Using Leading Indicators to Forecast Real Estate Returns

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Summary

Introduction

Although real estate represents an important component of investment funds, compared to other asset classes, there are relatively few studies that examine the performance characteristics of this asset class. In 2010, Dutch institutional investors had allocated about 10.5 percent, representing 122 billion euro in real estate, and in Europe it is estimated that around 700 billion euro had been invested in real estate. (Inrev, 2010) Looking at the number of studies focusing on forecasting returns of the other asset classes, it is surprising to see that the forecasting of real estate returns has not been given much academic attention.

In order to back up investment decisions, ASR Real Estate Investment Management has started the development of the Value Expectation Model. The model separates total return into income return and capital growth, according to the Investment Property Databank (IPD) calculation methods and after this distinction is made, the model splits up capital growth into rental value growth and yield shift, representing the rental and investment markets in which they operate.

The goal of this study is to find indicators that can provide early signals, so called leading indicators, that explain changes in yield shift and rental value growth of real estate so they can be used to forecast the change in real estate capital growth.

The main question this study aims to answer is: *How can leading indicators be used to forecast changes in international capital growth of real estate?*

Literature Review

Due to the fact that the separation of capital growth into rental value and yield shift is not common in real estate literature, the existing literature about the separate dependent variables, rental value and yield shift, is studied. This literature review has resulted in a long list of different variables per property type. Depending on the used theoretical model, changes in rental value are caused by changes in demand, supply and / or the spread between the natural vacancy rate and current vacancy rate, while changes in yield are mostly influenced by general economic growth indicators. Secondly, the application of economic leading indicators has been examined. Economic leading indicators give information about future business cycle behavior but can also be used to forecast capital growth. The review concludes that a combination of real estate variables and economic leading indicators has never been attempted before, and that it can be a good alternative to traditional forecasting techniques.

Data and methodology

By making use of quarterly return data of the Investment Property Databank for yield shift and rental value, and multiple national sources for the independent variables, the relationship between the dependent and independent variables is studied for the Netherlands. Because the goal is to forecast the direction of change and not the actual future returns, this study makes use of logistic regression. Logistic regression has the added advantage of not requiring linear relationships or normally distributed input data. The study makes use of a four-step methodology to generate the final models.

These steps are:

1. De-trending of time series by using quarterly growth rates
2. Transformation of dependent variables into binary variables
3. Univariate logistic regressions to find significant variables and best fitted number of leads
4. Multivariate logistic regressions to find best fitted combination of variables

In order to validate the methodology, an international comparison is made by running the models for the United States and United Kingdom. Furthermore, the models for the U.K. are tested for stability by making use of out-of-sample performance tests.

Results

The methodology results in the final regression models as shown in table 1 and 2. The tables show the variables, including the number of quarters they lead, which can be used to forecast the chance of actual yield shift / rental value growth per property type. Furthermore, the tables show the coefficients that indicate the weight of the variables and the significance of the variables. The McFadden R^2 that is listed per model indicates the statistical fit of the models and can range from zero to one.

Dependent variable	Variable	Coefficient	Significance	McFadden R2	Observations
Yield shift overall	Employment growth (10)	-435,550	0,036	0,80	34
	Money supply, M2 (1)	142,213	0,037		
	Constant	-1,336	0,426		
Yield shift retail	Consumer confidence (6)	-0,159	0,004	0,66	39
	Level of finished goods (6)	419,212	0,017		
	Constant	-1,163	0,159		
Yield shift industrial	Building permits (7)	17,536	0,099	0,81	34
	Employment growth (10)	-757,818	0,023		
	Constant	0,447	0,614		
Yield shift office	Employment growth (10)	-1002,878	0,015	0,88	34
	Constant	1,843	0,086		

Table 1: Best fitted regression equations for the Dutch quarterly yield shift models

Dependent variable	Variable	Coefficient	Significance	McFadden R2	Observations
Rental value overall	Investor sentiment (9)	47,123	0,060	0,68	34
	Money supply, M2 (1)	130,360	0,012		
	Constant	-5,829	0,005		
Rental value retail	Building permits (7)	12,446	0,010	0,40	42
	Money supply, M2 (10)	-95,452	0,006		
	Constant	2,611	0,029		
Rental value industrial	Consumer confidence (1)	0,266	0,019	0,61	34
	Constant	-0,579	0,503		
Rental value office	Consumer confidence (1)	0,266	0,019	0,61	34
	Constant	-0,579	0,503		

Table 2: Best fitted regression equations for the Dutch quarterly rental value models

The models consist out of a number of different variables, with employment growth being a common factor for the yield shift models and M2 money supply for the rental value models. According to the models, the chance of positive yield shift for the retail sector is negatively influenced by consumer confidence and positively influenced by level of finished goods. For the chance of retail real rental value growth the amount of building permits has a positive effect while M2 money supply has a negative effect.

The chance of positive yield shift for the industrial sector is positively influenced by the amount of building permits and negatively influenced by employment growth, showing the cyclic nature of the market. The chance of industrial real rental value growth is positively influenced by consumer confidence. The office models show a significant negative relationship between employment growth and the chance of positive yield shift. For the chance of real rental value growth, consumer confidence is found as a positive significant variable.

All models show good fits with McFadden R^2s ranging from 0.40 to 0.88 and all variables are significant on the five percent level. These results are satisfactory, however, they do not give any information about the forecasting performance.

The performance of the models can be measured by comparing the final models with a naïve model, which can be found in table 3. This naïve model consists out of a constant only and represent an educated guess based on the past performance. The comparison shows that the final models predict accurately (73 % to 94 %) and have significant gains over the naïve models, ranging from seven to 28 percent.

Model	Cutoff point	Cor. pred. naïve model (%)	Cor. pred. model (%)	Gain (%)
Yield Shift Overall	0,67	47,3	72,7	25,5
Yield Shift Retail	0,52	56,4	84,6	28,3
Yield Shift Industrial	0,45	60,0	81,8	21,8
Yield Shift Office	0,57	63,6	70,9	7,3
Rental Value Overall	0,29	69,1	79,2	10,2
Rental Value Retail	0,47	56,4	80,0	23,6
Rental Value Industrial	0,26	80,0	89,1	9,1
Rental Value Office	0,26	74,5	94,3	19,8

Table 3: Performance comparison between naïve and final models

International comparison

Due to the limited size of the observations (30 to 40), it is impossible to test the models for stability. In order to validate the methodology and somehow test the reliability of the results, back tests are done for the U.S. and the U.K.

The statistical performance of these tests are in line with the Dutch results. All models show good fits and predict accurately. The composition of the models is different for each country and the only common factor is money supply, which is present in almost all rental value models. However, it does become clear that all models are largely dominated by economic variables, indicating the impact of the economy on real estate.

Robustness tests

The international comparison has made clear that there are certainly differences between the three countries. However, the stability of the models has not yet been proven. By making use of monthly data of the United Kingdom, robustness tests can be run. These test first compare the results of the monthly and quarterly dataset and secondly compare in and out-of-sample performance.

The comparison between the monthly and quarterly dataset makes clear that, although there are some differences, the models generally consist out of the same variables. The differences that do occur are due to the larger amount of observations for the monthly dataset, creating models that consist out of more variables.

Table 4 shows the performance of the out-of-sample forecasts in comparison to the in sample forecasts and naïve model for the U.K. monthly models. The out-of-sample forecasts are created by using the method for data up to 2003. The results are then used to forecast up to 2008, creating out-of-sample forecasts. The in sample models predict more accurately, as is to be expected. However, the out-of-sample forecasts still have high accuracy (58 to 100 %) and most models still have gains over the naïve model, showing the stability of the models and proving the added value of the leading indicator approach.

Model	Cor. pred. naïve model (%)	Cor. pred. out of sample model (%)	Cor. pred. in sample model (%)	Dif. in sample & out sample (%)	Gain out sample & naïve (%)
Yield Shift Overall	73,3	58,3	98,3	-40,0	-15,0
Yield Shift Retail	73,3	93,3	93,3	0,0	20,0
Yield Shift Industrial	26,7	88,3	100,0	-11,7	61,7
Yield Shift Office	75,0	70,0	96,7	-26,7	-5,0
Rental Value Overall	28,3	96,7	100,0	-3,3	68,3
Rental Value Retail	70,0	90,0	91,7	-1,7	20,0
Rental Value Industrial	0,0	100,0	100,0	0,0	100,0
Rental Value Office	45,0	65,0	98,3	-33,3	20,0

Table 4: In and out-of-sample performance comparison for the U.K. monthly models

Overall, it can be said that this study has presented a method to improve the forecasting of real estate returns by combining both real estate and economic variables and using a logistic leading indicator approach. Furthermore, the final models show which variables are suitable to act as leading indicators for real estate forecasting in the Netherlands, United Kingdom and United States.

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1. Introduction

Although real estate represents an important component of investment funds, compared to other asset classes, there are relatively few studies that examine the performance characteristics of this asset class. When constructing funds, managers have to make decisions about which assets classes they want to invest in and to what amount. In order to make these profound strategic decisions about asset allocation, it is important to have an idea about the future performance of the different asset classes. In 2010, Dutch institutional investors had allocated about 10.5 percent, representing 122 billion euro in real estate, and in Europe it is estimated that around 700 billion euro has been invested in real estate. (Inrev, 2010) Looking at the number of studies focusing on forecasting returns of the other asset classes, it is surprising to see that the forecasting of real estate returns has not been given much academic attention. An explanation can be found in the limited availability of real estate data and the relatively young performance indices which in most countries have only been developed around 1990 - 2000.

The studies that can be found focus on the explanatory factors of real estate returns without trying to forecast them. When looking at the literature, three models have primarily been used in order to examine multiple factors influencing the returns of real estate. First, Chan, Hendershott and Sanders (1990) link bond and inflation related variables to returns. Second, Liu and Mei (1992) use bond and performance related variables; while third, Clayton and MacKinnon (2003) focus on the relationship with financial assets (i.e. stocks and bond) and real estate.

Since all three models have different approaches, they also find different factors that influence the returns of real estate. Chan, Hendershott, and Sanders (1990) find that the spread between high- and low-grade bonds, the slope of the term structure of interest rates, and unexpected inflation have explanatory power, while changes in expected inflation and industrial production do not. Liu and Mei (1992), on the other hand, find that cap rates are an important determinant of EREITs (European Real Estate Investment Trust) expected excess returns as they contain useful information about the general risk conditions in the economy. A third alternative to explain securitized real estate returns is to rely on the hybrid nature of this asset class. Clayton and MacKinnon (2003) find that the largest volatility in REITS is caused by large cap stocks, small cap stocks and bonds, with a real estate factor only causing small volatility.

While all three models give statistical significant results for the factors that influence real estate returns it appears that the factors that have an impact vary across country and time. In practice this means that portfolio managers are left with a wide choice of different models, all capable of explaining real estate returns to some degree. However, portfolio managers do not have the means to test all models, forcing them to choose the method that fits the company's way of thinking and develop this method the best way they can with the information that is available.

By using the known relationship between cap rates and return rates (Liu and Mei, 1992), ASR Real Estate Investment Management has started the development of a model to forecast the direction in which real estate returns will go. The so called Value Expectation Model links leading indicators and investor sentiment to changes in cap rates and thus changes in returns. These linkages are backed up by research of Chervachidze, Costello and Wheaton (2009), in which they proof that cap rates are influenced by risk free treasury rates, general corporate risk premium, liquidity, and investor sentiment.

However, the forecasting model goes further than just forecasting changes in cap rates. First, the model separates total return into income return and capital growth, according to the Investment Property Databank (IPD) calculation methods. After this distinction is made, the model splits up capital growth into rental value growth and yield shift, representing the rental and investment markets real estate operates in.

Rental value growth is the change in the level of rent that is estimated that a property might achieve were it to be let on the open market while yield shift quantifies the impact of change in yields on capital growth.

By finding leading indicators that effect the rental value and yield shift, the model is able to forecast changes in returns on the lowest possible level. Currently, the model uses changes in employment rates and economic sentiment to forecast changes in returns. Figure 1 clearly shows the distinctions that the model makes.

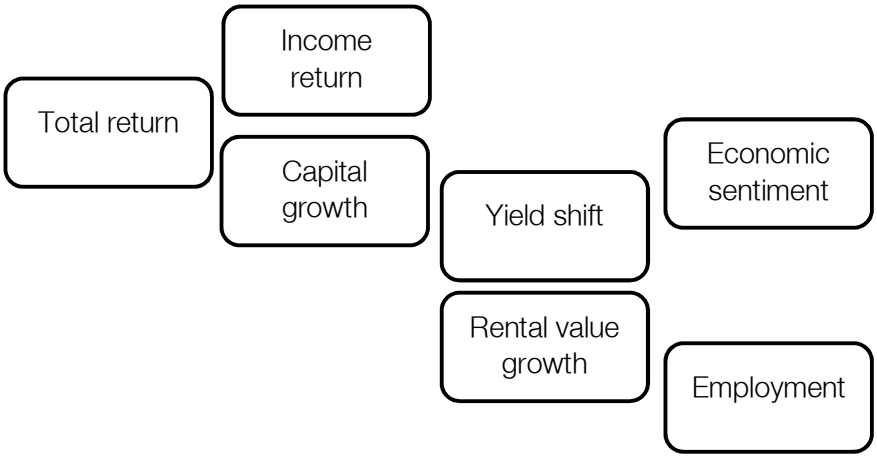


Figure 1: Distinctions made in the Value Expectation Model

Goal of the study

Because the Value Expectation Model currently relies on only economic sentiment and employment, the model gives a very rough estimation and can only be used for short term insights.

The goal of this study is to find indicators that can provide early signals, so called leading indicators, that explain changes in yield shift and rental value growth of real estate and that can be used to forecast the change in capital growth according to property types.

This study will mainly be of importance for fund managers. By developing a practical method to forecast changes in real estate returns, fund managers will be given a rough estimation of future performance of their real estate; improving decision making processes, decreasing risks and adding a useful tool to asset allocation. However, the developed methodology can also be used for the forecasting of other real estate related variables.

Problem statement

The main question this study aims to answer is:

How can leading indicators be used to forecast changes in international capital growth of real estate?

To answer this question, it is divided into multiple sub questions;

> Which explanatory variables can be found for changes in rental value growth for the different property types?
>
> Which explanatory variables can be found for changes in yield shift for the different property types?
>
> Which explanatory variables can be used to forecast changes in rental value growth and yield shift?

Scope of the research

It is important to apply boundaries to the research. First, the Value Expectation Model is used at an international level in order to compare future real estate returns across countries. Therefore the leading indicators for changes in yield shift and rental value growth have to be at a national level and not at a regional or local level.

Secondly, looking at the limited availability of time, the developed forecasting model will be constructed for the Netherlands and tested on the United States and United Kingdom. This creates the possibility to evaluate the model and test the suitability for international use. Furthermore, robustness tests will be run in order to evaluate the stability of the models.

Structure of the report

The report can be broadly divided into four major parts. First of all the theoretical background of the thesis will be discussed in the literature reviews of rental value growth, yield shift and economic leading indicators. The second part will focus on the methodology that is used and discusses the conceptual model, used data and actual methodology. The third part reports the results of the study, the international comparison and the robustness tests. The fourth and final part gives an example of practical use, the conclusions, and gives further recommendations.

2. Literature review

Due to the fact that the separation of capital growth into rental value and yield shift is not common in real estate literature, this literature review will focus on the existing literature concerning determinants that influence changes in rental value and yields. The most important studies will be shortly discussed and the explanatory variables that are found significant in current literature will be listed. Furthermore, the application of economic indicators in real estate literature will be studied.

Rental value growth

Determining the variables that influence rent levels and the forecasting of rent levels have been broadly researched in property literature. Forecasts of rent are a fundamental input into individual property valuation and rent is probably the most important variable in property economics. As a result, rent determination has been extensively covered in the academic literature, although dominated by U.S. and U.K. based researchers and mostly focused on office markets.

In literature two main models can be distinguished. First, the U.S. models focus on how real rent adjusts to deviations of the vacancy rate from the natural or equilibrium rate. (Hendershott, McGregor and Tse, 2002) Second, U.K. literature focuses on the relation between demand and supply characteristics and their influence on real rents. (Gardiner and Henneberry, 1991) This paragraph will discuss both models and the explanatory variables that are used in these models.

Rental adjustment approach

The rental adjustment approach has its origins in labor economics, where real wage inflation has been related to deviations of the employment rate from the natural or full employment rate. In essence, the rental adjustment approach states that, even when property markets are in equilibrium, some vacant space should be expected. This is due to two reasons. Firstly, frictional vacancies are inevitable in property markets since there are always people moving. Secondly, some landlords will choose to not let their properties at current market rents because they hope to find tenants who are prepared to pay more. (Henderschott et al., 1991)

The so called Natural Vacancy Rate (NVR) is the proportion of vacant space due to frictional vacancies and landlords waiting for better offers. Because this rate of vacancies is compatible with market equilibrium, the NVR is consistent with a stable rent level.

The rental adjustment approach states that when the actual vacancy rate exceeds the NVR, rents will fall in order to flow back to an equilibrium. Furthermore, when the actual vacancy rate is below the NVR, rents will rise. Thus, the rental adjustment approach expresses rental growth as the gap between the actual and natural vacancy rate.

There have been many studies that use the rental adjustment approach to explain changes in real rents, all with a slightly different methodology or different goal. The most important studies will be shortly discussed.

In 1983, Rosen and Smith studied the price adjustment process for rental housing and created a model that showed the relationship between the difference of natural vacancy rate and the current vacancy rate, and rent adjustments. Shilling, Sirmans, and Corgel (1985) analyzed the price adjustment process for rental office space across the United States and confirmed that the rental adjustment approach can also be used for office space.

Pollakowski, Wachter and Lynford (1992) made use of three equations in order to explain rent adjustments and test for structural differences in office markets by size class.

Their model makes use of demand side, supply side, and rental adjustment equations. In these equations they use office employment and rate of employment growth as demand side proxies and a combination of total amount of office space, construction costs, operating costs, and interest rates as supply side proxies. The rental price adjustment equation is calculated by using the spread between the natural vacancy rate and the current vacancy rate. By combining all three equations they are able to proof a difference between the models per Metropolitan Statistical Area (MSA).

In 1997 Wheaton, Torto, and Evans developed a methodology to estimating and forecasting the greater London office market. They estimate structural equations for office space demand, new supply, and rental movements. For office space demand they use existing literature to point out that employment growth is a good indicator. Rental movements are determined by the vacancy and absorption rates, while new supply is dependent of the asset price of office space relative to its replacement costs. The asset price of office space in turn should be based on current effective net rental income (considering vacancy) and a capitalization rate. Therefore, Wheaton et al. use office rents, vacancy rates, interest rates and replacement costs in their supply equation. By using the three equations and their variables, Wheaton et al. are able to model the cyclic behavior of the office market in greater London.

In short, the studies that make use of the rental adjustment approach use the difference between the Natural Vacancy Rate and the current vacancy rate to explain changes in rental value. By defining the NVR and current vacancy rate as a dependent of demand and supply side variables researchers are able to forecast future changes in rental value.

Demand – supply Framework

The demand – supply framework that is mostly found in U.K. literature considers real rent as a dependent of both demand and supply factors and is actually a part of bigger models made for total real estate markets. The model states that when the demand grows, all else equal, real rents will rise. Furthermore, if the supply grows while all else stays equal, real rent levels will lower. The model can be looked upon as a simplified version of the rental adjustment approach, used because vacancy rates were not available in Europe at the time.

There have been multiple studies that have researched the determinants of supply and demand characteristics in order to predict rents. Gardiner and Henneberry (1991) developed a simple regional office rent prediction model and found changes in regional gross domestic product to be the best indicator for variations in demand. The percentage change of total stock of office floor space was used to measure variations in supply. Forecasts of both indicators were used to forecast changes in rent.

Thompson and Tsolacos (2000) used a similar three-equation system as Wheaton et al. (1997) to model the industrial property market in Great Britain. They used previous work that has proven that industrial rents are impacted by macroeconomic and industrial sector trends, and variables such as the gross domestic product and manufacturing output have appeared significant. The three-equation system they use consists of new supply, rent, and availability of industrial floor space equations. The quantity of new industrial space supply is specified as a function of industrial rents and construction costs. Rents are a function of past rents and the level of available floor space. The availability of industrial floor space is on its turn determined by both supply and demand factors. These are proxied as an equation of the current gross domestic product, the past gross domestic product and the new supply.

D'arcy, McGough and Tsolacos took a different approach to existing literature and examined the influence of differences in market size and economic growth between cities in Europe on office markets. However, due to limited data availability they were only able to model the demand side of the framework. D'arcy et al. used two independent variables to capture the effect of general economic conditions on the demand of office space; GDP and short-term interest rates. Real GDP was included because previous work had indicated that it is a major determinant of office rents in European markets (Giussani et al., 1993). The incorporation of real short-term interest rates reflects the need to capture the impact of changes in monetary policy on the office market. (D'arcy, McGough and Tsolacos, 1997)

Benjamin, Jud, and Winkler (1998) studied the demand and supply for retail space by making use of a simultaneous model. This model uses four equations in order to explain the total retail market; a demand side, supply side, rental price, and vacancy rate equation. Demand is determined by the rental price of retail space and the level of retail sales. Supply is influenced by the previous rental price and the relative cost of producing. The rental price is determined as a function of the lagged rental price and the vacancy rate. Vacancy rate is in its turn related to the demand and supply equations. (Benjamin et al., 1998)

It has become apparent that every study of rental value has a slightly different approach but that the theoretical models have barely changed. Depending on the used theoretical model, changes in rental value are caused by changes in demand, supply and / or the spread between the natural vacancy rate and current vacancy rate. Table 1 shows all variables that are found significant in current literature.

Office market	Retail market	Industrial market	Housing market
Absorption rate	Retail sales	Past rents	Natural vacancy rate
New construction orders	Past rent	Construction costs	Vacancy rate
Vacancy rate	Cost of producing	Available floor space	
Total stock of space	Vacancy rate	GDP	
Occupied stock of space		Past growth GDP	
Office employment			
Replacement costs			
Interest rates			
Employment growth			
Natural vacancy rate			
Construction costs			
Operating costs			
GDP			

Table 1: Significant variables for rental value according to current literature

Yield shift

Yield shift is the change in capital values due to changes in capitalization rates. Capitalization rates or “cap” rates play a central role in real estate investment decisions since they offer a fast way of estimating property values. In essence, the cap rate is a way of quoting observed property prices in relation to the expected first year income. Thus, when the first year income stays the same while cap rates rise, the price investors are willing to pay will lower and vice versa.

Cap rates have received increased attention over the past decade as real estate has established itself as a mainstream investment category. Two streams of studies can be found in early cap rate literature. First, there have been studies explaining the role different factors play in cap rate fluctuations. Secondly, cross sectional variations of cap rates have been researched. More recent studies have focused on finding additional explanatory variables and use alternative models.

Dokko, Edelstein, Pomer, and Urdang (1993) were among the first to analyze the economic forces that determine the real rate of return and indirectly cap rates. They find that the real rate of return differs by land use, market area, and inflation. Ambrose and Nourse continue the research of Dokko et al. and analyze the difference by property type. Furthermore, they relate location factors, the stock market earning/price ration, and risk premium on long term debt to variation in cap rates and find that these are significant.

More recently, McGough, Olkkonen, and Tsolacos (2000) try to forecast office property returns in Helsinki by using econometric specifications. Their study shows that office returns are mostly influenced by variations in GDP. Furthermore, the index of all stock returns, that reflects market sentiment, also affects office returns.

In 2001, Sivitanides, Sothard, Torto, and Wheaton are the first to study how cap rates vary across markets and time using the NCREIF database. They model cap rates as an adjustment process around equilibrium values and state that cap rates are influenced by two sets of variables; discount rate influences and factors that shape income growth expectations (Sivitanides et al. 2001). In their study they find that the ten year Treasury rate, annual percentage change in Consumer Price Index (CPI), and a real rent index all explain variations in capitalization rates.

Chichernea, Miller, Fisher, Sklarz, and White (2007) take a different approach by making use of the classic Gordon growth model and applying it to commercial real estate. The model states that the cap rate is the nominal rate of return minus the expected long term income growth. By finding factors that influence differences in expected growth rates and risk premia, variations in cap rates can be explained.

According to previous literature, expected growth rates are influenced by demand and supply side effects, and risk premia are influenced by liquidity and capital flows. Chichernea et al. (2007) use employment growth, GMP growth, income growth and population growth as demand side effects, while they use indices reflecting supply regulation as supply side effects. Liquidity is proxied as the average sales volume and capital flows are reflected by a cap rate ratio. The research shows that variations in cap rates are largely determined by supply constraints and the liquidity of different geographical markets and that demand side variables are not found significant.

Chervachidze, Costello and Wheaton (2009) make use of existing cap rate literature that states that cap rates are determined by rent levels, rental growth and risk free interest rates. However, they add the idea that macro-economic capital flows and the availability of debt may also affect capital pricing. They add two factors to the commonly used cap rate determinants; first, the degree of general risk aversion in the economy is added, which is measured with a standardized corporate bond spread. Secondly, the availability of debt in the economy scaled by GDP is added. Although these two factors greatly add to the ability to explain cap rate variations, Chervachidze et al. test their model for other shifts in the cap rate and find that another factor is of great importance: investor sentiment.

Although capitalization rate research is not as abundant as the research done to rental values, there still is a standard framework of variables that has proven to be of influence to cap rates. Most studies rely on variables that influence general economic growth indicators, as can be seen in table 2.

Variables	
Real T-Bond yield	Capital flow (Cap rate ratio)
Risk spread (Moody's & 10 year t-bond)	Risk free rate (10 year Treasury)
Investor sentiment	Changes in rent
Supply constraints	GDP
Sales volume	Stock Total Return Index

Table 2: Significant variables for yield shift according to current literature

Economic indicators

In addition to the variables that are found in real estate literature this study looks at other factors that can explain future performance of real estate. Commonly known, real estate markets react slowly to changes in the business cycle, causing the real estate cycle to lag behind. Since economists have been researching ways to forecast changes in business cycles by using economic indicators, this source can also be useful to predict changes in the lagging real estate markets.

Economic indicators are statistics about the economy that have proven to be useful tools for analysing economic performance and predictions of future performance. By making use of the movement of business cycles, economic indicators can give insight into the current and future economic phases. Economic indicators are classified into three categories: leading, coincident and lagging, based on the timing of their movements.

Leading indicators are indicators that tend to shift direction in advance of the business cycle and are therefore useful as short-term predictors of the economy. Coincident indicators define the business cycle and provide information about the current state of the economy. Lagging indicators tend to change direction after the coincident cycles and help to confirm recent movement in the leading and coincident indicators. (The Conference Board, 2001)

The focus of this chapter will be on leading indicators since they are able to give information about future performance.

The Organisation for Economic Co-operation and Development (OECD) constructs the Composite Leading Indicators Index for all OECD member countries. This index makes use of different economic indicators per country, dependent on the statistical significance, and is able to identify turning points between two to eight months ahead. (OECD, 2012)

For the Netherlands, this composite index consists of the following leading indicators:

- Consumer confidence
- Share prices: total index
- Money supply, M2
- Order books: level (manufacturing)
- Production: future tendency (manufacturing)
- Finished goods stocks: level (manufacturing)
- Orders inflow: tendency (manufacturing)
- Ifo business climate indicator for Germany

In addition to the OECD Leading Index, The Conference Board (the official supplier of U.S. economic indicators) has also composed a leading index for the Euro Area in total, using slightly different indicators.

Although the two leading indicator indices give information about future business cycle turning points, it is important to use this information with caution. A brief decline in one month does not mean that there is indeed a cyclical downturn. The Conference Board gives three rules of thumb to evaluate the true signal of a cyclical movement; duration, depth and diffusion. They state that the longer the weakness lasts, the deeper it gets and the more widespread it becomes, the more likely a recession will occur. (The Conference Board, 2001)

In real estate literature, there are very few studies that have researched the potential of economic indicators to forecast changes in real estate returns.

Matysiak and Tsolacos (2003) studied the application of leading indicators in forecasting rental return in the U.K. They start with ten leading indicators that are commonly used in economic leading indicator indexes and are able to find a potential forecasting ability. Their study concludes that only four indicators qualify: the Treasury Bill rate, the gilt yield, the volume of retail sales and the narrow money supply measure. However, the results vary through time and across property types. In 2004, Krystalogianni, Matysiak and Tsolacos continue their research on leading indicators by using them to forecast changes in capital growth. By using a probit regression they are able to greatly reduce the number of indicators and find that different combinations of leading indicators are significant for the different property types. Even more, they calculate the number of lags of the indicators that suit best. Krystalogianni et al. (2004) conclude that their forecasting model offers a valuable means for turning point detection in the commercial property markets.

Economic leading indicators give information about future business cycle behavior but can also be used to forecast capital growth. These indicators can be a good alternative to traditional forecasting models, and the idea is that by combining them with the previously listed real estate variables, a better view of the future performance of real estate can be created.

3. Conceptual model

By making use of the information acquired by the literature review, the lists of variables are used to create the conceptual model. Figure 2 shows the relations between the dependent and independents variables, where economic leading indicators is a group variable which contains the leading indicators best fitted for each country. The variables of the conceptual model will be discussed in chapter four.

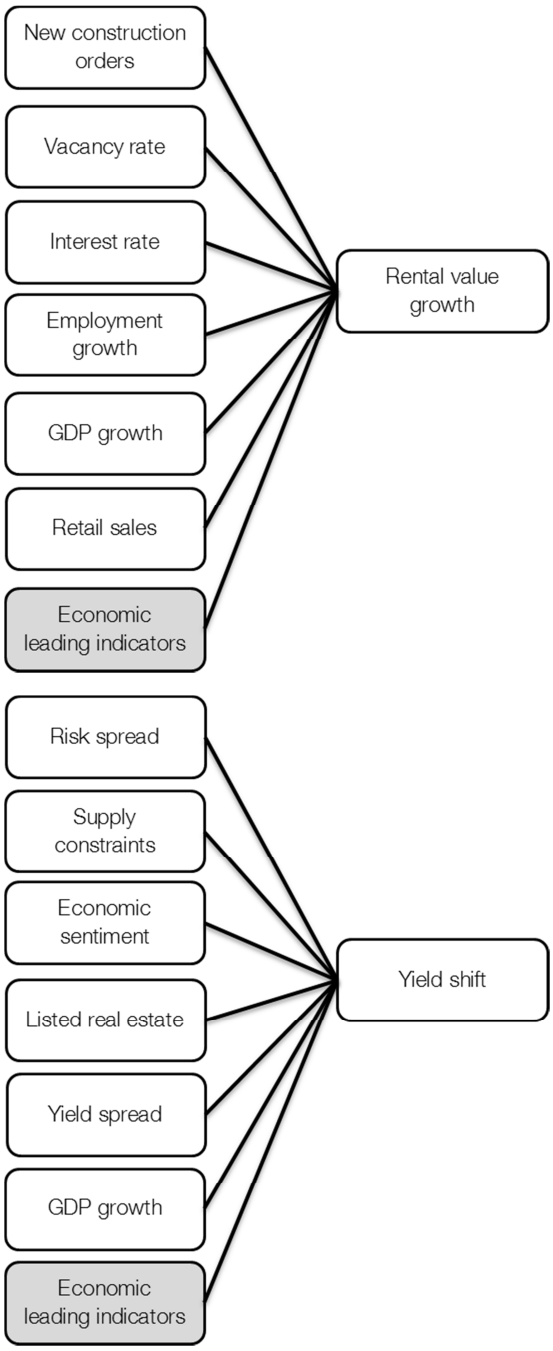


Figure 2: Conceptual model

4. Data

This chapter discusses the characteristics of the different variables that will be studied according to the conceptual model. Each variable will be shortly discussed, its relation with the dependent variables shown and the source and frequency of the data given.

Rental value growth and yield shift

As previously described rental value growth and yield shift are both responsible for changes in capital growth and represent the rental and investment market. These dependent variables are given by IPD and available on a quarterly basis.

New building permits

The amount of new construction orders should give a good indication of future construction and thus future additions to the stock. Although in some countries this variable is tracked, in most countries this is not the case. Instead, the amount of new building permits is used, which is available for almost every country. Theory suggests that when more building permits are issued, the economy is starting to recover. However, since more construction also means an increase in stock, it is believed that (when everything else stays the same) the rental value should decrease.

The amount of new building permits is available on a monthly basis and given by the Central Bureau of Statistics (CBS).

Spread natural – current vacancy rate

The spread between natural and current vacancy rate is a good indicator of the current state of the property market. If the current vacancy rate is bigger than the natural vacancy rate, rent levels should fall. If the opposite is the case, rents should rise. Problem of this definition is that the natural vacancy rate is very hard to calculate and that even the current vacancy rate is not available for most countries. Instead, the percentage of vacancy to rental value is used as an indicator. The higher the vacancy rate, the lower the rents.

This variable is given by IPD and available on an annual basis.

Interest rate

The interest rate is a variable that is used to give an indication of the monetary policy and its impact on real estate. It is widely known that interest rates have significant impact on economic activity and therefore the demand of space. Although the impact of interest rates on real estate returns has been researched multiple times, the outcomes of these studies where different every time. It is fair to not predict the negative or positive influence but to let the model decide.

The yield on the ten year Government Bond is used as a proxy for the interest rate and is available on a monthly basis, given by de Nederlandsche Bank (DNB).

Employment growth

There is considerable evidence that the demand of space is primarily driven by employment growth. An increase in employment should increase rent levels and vice versa. The employment variable is available on a monthly basis and is given by the CBS.

GDP growth

GDP captures the effects of general economic conditions on the demand of property space and thus the rent levels. Furthermore, GDP picks up a broader set of influences on the demand than narrower indicators like employment growth. GDP growth should increase the demand of space and increase rent levels, while a decay in GDP is expected to lower rent levels.

GDP is available on a quarterly basis and is given by the Central Bureau of Statistics.

Retail sales

The volume of retail sales has the most impact on retail property. However, this variable is also used as an indicator for the broader economy and thus might have an impact on rent levels of other property types. It has been proven that when the volume of retail sales rises, rent levels rise and vice versa.

The volume of retail sales is available on a monthly basis and supplied by the Central Bureau of Statistics.

Risk spread

The risk spread is used as an indicator of the degree of general risk aversion in the economy and is measured by the spread between corporate bonds and government bonds. A significant difference between the two bonds means that the associated premium demanded by investors will increase and thus real estate yields will have to increase. The risk spread is calculated on a monthly basis and based on the IBOXX European Corporate Bond yield and the ten year Government Bond yield.

Supply constraints

Although demand side effects play an important role in rental growth and yield shifts, supply side effects also influence the growth rates. If it is impossible to add new supply to a certain area, everything else staying equal, rents will rise and yields will grow. The value of supply constraints is thus an important factor to take into account. Although there have been some studies that researched these constraints, they are limited to the US and there is no universal method available. Future research might make it possible to use this variable in the model.

Economic sentiment

Economic sentiment can be defined as a qualitative outlook to future economic developments by different sectors. A good indicator for economic sentiment is the Economic Sentiment Index (ESI) created by the European Commission. The index consists of surveys for different sectors of the economy, hereby creating an index that is useful for monitoring economic developments. (The Joint Harmonised EU Programme of Business and Consumer Surveys User Guide, 2007) The ESI is also used for its ability to forecast turning points in the economy. Just like the economic leading index it gives information about future developments, the difference being that it is based on opinions and not on quantitative data. The index is available on a monthly basis.

Listed real estate

Listed or publicly traded real estate are real estate securities that are traded on the open market, offering the advantages of real estate, without the need to invest large amounts of money. It is believed that there is a relationship between the performance of listed real estate and the performance of the underlying direct real estate. The most widely used indices for listed real estate are the FTSE EPRA/NAREIT indices and for this study, the European version will be used. The index is available on a monthly basis.

Yield spread

The yield spread is the spread between the long term interest rate and the short term interest rate. The long term interest rate is defined by the ten year government bond yield, while the short term interest rate is defined by the 3 month government bond yield. Both variables are available on a daily basis.

Economic leading index

The Economic Leading Index is an index of multiple economic leading indicators designed by the OECD (Organisation for Economic Cooperation and Development) to anticipate turning points in economic activity. The index should signal a downturn in the economy a few months ahead and thus signal a decrease in rent levels and yields even earlier. The index is available on a monthly basis and consists out of the consumer confidence index, total share prices index, M2 money supply, level of order books, expectation of future production, level of finished goods, expectation of new orders, and the business climate indicator for Germany. The individual components will be discussed below.

Consumer confidence

Consumer confidence indicates the extent to which households think that the economy is doing better or worse. Consumer confidence is based on the sentiments of households about the economic climate and their financial situation.

Total share prices

The index of total share prices measures share value changes of all listed companies and is a good indicator of the current economic situation. In this study the MSCI All Share Index will be used which is available on a daily basis.

M2 Money supply

Money supply is the total amount of monetary assets available in an economy at a specific time. M2 money supply is a specified way of calculating this money supply and often used to forecast inflation rates due to the strong relation between money supply growth and long term inflation. Since rapid increases in money supply cause rapid increases in prices, governments often rely on monetary policy to control inflation.

Level of order books

Level of order books is part of a monthly business climate survey. In the survey, the question is asked whether the current overall order books are more than sufficient, sufficient or not sufficient. By transforming the results of the questions into an index, a view of the overall order books can be created. The index used in the economic leading index only uses the surveys of manufacturing companies.

Expectation of future production

The expectation of future production is also a part of the monthly business climate survey. The manufacturing companies are asked what their expectations of future production are and if the production will increase, remain unchanged or decrease. An increase in production could suggest economic growth.

Level of finished goods

Another part of the monthly business climate survey is the level of finished goods in stock. The question is asked whether the current stock of finished products is too large, adequate or too small.

Expectation of orders inflow

The last component of the economic leading index that is part of the business climate indicator is the expectation of orders inflow. Manufacturing companies are asked if the value of the orders they expect to place with suppliers will increase, remain unchanged or decrease.

German business climate indicator

Since the Dutch economy has a strong relation with the German economy, the German business climate indicator is part of the Dutch economic leading indicator index. The Ifo German Business Climate index is based on monthly survey responses of firms in manufacturing, construction, wholesaling and retailing. (Cesifo Group, 2013)

Table 3 gives an overview of the variables and their characteristics.

Variable	Source	Frequency	Available since
Yield shift	IPD	Quarterly	Q1 1998
Rental value growth	IPD	Quarterly	Q1 1998
Real estate literature variables			
New building permits	CBS	Quarterly	Q1 1994
Vacancy rate	IPD	Annual	Q1 1998
Interest rate	DNB	Monthly	Q1 1960
Employment growth	CBS	Monthly	Q1 2000
GDP growth	CBS	Quarterly	Q1 1988
Retail sales	CBS	Monthly	Q1 2000
Risk spread (corporate bond - government bond)	IBOXX	Monthly	Q1 1999
Supply constraints	n.a.	n.a.	
Economic sentiment	EC	Monthly	Q1 1985
Corporate bond yield	IBOXX	Daily	Q1 1999
3 month government bond yield	OECD	Quarterly	Q1 1986
Global trade	CPB	Monthly	Q1 1991
Listed real estate	EPRA	Monthly	Q1 1990
Yield spread (10 year gov - 3 month gov)	DNB	Monthly	Q1 1986
Economic leading index	EC	Monthly	Q2 1961
Economic leading indicators			
Consumer confidence	CBS	Monthly	Q2 1961
Total share prices	MSCI	Monthly	Q2 1961
Money supply, M2	DNB	Monthly	Q2 1961
Level of order books	CBS	Monthly	Q2 1961
Expectation of future production	CBS	Monthly	Q2 1961
Level of finished goods	CBS	Monthly	Q2 1961
Expectation of orders inflow	CBS	Monthly	Q2 1961
German business climate indicator	Cesifo	Monthly	Q2 1961

Table 3: Used variables; source, frequency and availability

Data limitations

The main limitations of the data are twofold. First of all, real estate data has a relatively young existence, the Dutch IPD indices are only available since 1998, causing the number of observations to be limited. Secondly, the data is limited by the frequency of the dependent variables. Because the highest frequency of the Dutch IPD indices is on a quarterly basis, the study with the highest amount of observations is on a quarterly basis, eliminating the possibility to use vacancy rate, which is only available on an annual basis. Although quarterly data can also be transformed to annual data, the number of observations would be too small to yield significant results.

As a summary, table 4 shows the descriptive statistics of the discussed variables on a quarterly frequency.

Variable	N	Mean	Median	SD	Min	Max
Yield shift overall	56	111,96	110,66	5,81	100,00	124,39
Yield shift industrial	56	103,99	105,71	6,21	89,25	113,94
Yield shift office	56	99,49	101,25	5,89	83,97	107,40
Yield shift retail	56	108,36	108,22	6,31	100,00	120,72
Rental value overall	56	119,95	120,20	9,33	100,00	132,71
Rental value industrial	56	108,91	108,57	4,20	100,00	115,54
Rental value office	56	115,05	116,40	5,02	100,00	119,65
Rental value retail	56	117,82	117,63	9,27	100,00	131,29
Real estate literature variables						
New building permits	56	19158,82	18277,00	4751,06	10843,00	30926,00
Interest rate	56	4,15	4,09	0,76	2,43	5,60
Employment	48	7168,67	7059,00	220,63	6868,00	7549,00
GDP (€)	56	128024,95	126541,00	9174,32	109449,00	141307,00
Retail sales	48	98,83	98,50	6,42	85,00	112,00
Risk spread	52	0,91	0,70	0,83	-0,06	4,06
Economic sentiment	56	101,16	101,55	10,83	69,70	116,10
Corporate bond yield	52	5,02	4,70	1,02	3,49	8,01
3 month government bond yield	56	2,90	2,99	1,26	0,66	5,02
Global trade	56	124,80	124,11	25,05	93,01	173,35
Listed real estate	56	1246,70	1199,48	333,09	779,09	2150,00
Yield spread	56	1,25	1,35	0,88	-0,50	2,78
Economic leading index	56	99,63	100,02	7,15	85,79	109,90
Economic leading indicators						
Consumer confidence	56	-8,18	-11,50	18,89	-38,00	26,00
Total share prices	56	100,12	100,28	1,86	96,02	103,11
Money supply, M2 (€)	56	508334,20	478879,50	148470,68	275128,00	727261,00
Level of order books	56	99,99	100,07	1,49	95,54	101,95
Expectation of future production	56	100,04	100,10	1,88	93,05	103,20
Level of finished goods	56	100,01	100,02	0,52	99,10	101,56
Expectation of orders inflow	56	99,95	100,35	1,83	92,94	102,40
German business climate indicator	56	100,05	100,30	1,47	95,54	102,16

Table 4: Descriptive statistics of the used data

The descriptive statistics of the data show that most variables are available as indices with means around 100 and relatively small standard deviations. However, there are also some variables where the data is used in absolute numbers, new building permits, employment, GDP, M2 money supply among others. The values of these variables differ significantly from the standardized indices and they have higher standard deviations. Although transformation into indices would resolve this, the choice is made to use the purest form of data in this stage, to avoid any unwanted effects of transformations.

5. Methodology

It is important to be aware of the goal of the research in order to choose the best method for analyzing the data and constructing the models. Although the goal is to forecast changes in rental value growth and yield shifts as a result of the listed explanatory variables, there is no intention to estimate exact growth rates. The emphasis of the forecast is on the direction of change i.e. will rental value growth / yield shift increase, stay the same, or decrease. Furthermore, the input data is not normally distributed and there is no linear relationship between the independent and dependent variables, limiting data analysis techniques.

The best way of analyzing the data is therefore by using a logistic regression. The logistic regression is a regression where the dependent variable is binary and thus can only take two values, one or zero. The logistic regression estimates the probability of a certain event occurring by transforming the binary dependent into a logit variable which is the natural logarithm of the odds of the dependent variable occurring or not.

Logistic regression looks very similar to linear regression, just like in linear regression, logit coefficients correspond to coefficients in the logistic regression equation, the standardized logit coefficients correspond to beta weights and a pseudo R^2 is available to indicate the fit of the statistical models.

However, there are some important differences between logistic regression and linear regression which make it perfect for this study. First of all, logistic regression does not require normally distributed variables. And secondly, logistic regression does not assume a linear relationship between the independent variables and the dependent variable, as can be seen in figure 3. (Rice, 1994)

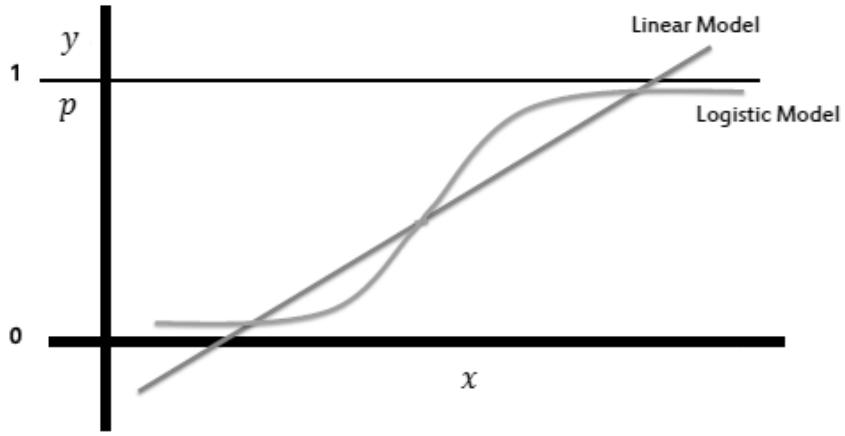


Figure 3: Linear model versus logistic model

Where linear regressions generate the following regression equation:

$$y = b_0 + b_1 x_1 + b_2 x_2 + b_n x_n + \varepsilon$$

in which b_1, b_2, b_n represent the regression coefficients, x_1, x_2, x_n represent the explanatory variables and ε represents the error term.

Logistic regression equations have a different form; $\ln \frac{p}{1-p} = b_0 + b_1 x_1 + b_2 x_2 + b_n x_n + \varepsilon$, in which the terms have the same meaning and p represents the chance that a certain event will occur.

This equation can be transformed into a chance model, indicating the probability of occurrence.

$$p = \frac{1}{1+e^{-(b_0+b_1x_1+b_2x_2+b_nx_n+\varepsilon)}}$$

The logistic regression can be explained by making use of a practical example, for instance the tossing of a coin. In this example, a coin is tossed ten times and whether the toss will be head or tail is in this example determined by the weight of the coin and the strength of the toss. In a linear regression, the outcome would be a precise number of heads, for example six, with a certain error range. The outcome of the logistic regression is different, this outcome, dependent on the definition of the variables, could indicate the chance that there will be seven or more heads. So where the linear regression generates a precise number with a broad error range, the logistic regression generates a chance model, for example, 90 % chance that the tosses yield seven or more heads.

In order to be able to predict changes in rental value growth and yield shifts by using a model based on logistic regressions a number of steps have to be taken. First of all, the time series have to be de-trended. Secondly, the dependent variables have to be recoded into binary dependent variables for the logistic regression to work. Third, univariate logistic regressions will be run in order to find the significant variables. At last multivariate logistic regressions will be run to find the best suited combination of variables.

De-trending

Often economic and financial time series contain a long time (upward) trend. Meaning they can wander a long way from their mean value and contain a so called single unit root. Since these trends can influence the outcomes of the regressions, it is important to test the input data for stationarity (i.e. not having a trend). To test the data for stationarity the Augmented Dickey Fuller (ADF) test is used. If a time series shows a trend the logarithm is taken and the series is transformed into annual growth figures. This way the time series is de-trended and can be used in the logistic regression. Figure 4 shows what effect de-trending has on time series. The interest rate series shows a clear downward trend, while the de-trended series eliminates this trend.

Transformation of dependent variables

Logistic regressions only work if the dependent variable is either zero or one, and thus binary. Yield shift is transformed into a binary variable by recoding so that:

1 means that yield shift is positive

0 means that yield shift will be neutral or negative

Due to the fact that rental value growth has only been positive in the last years, it is impossible to run a logistic regression, since this requires two value (zero and one). Rental value growth has been transformed by correcting it for inflation, turning rental value growth into real rental value growth. It is recoded into:

1 means that there is real rental value growth

0 means that the real rental value will stay the same or decline

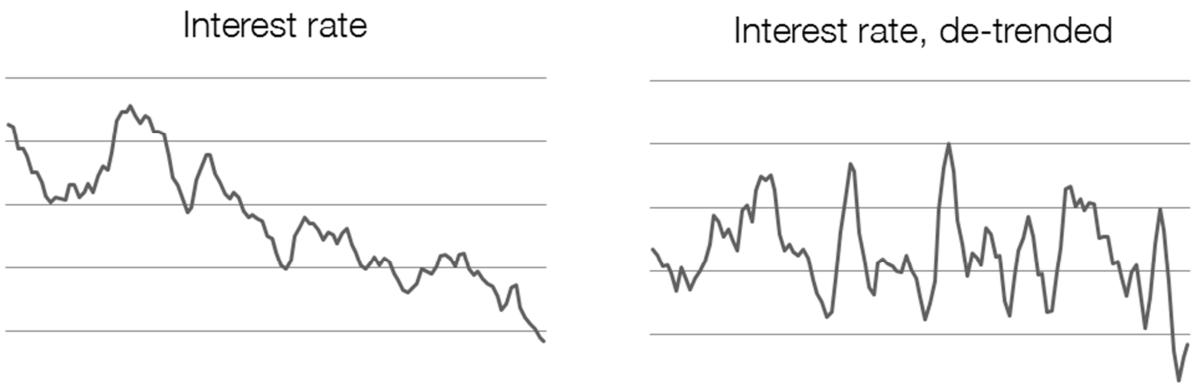


Figure 4: Example of the effects of de-trending

Univariate logistic regression

Due to the large amount of possible explanatory variables it is important to first test the ability of the individual variables to predict changes in rental value growth and yield shifts for the different property types. Furthermore, these univariate logistic regressions can be used to find the best suited number of leads that give the variables the most explanatory power. This number of leads shows how many quarters ahead a particular variable has the best predictive value and is based on the significance of the z-statistic and the modified McFadden R^2 (as developed by Estrella, 1998). The modified McFadden R^2 is a simple measure of goodness of fit that corresponds intuitively to the widely used coefficient of determination, R^2, in a standard linear regression. Unlike the R^2 used in an OLS regression, even low values of the modified McFadden R^2 (i.e. greater than 0.25) are considered acceptable (Krystallogianni et al., 2004).

The formula used to calculate the modified McFadden R^2 is: $R^2 = 1 - \left[\frac{LL_u}{LL_c}\right]^{-\left(\frac{2}{n}\right)LL_c}$

Where LL_u stands for the log likelihood of the unconstrained model (with variables)

LL_c stand for the log likelihood of the constrained model (constant only)

n stands for the amount of observations used in the regression

Multivariate logistic regression

Once the univariate logistic regressions have shown which variables are significant with the corresponding number of leads, the best fitted combination of variables can be researched. This is done by using a multivariate logistic regression. A stepwise method based on the Likelihood Ratio of the model provides the combination of variables that shows the best fit.

In short, the following methodology will be used to construct the regression models:

1. De-trending of time series by using quarterly growth rates
2. Transformation of dependent variables into binary variables
3. Univariate logistic regressions to find significant variables and best fitted number of leads
4. Multivariate logistic regressions to find best fitted combination of variables

6. Results

This chapter will discuss the execution of the different steps of the methodology and present the results of the regressions. The evaluation of the results and connection with the problem statement will be discussed in the conclusions of the thesis. As discussed earlier, the methodology will be used on the Netherlands by making use of quarterly data.

De-trending

As discussed earlier, economic and financial time series often contain long time trends. In order to de-trend the series the logarithm is taken and the series are transformed into annual growth rates. For this study, all variables have been transformed, with the exception of the risk spread, yield spread and consumer confidence. Table 5 displays the descriptive statistics of the transformed dataset. Due to the transformation, the number of observations is further limited, the dataset now contains data from Q1 1999 to Q4 2011.

Variable	N	Mean	Median	SD	Min	Max
Yield shift overall	52	0,0008	0,0012	0,0150	-0,0372	0,0209
Yield shift industrial	52	-0,0049	-0,0025	0,0158	-0,0461	0,0209
Yield shift office	52	-0,0056	-0,0025	0,0152	-0,0493	0,0157
Yield shift retail	52	0,0030	0,0022	0,0127	-0,0290	0,0244
Rental value overall	52	-0,0002	-0,0013	0,0043	-0,0078	0,0090
Rental value industrial	52	-0,0069	-0,0066	0,0099	-0,0301	0,0135
Rental value office	52	-0,0043	-0,0065	0,0088	-0,0216	0,0160
Rental value retail	52	-0,0003	-0,0006	0,0040	-0,0108	0,0086
Real estate literature variables						
New building permits	52	-0,0130	-0,0212	0,0868	-0,1902	0,1849
Interest rate	52	-0,0129	-0,0151	0,0641	-0,1407	0,1505
Employment	44	0,0026	0,0024	0,0065	-0,0111	0,0141
GDP	52	0,0073	0,0089	0,0096	-0,0207	0,0226
Retail sales	44	0,0024	0,0020	0,0122	-0,0248	0,0303
Risk spread	52	0,9033	0,6971	0,8375	-0,0625	4,0640
Economic sentiment	52	-0,0033	0,0008	0,0626	-0,1958	0,1396
Corporate bond yield	48	-0,0032	0,0061	0,1018	-0,2686	0,1882
3 month government bond yield	52	-0,0297	0,0070	0,2301	-0,7669	0,3104
Global trade	52	0,0171	0,0246	0,0352	-0,0868	0,0833
Listed real estate	52	0,0135	0,0427	0,1061	-0,2637	0,1540
Yield spread	52	1,2675	1,3750	0,9066	-0,5000	2,7800
Economic leading index	52	0,0074	0,0085	0,0104	-0,0252	0,0252
Economic leading indicators						
Consumer confidence	52	-10,1346	-12,0000	18,0902	-38,0000	26,0000
Total share prices	52	-0,0003	0,0024	0,0097	-0,0264	0,0170
Money supply, M2	52	0,0295	0,0297	0,0174	-0,0032	0,0648
Level of order books	52	0,0005	0,0003	0,0091	-0,0272	0,0175
Expectation of future production	52	0,0005	0,0000	0,0128	-0,0389	0,0368
Level of finished goods	52	0,0000	0,0000	0,0038	-0,0095	0,0083
Expectation of orders inflow	52	0,0002	0,0006	0,0131	-0,0377	0,0413
German business climate indicator	52	0,0005	0,0009	0,0093	-0,0245	0,0206

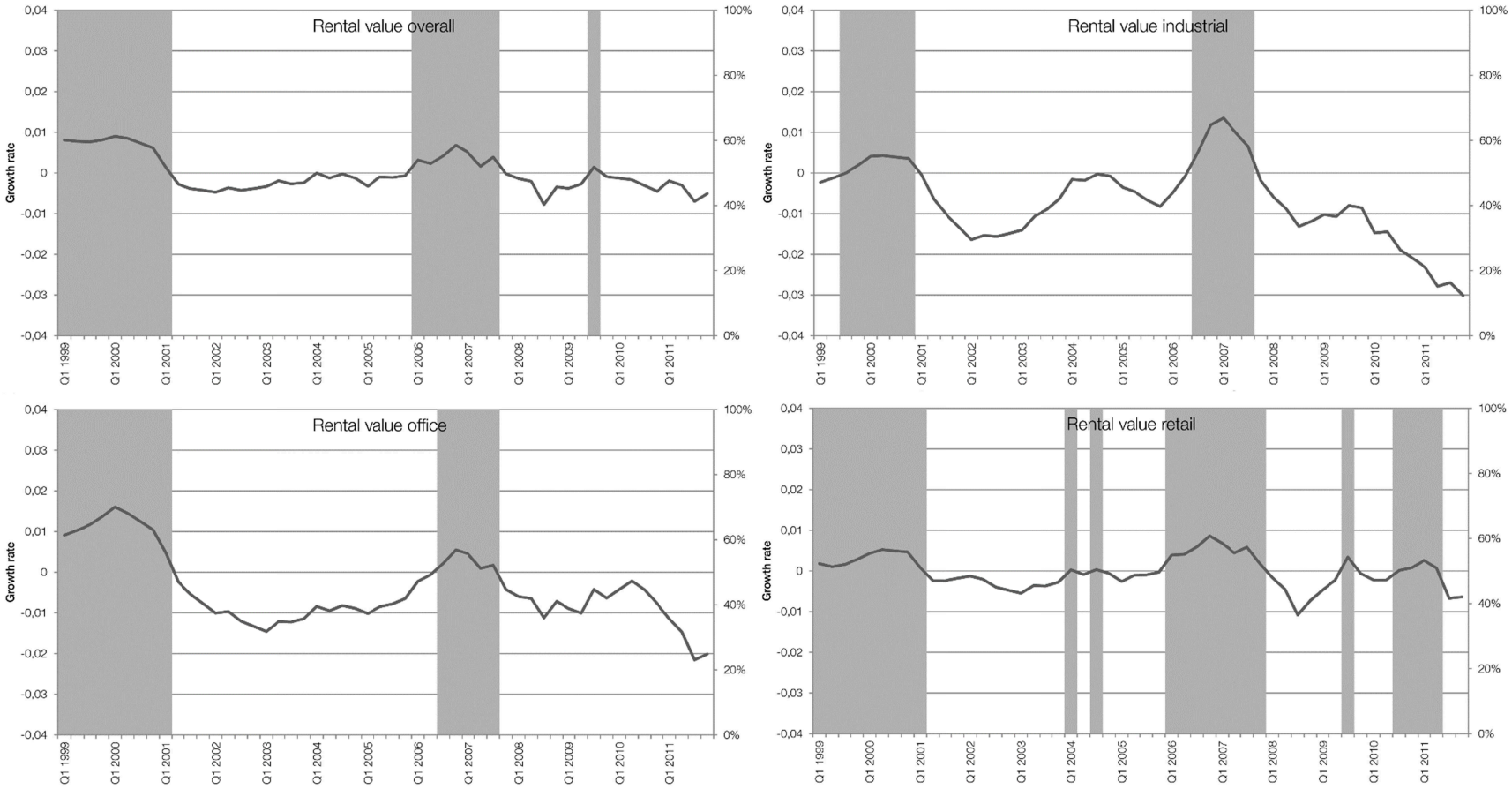
Table 5: Descriptive statistics of the used dataset after de-trending

Transformation of dependent variables

The dependent variables have been transformed according to the described methodology. Figure 5 and 6 show the graphs per property type for real rental value growth and yield shift. The lines in the graphs show the annual growth rate, the grey bars in the graphs show where the binary dependent variable has the value one, which corresponds to a growth rate above zero.

It becomes apparent that real rental value has seen relatively few periods of growth, with the exception of the retail market, which shows the most periods of real rental growth.

The yield shift graphs show a different picture than the real rental value growth graphs. There are more periods of positive yield shift and the periods last longer.


Rental value overall
Rental value industrial
Rental value office
Rental value retail
Growth rate
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-0,01
-0,02
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100%
80%
60%
40%
20%
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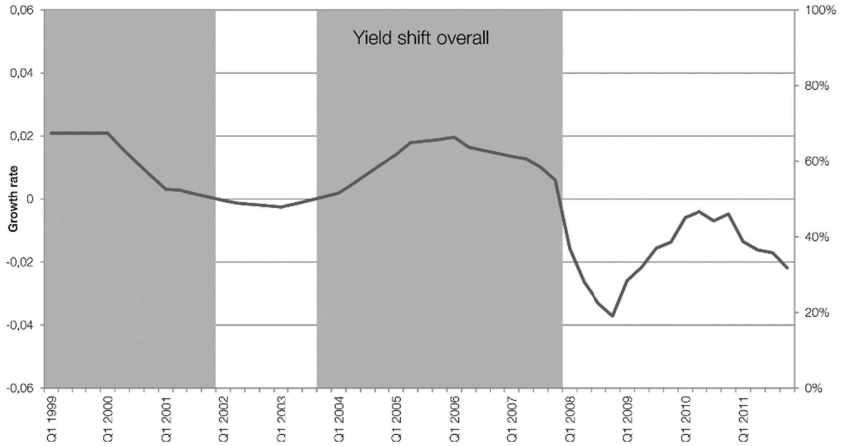
Q1 2011


Yield shift overall
Growth rate
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0
-0,02
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100%
80%
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20%
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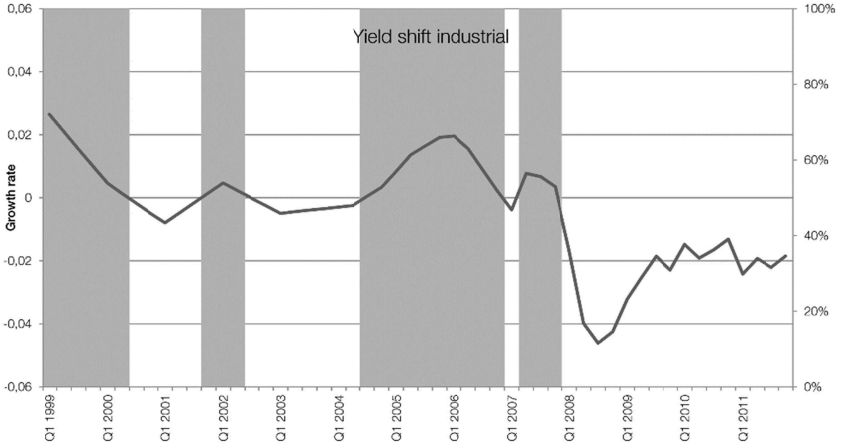
Yield shift industrial
Growth rate
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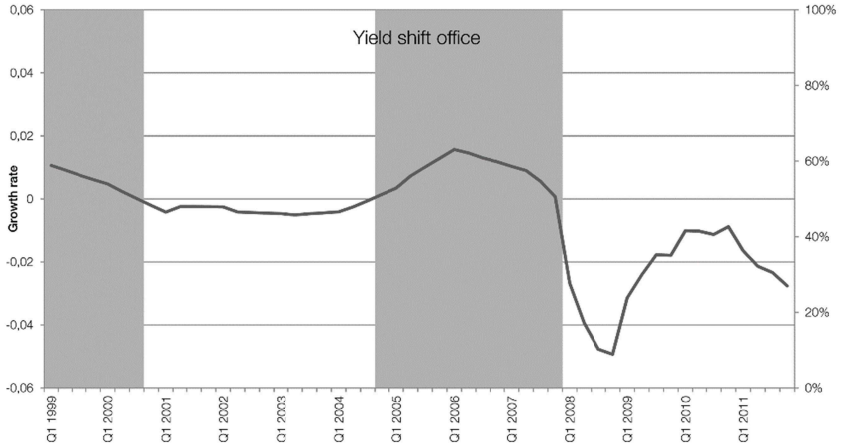
Q1 2010
Q1 2011


Yield shift office
Growth rate
0,06
0,04
0,02
0
-0,02
-0,04
-0,06
100%
80%
60%
40%
20%
0%
Q1 1999
Q1 2000
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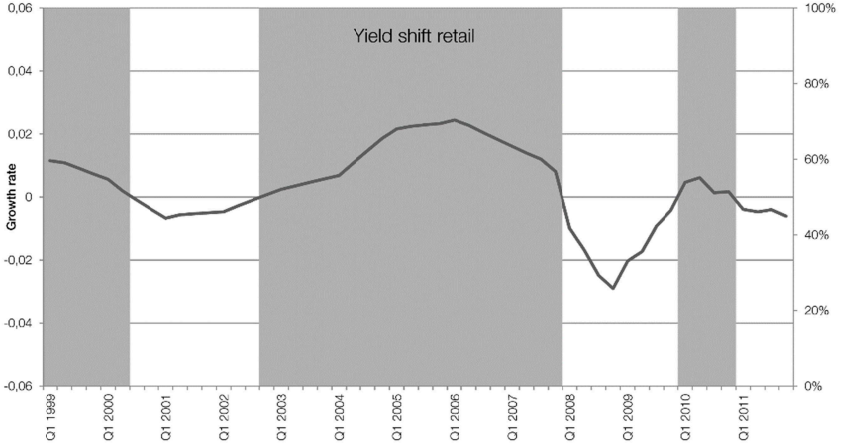
Yield shift retail
Growth rate
0,06
0,04
0,02
0
-0,02
-0,04
-0,06
100%
80%
60%
40%
20%
0%
Q1 1999
Q1 2000
Q1 2001
Q1 2002
Q1 2003
Q1 2004
Q1 2005
Q1 2006
Q1 2007
Q1 2008
Q1 2009
Q1 2010
Q1 2011

Univariate logistic regression

By making use of the de-trended data and the transformed dependent variables, the univariate logistic regressions are run. These regressions have resulted in a list of significant variables that are significant for the dependent variables on the 95 % level. Table 6 and 7 show these variables, including the best fitted number of leads.

Yield Shift Overall	Yield Shift Retail	Yield Shift Industrial	Yield Shift Office
Building permits (6)	Building permits (5)	Building permits (7)	Building permits (8)
Interest rate (10)	Interest rate (7)	Employment growth (10)	Interest rate (8)
Employment growth (10)	Employment growth (3)	GDP growth (1)	Employment growth (10)
GDP growth (1)	GDP growth (5)	Retail sales (10	GDP growth (1)
Retail sales (1)	Economic leading index (1)	Risk spread (2)	Retail sales (10)
Economic leading index (1)	Risk spread (1)	Corporate bond index (10)	Economic leading index (1)
Risk spread (2)	Investor sentiment (1)	3-month Gov. Bond (10)	Risk spread (5)
Corporate bond index (9)	Corporate bond index (9)	Listed real state index (4)	Investor sentiment (2)
3-mont Gov. Bond (10)	3-mont Gov. Bond (4)	Yield spread (10)	Corporate bond index (9)
Listed real estate index (1)	Yield spread (3)	Global trade (8)	3-month Gov. Bond (1)
Yield spread (9)	Consumer confidence (6)	Consumer confidence (10)	Listed real state index (2)
Consumer confidence (10)	Total share prices (1)	Total share prices (1)	Yield spread (10)
Total share prices (1)	Money supply, M2 (9)	Money supply, M2 (1)	Global trade (9)
Money supply, M2 (1)	Order book volume (5)	Order book volume (7)	Consumer confidence (9)
	Future production (1)	Level of finished goods (8)	Total share prices (1)
	Level of finished goods (6)	Exp. order inflow (9)	Money supply, M2 (1)
	Exp. order inflow (1)	German BCI (8)	

Table 6: Significant variables for the yield shift models according to the univariate regressions

Rental Value Overall	Rental Value Retail	Rental Value Industrial	Rental Value Office
Building permits (4)	Building permits (7)	Building permits (5)	Building permits (4)
Interest rate (1)	Interest rate (6)	Interest rate (1)	Interest rate (1)
Employment growth (10)	GDP growth (6)	Employment growth (10)	Employment growth (10)
GDP growth (1)	Economic leading index (1)	GDP growth (2)	GDP growth (2)
Retail sales (2)	Investor sentiment (1)	Retail sales (2)	Retail sales (2)
Economic leading index (1)	Listed real estate (1)	Economic leading index (1)	Economic leading index (2)
Risk spread (10)	Global trade (10)	Risk spread (9)	Risk spread (6)
Investor sentiment (9)	Consumer confidence (1)	Investor sentiment (10)	Investor sentiment (10)
Corporate bond index (1)	Total share prices (1)	Corporate bond index (1)	Corporate bond index (2)
Yield spread (10)	Money supply, M2 (10)	3-month Gov. Bond (1)	3-month Gov. Bond (1)
Global trade (9)	Order book volume (1)	Yield spread (10)	Yield spread (10)
Consumer confidence (1)	Future production (3)	Consumer confidence (1)	Money supply, M2 (2)
Total share prices (9)	Level of finished goods (1)	Total share prices (1)	Order book volume (10)
Money supply, M2 (1)	Exp. order inflow (3)	Money supply, M2 (2)	
	German BCI (1)	Order book volume (10)	

Table 7: Significant variables for the rental value models according to the univariate regressions

As expected, it becomes apparent that the economic variables are mostly found significant for yield shift, while the real estate variables are mostly found significant for rental value growth. Furthermore, the best fitted number of leads differs heavily per variable with some variables only having a lead of one quarter, while other variables have leads of 10 quarters. This might mean that the final models consist of variables with long and short leads, limiting the forecasting ability of the models to the shortest lead. For example, if a model consists out of two variables, with respectively eight and one quarter leads, the model is only able to forecast one quarter ahead.

Multivariate logistic regression

By using the variables that are found significant in the univariate regressions with the corresponding number of leads, the multivariate regressions are run. The best fitted combinations of variables are shown in table 8 and 9. The tables show the variables, including the number of quarters lead, which can be used to forecast the chance of actual yield shift / rental value growth per property type. Furthermore, the tables show the coefficients that indicate the weight of the variables and the significance of the variables. The McFadden R^2 that is listed per model indicates the statistical fit of the models and can range from zero to one.

Dependent variable	Variable	Coefficient	Significance	McFadden R2	Observations
Yield shift overall	Employment growth (10)	-435,55	0,036	0,80	34
	Money supply, M2 (1)	142,213	0,037		
	Constant	-1,336	0,426		
Yield shift retail	Consumer confidence (6)	-0,159	0,004	0,66	39
	Level of finished goods (6)	419,212	0,017		
	Constant	-1,163	0,159		
Yield shift industrial	Building permits (7)	17,536	0,099	0,81	34
	Employment growth (10)	-757,818	0,023		
	Constant	0,447	0,614		
Yield shift office	Employment growth (10)	-1002,878	0,015	0,88	34
	Constant	1,843	0,086		

Table 8: Best fitted regression models for yield shift according to the multivariate regressions

Table 8 shows that for the retail sector consumer confidence and level of finished goods is found significant. It is interesting to see that consumer confidence of six quarters back has a negative effect on the chance of growth, this shows the cyclic nature of the markets. Furthermore, the level of finished goods is an interesting explanatory variable that shows the relationship between produced goods and retail yield shift. When the level of finished goods increases, the chance of a positive yield shift will also increase.

The industrial sector has, as expected, different explanatory variables. The model indicates that the amount of building permits has a positive effect on the chance of positive yield shift, while employment growth has a negative effect. This negative effect, just like the one found for consumer confidence, indicates the cyclic nature of the market.

For the office sector only one explanatory variable is found to be significant. Employment growth of ten quarters back has a negative influence on the chance of positive yield shift. This is in line with the results of the industrial model.

The overall model consists out of employment growth and M2 money supply. Because this model covers the total market, is was to be expected that the model consisted out of a combination of variables found in the other models. Although M2 money supply is not found significant in the other models, employment growth is.

By making use of table 8, the chance that there will be positive yield shift can be calculated by making use of a formula. As an example, the formula is used on the overall yield shift model.

$$p=\frac{1}{1+e^{-(-1.336+\text{employment growth} * -435.55+\text{money supply} * 142.213)}}$$

The formula shows that when employment growth of ten quarters back increases, the chance that there will be yield shift growth will decrease. Furthermore, if M2 money supply of one quarter back increases, the chance that there will be yield shift growth will also increase. By using the variables in table 8 for the retail, industrial and office models, the chances of growth can be calculated the same way.

It becomes apparent that the yield shift models have employment growth as a common factor, although this variable was expected to be found significant for rental value growth. In addition, the yield shift models contain variables with a lead ranging from one to ten quarters, but since the variable with the shortest lead decides how many quarters the model can forecast, the forecasting abilities of the models are limited to one, six, seven and ten quarters. The yield shift models have McFadden R^2s ranging from 0.66 for the retail market to 0.88 for the office market, showing that the models have an unexpected good fit.

Looking at the literature review, it can be concluded that the yield shift models do not resemble current real estate theory but are dominated by economic variables and variables that where expected to be relevant for the rental value models. For instance, investor sentiment, retail sales, interest rate and GDP growth where all found significant in earlier studies, but are not present in the yield shift model. On the other hand, employment growth and building permits are found significant for yield shift, while previous literature found them significant for rental value. The limited resemblance was to be expected due to the fact that these studies focus on the U.S. and U.K., and not on the Netherlands.

Dependent variable	Variable	Coefficient	Significance	McFadden R2	Observations
Rental value overall	Investor sentiment (9)	47,123	0,060	0,68	34
	Money supply, M2 (1)	130,36	0,012		
	Constant	-5,829	0,005		
Rental value retail	Building permits (7)	12,446	0,010	0,40	42
	Money supply, M2 (10)	-95,452	0,006		
	Constant	2,6112	0,029		
Rental value industrial	Consumer confidence (1)	0,266	0,019	0,61	34
	Constant	-0,579	0,503		
Rental value office	Consumer confidence (1)	0,266	0,019	0,61	34
	Constant	-0,579	0,503		

Table 9: Best fitted regression models for rental value according to the multivariate regressions

Table 9 shows the results of the real rental value models. It becomes apparent that for the retail sector, building permits and M2 money supply have a significant effect on the chance of real rental value growth. When the amount of building permits of seven quarters back increases, the chance of real rental value growth will increase. Furthermore, if M2 Money supply of ten quarters back increases, the chance of real rental value growth will decline. Both relationships are expected, more building permits indicate a better state of economy, which has a positive effect on rents, while a higher money supply indicates a decline in economic growth and thus lower rental values.

The industrial and office models are different from the retail model, but show the exact same results. This is due to the available time series, in which the dependent variables (industrial real rental value and office real rental value) show the same trend. For both of the sectors consumer confidence is found as the only explanatory variable, having a positive effect.

The overall model is again a combination of all property sectors and has investor sentiment and M2 money supply as significant explanatory variables, with both having positive effects on the chance of real rental value growth.

Unlike the yield shift models, the rental value models do not have a common factor, all models consist of different variables with leads ranging from one to ten quarters. Again, the models are limited by the variable with the shortest lead, causing the retail market model to be the only model with a long lead of seven quarters. The rental value models have McFadden R^2s ranging from 0.40 for the retail market to 0.68 for the overall model, indicating a moderate fit.

Comparing the rental value models with current real estate literature, it becomes apparent that the results were not expected. Again the models are dominated by economic variables, suggesting that these have more impact on rental value growth than was to be anticipated.

To examine the performance of the final logit models, the amount of correct predictions can be used. Furthermore, a comparison will be made in regard to a naïve model, a model that is run with only a constant factor, resembling a guess bases on the total performance of the series. The cutoff point, indicating whether or not growth is to be expected, is taken to be the mean of the probabilities. Table 10 shows the results of the performance comparison.

Model	Cutoff point	Cor. pred. naïve model (%)	Cor. pred. model (%)	Gain (%)
Yield Shift Overall	0,67	47,3	72,7	25,5
Yield Shift Retail	0,52	56,4	84,6	28,3
Yield Shift Industrial	0,45	60,0	81,8	21,8
Yield Shift Office	0,57	63,6	70,9	7,3
Rental Value Overall	0,29	69,1	79,2	10,2
Rental Value Retail	0,47	56,4	80,0	23,6
Rental Value Industrial	0,26	80,0	89,1	9,1
Rental Value Office	0,26	74,5	94,3	19,8

Table 10: Performance comparison between naïve and final models

The overall yield shift model has a cutoff point of 0.67, meaning that at a level above 0.67, the model forecasts growth, while when the model is at a level lower than 0.67, no growth is forecast. The overall yield shift model has a moderate percentage of success (73 %), in comparison to the naïve model, which has only 47.3 percent success, this indicates an absolute gain of 25.5 percent.

The overall rental value model performs better, with 79.2 percent of successive predictions but only an absolute gain of 10.2 percent over the naïve model. Generally speaking, the models all have high percentages of correct predictions ranging from 70 to 80 percent. The absolute gains over the naïve models range from seven to 28 percent, proving that the used leading indicator approach gives better results that the blind guess.

Although the models have high percentages of correct predictions and have high McFadden R^2s, there are two things that remain. First of all, the found variables are not in line with current real estate literature. Secondly, due to the small number of observations, the stability of the models cannot be tested.

The limited resemblance with current real estate theory can be largely explained. First of all, when looking at the literature review, one can see that although the used theories are equal, the variables that are found significant differ per country and per sector. The U.K. studies differ from the U.S. studies, and there are no scientific studies about the Netherlands, making it acceptable that the variables that are found in this study differ from other studies. Furthermore, this study combines variables found in literature with economic leading indicators, which apparently results in models dominated by these economic variables.

Secondly, the small number of observations due to the relative young age of real estate indices in the Netherlands makes it hard for the regression models to find good fitted variables that resemble real estate theory. In addition, this small number of observations makes it impossible to test for robustness of the models.

In order to validate the methodology and somehow test the reliability of the results, back tests are done for the U.S. and the U.K. Although the IPD data for the U.S. is very young, the country has a long history of real estate data in the form of the NCREIF index and an even longer history for economic data.

For the U.K., real estate indices also have a longer history and thus the number of observations is larger, making it possible to test the reliability of the logistic approach. Even more, IPD also reports monthly data for the U.K., increasing the sample size even more and making it possible to make use of a robustness test.

However, back testing the methodology also has its restrictions. Due to country specific variations in data, different regulations and different market mechanisms, the final results of the regression models are expected to differ per country. Furthermore, the increase in observations may also have an effect on the final results.

To summarize, the generated logistic models predict real rental value growth and yield shift accurately. Furthermore, the models show high McFadden R^2s, indicating good fits, with variables that are significant on the 5 percent level. The models consist of different variables per property sector, with the yield shift models having employment growth as a common factor and the rental value models having no common factor. However, all models are mostly dominated by economic variables. An international comparison with the U.S. and U.K. will be done to validate the method and robustness tests will be executed to test the stability of the models.

7. International comparison

This chapter will look at the results of the Dutch model and compare these with the results of models for the United States and the United Kingdom. First the models for the United States will be discussed and compared. Secondly, the same will be done for the U.K. models.

United States

Although the United States have a longer history of real estate data, this is not the case for IPD data, which has a very young existence in the U.S. In the U.S., NCREIF has been responsible for collecting real estate data since 1982. The problem with NCREIF data is that they make use of different valuation and return calculation methods and only report capital growth and yield shift. To make the data suitable for testing, the NCREIF data is edited, creating a derived real rental value variable by subtracting yield shift from capital growth and correcting it for inflation. In addition to the overall, retail, industrial and office market models, NCREIF also report data for residential apartments, which is also included in these tests.

For the back tests, the same methodology for constructing the models will be used, however, for the readability of the report, only the results of the multivariate regressions will be discussed. The descriptive statistics, de-trending results, transformation of the dependent variables and univariate regressions can be found in appendix 1. It is important to note that the leading economic indicators that act as input for the models are different for every country and that the eventual multivariate models will thus be different.

Multivariate logistic regression

Dependent variable	Variable	Coefficient	Significance	McFadden R2	Observations
Yield shift overall	Consumer confidence (5)	-4,607	0,015	0,87	78
	Total share prices (2)	37,374	0,039		
	Money supply, M2 (1)	906,341	0,005		
	Leading credit index (6)	-3,023	0,005		
	Initial unemployment claims (2)	-70,437	0,004		
	Constant	-17,873	0,005		
Yield shift retail	Vacancy rate (5)	-259,739	0,038	0,93	79
	GDP growth (1)	-1351,114	0,017		
	Risk spread (10)	19,273	0,019		
	Corporate bond index (4)	-161,700	0,034		
	Money supply, M2 (1)	555,844	0,022		
	Average weakly hours (1)	3051,671	0,023		
	Initial unemployment claims (6)	-100,312	0,012		
	Vendor performance (9)	-52,876	0,088		
	Constant	-21,634	0,046		
Yield shift industrial	Risk spread (10)	2,537	0,017	0,64	83
	Listed real estate index (4)	12,758	0,022		
	Money supply, M2 (1)	204,705	0,000		
	Leading credit index (6)	-1,232	0,004		
	Constant	-7,440	0,000		
Yield shift office	Corporate bond index (4)	-42,900	0,025	0,82	78
	Global trade (1)	144,591	0,001		
	Total share prices (3)	70,779	0,003		
	Money supply, M2 (1)	369,491	0,003		
	Constant	-10,827	0,003		
Yield shift apartment	Economic leading index (4)	13,216	0,045	0,79	79
	Money supply, M2 (1)	671,764	0,003		
	Interest rate spread (10)	3,278	0,009		
	Average weakly hours (1)	600,326	0,003		
	Constant	-16,301	0,004		

Table 11: Final regression models for U.S. yield shift

The yield shift models have McFadden R^2s ranging from 0.64 for the industrial market to 0.93 for the retail market, showing a good fit. Where the Dutch models show employment growth as a common factor, the US models have M2 Money Supply as a common factor, with the other variables being mostly economically orientated. As expected, the number of variables in the final yield shift models is larger than the Dutch models. The US models consist of four to eight variables while the Dutch models only consist of one or two variables. Just like the Dutch models, the US models are limited by the variable with the shortest lead, limiting the forecasting ability to one quarter.

Dependent variable	Variable	Coefficient	Significance	McFadden R2	Observations
Rental value overall	Retail sales (3)	99,042	0,005	0,31	77
	Constant	1,190	0,096		
Rental value retail	GDP growth (2)	354,503	0,033	0,60	77
	Listed real estate index (3)	17,670	0,049		
	Money supply, M2 (1)	329,016	0,014		
	Constant	-7,185	0,031		
Rental value industrial	Risk spread (10)	7,396	0,030	0,85	76
	Listed real estate index (3)	23,701	0,040		
	Money supply, M2 (1)	574,131	0,003		
	Leading credit index (6)	-3,837	0,013		
	Initial unemployment claims (3)	-64,164	0,008		
	Constant	-22,52	0,006		
Rental value office	Total share prices (3)	32,511	0,000	0,72	78
	Money supply, M2 (1)	297,437	0,001		
	Initial unemployment claims (1)	-33,035	0,001		
	Constant	-6,681	0,001		
Rental value apartment	Building permits (3)	45,578	0,003	0,73	79
	Money supply, M2 (1)	456,678	0,002		
	Average weakly hours (1)	456,752	0,010		
	Constant	-6,344	0,004		

Table 12: Final regression models for U.S. rental value

The rental value models have McFadden R^2s ranging from 0.31 for the overall model to 0.85 for the industrial market. Showing a relative good fit, with the exception of the overall model. Just like the yield shift models, M2 Money supply can be found as a common factor, making this variable an important one to keep track of. The rental value models show little resemblance with real estate theory, with the models again being dominated by economic variables.

Just like for the Netherlands, the amount of successful predictions should be inspected. Table 13 shows the results for the U.S. models.

Model	Cutoff point	Cor. pred. naïve model (%)	Cor. pred. model (%)	Gain (%)
Yield Shift Overall	0,64	62,61	85,22	22,61
Yield Shift Retail	0,49	64,29	79,46	15,18
Yield Shift Industrial	0,56	58,26	79,13	20,87
Yield Shift Office	0,60	57,39	87,83	30,43
Yield Shift Apartment	0,71	60,87	80,87	20,00
Rental Value Overall	0,86	81,42	76,99	-4,42
Rental Value Retail	0,85	80,00	91,30	11,30
Rental Value Industrial	0,50	52,17	80,87	28,70
Rental Value Office	0,61	50,44	81,42	30,97
Rental Value Apartment	0,75	58,41	75,22	16,81

Table 13: Performance comparison of the U.S. models

The overall yield shift model has a cutoff point at 0.64 with the final model having a high percentage of success (85 %). In comparison to the naïve model, which has only 63 percent success, this indicates an absolute gain of 22 percent. The overall rental value model is an exception, with the naïve model performing better than the final model. This can be explained by the nature of the overall rental value index, which has seen almost no declines. The rest of the rental value models perform better than the naïve models, with gains ranging from 11 to 31 percent.

In general, the comparison of the U.S. results with the Dutch results yields interesting results. The models show good results for both countries, all having high McFadden R^2s and high percentages of successive predictions. However, the composition of the models differs significantly. The Dutch models consist of one or two variables, while the U.S. models consist of four to eight variables. This can probably be explained due to the higher amount of observation for the U.S. models. Furthermore, although the models for both countries are dominated by economic variables, there is no common factor to be found between the compositions of the models, showing that the countries differ more than expected.

It can be concluded that the U.S. models show good fits and generally predict accurately, with gains indicating the added value of the approach. The number of variables in the final models is higher than for the Netherlands, however this might be due to the larger amount of observations. There is no common factor to be found between the U.S. and Dutch models, implying that the countries differ more than expected.

United Kingdom

The U.K. data is ideal for back testing the methodology. The availability of monthly data makes it possible to verify the suspicion that results are influenced by the amount of observations, and also makes it possible to carry out robustness tests. Again, only the results will be discussed, starting with the quarterly data results. The descriptive statistics, de-trending results, transformation of the dependent variables and univariate regressions can be found in appendix 2.

Multivariate logistic regression

Dependent variable	Variable	Coefficient	Significance	McFadden R2	Observations
Yield shift overall	Global trade (4)	59,918	0,014	0,68	69
	Consumer confidence (1)	-0,220	0,056		
	Total share prices (1)	-34,293	0,002		
	Business climate indicator (6)	0,272	0,001		
	Constant	-0,233	0,775		
Yield shift retail	Interest rate (4)	66,116	0,011	0,86	63
	Global trade (10)	-135,215	0,005		
	Total share prices (9)	62,819	0,022		
	Productivity (1)	-268,235	0,093		
	Business climate indicator (5)	0,178	0,039		
	Constant	3,219	0,103		
Yield shift industrial	Consumer confidence (1)	-0,647	0,119	0,94	69
	Car registrations (1)	1859,044	0,071		
	Total share prices (1)	-217,543	0,071		
	Order book volume (5)	1,521	0,061		
	Business climate indicator (1)	0,705	0,460		
	Constant	17,639	0,049		
Yield shift office	Economic leading index (2)	40,713	0,009	0,71	69
	Total share prices (1)	-35,355	0,001		
	Business climate indicator (6)	0,478	0		
	Constant	2,946	0,002		

Table 14: Final regression models for U.K. yield shift

The yield shift models have McFadden R^2s ranging from 0.68 for the overall models to 0.94 for the industrial market, showing a good fit. The composition of the different models is dominated by economic variables, which was expected. Again a common factor between the different models can be found. Where the Dutch models showed employment growth as a common factor and the U.S. models showed M2 money supply, the U.K. yield shift models have the U.K. business climate indicator and the total share prices as common factors. Just like the Dutch models, the U.K. models are also limited by the variable with the shortest lead, causing all models to have a maximum forecast of one quarter.

The number of variables in the models is however different from the Dutch and U.S. models. Where the Dutch models only showed one or two variables and the U.S. models showed four to eight variables, the U.K. models consist of three to five individual variables. The difference in the number of variables is probably due to the different number of observations.

Dependent variable	Variable	Coefficient	Significance	McFadden R2	Observations
Rental value overall	Employment growth (2)	2470,637	0,007	0,92	74
	Yield spread (1)	-2,844	0,006		
	Total share prices (5)	36,239	0,022		
	Constant	-9,522	0,014		
Rental value retail	Employment growth (1)	826,35	0,148	0,87	63
	Global trade (10)	-62,745	0,088		
	Consumer confidence (5)	0,813	0,022		
	Money supply, M4 (10)	-207,673	0,041		
	Industrial production (4)	-300,043	0,036		
	Constant	10,905	0,098		
Rental value industrial	3-month Gov. Bond (1)	-9,437	0,030	0,83	66
	Yield spread (1)	-2,900	0,013		
	Global trade (7)	-70,047	0,017		
	Money supply, M2 (10)	-469,013	0,002		
	Constant	15,409	0,003		
Rental value office	Yield spread (1)	-7,866	0,012	0,92	70
	Global trade (3)	-270,562	0,020		
	Money supply, M4 (1)	269,342	0,021		
	Constant	-5,412	0,081		

Table 15: Final regression models for U.K. rental value

The rental value models show a better fit than the yield shift models, with McFaddden R^2s ranging from 0.83 for the industrial market to 0.92 for the office market and overall model, indicating an even better fit. Unlike the yield shift models, the rental value models do not have variables that are present in every model. However, global trade and money supply are present in three out of four models, emphasizing the importance of these variables.

Just like for the Netherlands and the U.S., the amount of successful predictions should be inspected. Table 16 shows the results for the U.K. models.

Model	Cutoff point	Cor. pred. naïve model (%)	Cor. pred. model (%)	Gain (%)
Yield Shift Overall	0,40	54,84	78,5	23,7
Yield Shift Retail	0,42	49,46	84,4	35,0
Yield Shift Industrial	0,37	61,29	79,6	18,3
Yield Shift Office	0,41	54,84	78,5	23,7
Rental Value Overall	0,52	53,76	89,0	35,2
Rental Value Retail	0,56	51,61	89,2	37,6
Rental Value Industrial	0,37	68,82	88,2	19,4
Rental Value Office	0,52	61,29	82,4	21,1

Table 16: Performance comparison of the U.K. models

The overall yield shift model has a cutoff point at 0.40 with the final model having a high percentage of success (79 %). In comparison to the naïve model, which has only 55 percent success, this indicates an absolute gain of 24 percent. The overall rental value model performs better, with 89 percent of successive predictions and an absolute gain of 35 percent over the naïve model. Overall, the U.K. models show high percentages of absolute gains over the naïve models, ranging from 19 to 37 percent. The final models have successive predictions in 70 to 90 percent of the cases, which is in line with the Dutch and U.S. models.

When comparing the results of the three different countries it can be concluded that all models have high percentages of correct predictions and all models show good statistical fits. As expected, the composition of the final models differ significantly per country, with the only common factor being money supply, which is found in almost all rental value models. The finding of this common variable means that it is an important one to keep track of in all countries.

Another observation that can be made is the difference in the amount of variables the final models. The current results suggest that as the number of observations increases, the number of variables in the models also increases. To find out if this is the case, a comparison between the U.K. monthly and quarterly data is made in the next chapter, which acts as a robustness test.

In short, the U.K. models, just like the Dutch and U.S. models, show good fits and predict accurately. Money supply is a variable that is present in almost all rental value models, indicating the importance of the variable. Any other common factors between the countries have not been found. The final U.K. models consist of three to five variables, which is different from the Dutch and U.S. models. Whether this is the result of the difference in the amount of observations will be studied in the form of a robustness test in the next chapter.

8. Robustness tests

Because of the different independent variables that are found significant in the final models for the different countries, further testing has to be done. This chapter focuses on testing the robustness of the generated models. First of all, the influence of the amount of observations will be studied and secondly the out-of-sample performance will be measured. Both tests will be performed on monthly data for the U.K.

Frequency test

To find out whether or not the amount of variables in the final models is influenced by the amount of observations, the same method used for the quarterly U.K. data is now used for the monthly data. Where the quarterly data set has around 70 cases, the monthly data set has over 160 cases. Again, only the final multivariate regression models will be discussed.

Multivariate logistic regression

Dependent variable	Variable	Coefficient	Significance	McFadden R2	Observations
Yield shift overall	Interest rate (5)	-55,266	0,007	0,88	166
	Employment growth (7)	494,222	0,032		
	Economic leading index (1)	-771,490	0,009		
	Economic sentiment (1)	-41,570	0,046		
	Listed real estate index (2)	42,323	0,002		
	Yield spread (4)	-2,595	0,007		
	Consumer confidence (1)	1,259	0,002		
	Car registrations (5)	670,743	0,030		
	Total share prices (10)	-83,522	0,004		
	3 month bank bills (4)	-1791,783	0,001		
	Industrial production (1)	440,719	0,002		
	Constant	16,039	0,003		
Yield shift retail	Interest rate (4)	-80,396	0,001	0,90	157
	Listed real estate index (2)	28,369	0,022		
	Global trade (10)	161,357	0,001		
	Consumer confidence (1)	0,472	0,009		
	Total share prices (9)	-47,283	0,003		
	Money supply, M2 (9)	294,302	0,043		
	Money supply, M4 (3)	-377,038	0,004		
	Industrial production (5)	-231,118	0,026		
	Constant	6,632	0,042		
Yield shift industrial	Employment growth (10)	633,365	0,053	0,92	166
	Economic leading index (2)	981,528	0,040		
	3-month Gov. Bond (5)	123,133	0,002		
	Yield spread (4)	-1,903	0,012		
	Total share prices (1)	114,746	0,001		
	3 month bank bills (5)	-3873,751	0,000		
	Order book volume (1)	-0,294	0,002		
	Constant	-12,594	0,048		
Yield shift office	Retail sales (5)	225,528	0,054	0,93	157
	Listed real estate index (2)	60,618	0,014		
	Consumer confidence (9)	1,432	0,009		
	Car registrations (5)	2836,529	0,016		
	Total share prices (1)	192,248	0,009		
	Money supply, M2 (9)	352,888	0,011		
	3 month bank bills (4)	-1524,560	0,010		
	Money supply, M4 (4)	-520,339	0,007		
	Expected output (1)	-0,192	0,031		
	Constant	10,128	0,065		

Table 17: Final U.K. monthly yield shift models

Dependent variable	Variable	Coefficient	Significance	McFadden R2	Observations
Rental value overall	Interest rate (7)	-61,846	0,035	0,95	166
	Listed real estate (3)	33,872	0,021		
	Yield spread (1)	-7,490	0,019		
	Total share prices (4)	63,575	0,011		
	3 month bank bills (1)	-901,640	0,013		
	Expected output (10)	0,168	0,118		
	Constant	2,911	0,066		
Rental value retail	Employment growth (5)	525,134	0,010	0,80	172
	Retail sales (4)	147,931	0,017		
	Listed real estate (1)	11,186	0,004		
	Consumer confidence (6)	0,606	0,000		
	Total share prices (10)	-24,765	0,013		
	Money supply, M2 (10)	-297,690	0,001		
	Constant	11,851	0,002		
Rental value industrial	Interest rate (8)	-41,923	0,000	0,92	163
	Global trade (2)	-258,608	0,000		
	Constant	-1,097	0,069		
Rental value office	Yield spread (1)	-7,389	0,001	0,95	169
	Global trade (3)	-325,192	0,001		
	Total share prices (6)	67,492	0,006		
	Money supply, M4 (1)	351,255	0,003		
	Constant	-10,568	0,006		

Table 18: Final U.K. monthly rental value models

When comparing the yield shift and rental value models (table 17 and 18) of the monthly dataset with the quarterly dataset models (table 14 and 15), the difference immediately becomes apparent. The amount of variables in the monthly models is indeed a lot higher, exactly what was expected. It is however good to see that most variables that are significant in the quarterly models are also present in the monthly models, indicating stable results.

Model	Cutoff point	Cor. pred. naïve model (%)	Cor. pred. model (%)	Gain (%)
Yield Shift Overall	0,55	55,83	92,9	37,1
Yield Shift Retail	0,52	51,67	87,3	35,7
Yield Shift Industrial	0,60	59,58	82,9	23,3
Yield Shift Office	0,54	53,75	94,2	40,4
Rental Value Overall	0,53	52,92	86,6	33,6
Rental Value Retail	0,61	60,83	92,5	31,7
Rental Value Industrial	0,37	36,67	77,1	40,4
Rental Value Office	0,45	45,42	74,7	29,3

Table 19: Performance comparison of the U.K. monthly models

The second comparison that can be made is the percentage of correct predictions and the gains over the naïve models. Where the quarterly models have successive predictions in 70 to 90 percent of the cases, the monthly models have an even higher percentage of correct predictions of 75 to 94 percent. The absolute gains are also higher, with the quarterly model having gains ranging from 19 to 37 percent, and the monthly model having gains ranging from 29 to 40 percent. The overall conclusion is that, when data is available on a higher frequency, this will possibly increase the reliability and accurateness of the model.

Out-of-sample performance

The final test that can prove the reliability of the generated models is a so called out-of-sample robustness test. Because of the limited amount of observations for the quarterly models, the monthly models for the U.K. are the only models for which this test is available. The goal of the robustness test is to find out how good a certain regression equation works when it is used on data outside the dataset.

In the previous chapter, the regression equations for the U.K. monthly dataset have been generated. In this chapter, the same method will be used, however, only the data up to December 2003 will be used. The outcome of the regression will then be used to estimate the remaining values (January 2004 to December 2008), also called out-of-sample estimation. The out-of-sample results will then be compared to the naïve model and the full sample model.

Figure 7 shows the probability outcomes of the yield shift overall and rental value overall regressions. The grey bars indicate actual growth, the solid lines represent the full sample regressions and the dashed lines represent the out-of-sample forecasts. In these figures, rising lines indicate a growing probability that actual growth will occur.

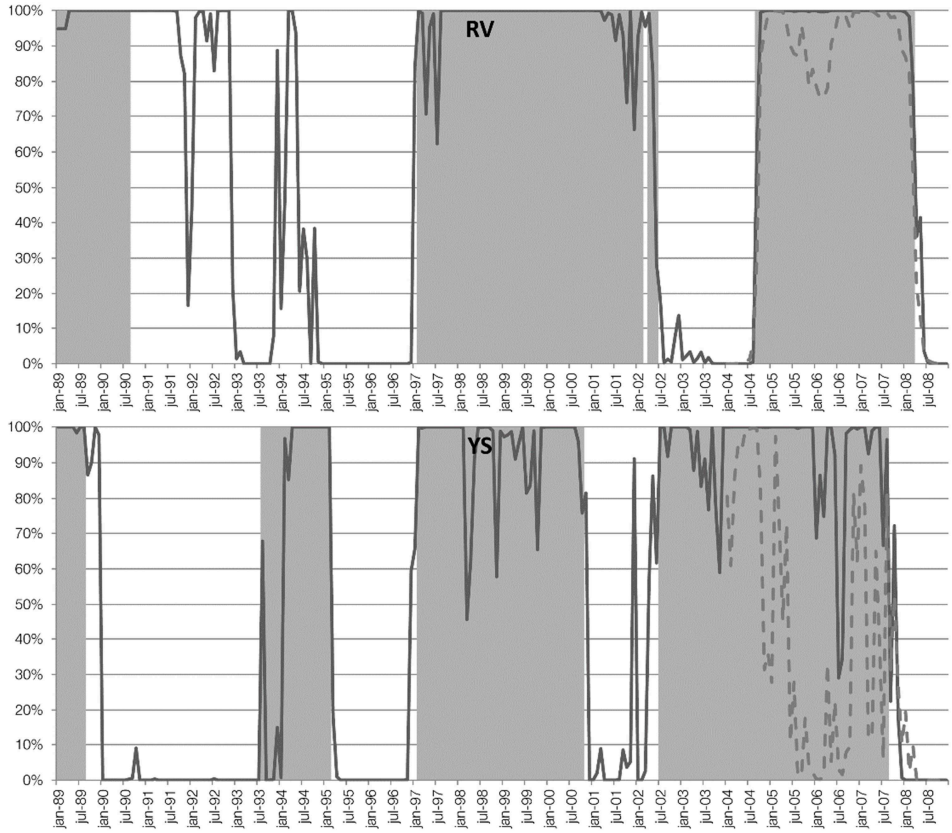

Figure 7: In and out of sample performance of U.K. monthly overall rental value and yield shift models

As can be seen, for the rental value model, the dashed line follows the solid line closely, while for the yield shift model this is not so the case. However, since the amount of correct predictions depends on the selected cut off point, this might not have very negative effects.

Table 20 shows the performance of the out of sample forecasts in comparison to the full sample regressions and the naïve models.

Model	Cor. pred. naïve model (%)	Cor. pred. out of sample model (%)	Cor. pred. in sample model (%)	Dif. in sample & out sample (%)	Gain out sample & naïve (%)
Yield Shift Overall	73,3	58,3	98,3	-40,0	-15,0
Yield Shift Retail	73,3	93,3	93,3	0,0	20,0
Yield Shift Industrial	26,7	88,3	100,0	-11,7	61,7
Yield Shift Office	75,0	70,0	96,7	-26,7	-5,0
Rental Value Overall	28,3	96,7	100,0	-3,3	68,3
Rental Value Retail	70,0	90,0	91,7	-1,7	20,0
Rental Value Industrial	0,0	100,0	100,0	0,0	100,0
Rental Value Office	45,0	65,0	98,3	-33,3	20,0

Table 20: Performance comparison of in and out-of-sample U.K. monthly models

As expected, the in sample estimates perform better than the out-of-sample forecasts, although the difference is for some sectors very small. There is no difference for yield shift retail and only -1,7 % difference for rental value retail. However, comparing the out-of-sample forecasts with the naïve models is of the most importance. As can be seen, most of the models still predict correctly in more cases than the naïve model, with gains ranging from 20 to 100 percent. However, for the yield shift overall and yield shift office model, the naïve model predicts better. Still, in six out of eight cases these results confirm the usefulness of using the multivariate logistic models to forecast rental value and yield shift. Furthermore, they show that the generated models are probably stable.

Overall, this chapter has proven the usefulness of the logistic approach by showing the good performance of the out-of-sample forecasts in comparison to the full sample and naïve models. Furthermore, the comparison between the quarterly and monthly U.K. models shows that there are relatively few differences and proves that the models are stable even though the number of observations changes.

9. The model in practice

So far, the literature review, development of the model and presentation of results have had a mostly academic approach. Although the robustness of the models has been proven and the added value of the models in a scientific way is clear, it is also interesting to consider how the methodology can be applied in reality. This chapter will focus on how forecasting is actually conducted in practice and will explain how the leading indicator approach can be used in practice.

Although there are some firms that do not make use of the contributions of quantitative analysis and form expectations purely on the basis of market experience and judgement, most companies do make use of certain models. However, these companies do not just run a model and use the results directly, mostly they adjust the model-based outcomes to incorporate judgement and expert opinion. These judgemental adjustments are based on a subjective assessment of the expert, who has vision and claims a deep knowledge of how real estate markets work, knows the ways that environmental aspects impact the markets and is furthermore aware of recent trends. Although there are certainly benefits of using judgemental forecasting, there are also a number of issues and risks when using judgment:

- Exaggeration. Experts may see more in the data than there actually is and exaggerate future impacts.

- Anchoring. When a starting value or anchor is used, for example the most recent rent or yield, it can be the cause of adjustments that are too small and therefore result in under-predicting future outcomes.

- Overconfidence. Experts may tend to be overconfident in their sources of information and think they possess complete information, while in reality this may not be the case.

- Inconsistency. Judgemental forecasts do not make optimal use of information and are not consistent due the fact that they are influenced by recent or easily recalled events.

- Inefficient use of past relationships. A good model will provide unbiased forecasts based on the full history. Judgemental forecasts can be biased due to the inability to make use of all relationships in prior data. (Brooks and Tsolacos, 2010)

These risks can be seen very clearly in practice. When examining the results of the ECB Survey of Professional Forecasters (ECB SPF), a quarterly survey that aims to forecast rates of inflation, GDP and unemployment, it becomes clear how hard judgemental forecasting is. The spreads of the expected rates are high, even for relative short term forecasting. As an example, figure 8 shows the expected interest rates for 2014 according to the ECB SPF.

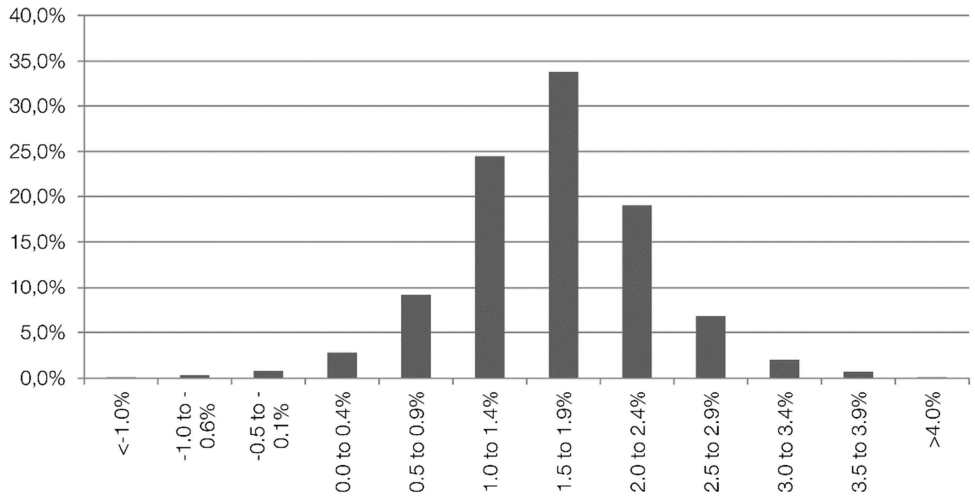

Figure 8: Expected interest rates for 2014 according to ECB SPF

In order to decrease the risks of biased judgemental forecasting, it is important to try to minimize the need for judgement. Whether only the results of a model, a combination of a model and judgement, or judgement alone is used depends primarily on:

- The level of confidence in the model. When the expert has evidence that the model is not well specified and its forecasting ability is not acceptable, there should be little reliance on the models forecasts.

- Quality of inputs in the model. When the expert has no confidence in the reliability of the input data of the model, there will also be no confidence in the outcomes of the model.

- The models ability to incorporate important information or market developments. Due to the fact that a model is always a simplification of the real world, it will never be able to incorporate all information and thus can only be relied on up to a certain point.

- The discrepancy between model-based forecasts and experts' expectations. If the forecasts of the model do not match the expectations of the expert, the expert will have very little confidence in the model. (Brooks and Tsolacos, 2010)

Reviewing the models constructed in this thesis, it can be concluded that there is some sort of judgemental adjustment needed. Even though the models are well specified, the forecasting abilities are acceptable, the input data is reliable and the models are comparable with expert expectations, there are two aspects that create the need of judgemental adjustment.

First, the models are still models and are unable to fully recreate reality and cannot incorporate all information. This means that certain market development may not be specified in the models, creating the need for an expert. Secondly, although the out-of-sample performance has been tested for the UK monthly models, this is not the case for the other models. More observations will be needed in order to test the robustness of these models and thus a judgemental adjustment is still needed.

A combination of the results of the models and judgemental forecasting is thus the most reliable way of using the methodology described in this thesis. By first running the models, the results can be compared to the expected outcomes of the experts and, if needed, be adjusted to incorporate any unused information. This way, the statistically accurate results of the models and the deep knowledge or real estate markets of the expert can be used to create forecasts for rental value growth and yield shift, creating an optimal combination of the academic world and reality.

10. Conclusions

This study has presented a method to forecast real estate capital growth by combining both real estate and economic variables. The leading indicator approach consist of multiple steps that eventually result in accurate, stable and statistically significant models that are able to forecast the direction of change for both real rental value and yield shift. The steps are:

1. De-trending the input data
2. Transforming the dependent variables into binary variables
3. Running univariate regressions
4. Running multivariate regressions

The literature review has resulted in a long list of possible explanatory variables for both yield shift and rental value growth. The review also gives insight into the differences between property types. However, the univariate logistic regressions show that the significant variables also differ per country, resulting in different results for the Netherlands than where to be expected according to the literature review. The list of significant variables consists mostly out of economic leading indicators while the presence of real estate variables is fairly low. Tables 6 and 7 in the report show the full list of explanatory variables.

By making use of the results of these univariate logistic regressions, the best fitted combinations of variables have been calculated by making use of multivariate logistic regressions for the Netherlands, United States and United Kingdom. All regressions have resulted in models that;

- have high McFadden R^2s, showing good fits;
- have high percentages of correct predictions;
- consist out of variables that are significant on the five percent level.

The composition of the regression models gives insight into the best combination of explanatory variables for rental value growth and yield shift. For the Dutch models, employment growth is found as a common factor for the yield shift models and consumer confidence, building permits and investor sentiment are found significant for the rental value models. The models for the United States show a different picture, with M2 Money Supply as a common factor for the both the yield shift and rental value models. The United Kingdom models have M2 Money Supply and the business climate indicator as common factors for the yield shift models, while the rental value models do not have any common factors. Overall, all models, both yield shift and rental value, are dominated by economic variables and there is no real common factor between the different countries.

The regression equations that flow out of the multivariate regression can be used to calculate the probability of actual rental value / yield shift growth, a few quarters ahead. Furthermore, the composition of the models show which variables are important to keep track of.

For the Netherlands, the final models show significant improvements over the naïve model, with gains ranging from seven to 28 percent. The U.K and U.S. models furthermore confirm the reliability of the method, with results that indicate significant gains. In addition, the U.K. monthly results show that the generated models are stable and able to perform accurately, even when used out-of-sample.

11. Recommendations

The outcome of this study shows that the leading indicator approach can be used as a reliable tool to forecast the direction of real estate returns on the short term. The final models help current decision making processes by adding a quantitative approach to the spectrum of tools, improving the reliability of forecasting and decreasing the risks of judgmental forecasting.

Furthermore, the study is helpful in determining which indicators are worth monitoring for the prediction of Dutch, U.K. and U.S. real estate returns. For the Netherlands, these indicators are employment growth, M2 money supply, consumer confidence, level of finished goods, the amount of new building permits and investor sentiment. It must be noted that although the results of the models are statistically significant, accurate and, for the U.K., stable; further judgement of experts is still needed to adjust for any flaws.

There are a number of ways in which further research can help to improve the current model. First of all, the quarterly models can be tested for in and out-of-sample performance when more observations become available in the future.

Secondly, the current models are only able to forecast a few quarters ahead. Further research can focus on improving the forecasting time by using different leads. The effect of longer leads on the stability of the models is an interesting research topic.

Thirdly, the methodology is currently used on an international level, however, the method can also be used on a regional or local scale, possibly giving more detailed insights into the development of future real estate capital growth.

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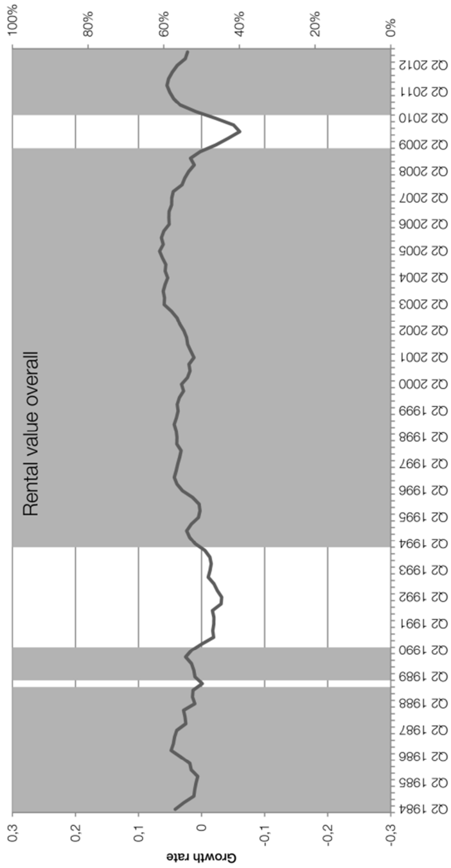
Appendix 1: results U.S.

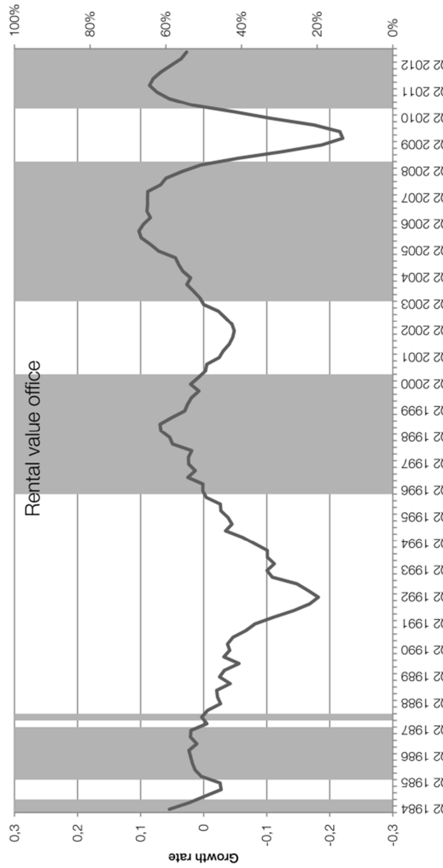
Descriptive statistics before transformation

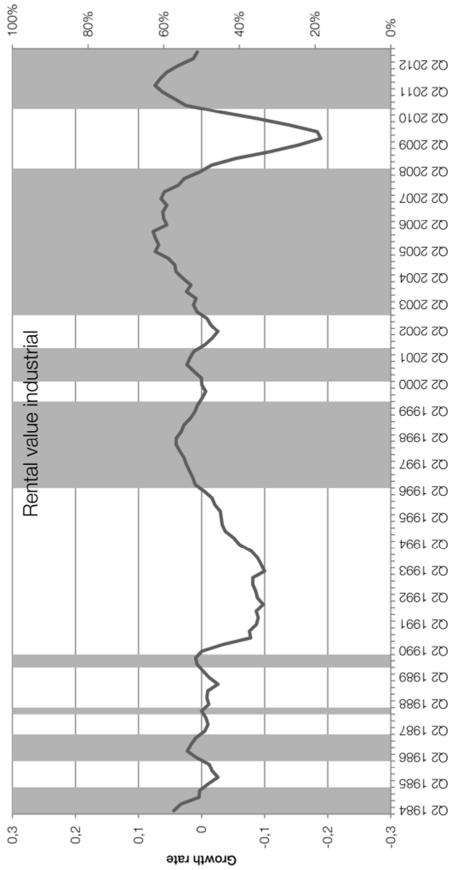
Variable	N	Mean	Median	SD	Min	Max
Yield shift overall	115	0,003	0,008	0,027	-0,085	0,048
Yield shift industrial	115	0,003	0,005	0,025	-0,074	0,052
Yield shift office	115	0,003	0,009	0,038	-0,115	0,062
Yield shift retail	115	0,004	0,009	0,027	-0,060	0,057
Yield shift apartment	115	0,002	0,006	0,037	-0,123	0,108
Rental value overall	115	0,023	0,026	0,027	-0,061	0,067
Rental value industrial	115	-0,008	0,003	0,054	-0,189	0,077
Rental value office	115	-0,012	0,001	0,072	-0,221	0,103
Rental value retail	115	0,023	0,028	0,027	-0,045	0,074
Rental value apartment	115	-0,002	0,008	0,057	-0,191	0,096
Real estate literature variables						
New building permits	115	1409,930	1457,000	429,268	539,000	2228,000
Vacancy rate overall	99	9,446	9,930	2,376	5,660	14,190
Vacancy rate industrial	99	9,028	8,910	3,316	4,330	17,430
Vacancy rate office	99	12,089	13,020	3,356	5,570	16,310
Vacancy rate retail	99	7,529	7,690	1,859	4,820	10,960
Vacancy rate apartment	99	6,624	6,340	1,217	4,440	9,060
Interest rate	115	6,001	5,880	2,369	1,640	13,200
Employment	115	129086,887	131568,000	12182,654	105040,000	146271,000
GDP	115	10282,416	10320,000	2290,089	6554,000	13665,400
Retail sales	84	868148,512	868368,500	217299,438	492090,000	1242103,000
Risk spread	115	1,257	1,140	0,499	0,010	2,570
Corporate bond yield	115	7,258	7,110	2,022	3,460	13,210
3 month government bond yield	115	4,602	5,260	2,750	0,210	11,440
Global trade	88	122,422	115,087	23,160	93,005	173,346
Listed real estate	92	1385,522	1221,055	614,749	404,400	2942,570
Yield spread	115	1,399	1,430	1,275	-1,020	3,510
Economic leading index	115	82,406	85,033	14,148	57,433	107,633
Economic leading indicators						
Index of consumer expectations	115	0,110	0,300	0,902	-2,500	1,600
Stock prices, 500 common stocks	115	821,242	894,650	441,453	155,757	1496,430
Money supply, M2	115	5027,225	4215,800	2207,650	2204,000	10317,600
Leading Credit Index	90	0,019	-0,439	1,695	-1,845	8,749
Interest rate spread	115	1,563	1,657	1,302	-0,977	3,707
Average weekly hours, manufacturing	115	40,943	41,000	0,489	39,500	41,800
Weekly initial claims for unemployment	115	370,357	354,700	62,677	281,300	631,600
Manufacturers' new orders	115	390004,174	392381,000	51118,316	301740,000	463665,000
Vendor performance	115	54,714	55,500	6,417	28,000	68,300
Manufacturer's new orders, nondefense capital goods	115	35422,046	35960,667	6316,989	25376,667	47232,667
Business climate indicator	115	99,995	100,052	0,926	96,924	101,905
Industrial production	115	78,688	84,583	15,487	54,030	100,616

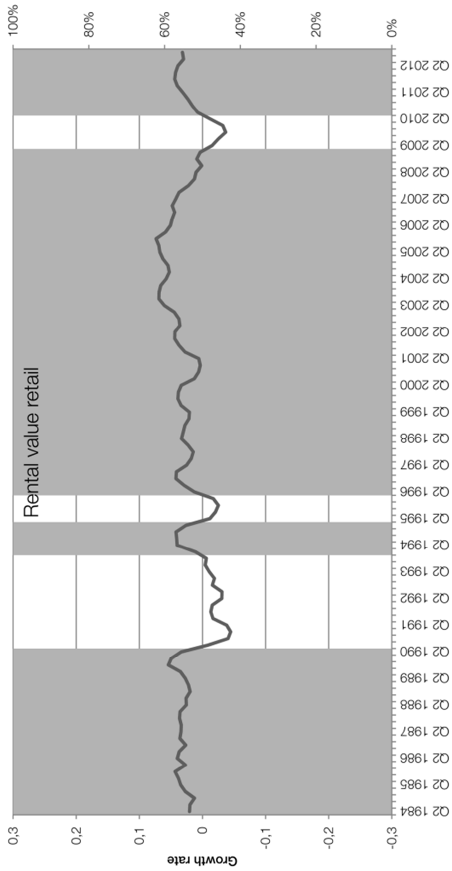
Descriptive statistics after transformation

Variable	N	Mean	Median	SD	Min	Max
Yield shift overall	115	0,003	0,008	0,027	-0,085	0,048
Yield shift industrial	115	0,003	0,005	0,025	-0,074	0,052
Yield shift office	115	0,003	0,009	0,038	-0,115	0,062
Yield shift retail	115	0,004	0,009	0,027	-0,060	0,057
Yield shift apartment	115	0,002	0,006	0,037	-0,123	0,108
Rental value overall	115	0,023	0,026	0,027	-0,061	0,067
Rental value industrial	115	-0,008	0,003	0,054	-0,189	0,077
Rental value office	115	-0,012	0,001	0,072	-0,221	0,103
Rental value retail	115	0,023	0,028	0,027	-0,045	0,074
Rental value apartment	115	-0,002	0,008	0,057	-0,191	0,096
Real estate literature variables						
New building permits	115	-0,012	0,010	0,080	-0,279	0,139
Vacancy rate overall	95	-0,001	-0,016	0,061	-0,134	0,163
Vacancy rate industrial	95	-0,001	-0,006	0,093	-0,243	0,200
Vacancy rate office	95	-0,002	-0,014	0,075	-0,127	0,244
Vacancy rate retail	95	0,006	0,001	0,055	-0,090	0,167
Vacancy rate apartment	95	-0,005	-0,002	0,059	-0,149	0,176
Interest rate	115	-0,028	-0,031	0,075	-0,246	0,145
Employment	115	0,005	0,007	0,006	-0,018	0,022
GDP	115	0,012	0,013	0,008	-0,020	0,033
Retail sales	80	0,019	0,023	0,017	-0,049	0,039
Risk spread	115	1,257	1,140	0,499	0,010	2,570
Corporate bond yield	115	-0,018	-0,023	0,045	-0,123	0,098
3 month government bond yield	115	-0,053	-0,022	0,231	-1,108	0,423
Global trade	115	-0,018	-0,023	0,045	-0,123	0,098
Listed real estate	88	0,030	0,054	0,100	-0,342	0,202
Yield spread	115	1,399	1,430	1,275	-1,020	3,510
Economic leading index	115	0,008	0,016	0,026	-0,097	0,045
Economic leading indicators						
Index of consumer expectations	115	-0,053	-0,022	0,231	-1,108	0,423
Stock prices, 500 common stocks	115	0,032	0,044	0,071	-0,222	0,149
Money supply, M2	115	0,024	0,024	0,010	0,002	0,042
Leading Credit Index	90	0,019	-0,439	1,695	-1,845	8,749
Interest rate spread	115	1,563	1,657	1,302	-0,977	3,707
Average weekly hours, manufacturing	115	0,000	0,001	0,006	-0,018	0,018
Weekly initial claims for unemployment	115	-0,001	-0,013	0,067	-0,122	0,255
Manufacturers' new orders	115	0,004	0,010	0,027	-0,124	0,048
Vendor performance	115	-0,003	-0,004	0,082	-0,267	0,340
Manufacturer's new orders, nondefense capital goods	115	0,006	0,016	0,044	-0,174	0,085
Business climate indicator	115	0,000	0,000	0,006	-0,015	0,018
Industrial production	115	0,010	0,012	0,018	-0,069	0,045


Rental value overall
Growth rate
0,3
0,2
0,1
0
-0,1
-0,2
-0,3
0%
20%
40%
60%
80%
100%
Q2 1984
Q2 1985
Q2 1986
Q2 1987
Q2 1988
Q2 1989
Q2 1990
Q2 1991
Q2 1992
Q2 1993
Q2 1994
Q2 1995
Q2 1996
Q2 1997
Q2 1998
Q2 1999
Q2 2000
Q2 2001
Q2 2002
Q2 2003
Q2 2004
Q2 2005
Q2 2006
Q2 2007
Q2 2008
Q2 2009
Q2 2010
Q2 2011
Q2 2012


Rental value office
Growth rate
0,3
0,2
0,1
0
-0,1
-0,2
-0,3
0%
20%
40%
60%
80%
100%
Q2 1984
Q2 1985
Q2 1986
Q2 1987
Q2 1988
Q2 1989
Q2 1990
Q2 1991
Q2 1992
Q2 1993
Q2 1994
Q2 1995
Q2 1996
Q2 1997
Q2 1998
Q2 1999
Q2 2000
Q2 2001
Q2 2002
Q2 2003
Q2 2004
Q2 2005
Q2 2006
Q2 2007
Q2 2008
Q2 2009
Q2 2010
Q2 2011
Q2 2012


Rental value industrial
Growth rate
0,3
0,2
0,1
0
-0,1
-0,2
-0,3
0%
20%
40%
60%
80%
100%
Q2 1984
Q2 1985
Q2 1986
Q2 1987
Q2 1988
Q2 1989
Q2 1990
Q2 1991
Q2 1992
Q2 1993
Q2 1994
Q2 1995
Q2 1996
Q2 1997
Q2 1998
Q2 1999
Q2 2000
Q2 2001
Q2 2002
Q2 2003
Q2 2004
Q2 2005
Q2 2006
Q2 2007
Q2 2008
Q2 2009
Q2 2010
Q2 2011
Q2 2012


Rental value retail
Growth rate
0,3
0,2
0,1
0
-0,1
-0,2
-0,3
0%
20%
40%
60%
80%
100%
Q2 1984
Q2 1985
Q2 1986
Q2 1987
Q2 1988
Q2 1989
Q2 1990
Q2 1991
Q2 1992
Q2 1993
Q2 1994
Q2 1995
Q2 1996
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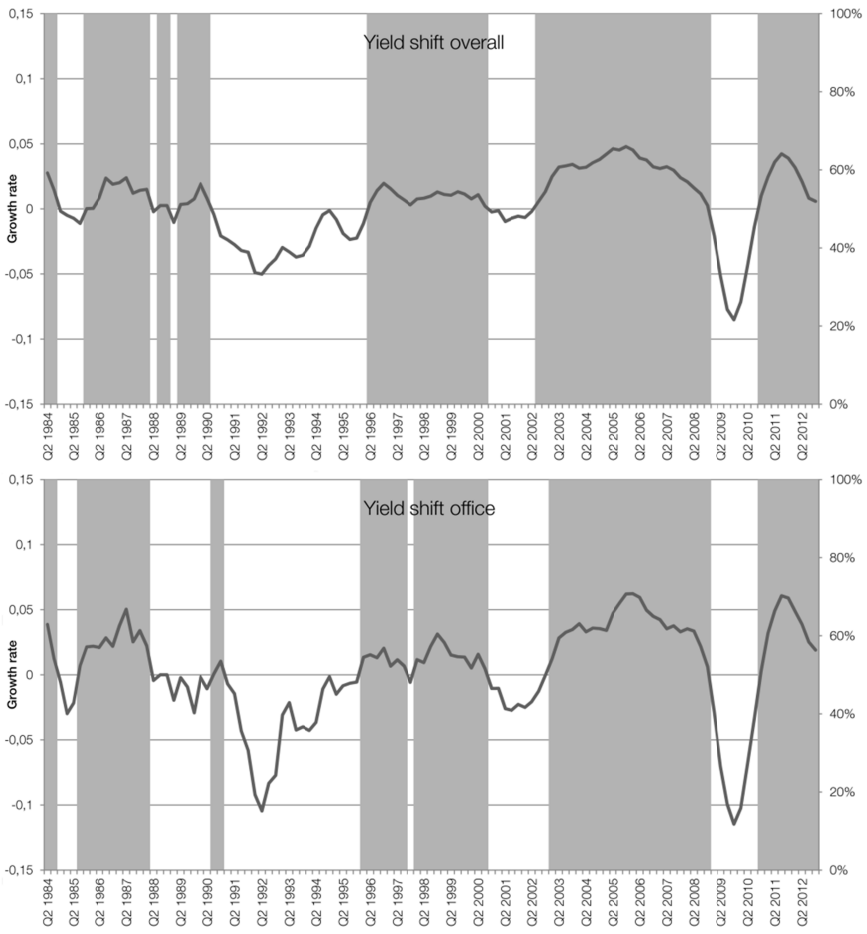
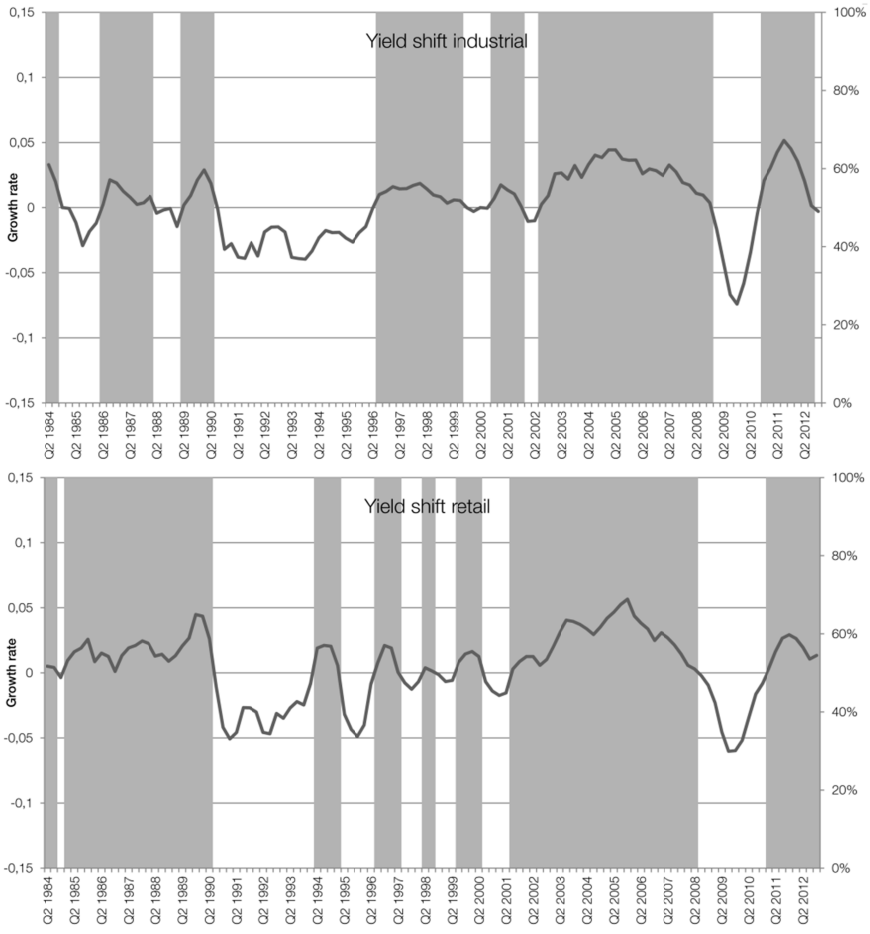
Q2 2006
Q2 2007
Q2 2008
Q2 2009
Q2 2010
Q2 2011
Q2 2012


Yield shift overall
Growth rate
0,15
0,1
0,05
0
-0,05
-0,1
-0,15
100%
80%
60%
40%
20%
0%
Q2 1984
Q2 1985
Q2 1986
Q2 1987
Q2 1988
Q2 1989
Q2 1990
Q2 1991
Q2 1992
Q2 1993
Q2 1994
Q2 1995
Q2 1996
Q2 1997
Q2 1998
Q2 1999
Q2 2000
Q2 2001
Q2 2002
Q2 2003
Q2 2004
Q2 2005
Q2 2006
Q2 2007
Q2 2008
Q2 2009
Q2 2010
Q2 2011
Q2 2012


Yield shift industrial
Growth rate
0,15
0,1
0,05
0
-0,05
-0,1
-0,15
100%
80%
60%
40%
20%
0%
Q2 1984
Q2 1985
Q2 1986
Q2 1987
Q2 1988
Q2 1989
Q2 1990
Q2 1991
Q2 1992
Q2 1993
Q2 1994
Q2 1995
Q2 1996
Q2 1997
Q2 1998
Q2 1999
Q2 2000
Q2 2001
Q2 2002
Q2 2003
Q2 2004
Q2 2005
Q2 2006
Q2 2007
Q2 2008
Q2 2009
Q2 2010
Q2 2011
Q2 2012

Yield shift office
Growth rate
0,15
0,1
0,05
0
-0,05
-0,1
-0,15
100%
80%
60%
40%
20%
0%
Q2 1984
Q2 1985
Q2 1986
Q2 1987
Q2 1988
Q2 1989
Q2 1990
Q2 1991
Q2 1992
Q2 1993
Q2 1994
Q2 1995
Q2 1996
Q2 1997
Q2 1998
Q2 1999
Q2 2000
Q2 2001
Q2 2002
Q2 2003
Q2 2004
Q2 2005
Q2 2006
Q2 2007
Q2 2008
Q2 2009
Q2 2010
Q2 2011
Q2 2012

Yield shift retail
Growth rate
0,15
0,1
0,05
0
-0,05
-0,1
-0,15
100%
80%
60%
40%
20%
0%
Q2 1984
Q2 1985
Q2 1986
Q2 1987
Q2 1988
Q2 1989
Q2 1990
Q2 1991
Q2 1992
Q2 1993
Q2 1994
Q2 1995
Q2 1996
Q2 1997
Q2 1998
Q2 1999
Q2 2000
Q2 2001
Q2 2002
Q2 2003
Q2 2004
Q2 2005
Q2 2006
Q2 2007
Q2 2008
Q2 2009
Q2 2010
Q2 2011
Q2 2012

Results univariate regression

Rental Value Overall	Rental Value Retail	Rental Value Industrial	Rental Value Office	Rental Value Appartment
Building permits (4)	Building permits (3)	Building permits (4)	Building permits (4)	Building permits (3)
Vacancy rate (5)	Vacancy rate (5)	Employment growth (1)	Vacancy rate (1)	Employment growth (1)
Employment growth (1)	Employment growth (1)	GDP growth (1)	Employment growth (1)	GDP growth (1)
GDP growth (3)	GDP growth (2)	Retail sales (3)	GDP growth (1)	Retail sales (1)
Retail sales (3)	Retail sales (3)	Economic leading index (3)	Retail sales (2)	Economic leading index (1)
Economic leading index (4)	Economic leading index (4)	Risk spread (10)	Economic leading index (4)	Risk spread (7)
Risk spread (10)	Risk spread (10)	3-mont Gov. Bond (2)	Risk spread (10)	Corporate bond index (4)
3-mont Gov. Bond (1)	3-mont Gov. Bond (1)	Listed real estate index (3)	Corporate bond index (4)	3-mont Gov. Bond (1)
Listed real estate index (4)	Listed real estate index (3)	Yield spread (1)	3-mont Gov. Bond (1)	Listed real estate index (3)
Yield spread (10)	Yield spread (10)	Consumer confidence (4)	Listed real estate index (4)	Yield spread (9)
Global trade (2)	Consumer confidence (5)	Total share prices (4)	Yield spread (10)	Consumer confidence (1)
Consumer confidence (5)	Total share prices (3)	Money supply, M2 (1)	Global trade (4	Total share prices (3)
Total share prices (3)	Money supply, M2 (1)	Leading credit index (6)	Consumer confidence (6)	Money supply, M2 (1)
Money supply, M2 (1)	Leading credit index (6)	Interest rate spread (1)	Total share prices (3)	Leading credit index (4)
Leading credit index (6)	Interest rate spread (10)	Average weakly hours (3)	Money supply, M2 (1)	Interest rate spread (9)
Interest rate spread (10)	Average weakly hours (3)	Initial unemployment claims (3)	Leading credit index (6)	Average weakly hours (1)
Average weakly hours (3)	Initial unemployment claims (4)	Man. new orders (3)	Interest rate spread (10)	Initial unemployment claims (1)
Initial unemployment claims (4)	Man. new orders (3)	Vendor performance (6)	Average weakly hours (3)	Man. new orders (1)
Man. new orders (3)	New orders non def. (2)	New orders non def. (3)	Initial unemployment claims (1)	Vendor performance (3)
Vendor performance (1)	Industrial production (3)	Industrial production (2)	Man. new orders (3)	BCI (2)
New orders non def. (2)		BCI (5)	New orders non def. (3)	Industrial production (1)
Industrial production (3)		Industrial production (2)	Industrial production (1)	

Yield Shift Overall	Yield Shift Retail	Yield Shift Industrial	Yield Shift Office	Yield shift Appartment
Building permits (4)	Building permits (4)	Building permits (4)	Building permits (5)	Building permits (4)
Employment growth (1)	Vacancy rate (5)	Interest rate (8)	Employment growth (1)	Vacancy rate (1)
GDP growth (1)	Employment growth (1)	Employment growth (1)	GDP growth (1)	Employment growth (1)
Retail sales (2)	GDP growth (1)	Economic leading index (4)	Retail sales (2)	GDP growth (1)
Economic leading index (4)	Retail sales (1)	Risk spread (10)	Economic leading index (4)	Retail sales (1)
Risk spread (10)	Economic leading index (5)	Corporate bond index (3)	Risk spread (10)	Economic leading index (4)
Corporate bond index (4)	Risk spread (10)	3-mont Gov. Bond (1)	Corporate bond index (4)	Risk spread (10)
3-mont Gov. Bond (1)	Corporate bond index (4)	Listed real estate index (4)	3-mont Gov. Bond (1)	Corporate bond index (5)
Listed real estate index (4)	3-mont Gov. Bond (1)	Yield spread (1)	Listed real estate index (4)	3-mont Gov. Bond (1)
Yield spread (1)	Listed real estate index (4)	Global trade (1)	Yield spread (10)	Listed real estate index (4)
Global trade (1)	Yield spread (9)	Consumer confidence (5)	Global trade (1)	Yield spread (10)
Consumer confidence (5)	Global trade (1)	Total share prices (2)	Consumer confidence (5)	Global trade (1)
Total share prices (2)	Consumer confidence (1)	Money supply, M2 (1)	Total share prices (3)	Total share prices (4)
Money supply, M2 (1)	Money supply, M2 (1)	Leading credit index (6)	Money supply, M2 (1)	Money supply, M2 (1)
Leading credit index (6)	Leading credit index (4)	Interest rate spread (2)	Leading credit index (6)	Leading credit index (5)
Interest rate spread (1)	Interest rate spread (9)	Average weakly hours (4)	Interest rate spread (10)	Interest rate spread (10)
Average weakly hours (2)	Average weakly hours (1)	Initial unemployment claims (4)	Average weakly hours (4)	Average weakly hours (1)
Initial unemployment claims (2)	Initial unemployment claims (6)	Man. new orders (3)	Initial unemployment claims (1)	Initial unemployment claims (1)
Man. new orders (3)	Man. new orders (3)	Vendor performance (5)	Man. new orders (3)	Man. new orders (2)
	Vendor performance (9)		New orders non def. (3)	New orders non def. (3)
	New orders non def. (4)		Industrial production (1)	Industrial production (1)
	BCI (10)			
	Industrial production (3)			

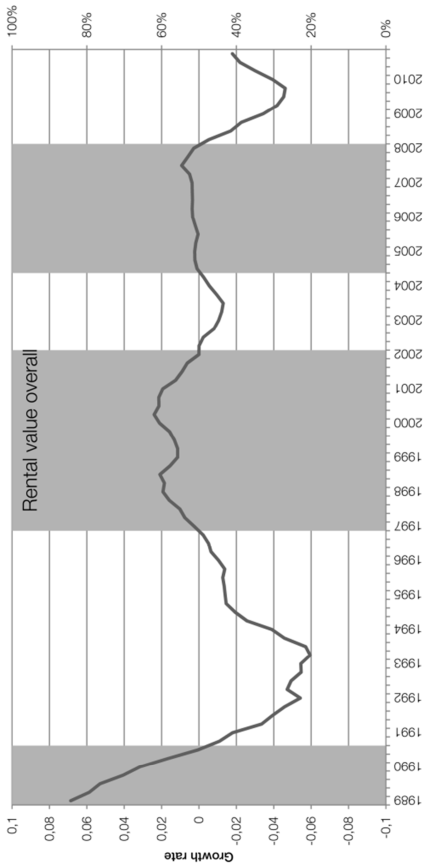
Appendix 2: results U.K.

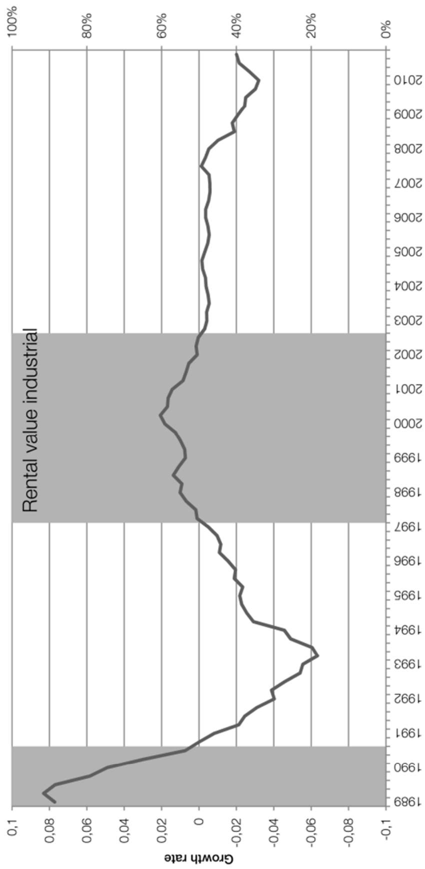
Descriptive statistics before transformation

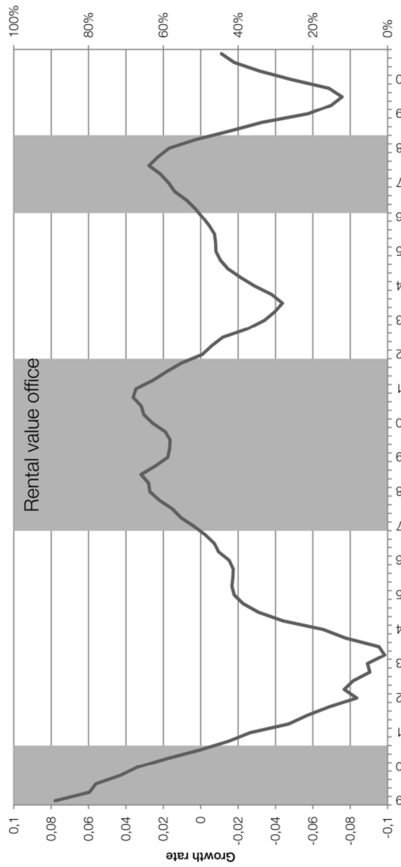
Variable	N	Mean	Median	SD	Min	Max
Yield shift overall	93	115,439	117,039	14,435	82,324	143,614
Yield shift industrial	93	94,533	95,986	12,041	66,241	116,066
Yield shift office	93	125,422	129,036	14,555	92,776	158,005
Yield shift retail	93	115,696	116,540	15,282	81,842	148,438
Rental value overall	88	-0,006	-0,001	0,026	-0,059	0,069
Rental value industrial	88	-0,002	0,002	0,019	-0,040	0,054
Rental value office	88	-0,006	-0,005	0,027	-0,063	0,083
Rental value retail	88	-0,012	-0,008	0,039	-0,099	0,078
Real estate literature variables						
New building permits	84	36414,762	37710,000	7104,834	16420,000	49660,000
Interest rate	93	6,577	5,500	2,390	3,260	12,320
Employment	93	29623,204	29216,000	1539,872	27275,000	32154,000
GDP	93	289291,247	284159,000	52808,779	211571,000	372659,000
Retail sales	93	77,234	72,200	14,910	57,600	100,700
Risk spread	48	0,443	0,377	1,070	-0,947	3,864
Economic sentiment	93	102,016	102,800	11,261	66,600	127,200
Corporate bond yield	48	5,063	4,772	1,047	3,491	8,014
3 month government bond yield	93	6,123	5,370	3,363	0,400	14,500
Global trade	80	117,831	111,402	18,839	93,005	169,930
Listed real estate	84	1142,724	1023,995	500,086	469,650	2851,140
Yield spread	93	0,454	0,140	1,663	-3,980	3,560
Economic leading index	93	83,570	82,823	15,304	61,672	106,370
Economic leading indicators						
Consumer Confidence Indicator	93	-8,559	-6,000	8,011	-31,000	4,700
New car registrations sa (number)	93	100,038	100,125	1,024	96,825	102,322
FTSE All-Share Index	93	2116,968	2197,000	740,224	870,220	3404,140
Money supply, M2	93	627474,376	532126,000	302886,596	220542,000	1234992,000
3-month eligible bank bills (% p.a.)	93	99,962	100,106	1,668	94,620	104,290
Money supply, M4	93	953052,753	796171,000	522917,117	304450,000	2211772,000
Industrial production	93	107,672	110,200	6,129	96,800	116,400
Order Book Volume	93	-18,892	-16,000	18,776	-58,000	20,000
Volume of Expected Output	93	6,000	9,000	14,827	-45,000	33,000
Productivity, Whole Economy	93	86,756	86,200	12,122	67,800	105,000
Total Gross Operating Surplus of Corporations	93	52663,817	50934,000	17420,873	25928,000	84739,000
Business climate indicator (% balance)	93	-9,484	-8,000	13,247	-49,000	18,000
Production: future tendency (% balance)	93	99,981	100,287	1,279	95,598	101,736
Finished goods stocks: tendency (% balance)	93	99,958	99,999	1,242	97,348	103,746

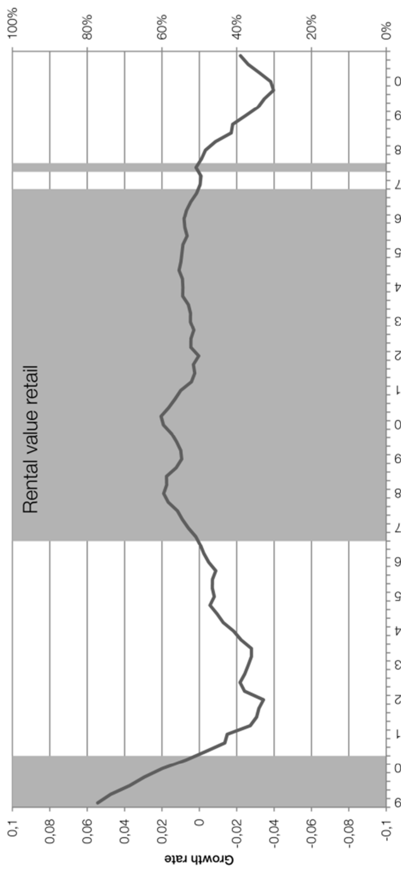
Descriptive statistics after transformation

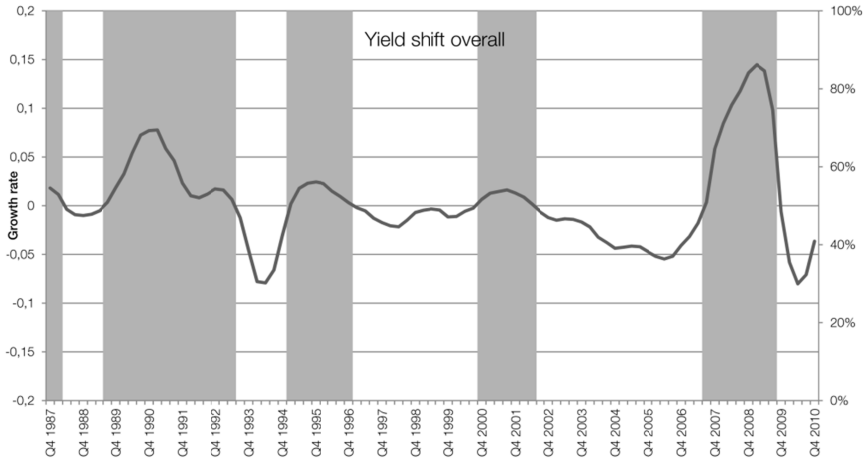
Variable	N	Mean	Median	SD	Min	Max
Yield shift overall	93	0,003	-0,004	0,046	-0,080	0,145
Yield shift industrial	93	-0,001	-0,008	0,044	-0,074	0,134
Yield shift office	93	0,004	-0,003	0,047	-0,088	0,130
Yield shift retail	93	0,003	0,000	0,049	-0,093	0,160
Rental value overall	88	-0,006	-0,001	0,026	-0,059	0,069
Rental value industrial	88	-0,002	0,002	0,019	-0,040	0,054
Rental value office	88	-0,006	-0,005	0,027	-0,063	0,083
Rental value retail	88	-0,012	-0,008	0,039	-0,099	0,078
Real estate literature variables						
New building permits	77	-0,008	0,006	0,095	-0,390	0,197
Interest rate	93	-0,019	-0,026	0,057	-0,137	0,111
Employment	93	0,003	0,004	0,007	-0,015	0,017
GDP	93	0,010	0,013	0,010	-0,027	0,028
Retail sales	93	0,011	0,011	0,010	-0,011	0,030
Risk spread	45	0,494	0,406	1,086	-0,947	3,864
Economic sentiment	93	-0,002	-0,004	0,060	-0,196	0,180
Corporate bond yield	41	-0,019	-0,021	0,100	-0,269	0,188
3 month government bond yield	93	-0,055	-0,024	0,207	-1,084	0,200
Global trade	80	117,831	111,402	18,839	93,005	169,930
Listed real estate	77	-0,002	0,023	0,144	-0,438	0,288
Yield spread	93	0,454	0,140	1,663	-3,980	3,560
Economic leading index	93	0,011	0,012	0,009	-0,021	0,029
Economic leading indicators						
Consumer Confidence Indicator	93	-8,559	-6,000	8,011	-31,000	4,700
New car registrations sa (number)	93	0,000	0,000	0,006	-0,019	0,020
FTSE All-Share Index	93	0,019	0,038	0,072	-0,173	0,166
Money supply, M2	93	0,033	0,034	0,011	0,009	0,065
3-month eligible bank bills (% p.a.)	93	0,000	0,000	0,009	-0,039	0,016
Money supply, M4	93	0,039	0,036	0,017	0,010	0,076
Industrial production	93	0,002	0,003	0,014	-0,051	0,025
Order Book Volume	93	-18,892	-16,000	18,776	-58,000	20,000
Volume of Expected Output	93	6,000	9,000	14,827	-45,000	33,000
Productivity, Whole Economy	93	0,008	0,008	0,007	-0,023	0,020
Total Gross Operating Surplus of Corporations	93	0,022	0,025	0,025	-0,044	0,077
Business climate indicator (% balance)	93	-9,484	-8,000	13,247	-49,000	18,000
Production: future tendency (% balance)	93	0,000	0,000	0,008	-0,022	0,025
Finished goods stocks: tendency (% balance)	93	0,000	0,000	0,008	-0,023	0,018

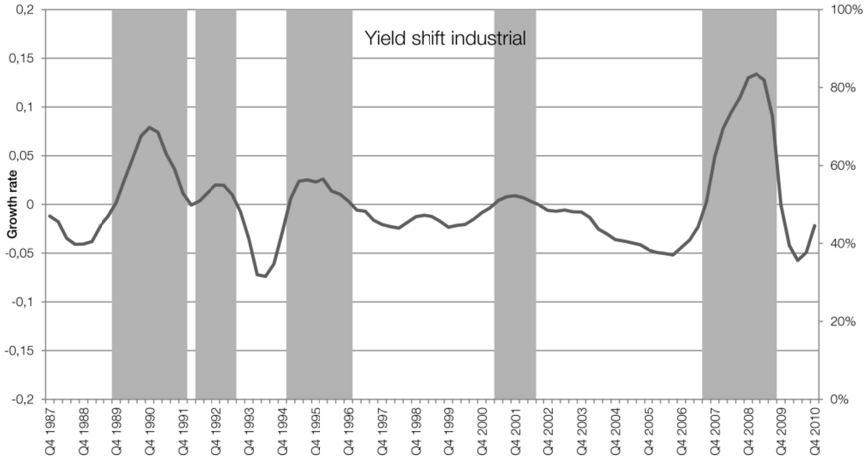

Rental value overall
Growth rate
0,1 0,08 0,06 0,04 0,02 0 -0,02 -0,04 -0,06 -0,08 -0,1
Q1 1989 Q1 1990 Q1 1991 Q1 1992 Q1 1993 Q1 1994 Q1 1995 Q1 1996 Q1 1997 Q1 1998 Q1 1999 Q1 2000 Q1 2001 Q1 2002 Q1 2003 Q1 2004 Q1 2005 Q1 2006 Q1 2007 Q1 2008 Q1 2009 Q1 2010
100% 80% 60% 40% 20% 0%

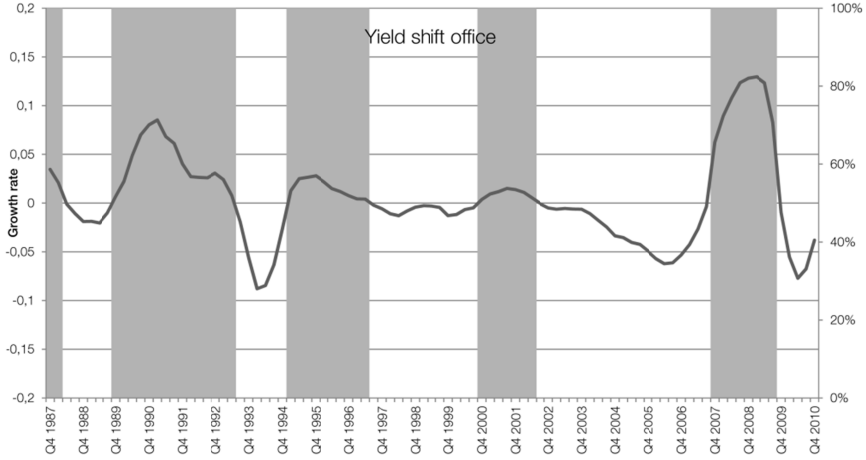

Rental value industrial
Growth rate
0,1 0,08 0,06 0,04 0,02 0 -0,02 -0,04 -0,06 -0,08 -0,1
Q1 1989 Q1 1990 Q1 1991 Q1 1992 Q1 1993 Q1 1994 Q1 1995 Q1 1996 Q1 1997 Q1 1998 Q1 1999 Q1 2000 Q1 2001 Q1 2002 Q1 2003 Q1 2004 Q1 2005 Q1 2006 Q1 2007 Q1 2008 Q1 2009 Q1 2010
100% 80% 60% 40% 20% 0%

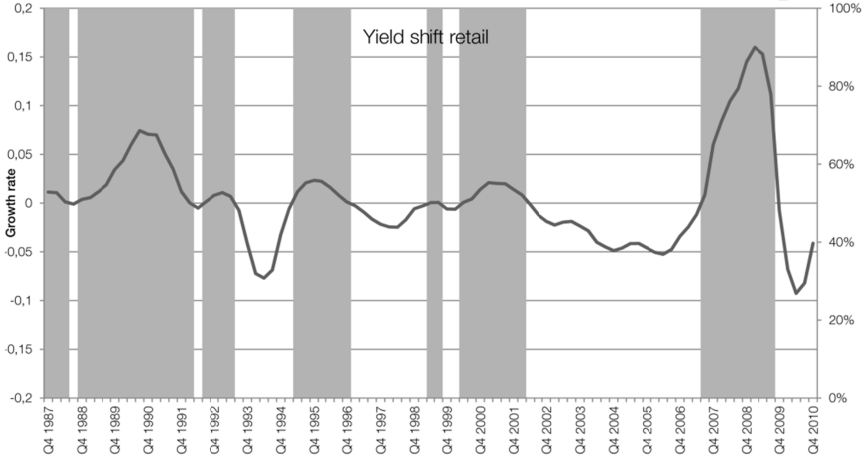

Rental value office
Growth rate
0,1 0,08 0,06 0,04 0,02 0 -0,02 -0,04 -0,06 -0,08 -0,1
Q1 1989 Q1 1990 Q1 1991 Q1 1992 Q1 1993 Q1 1994 Q1 1995 Q1 1996 Q1 1997 Q1 1998 Q1 1999 Q1 2000 Q1 2001 Q1 2002 Q1 2003 Q1 2004 Q1 2005 Q1 2006 Q1 2007 Q1 2008 Q1 2009 Q1 2010
100% 80% 60% 40% 20% 0%


Rental value retail
Growth rate
0,1 0,08 0,06 0,04 0,02 0 -0,02 -0,04 -0,06 -0,08 -0,1
Q1 1989 Q1 1990 Q1 1991 Q1 1992 Q1 1993 Q1 1994 Q1 1995 Q1 1996 Q1 1997 Q1 1998 Q1 1999 Q1 2000 Q1 2001 Q1 2002 Q1 2003 Q1 2004 Q1 2005 Q1 2006 Q1 2007 Q1 2008 Q1 2009 Q1 2010
100% 80% 60% 40% 20% 0%


Yield shift overall
Growth rate
0,2
0,15
0,1
0,05
0
-0,05
-0,1
-0,15
-0,2
100%
80%
60%
40%
20%
0%
Q4 1987
Q4 1988
Q4 1989
Q4 1990
Q4 1991
Q4 1992
Q4 1993
Q4 1994
Q4 1995
Q4 1996
Q4 1997
Q4 1998
Q4 1999
Q4 2000
Q4 2001
Q4 2002
Q4 2003
Q4 2004
Q4 2005
Q4 2006
Q4 2007
Q4 2008
Q4 2009
Q4 2010


Yield shift industrial
Growth rate
0,2
0,15
0,1
0,05
0
-0,05
-0,1
-0,15
-0,2
100%
80%
60%
40%
20%
0%
Q4 1987
Q4 1988
Q4 1989
Q4 1990
Q4 1991
Q4 1992
Q4 1993
Q4 1994
Q4 1995
Q4 1996
Q4 1997
Q4 1998
Q4 1999
Q4 2000
Q4 2001
Q4 2002
Q4 2003
Q4 2004
Q4 2005
Q4 2006
Q4 2007
Q4 2008
Q4 2009
Q4 2010


Yield shift office
Growth rate
0,2
0,15
0,1
0,05
0
-0,05
-0,1
-0,15
-0,2
100%
80%
60%
40%
20%
0%
Q4 1987
Q4 1988
Q4 1989
Q4 1990
Q4 1991
Q4 1992
Q4 1993
Q4 1994
Q4 1995
Q4 1996
Q4 1997
Q4 1998
Q4 1999
Q4 2000
Q4 2001
Q4 2002
Q4 2003
Q4 2004
Q4 2005
Q4 2006
Q4 2007
Q4 2008
Q4 2009
Q4 2010


Yield shift retail
Growth rate
0,2
0,15
0,1
0,05
0
-0,05
-0,1
-0,15
-0,2
100%
80%
60%
40%
20%
0%
Q4 1987
Q4 1988
Q4 1989
Q4 1990
Q4 1991
Q4 1992
Q4 1993
Q4 1994
Q4 1995
Q4 1996
Q4 1997
Q4 1998
Q4 1999
Q4 2000
Q4 2001
Q4 2002
Q4 2003
Q4 2004
Q4 2005
Q4 2006
Q4 2007
Q4 2008
Q4 2009
Q4 2010

Results univariate regression

Yield Shift Overall	Yield Shift Retail	Yield Shift Industrial	Yield Shift Office
Interest rate (5)	Interest rate (4)	Interest rate (7)	Interest rate (6)
Employment growth (1)	Employment growth (9)	Employment growth (1)	Employment growth (1)
GDP Growth (1)	GDP Growth (6)	GDP Growth (1)	GDP Growth (1)
Retail sales (2)	Retail sales (2)	Retail sales (2)	Retail sales (2)
Economic leading index (1)	Economic leading index (1)	Economic leading index (1)	Economic leading index (2)
Risk spread (1)	Risk spread (1)	Risk spread (10)	Risk spread (1)
Economic sentiment (1)	Economic sentiment (1)	Economic sentiment (1)	Economic sentiment (1)
Corporate bond index (3)	Corporate bond index (3)	Corporate bond index (3)	Corporate bond index (3)
3-month Gov. Bond (4)	3-month Gov. Bond (4)	3-month Gov. Bond (5)	3-month Gov. Bond (5)
Listed real estate index (1)	Listed real estate index (1)	Listed real estate index (1)	Listed real estate index (1)
Yield spread (4)	Yield spread (3)	Yield spread (4)	Yield spread (5)
Global trade (4)	Global trade (10)	Global trade (4)	Global trade (4)
Consumer confidence (1)	Consumer confidence (1)	Consumer confidence (1)	Consumer confidence (1)
Car registrations (2)	Car registrations (2)	Car registrations (1)	Car registrations (2)
Total share prices (1)	Total share prices (9)	Total share prices (1)	Total share prices (1)
Money supply, M2 (9)	Money supply, M2 (10)	Money supply, M2 (9)	Money supply, M2 (9)
3 month bank bills (4)	3 month bank bills (4)	3 month bank bills (4)	3 month bank bills (4)
Money supply, M4 (9)	Money supply, M4 (9)	Money supply, M4 (10)	Money supply, M4 (9)
Industrial production (8)	Industrial production (6)	Industrial production (8)	Industrial production (9)
Order book volume (6)	Order book volume (5)	Order book volume (5)	Order book volume (6)
Expected output (1)	Expected output (5)	Expected output (1)	Expected output (1)
Productivity (1)	Productivity (1)	Productivity (1)	Total gross oper. Surpl. Of corp. (8)
Total gross oper. Surpl. Of corp. (8)	Business climate indicator (5)	Total gross oper. Surpl. Of corp. (8)	Business climate indicator (6)
Business climate indicator (6)	Exp. Future production (1)	Business climate indicator (1)	Exp. Future production (1)
Exp. Future production (1)	Exp. Finished goods stocks (1)	Exp. Future production (1)	Exp. Finished goods stocks (1)
Exp. Finished goods stocks (1)		Exp. Finished goods stocks (1)	

Rental Value Overall	Rental Value Retail	Rental Value Industrial	Rental Value Office
Employment growth (2)	Employment growth (1)	Interest rate (7)	Employment growth (3)
GDP growth (6)	GDP growth (3)	Employment growth (2)	GDP growth (3)
Retail sales (2)	Retail sales (3)	GDP growth (4)	Retail sales (1)
Economic leading index (7)	Economic leading index (7)	Retail sales (4)	Economic leading index (7)
Risk spread (6)	Risk spread (1)	Economic leading index (5)	Corporate bond index (10)
Corporate bond index (9)	Investor sentiment (7)	3-month Gov. Bond (1)	3-month Gov. Bond (2)
3-month Gov. Bond (2)	Corporate bond index (7)	Yield spread (1)	Yield spread (1)
Listed real estate (3)	3-month Gov. Bond (1)	Global trade (7)	Global trade (3)
Yield spread (1)	Listed real estate (3)	Consumer confidence (4)	Consumer confidence (6)
Consumer confidence (4)	Yield spread (1)	Car registrations (4)	Total share prices (6)
Total share prices (5)	Global trade (10)	Money supply, M2 (10)	Money supply, M2 (10)
Money supply, M2 (10)	Consumer confidence (5)	Industrial production (4)	3 month bank bills (1)
3 month bank bills (2)	Money supply, M2 (10)	Order book volume (9)	Money supply, M4 (1)
Money supply, M4 (1)	Money supply, M4 (10)	Expected output (5)	Industrial production (4)
Industrial production (4)	Industrial production (4)	Business climate indicator (5)	Order book volume (2)
Order book volume (2)	Order book volume (1)		Expected output (7)
Expected output (4)			Business climate indicator (3)
Business climate indicator (3)			