate submarket models added up averaged £75.56 per square foot.

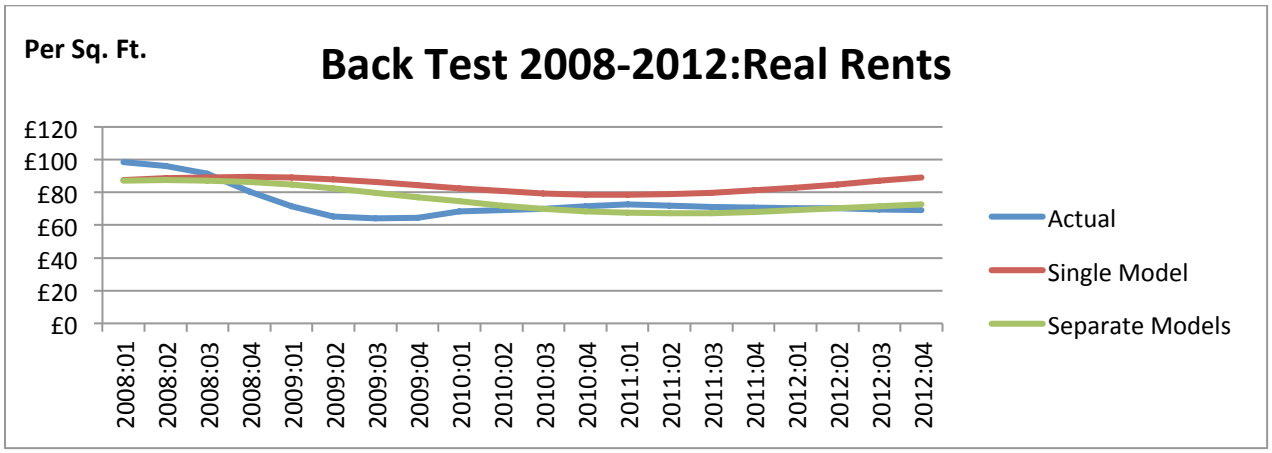

Figure 42 Source: CBRE and Author

5.1.2 10 Year Model Projections

For the 10 year projections rents, the single model projects a much sharper increase for the first five years. Real rents begin at £71.17 per square foot in 2013 and are projected to end at £74.47 per square foot at the end of 2022 in the single model while the separate model projects rents beginning at £70.72 per square foot and ending 2022 at £73.16 meaning both models project similar real rents. Overall, this is comparable to the back test of the two models as the separate models projects lower rental rates when compared to the single model.

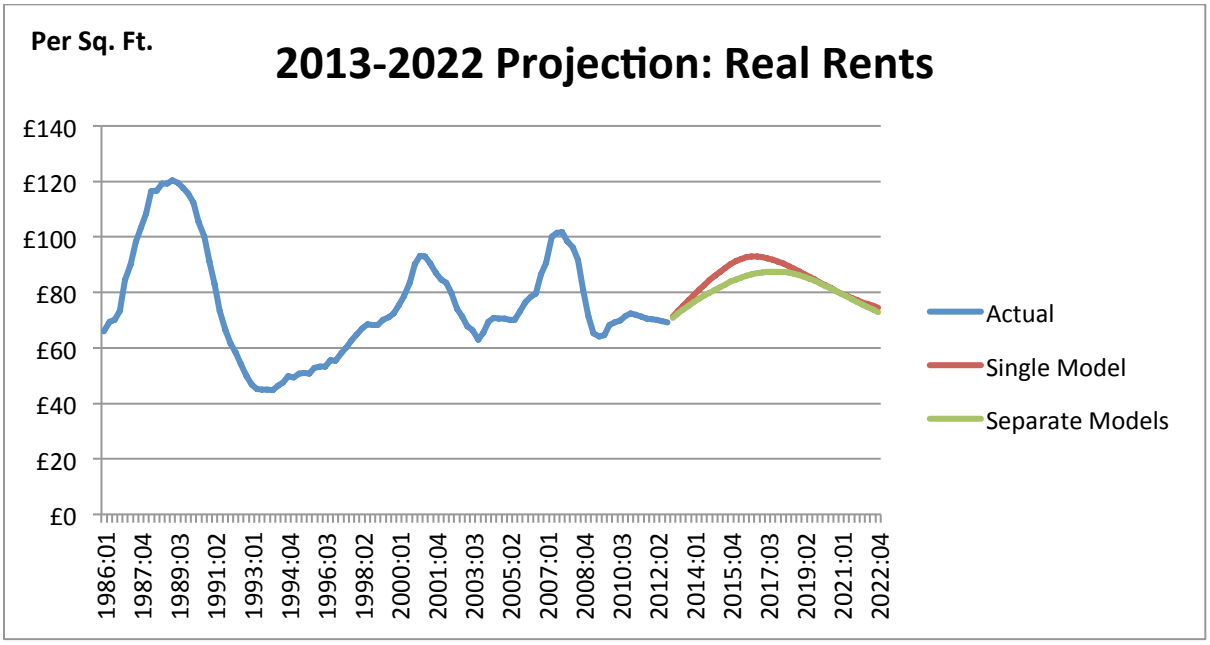

Figure 43 Source: CBRE and Author

5.2 Vacancy

5.2.1 Back Test 2008-2012

In contrast to rents, neither the single model nor aggregated submarket models provides a more accurate model for the 5 year period back test. In the first year of the analysis the separate models closely mirror the actual data. However, in 2009 the actual data decreases and mirrors the single

model for about one year. Following, the actual data then closely resembles the aggregated submarket models. Therefore, for vacancy, neither model provides a more accurate depiction to what actually occurred. Overall, the single model averaged 4.66% for the 5 year period while the separate models averaged 6.31%. Overall, the actual data averaged a vacancy of 5.82% from 2008-2012.

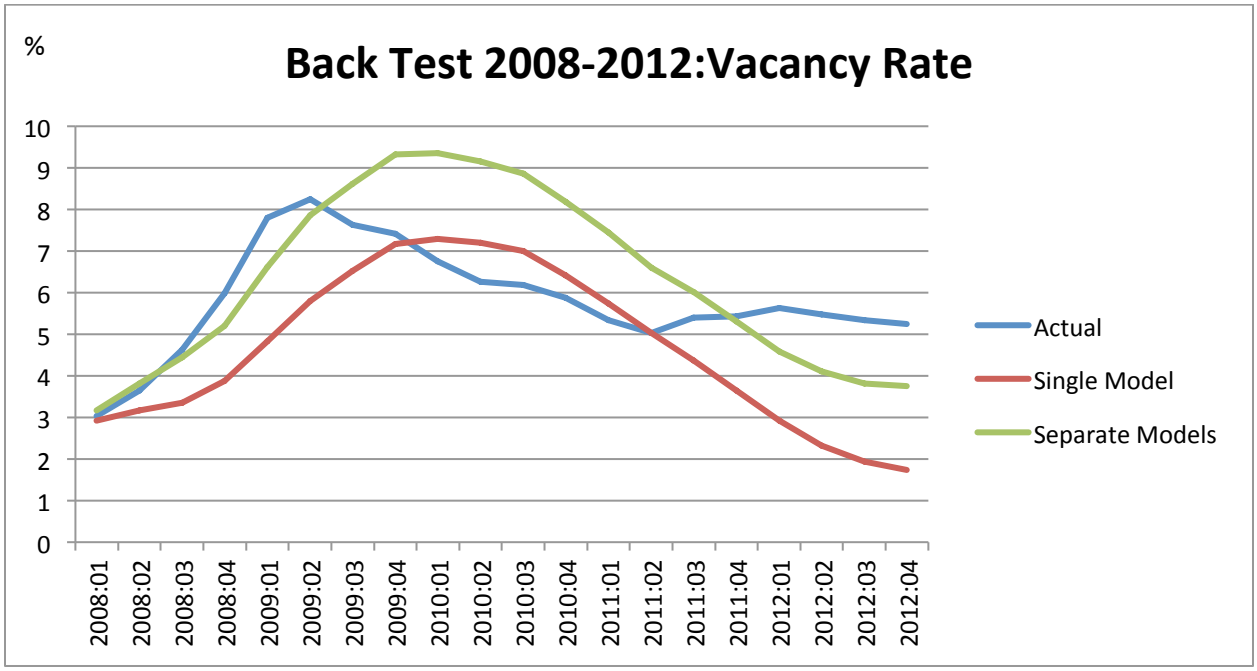

Figure 44 Source: CBRE and Author

5.2.1 10 Year Vacancy Projection

For the 10 year projections, initially both models provide similar decreasing vacancy rates until the end of the 4th quarter 2015. However, due to more completions projected in the single model[53], the single model projects a higher vacancy rate for the duration of the projection albeit at a similar slope as the separate models. For the 26 years previous, the Central London aggregate market averaged a

[53] Will be discussed in section 5.4 and 5.5.

vacancy rate of 6.54%. For the 10 year projections, the single model projects vacancy of 5.54% while the separate models projects a lower vacancy of 4.76%.

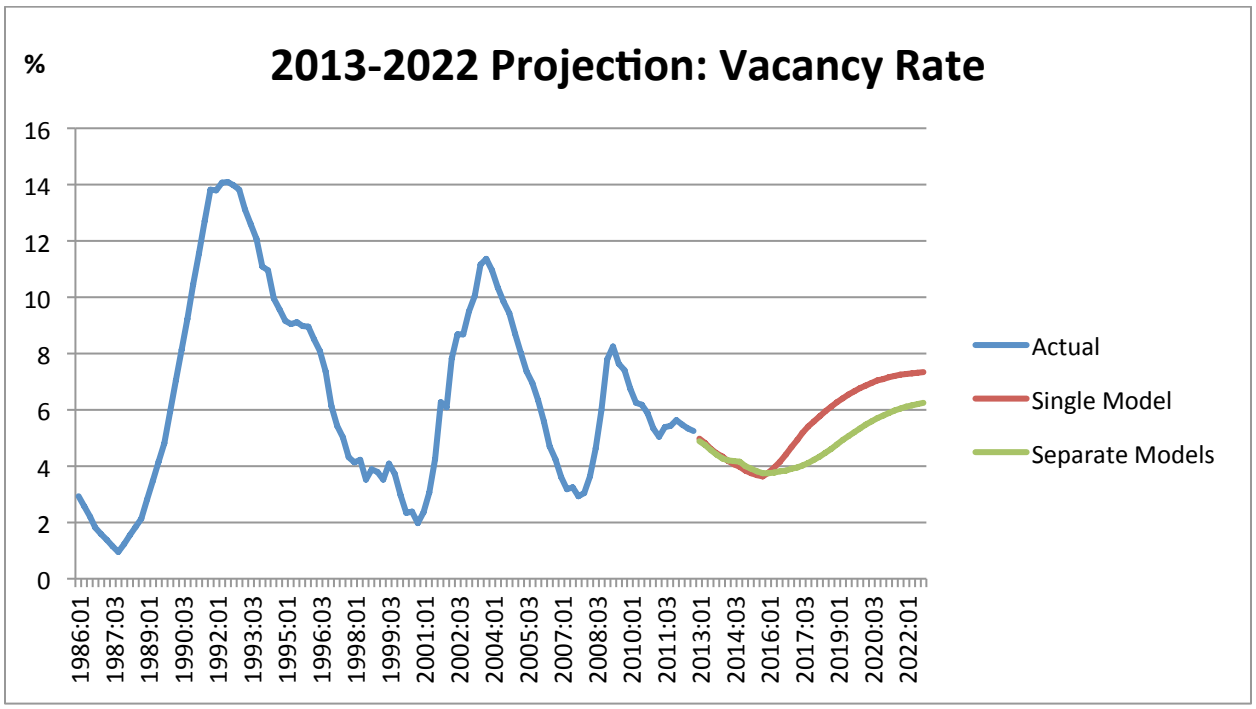

Figure 45 Source: CBRE and Author

5.3 Stock

5.3.1 Back Test 2008-2012

The back test for stock gives the statistical edge to the single model as the separate models aggregated projects a stock that is much higher than what actually occurred. This is most likely due to the fact that the submarkets did not interact with each other during the turbulent financial times when modeled individually and the single model could account for the decrease in stock to some degree.

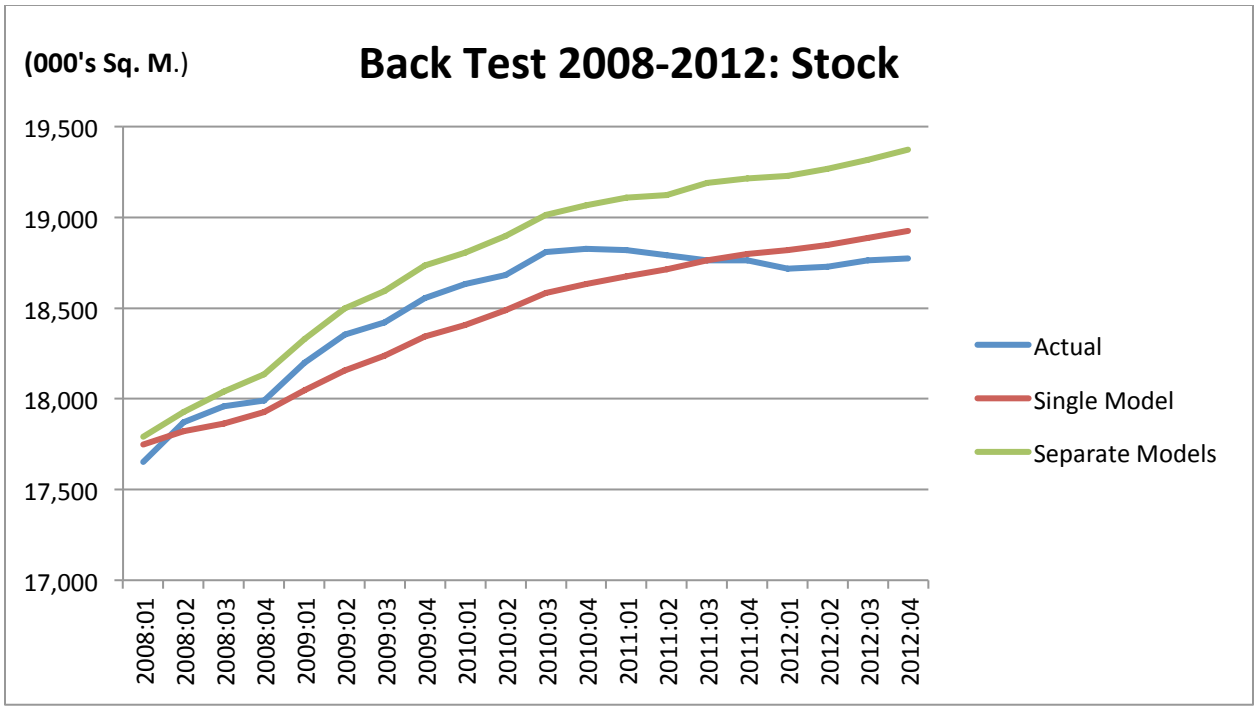

Figure 46 Source: CBRE and Author

5.3.2 10 Year Stock Projection

In contrast to the back test, the 10 year projection depicts the single model adding more stock to the Central London office market versus the aggregate submarket models. This actually makes the single model the more accurate indication when comparing the two methods versus the historical trends.

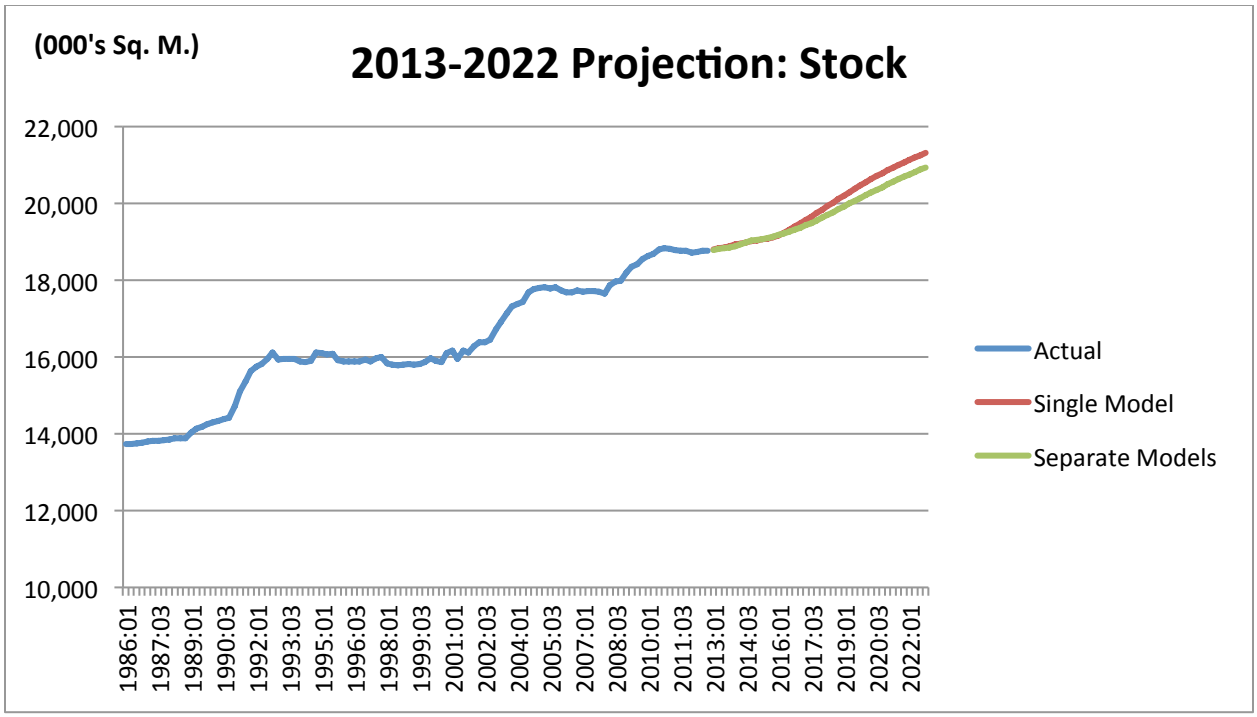

Figure 47 Source: CBRE and Author

5.4 Completions

5.4.1 Completions Back Test 2008-2012

Both the single and separate models provide very similar completion projections on the back test[54], although the separate models would have projected initial completions higher in 2008. This is most likely an indication that the separate models would not have interacted with each other as the market conditions declined very quickly during this time period. The actual data averaged 30,000 square meters delivered per quarter which makes both models having dramatically overestimated the completions but the single model having the lower estimate.

[54] 61,000 square meters per quarter for the single model and 84,000 square meters per quarter for the separate models.

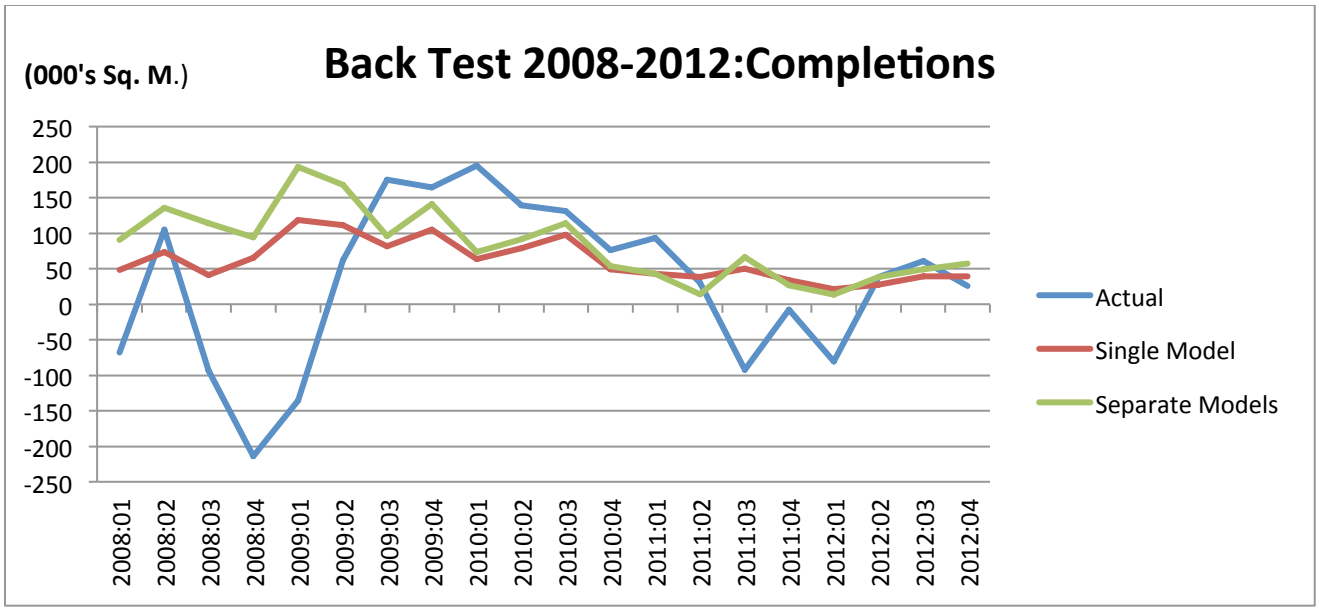

Figure 48 Source: CBRE and Author

5.4.2 10 Year Completion Projection

The separate and single models provide similar projections in terms of completions although the single model does project a higher completion rate, especially between 2016 and 2019.[55] Overall, the actual data averaged about 47,000 square meters delivered per quarter while the single model projects completions of 63,500 square meters per quarter and the separate models projects completions of 54,000 square meters per quarter.

[55] The single model projects 82,000 square meters per quarter for this period while the summed separate models project 69,000 square meters during this period.

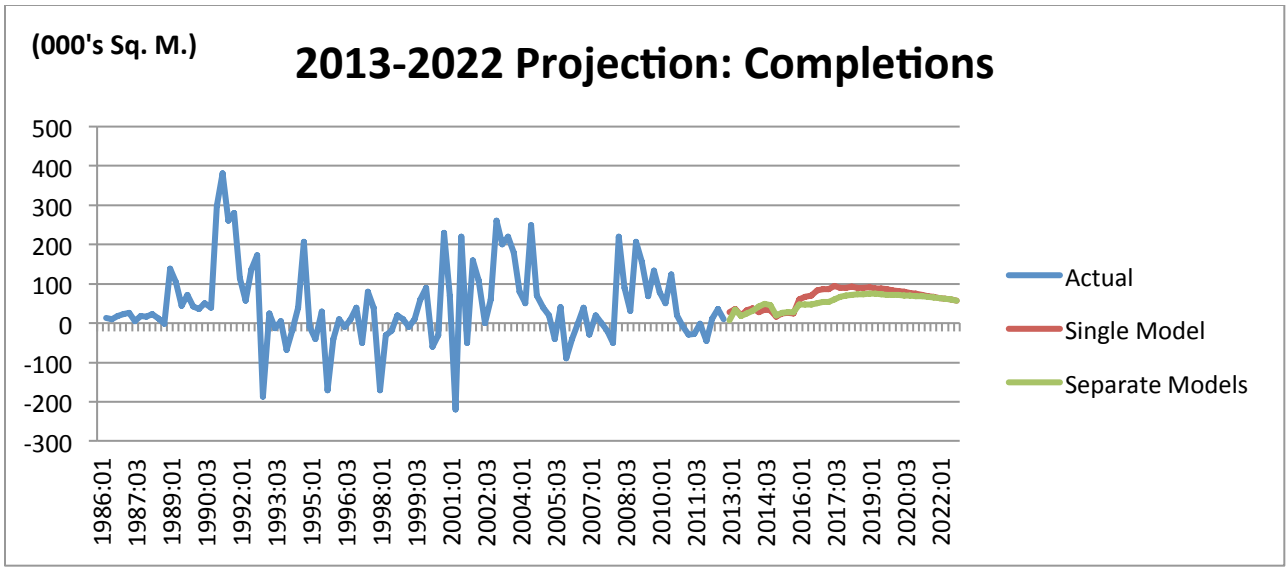

Figure 49 Source: CBRE and Author

5.5 Absorption

5.5.1 Back Test 2008-2012

Both the single and separate models predicted similar absorption trends over the 5 year time period with the aggregated separate models being more extreme in both the highs and lows. Overall, the actual data averaged 30,000 square meters absorbed for the 5 year period but the single model estimated absorption of 71,000 square meters per quarter and the separate model projected 73,000 square meters per quarter. Neither model is a strong back test for what actually occurred.

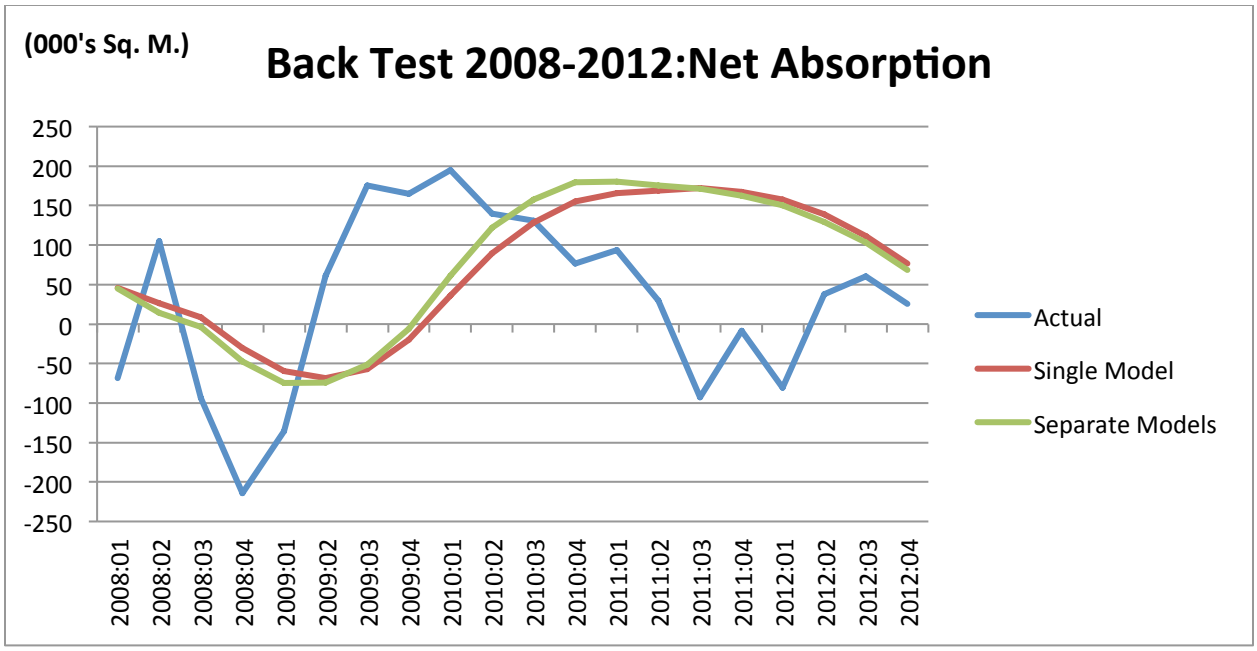

Figure 50 Source: CBRE and Author

5.5.2 10 Year Net Absorption Projection

In contrast to the back test, the single model projects higher and lower extreme net absorption for the 10 year projection with overall more extreme highs and a higher overall average. The actual data averaged net absorption of about 42,000 square meters absorbed per quarter for the data in the analysis. The single model projects absorption of 49,000 square meters per quarter while the separate aggregate models averages 46,000 square meters per quarter.

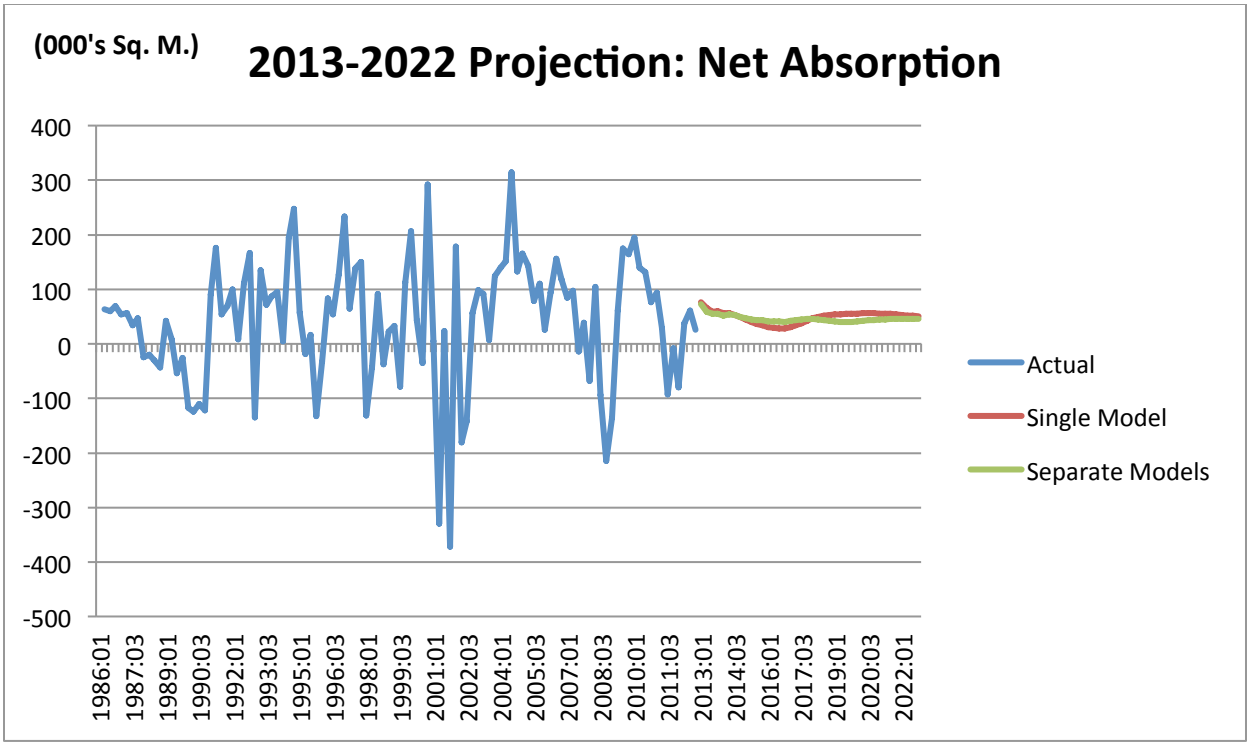

Figure 51 Source: CBRE and Author

5.6 Coefficient Comparisons

5.6.1 Rental Equation

	RRENT	VAC	R Squared
Central London	0.9012	-0.8887	0.98
Docklands	0.9469	-0.0149	0.93
Midtown	0.9276	-0.7437	0.98
City	0.9385	-0.6424	0.98
West End	0.8893	-1.3305	0.97

5.6.2 Demand Equation

	OCSTK	GSERV	FIRE	VAC	R Squared
Central London	-0.0546	1164.08	2.5415	18.5577	0.6
Docklands	0.0133	-264.48	-0.3815	-0.5631	0.29
Midtown	-0.1565	129.11	0.4926	2.6395	0.63
City	-0.0765	606.37	1.2349	6.5572	0.56
West End	-0.0606	675.45	0.692	6.207	0.66

5.6.3 Supply Equation

	RRENT	R Squared
Central London	2.5783	0.37
Docklands	-0.0457	0.36
Midtown	0.4415	0.14
City	1.02	0.26
West End	0.4983	0.13

Overall, both models seem to be reasonable fits in terms of the back tests and are very comparative in what they would have projected for the previous 5 years. The 10 year projections show no conclusive answer to which model is better although the separate model also has a slight edge in comparison to what's occurred in the previous 10 years. In conclusion, however, it does not appear that there is a clear answer to whether the market should be modeled as separate submarkets or as one single market. The estimates on both the back tests and projections seem to be accurate or to miss in similar directions for both methodologies.

Chapter 6: Conclusion

This paper analyzes and projects rental conditions within the Central London Office market. The study applies a structural economic model utilizing data from 1986-2012 and projects conditions both on the single market level and for the four largest submarkets within the Central London Office market. Following, the paper discusses and analyzes whether it is better to use the structural model on the single market or to model the submarkets separately and aggregate the outputs.

After examining several other econometric models, the paper uses three equations for rent, demand, and supply on Central London as well as the Docklands, Midtown, City, and West End submarkets. The rental equation is explained by a lag of 1 year of rent and the current quarter's vacancy. The demand equation is explained by a 1 year lag in occupied stock, the current level of government service employment, the current level of fire, insurance, and real estate employment, and a four year lagged vacancy. The supply equation is explained by a 1 quarter lag in yield, a 1 year lag in yield, the current bond rate, the current real rental rate, a 1 quarter lag in real rental rate, and the spread between government bonds and corporate bond rates. Myopic expectations in the London office market can explain why there were was a need to utilize lags on some of the variables as developers expectations going forward are typically what is presently occurring. However, by the time new stock is delivered to the market, conditions have typically changed.

The Central London and submarket models produced varying projections. The Central London single model expects improving conditions in terms of rental rates and decreased vacancy until too much supply hits the market in the middle of the 10 year projection which will over supply the market and decrease the rental rates and increase vacancy rates. Similar attributes are true for the Midtown, City, and West End submarkets although the Docklands submarket projects increased

rental rates and no cyclical trends. This is most likely due to the weakness of the data utilized in this econometric model.

Following the projections, the paper tries to answer a question within an econometric model framework: should large commercial markets be modeled as a single market or as separate submarkets then have the outputs summed? When comparing these two methodologies, it appears that neither method produces the better way to model the markets. Both methods project similar conditions for the 10 year outlook and have similar results when back testing them versus the previous 5 years of actual data. In conclusion, it appears that there is no superior way to model large office markets. They can be modeled as one market or as separate submarkets followed by summing the outputs. The purpose and intent of modeling a market or submarkets will most likely determine which method you would utilize to project conditions within an office market.

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