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Empirical Study on the Term Structure for Stockholm Commercial Property Leases

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Abstract

Over recent years, the economic climate on the Swedish office market has been advantageous, and, as a result, both property prices and market rents have been on a constant rise for almost a decade. Moreover, an increased demand for flexibility in lease terms has been seen on the market, which begs the question; how would changing preferences in length of tenure affect rent levels? There exist several convincing theoretical cases that leases should yield different pricing dependent on its maturity and expectation about future market conditions. The conceptual framework developed by Grenadier (1995, 2005) has been used for the valuation of general leasing contracts and lease terms - applying an option-pricing approach. In total, three papers have analysed the effect length of tenure has on office equilibrium lease rates. However, the empirical evidence, to this date, has been inconclusive in its result when trying to isolate the effects.

The purpose of this report is to investigate the relationship between rent and lease maturity. A hedonic pricing model will be developed, which allows for different shapes of the term structure curve, building on the model created by Gunnelin and Soderberg (2003), while controlling for price-relevant characteristics omitted in previous research – such as, building quality, quality of office premise, location, and tenant industry. The model will be used in an empirical study applied to commercial office contracts in Stockholm, Sweden, concluded between 2012 and 2019.

The data used in the regression comprise of 1 508 office leases, contracted on the Stockholm market during the investigated period. The result showed a significant term structure for 4 out of 8 years for the full sample, and 5 out of 8 years for the subsample only including leases signed in the CBD. Concludingly, giving further evidence to the reasoning that the market adjusts the rents after lease length, according to future market expectations.

Acknowledgement

With this thesis, we complete our studies in the Department of Real Estate and Construction Management at the Royal Institute of Technology. The chosen subject to study brought us great insights and knowledge of the contractual agreements associated with office leases, which will be of great use for our future careers in the real estate industry.

We want to express our sincere gratitude to our supervisor, Åke Gunnelin, who contributed to our report, both with his previous research and as a knowledgeable supervisor. We would also like to show appreciation to the real estate company supplying our thesis with data, and, thus, making this research possible.

Stockholm, June 2019

Filip Alveman & Gustav Karlsson

Table of Contents

1 Introduction

When determining the interest rate for bonds with different maturities, the expectations of future market conditions will play an essential part. The relationship between interest rates and maturities is reflected in the term structure. Grenadier (1995) uses the concept of bond pricing as an analogy to lease pricing for the rental market, comparing the length of tenure to that of the maturity of bonds. His work has provided a theoretical framework for valuation of general leasing contracts and lease terms, from the perspective of the asset values to the landlord, using an option-pricing approach. However, it has not yet been fully explored whether the term structure in rent (the relationship between lease length and initial rent) is similar to that in the term structure of interest rates (the relationship between interest rates and corporate bond price). Although, there have been some empirical investigations paying attention to the effect length of tenure has on equilibrium lease rates.

Gunnelin and Soderberg (2003) were the first to empirically analyse the term structure of office rents using a hedonic rent equation, building on the work of Grenadier (1995). Their model specification allowed the term structure to vary, reflecting different term structure in a changing market – as showed by Grenadier (1995). The findings revealed some evidence of a significantly varying term structure on the Stockholm office market.

Following the model set-up by Gunnelin and Soderberg (2003), other researchers contributed to the field by conducting a similar hedonic rent equation on the office markets of London, and Shanghai, finding, respectively, evidence of significant upward- and downward-sloping term structures (Bond et al. 2008, Fang and Ruichang 2009).

1.1 Research Gap

The existing research is inconclusive in that it fails to consistently determine the effect length of tenure has on equilibrium lease rates through its term structure slope. Our research will, therefore, further investigate the term structure in Stockholm, following the work of Gunnelin and Soderberg (2003). This study will explain why previous research, when compared, has yielded indecisive and different results. Also, it will increase the explanatory power of the work of Gunnelin and Soderberg (2003) by expanding the investigated period. Furthermore, hypothesised price-relevant characteristics omitted in previous research will be added, with special regard to a proxy for quality of the office premise.

1.2 Aim

This study aims to investigate the relationship between rent and lease maturity for office leases in Stockholm during the period 2012-2019. The following are our critical questions:

- $CQ_{(1)}$: Is the term structure in leases an accurate representation of landlord behaviour?
- $CQ_{(2)}$: Does a relationship between rent and lease maturity exists?
- $CQ_{(3)}$: What shape does the rental term structures have during the investigated period?

2 Theory

2.1 Term Structures

Following logical reasoning and given rational actors, the lease rate should vary for different lease lengths depending on their expectations of future market rent levels (Grenadier 1995). To illustrate this, Figure 1 below shows an example of a market with rising lease rates. Consider the option of two contracts, one with a long lease length and another one with a short lease length. During the lease term, the lease rate (or rent) is fixed. Only when a lease expires, the landlord can renew the contract with an increased rent at the current market level – according to Swedish law (SFS 1974:994).

In the instance of an upward rising market, the consequence of signing leases with a long term becomes, from the landlord's perspective, the loss of potential income from not renewing more often – under the assumption that the rent is renegotiated to market rent during the end of each contracted period. The dotted areas between the lines illustrate this consequence. In a rapidly increasing market, as seen in the first years, the effect is more noticeable. As follows, a rational actor would, in this example, demand a higher lease rate for an extended contract period, thus, making the value of the two contracts equal. Subsequently, in the opposite situation with a declining market, the inverse logic would apply. Therefore, depending on the current future expectations of market levels, the lease rates will vary over time with the lease term, hence, creating a term structure (Grenadier 1995).

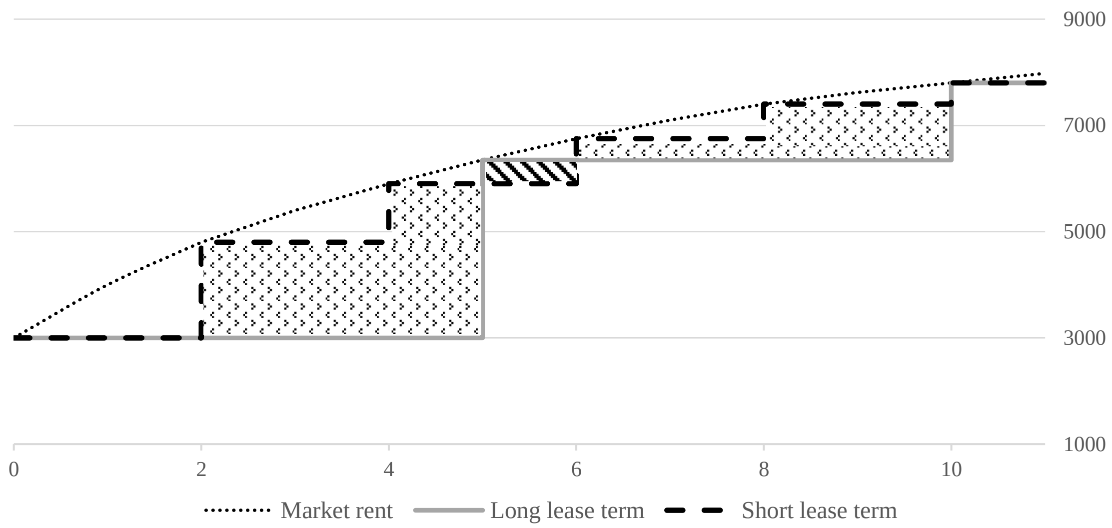

Figure 1. An example illustrating the adverse effects of signing long leases in an upward rising market. The dotted area represents the losses a landlord suffers from long leases in comparison to a shorter one. In turn, the striped area represents the small period where the longer lease is superior.

Lease pricing has had several theoretical advances over the last decades (Miller and Upton 1976, McConnell and Schallheim 1983, Grenadier 1995, Grenadier 2005). The current research providing empirical support for these models have typically used regression analysis as a tool to explain the effect various explanatory variables have on lease rates. The earlier empirical studies that analyse the term structure of office rent has primarily been conducted in multiple metropolitan areas in the United States using data from the late ’70s and early ’90s (Brennan et al. 1984, Wheaton and Torto 1994, Webb and Fisher 1996). The studies showed inconclusive and different results concerning the significance of the term variable. In other words, how the lease length is affecting the lease rate. However, as argued by Gunnelin and Soderberg (2003), a shortcoming of earlier research is not allowing the term structure of lease rates to vary over time.

To accommodate this, Grenadier (1995) used the analogy of bond pricing with varying maturities to produce a theoretical framework that accounts for variation in the lease lengths and its effect on the lease term structure. The term structure of interest rate, in the setting of option and bonds pricing, explains the relationship between interest rates and different maturities. The analogy uses an equilibrium model of lease valuation, drawing from the assumption that landlords will extract the same value regardless of lease structure. The shape of the term structure will reflect the expectations of future market supply and demand changes possessed by the participants of the market and, accordingly, the market rent. Moreover, the three shapes which the term structure can take on are related to specific market developments. The addition of a time-dependent variable, when considering lease length, provided a possibility to improve the specification of the hedonic rent equation. The term structure, and its shape, will reflect the rational response of the participants in the market due to an anticipated increase in the markets’ future supply or demand, which in return, will explain expectation of future rents. Hence, a pattern of length of leases can, in theory, anticipate property cycles and future change in a market’s conditions. Grenadier (1995) presented three possible shapes of the term structure; upward, downward, and single-humped.

To exemplify the different shapes of the term structure, an upward-sloping term structure indicates that the demand for offices is expected to grow in the future, with little or no addition of supplied offices anticipated. An upward-sloping term would, therefore, increase the short-term lease rate, hence, making the equilibrium lease rate an increasing function of the length of the contract. In other words, if the market condition is expected to improve, the rational response of a landlord would be to sign leases with short tenure, hoping to take advantage of the improved market condition in the next renegotiation. An illustration of this can be seen in Figure 2 below. A similar but converse interpretation holds for a downward-sloping term structure – the expectation of deteriorating market conditions makes signing long leases the rational response of the landlord, as seen in Figure 4. Moreover, a single-humped term structure will reflect the market's anticipation of a rising market in the coming years, to later decline and return to its initial state – making the choice of term rather irrelevant or equivalent for its actors.

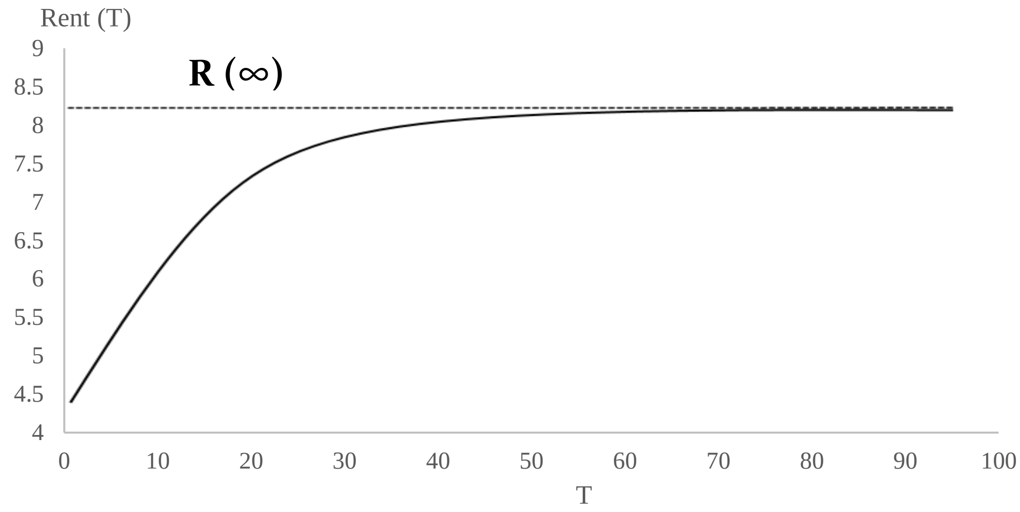

Figure 2. Upward-sloping term structure. Adapted from Grenadier (1995)

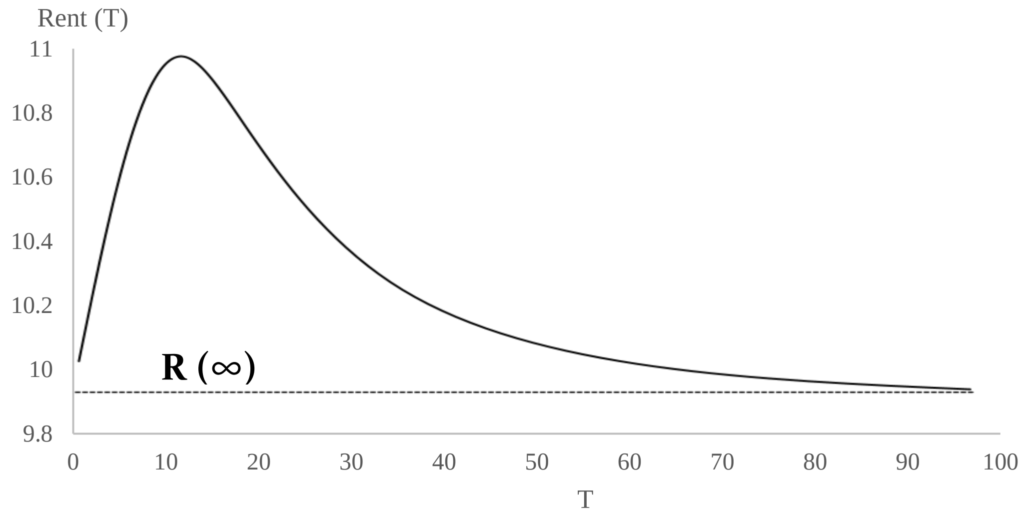

Figure 3. Single-humped term structure. Adapted from Grenadier (1995)

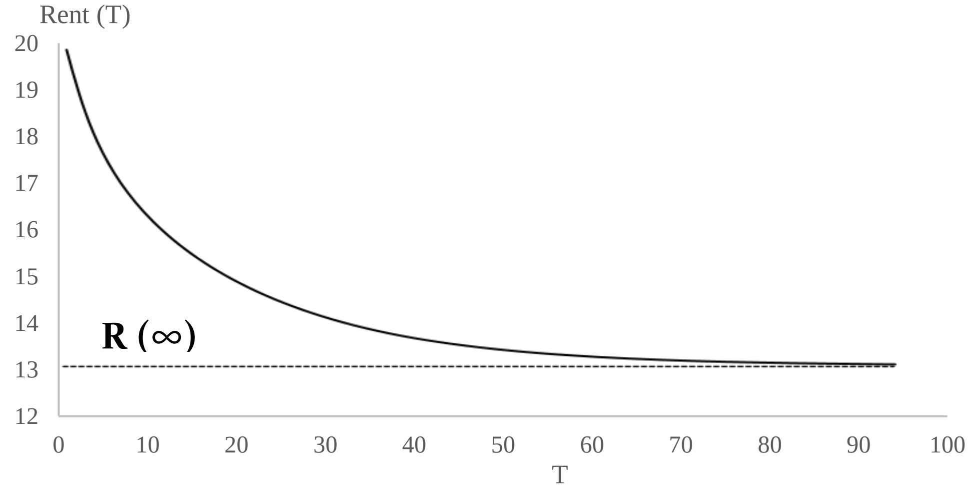

Figure 4. Downward-sloping term structure. Adapted from Grenadier (1995)

Continuing the work of Grenadier (1995), several models have been developed for pricing of lease cash flow, using the concept of market equilibrium relationships (Ambrose et al. 2002, Hendershott and Ward 2003, Stanton and Wallace 2009, Clapham and Gunnelin 2003). The theory of market equilibrium relationship states that; if two leases have the same maturity, they will yield equal present value for the landlord – making the choice of rental rate irrelevant. Assumptions about, rental behaviour, volatility, risk-free rates, and growth in rents, are used when determining the optimal pricing solution.

Few of earlier empirical studies have taken the rental term structure into account in their model, and only in the paper of Stanton and Wallace (2009) it is considered as an important theme. To account for this gap, Gunnelin and Soderberg (2003) and Englund et al. (2004) determined a regression model which can estimate the linear and quadratic functions of the term structure and applied it for lease rates on the Swedish office rental market.

Gunnelin and Soderberg (2003) used hedonic regression analysis, with data from the office market in the CBD (Central Business District) of Stockholm during the time period 1977-1991. The chosen period contained both a boom and a bust phase to help illustrate and determine the term structure during various property cycles. In the years analysed, 7 out of 15 years showed a significant term structure, and future rent levels could be predicted to a certain degree. Two other papers have followed the model set up by Gunnelin and Soderberg (2003) investigating the term structure for office leases.

Bond et al. (2008) conducted an empirical study on the office market of the UK during the time period 1994-2004. Their data had information from 726 office leases signed in the central of London. In their model, which they Gunnelin and Soderberg (2003), they also controlled for options break clauses, which was far more commonly found in leases from the US and the UK compared to Swedish ones (Bond et al. 2008, Stanton and Wallace 2009). Furthermore, their model specification also controlled for micro-location, tenant credit ratings, and tenant industry. The findings showed an upward-sloping term structure.

Fang and Ruichang (2009) examined the terms structure on the office market of Shanghai. A total of 555 leases were used in their regression which spanned the period 2005-2008. The main addition in the model was increased control for the quality of the building, which has shown to be significant in earlier studies. The findings showed a downward-sloping term structure.

A more recent study has attempted to apply the model of term structure of rents to the land rental markets of agricultural use (Huttel et al. 2016). Using data of 2 123 rental contracts, over the time period 2002-2010, they discovered a significant term structure for 6 out of 9 years, and a varying slope over the price boom analysed.

2.2 Theoretical Framework

The research of Gunnelin and Soderberg (2003), Bond et al. (2008), and Fang and Ruichang (2009), which empirically analyse the term structure of office leases, is inconclusive in its results when determining the effect length of tenure has on equilibrium lease rates. These three research papers have all reported varying significance of the term structure.

Moreover, Stanton and Wallace (2009) question whether the hypothesis provided by Grenadier (1995) is an applicable and accurate representation of landlord behaviour. They acknowledge that leases are similar to that of corporate bonds in many ways, but presents two fundamental differences. First, a lease cannot be judged if its correctly priced just by analysing its payments, as corporate bonds can. Second, an office lease and its attributes are considerably more heterogeneous compared to a corporate bond.

These two problems can be solved by testing the validity of the existing frameworks on option pricing theory provided by Grenadier (1995). Through analysing different settings and periods, the implications of the equilibrium lease rate and term structure can be determined. However, the framework of Grenadier (1995) cannot directly be used for empirical estimation, since office leases are heterogeneous goods – in contrast to other financial assets. Therefore, the theoretical model needs variables that control for attributes of the leased office.

The following model was presented by Gunnelin and Soderberg (2003):

$$R(T) = e^{f_1(T)} \cdot e^{f_2(A_j)} \quad (1)$$

Where:

$R(T)$	= rent per square meter
$f_1(T)$	= non-linear function of the contract term T
$f_2(A_j)$	= function of attributes A_j, j indexing the number of attributes of the office lease considered in the hedonic pricing model

The equation provides an estimation of the term structure curves. In our empirical application, we will build on the model used by Gunnelin and Soderberg (2003), adding hypothesised significant attributes to the equation which has not been previously analysed for the Stockholm market, e.g. quality of the building, quality of the leased office premise, location, and tenant industry.

3 Methods

This report aims to explain the relationship between rent and lease maturity for office leases, and, to do so, also create a generalisation for office leases and their expected term structure. In research, using the approach of a qualitative method can be unreliable when trying to estimate and quantify attributes, while a quantitative method excels at this. Hence, an explanatory quantitative methodology will be conducted in this paper. The method used must be able to statistically analyse quantitative data, and describe the relationship between variables, as well as quantify them. The most common and accepted method fulfilling this description is the computational technique of regression analysis. Regression analysis statistically analyses and answers the research question by testing the likelihood of a relationship existing (Robson 2011). In other words, you are comparing data with theory, analysing what is expected to happen, and comparing it with what the data gathered says (Saunders et al. 2009). Therefore, a regression analysis will act as the method which forms the foundation when explaining the term structure of office leases.

3.1 Hedonic Pricing Model

A hedonic pricing model identifies price factors according to the principle that price is determined both by; internal characteristics of the good, and the external factors affecting it. Earlier studies in this field comprise of Waugh (1928), studying price difference between vegetables, and Court (1939), studying price development and quality increases in the car industry. Both studies focused on the product and its attributes as a way to be able to explain the price, but it was first in the article "Hedonic Price and Implicit markets", published in 1974, as the theory further focused on individual characteristics (Rosen 1974). The perspective has moved from the heterogeneous product to the estimation of individual characteristics. Rosen's article became part of a breakthrough for theoretical debates within hedonic research that has led to different authors trying to develop the model further.

Rosen's model is intended to estimate the impact of the individual attributes on the total price. The method is rarely used as a valuation method, but instead used as, more often than not, when analysing various factors that affect the price on the property market. The theory is to break down a commodity into its attributes and then estimate the value of each attribute. A hedonic rent equation estimates the value of commodity characteristics that indirectly affects its market price, i.e. the value of a commodity can be calculated by adding up the estimated values of its separate attributes (Herath and Maier 2010). These attributes affect the price of the product depending on how much benefit it creates for the potential buyer. To estimate the benefit, one must study how the product's attributes are implicitly priced. The product's characteristics are represented by a vector consisting of defined attributes. The price of the product will be a function of the vector, seen in equation (2) below.

$$y = \beta_0 + \sum_{j=1}^{k} \beta_j x_j + \varepsilon \tag{2}$$

In the equation, the price of the good becomes the dependent variable y, and is explained by a number of independent variables x_j, also called explaining variables. The *dependent variable* is the main factor that is trying to be understood or predicted, while the *independent variables* are the factors that has been hypothesised to have an impact on the dependent variable. The essence of the method is to find constant and verifiable values for the regression coefficient in the model, denoted as β_j. Moreover, β_0 is the intercept of the equation and shows where the straight line intersects the Y-axis. The random error term, ε, indicates that the relationship predicted in is not perfect, and that the line does not perfectly predict Y. The error term has the expectation of the value zero and a variance σ^2, the reasoning of this is explained in the next section of the report.

A standard method to acquire a hedonic pricing model is to conduct a regression analysis. It is used to quantify the relationship between the dependent variable and several explaining (independent) variables.

3.2 Regression Analysis

Regression analysis aims to construct mathematical models that can explain or describe relationships that are hypothesised to exist between variables. Moreover, it creates a greater understanding of how the dependent variable changes due to variation in the independent variables, while keeping the other independent variables fixed. The fitting of the model is done for several reasons, but the two most important are; (i) uncover causes by studying the relationship between variables, (ii) and examine and test the scientific hypothesis (Seber and Lee 2012). In this study, causality between variables is sought after, in particular, that of the term structure – term and rent.

3.2.1 Linear Regression

Linear regression is one of the most widely known and used regression techniques. The dependent variables must be continuous, while the independent can be continues or discrete. If more than one independent variable exists, the regression becomes a multiple linear regression, whereas simple linear regression only has one. Several more types of non-linear regression techniques exist, e.g., logistic regression, used to find the probability of an event, and polynomial regression, utilised when the power of the independent variable is more than one, but for this paper, the focus will be on that of log-linear regression technique. More on this in later sections. The linearity of an equation lies in its parameters; however, this does not prevent the model from predicting variables which produce curvature. A second-order variable component to create curvature is essential for this paper to show the shape of the term structure. However, linear regression cannot control for non-linear relationships within the model. In case such relationships exist, logarithmic transformations of variables can be used to handle this issue. While this method allows for non-linear relationships between the independent and dependent variables, it does not alter the linear regression (Benoit 2011).

The linear mathematical function is then fitted to a series of data points. The linear regression models often use the least squared approach when trying to find the best fit for the data.

We assume n sets of observations in the sample, hence creating a vector of all outputs. The equation (2) can therefore be rewritten as,

$$y_i = \sum_{j=0}^{k} \beta_j x_{ij} + \varepsilon_i \qquad i = 1,2, \dots, n \tag{3}$$

Now, a method is needed to estimate the unknown parameters in the equation model. The approach used in the report is the method of ordinary least squares.

3.2.2 Ordinary Least Squares (OLS)

Ordinary least squares regression is one of the primary techniques used to analyse data, and it forms the basis of many other methods. The technique will seek a line of best fit that explains the potential relationship between an independent variable and a dependent variable. It does this by estimating the slope and intercept of the regression line and trying to minimise the residuals. The residuals are calculated as differences between the observed y-values and the fitted y-values, denoted as $\hat{y}$.

$$e_i = y_i - \widehat{y_i} \tag{4}$$

According to the Gauss–Markov theorem, to find the best linear unbiased estimator (BLUE), a linear regression model assumes the error term to be zero. Hence, the sum of residuals is expected to be zero for any observation.

$$\sum_{i=1}^{n} (y_i - \widehat{y_i}) = 0 \tag{5}$$

The OLS method tries to minimise the sum of squared differences between the observed and predicted values. But, since the goal is to minimise *all* the residuals, consideration must be taken to the sum of the squared residuals (SSE),

$$SSE = \sum_{i=1}^{n} (y_i - \widehat{y_i})^2 = \sum_{i=1}^{n} \left(y_i - \sum_{j=1}^{k} \widehat{\beta_j}\, x_i \right)^2 \tag{6}$$

To find our OLS estimators, we first need to find the vector $\hat{\beta}$ that minimize the sum squared of residuals in equation (6). The ordinary least squares estimator is the function;

$$\hat{\beta} = (X^T X)^{-1} X^T y \tag{7}$$

Where X denotes the design matrix consisting of $N \times k$ inputs, and X^T denotes the transpose of X. The Gauss–Markov theorem now states that the OLS estimator is BLUE.[1] The least

[1] See Draper and Smith Draper, N. R. and Smith, H. (2014) *Applied regression analysis*, John Wiley & Sons. p.32 for full proof of the Gauss-Markov theorem.

squares method will provide the overall rationale for the placement of the line to get the best fit given the data studied.

3.2.3 Tools in Regression Analysis

Residuals, beta coefficients, and t-test

The residual between the observed and the fitted values, given by the dependent variable, will form the base to determine if the assumptions and model specification is good. Moreover, to determine each attribute's contribution to the regression model, the values of the standardised beta coefficients must be examined. The beta values for the given independent variable can be used to determine the effect each variable has on the dependent variable – if any. However, the beta coefficient does only provide an indication of the average expected change. The analysis also has to interpret the confidence intervals for the estimated values. The interpretation of significance can be done using a t-test, commonly used for normally distributed variables.

The purpose of conduction a t-test is as a hypothesis testing tool, testing if the assumption applies to the whole population. A t-test investigates if the difference in mean value is significantly different from 0, that is, if we can say that there is a significant difference between the groups. The confidence interval is given by the critical t-value, calculated from the desired probability level and degree of freedom.

Dummy variable

The usefulness of regression analysis can be extended by adding qualitative independent variables – called dummy variables. Dummy variables are a boolean indicator, possible to take the value of either 0 or 1. The use of this type of variable is the possibility to sort data which is mutually exclusive to one another.

Interaction term

Sometimes there is a reason to suspect that the effect of a variable varies between different groups, caused by the interaction effect. An interaction variable should be used when there exists a relation between variables, i.e. variables are integrating with each other. When independent variables interact with each other, the effects might indicate that a third variable influences the relationship between the independent and dependent variable. If this type of relationship exists, it is critical to incorporate it into the model. Moreover, adding an interaction term is a good way to try a hypothesis in the regression analysis. Adding a second-order model with interaction makes the regression model capable of taking on a wide variety of shapes, i.e., making the model very flexible (Montgomery et al. 2012).

Logarithmic transformations of variables

Transforming the dependent variable using the natural logarithm is a common way to handle situations when the relationship between the independent and dependent variables is non-linear. The transformation converts the exponential growth pattern into a linear one. Using the logarithm form makes the *relationship* non-linear, while still preserving the *model* as linear. Moreover, a logarithmic transformation can also be used to remedy heteroscedasticity - unequal scatter of the residual variance. Another noteworthy effect of the transformation is changing the trend line and the fitted data, making it approximately equal to the average percentage growth. Logarithmic transformations are also used as a mean to handle highly skewed variables and making it into more approximately normal.

Back transformation

When using log transformations of the dependent variable in order to handle non-linear relationships, the result becomes harder to interpret. Therefore, there is often a need to back-transform the estimates to get a coherent result. However, since the regression includes an error term, as can be seen in equation (3), the back-transformation need to account for bias in the predictions (Lawner Weinberg and Knapp Abramowitz 2016). Hence, the transformation equation is as follows,

$$y_i{}^* = e^{[\ln(y_i)]^* + \frac{\hat{\sigma}^2}{2}} \tag{8}$$

Where $\hat{\sigma}^2$ represents an unbiased estimator of the variance in the error term. This works under the assumptions that; the errors are not heteroskedastic, have a mean of zero, and are serially independent. Additionally, it is assumed that the error term is normally distributed (Neyman and Scott 1960).

Endogeneity

Endogeneity occurs when the error term is correlated with at least one of the explanatory variables. The consequence of this makes the expected value of the residual not meeting the assumption of being zero. The cause of endogeneity can be when the unobserved or omitted variable is reflected in both the independent and dependent variables. Another reason can be when the independent variables are measured with an error (Lang 2016).

Multicollinearity

Multicollinearity is a phenomenon when one of the independent variables is correlated with one or more of the other independent variables. The consequence of multicollinearity is the problem of trying to distinguish the individual effect a variable has on the dependent variable. In turn, affecting the standard deviations and making it difficult to estimate. A possible solution for multicollinearity is to analyse a correlation matrix and, possibly, drop one of the variables.

Coefficient of determination

The coefficient of determination, often referred to as R squared, tells the proportion of variance in the dependent variable, and at which level it can be predicted from the independent variables. In a regression model, the value goes from 0 and 1 and should be interpreted as a percentage level. The percentage of R squared tells at what level the variation can be explained by the model's inputs. Moreover, in a multiple regression model, adjusted R squared is recommended to be used. Adjusted R squared corrects for the number of predictors in the model; it does this to become a better estimate of the population.

Joint significance

The previously mentioned t-tests is a useful tool for determining whether a single variable is *individually* statistically significant. However, it could be of importance to test whether a *group of variables* has an effect, also called joint significance. It could be that two or more variables have statistically insignificant t-scores but are jointly significant. The cause of this could be explained from the collinearity between variables.

Joint significance is examined using an F-test. An F-test analyse the sum of squares of residuals in the unrestricted model (the original model), and the restricted model (the model which drops the group of variables controlled for). The computed F-value is compared to the desired probability level using a critical F-value.

3.3 Data Gathering Process

In order to analyse the term structure, data must be collected for the regression. In this report, data will be gathered about; the Swedish property market, leases and their attributes, and property information for which observations are present. The data will be collected through pre-existing statistical data (secondary data), gathered from institutional authorities, and as primary data from commercial real estate companies active in Stockholm. The data gathered will be of both numerical and categorical data. Information about, e.g., initial lease rent, lease term, and CPI, will be numerical, and can be measured in quantities, while information about, e.g., property name, and tenant, will be categorical. The layout of the data should be compatible with the analysis software and, therefore, be specified correctly. The initial analysis of the data will entail several coding processes, which ensure there exist no outliers in the process to convert data to information. The data is explored using, e.g., tables, graphs, and statistics.

3.4 Model Specification and Analysis

The model specification is then to be formed based on previous theory on lease pricing, both from the purely theoretical model specifications, as well as from regression models used empirically (McConnell and Schallheim 1983, Grenadier 1995, Clapham and Gunnelin 2003, Gunnelin and Soderberg 2003, Grenadier 2005, Bond et al. 2008).

When the model is defined and specified, the data is converted to fit the specified model. After the regression is run, the subsequent analysis starts. The analysis involves testing the regression using statistical tools, i.e., checking for, e.g., interdependency, correlation, causality, and significance. Since the central theme of the report is to analyse if a relation exists, the significance of the term structure becomes essential. Testing for significance revolves around testing the probability that a relationship is just occurring by chance (Berman Brown and Saunders 2008).

More knowledge about the term structure will be gained by conducting the hedonic rent equation, while studying the significance and slope of the regression. In return, this will yield the answer if a statistical relation exists - which is sought after in this thesis, while also show the interdependence between cases for variables and the strength of their relationship.

3.5 Expected Findings and Implications

The results of this research will show if the term structure is a significant explanatory variable in lease pricing. The report will determine, if proven to be significant, the slope of the term structure for office leases at the corresponding year.

Whether the hypothesis provided by Grenadier (1995) is applicable and an accurate representation of landlord behaviour is questioned by several researchers (Stanton and Wallace 2009, Fang and Ruichang 2009). As mentioned in the introduction, existing research is inconclusive of the effect and significance of the term structure. Our research will increase the limited empirical knowledge existing for lease pricing with a varying term structure and, possibly, provide further empirical evidence that option pricing can be used as a representation of landlord behaviour in the valuation for length of tenure. However, even though the hypothesis provided by Grenadier (1995) about option pricing for valuation of leases is showing signs of being true, and its null-hypothesis of significant terms structure is rejected in some instance, further empirical evidence in other cities and countries is needed to increase the validity and reliability of his and our work.

3.6 Limitations

The report runs the risk of being severely limited depending to which extent data is provided. If data about significant hypothesised variables are not gathered, it could potentially drastically decrease the explanatory power of the report. Moreover, even if essential data is provided, additional data which could be used to build the model further could increase the explanatory power of this research.

4 The Swedish Market

The real estate market, in both a global and a local perspective, undergo constant changes, caused by internal and external forces. Therefore, a brief examination of the market under study is justified before beginning to analyse our data using descriptive statistics and building the regression model. To understand the current market situation, it could be of interest to revise how the market has developed over recent years. Thus, this segment will examine the property market and determine the forces which have driven the market change, as well as explain the regulatory premise which the market must abide. Furthermore, this report studies the office market and, subsequently, this section will focus on that market segment.

4.1 Lease Regulations

The rental market in Sweden is a complex and regulated sector. The Land Code of 1970 – Jordabalken – contains statutory rules for real estate, and the stipulations on tenancy are covered in the tenancy act – called "hyreslagen". The rules are, in general, meant to protect the tenant and their rental contract. Two noteworthy legal concepts, present in the Swedish office market, are of necessity to be defined. These laws are; the indirect protection of possession, and the condition of market rent in dismissal for change.

First, the indirect protection of possession comes into place if the landlord chooses to; terminate the lease and refuse extension, or the extension between the parties does not come about because the tenant does not accept the landlord's requirement for the extension. If this occurs, then the tenant is entitled to compensation. The financial compensation shall be paid with an amount corresponding to, at the minimum, an annual rent for the premises under the terminated lease agreement. Moreover, if the tenant is affected by a financial loss which is not covered by the compensation, e.g. indirect loss in revenues due to not having an office space, the landlord shall also cover this loss. To determine whether the tenant has the right to compensation, in many cases, a balancing of interests must be made in order to determine if the landlord has a reasonable cause to dissolve the lease.

Second, in dismissal for change of condition, the proposed rent level is regulated, determined by the market rent of the premise.[2] In other words, in a renegotiation, the rent must be reasonable compared to the rent for equivalent offices. Rent that exceeds the level for which similar premises on the market would yield should, therefore, not be considered reasonable and, thus, constitutes a breach of ownership protection.

Hence, the rules on market rent and the indirect ownership protection of premises interact with each other. These two legal concepts are important factors for the landlord to consider in their rental negotiation.

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[2] For full definition of market rent, see RICS Valuation – Global Standards, or 12 kap. 57a§ Jordabalken

4.2 Macro Economics and Real Estate

Sweden has over the recent decades seen a total of three market crashes, all of which have had a substantial effect on the commercial real estate market. First, the Swedish real estate bubble in the early ’90s. It contributed to problems in the commercial real estate sector, causing major credit losses and difficulties for the Swedish banking system. Second, the global IT bubble in the early ’00s. Third, and most recent, the global financial crisis in 2007 and 2008, triggered by the increase in loan losses in the US. All three crashes can be argued to be caused primarily by market psychological phenomenon and a spiral of overvaluations of companies.

Today, the commercial real estate sector stands for a large share of the Swedish economy. The value of the Swedish commercial properties, as of 2016, amounts to approximately SEK 1 700 billion (Thedéen 2017). This amount, in correlation with Sweden’s GDP at the time, was about 40 per cent. The real estate market in Sweden has over last decades become a capital-intensive industry, and the companies active in the market often take upon them a large share of borrowed capital – both in the form of bank loans and as market financing.

In recent years, expansive monetary policies have become the norm. Lowered interest rates in an attempt to boost inflation and, thereby, stimulate the economy, has been a widely used tool by the Swedish central bank.[3] This type of policy is not in any way exclusive to Sweden but can be found to be used by several other central banks around the globe (Business Sweden 2019). In Figure 5 below, the repo rate and its correlation to the inflation rate can be seen.

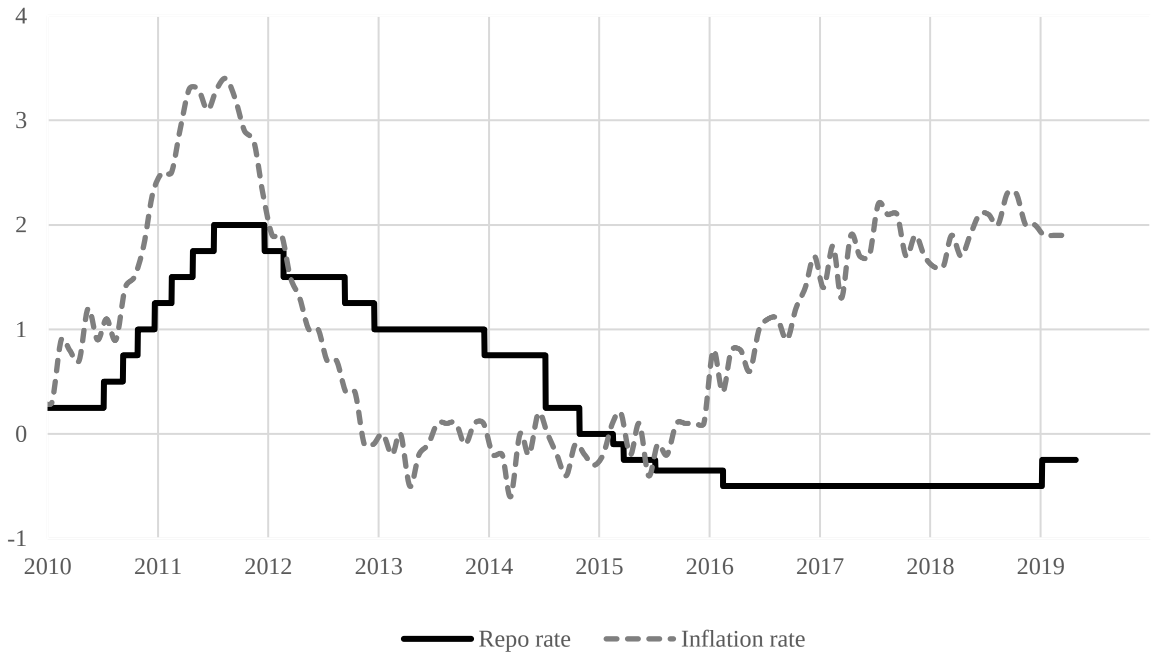

Figure 5. Repo rate, deposit and lending rate (The Riksbank 2019), and inflation rate according to CPI (SCB 2019a).

3 The Swedish Riksbank determines the policy rate repo rate, the interest at which banks can borrow or deposit funds at the for a period of seven days.

The activity on the Swedish market, measured as transaction volumes, is high in relative to the rest of Europe. Transactions volumes in Sweden during 2018 amounts to 15.2 billion euro, placing Sweden at the top in Europe of percentage turnover of stock (10Y) with a total of 6.3% (Pangea Property Partners 2019). The activity can be explained to be a product of decreasing interest rate – as exhibited above – in all Nordic countries for over 20 years, causing the market to remain very attractive amongst both local and foreign investors.

However, lately, there have been suggestions that the measures taken to achieve the targeted inflation rate, e.g. increasing the money supply or lowering interest rates, has not had the desired effect. Instead, it seems to have led to high property prices and escalating household debt (JLL 2016). The price of commercial property has increased almost tenfold since 1981, while the inflation, according to the consumer price index, has tripled in the same period. This market trend is referred to as; "flattening of the yield curves".[4]

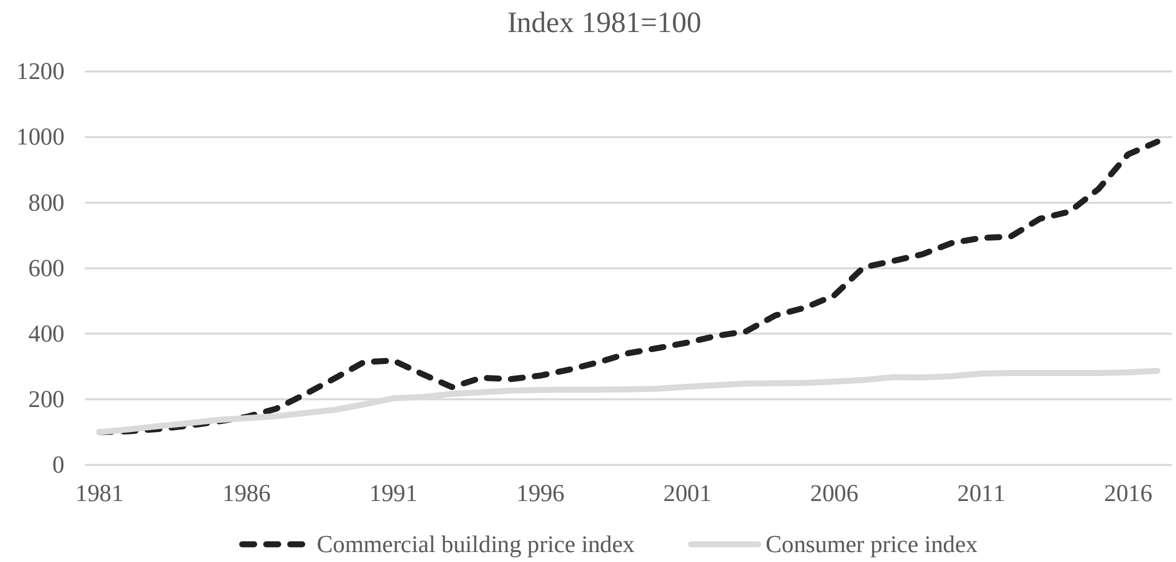

Figure 6. The property price index for commercial property in comparison to the consumer price index. 1980 = 100 (SCB 2019b)

4.3 Stockholm Market

The economic conditions in Sweden have been favourable, which has contributed to the conditions on the Stockholm office market and its high activity. The commercial rental market, both concerning rent and vacancy rates, are largely dependent on how the economy looks as a whole, regionally and nationally, and how the economic growth appears. The consistently favourable economic environment present - robust demand and limited supply - is reflected in upward trending rents, primarily in the central parts of Stockholm, but can also be viewed in other office submarkets. Vacancy rates have historically been on a downward trend since the end of the IT-crash in 2004 – peaking at 13 per cent. Today, the vacancy in Stockholm lies

[4] Property yield is a way to measure future income of a property. The yield is calculated as a percentage from a property's market value or cost, annual rental income and running costs.

around 2%, as seen in Figure 7 below. Furthermore, rents and vacancy rates do show an inversed relationship, as often exhibited in rental markets (Englund et al. 2008).

The development of commercial real estate expected to enter the market is strong. As of autumn 2018, a total of 345,000 sqm new development office space in Stockholm is under construction and expected to enter the market within three years – as of which nearly 50 per cent has already been pre-let (JLL 2018). However, as for the CBD, the new office supply is expected to be limited. New office space in the CBD is often a product of a demolished old buildings, hence, the addition of new space is marginal in some instances. Consequently, the factors of a low vacancy and limited construction in CBD might further fuel the rent development in the market.

Figure 7. Average office rent in Stockholm (left), and office vacancy in Stockholm (right). (Pangea Property Partners 2017)

4.4 Market Outlook

A hot topic on most office markets over the world has been the emerging market for coworking space. Subsequently, a strong coworking space growth rate can be observed in Stockholm over the past years (Newsec 2019). Even though the term coworking recently has gotten increasingly popular, similar concepts have been known under many names, often referred to as collaborative or flexible workspaces. For example, telecentres, office hotels, and serviced offices – with definitions that explain aspects similar to coworking – has been around for over 50 years (Kojo and Nenonen 2017). However, the main takeaway from the increasingly growing coworking market is the increased demand for flexibility.

On an ending note, many current global issues have a chance of affecting the financial state, and, in turn, the office demand and the market. Ongoing uncertainties with Britain leaving the

European Union, the increasing division between Europe and the US, global trade wars, and the seemingly indisputable end of the bull market are a few (Newsec 2018). This report will try to help understand if the changes in term structure might indicate how actors on the market react to these uncertainties. In turn, it might also help understand if examining term structures could give a sign of an incoming market turn.

5 Data and Variables

5.1 Data Sources and Collection

5.1.1 Properties and Geographical Dispersion

Location is often recognised as one of the primary determinants for property value and office rent. In this study, two geographical areas are of interest. First, the Stockholm market as a whole. Second, a delimitation of the market with the properties clustered in the Stockholm CBD.

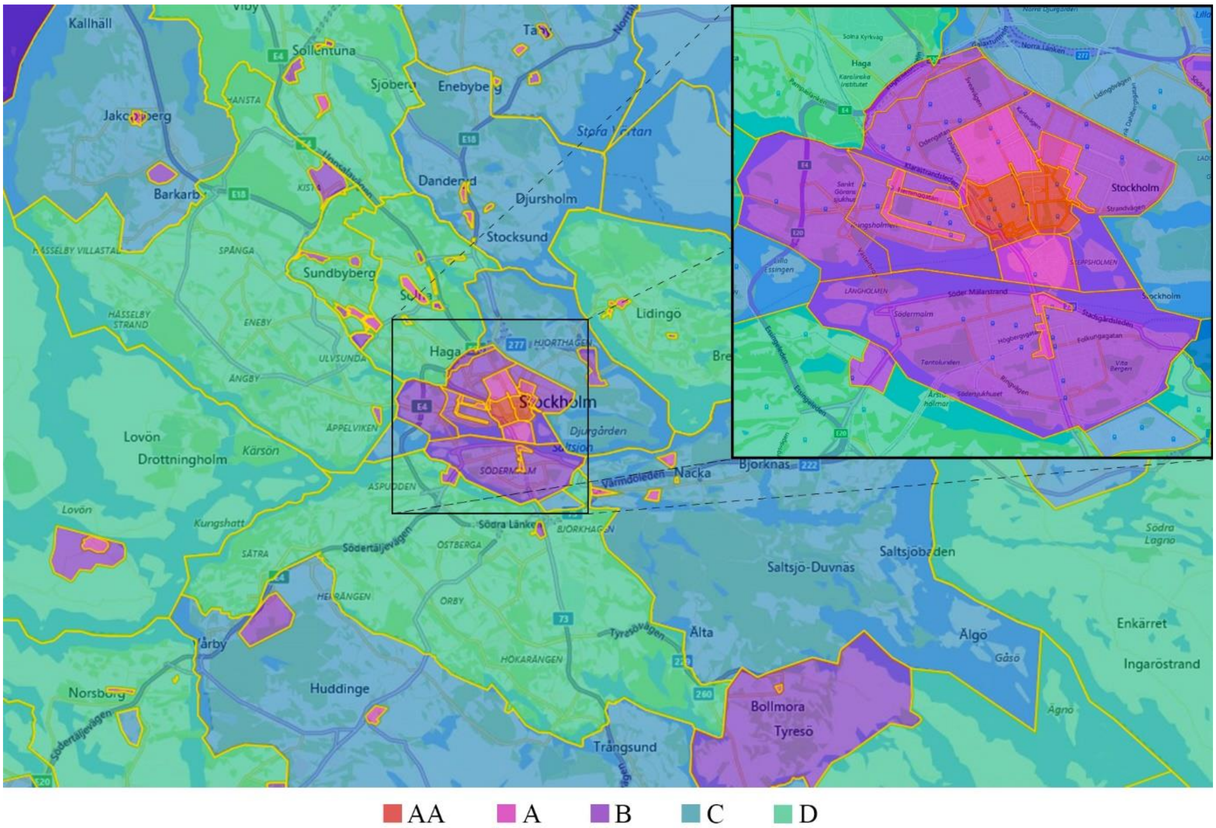

Figure 8. Market information and locational ranking of office markets in Stockholm according to Newsec, published through the 3rd party database Datscha. The rank of AA indicates submarkets yielding prime office rents, while the rank of D will correspond to submarkets yielding the lowest rent.[5]

The data is gathered from a large property owner active in the Stockholm office market. The private data set which was given access to contain leases signed between the time period 2012 to 2019, comprising of 59 multi-let properties located in Stockholm. The properties have a wide geographical distribution, but the majority lies in the inner city instead of the suburbs of Stockholm. A total of 1 508 office leases forms the sample.

[5] See Appendix C for a list of submarkets and corresponding ranking.

The CBD can be characterised as having a distinct land use pattern which can be delimited from the rest of the city. The land in the area is often highly developed and maximised, described as the geographical centre. The area has the highest land values of the region, thereof, also generating prime office rents. This rent represents the top market rent that is to be expected for an office unit which attributes of the highest quality and specification in the best location. In a consensus report compiled by The Swedish Property Research Forum, the locational boundary of Stockholm CBD is defined (SEPREF 2011). By previously mentioned characteristics, Figure 9 below shows the geographical boundary of the CBD in Stockholm.

Figure 9. The Central Business District (CBD) in Stockholm. (SEPREF 2011)

One of the earliest researcher describing urban regions and cities was Alonso (1964) and his applied theory of the monocentric model to the land use of agriculture land, first presented by Thünen (1826). The theory describes cities having a circular area, for which the economic landscape varies in relation to the proximity to the CBD. The variation is explained by transportation costs and the indifference curve of rent and price. In other words, the willingness to pay by its actor for proximity to the CBD. Stockholm is a city known for its dominant central core and long-term monocentric planning (Cats et al. 2015). The intersection of the two streets

Birger Jarlsgatan and Hamngatan is often referred to as the focal point of business activity – albeit not exclusively containing office buildings (Enstrom and Netzell 2008). Although, in recent years, a shift from the monocentric planning policy towards a more polycentric policy has been viewed. However, the results of this shift have not been realised so far (Cats et al. 2015).

Hence, with the theory presented above, in conjunction with the delimitation of CBD provided by SEPREF, a subsample can be formed based on the contracts observed in the properties which lie within this limitation. Out of the 59 properties in the sample, about half of them are located in the CBD. The subsample reduces the number of office leases to 524 observations.

To represent the geographical characteristic for a lease, a rough proxy can either be; the distance from the property to the CBD, or neighbourhood amenities and ranking of the area which the property is located within. Both alternatives will, to some extent, have disparities in accessibility and other micro-locational aspects.

However, for the subsample comprising of leases signed in CBD, offices located in this rental market could be characterised as homogeneous products – compared to other market areas and types of commercial rental units. Hence, the geographical variable will be excluded in the model used for the subsample.

5.1.2 Inflation Adjustment Clauses

Inflation adjustment clauses often exist in a contract agreement and are used as a tool to handle deflation as well as falling prices. The clause can take on several forms; fixed, fully variable, or partially variable. Irrespectively of chosen clause form, the inflation adjustment clause will influence the equilibrium lease rate of the contract. Hence, different term structure is expected to exist with respect to the chosen lease index clause. Previous reports have controlled for the selected inflation adjustment clause by creating subsamples of the data, excluding leases which are not fully, or almost fully, adjusted to the inflation rate (Gunnelin and Soderberg 2003, Bond et al. 2008, Fang and Ruichang 2009).

Moreover, another model specification was developed which allowed leases with different index clauses to be used in the same sample, therefore, increasing the number of observations which could be used (Grenadier 1995, Stanton and Wallace 2009). The model used the concept of market equilibrium relationship when pricing lease cash flows. The assumption of market equilibrium implies that leases with the same maturity should provide the lessor with the same present value, regardless of what inflation adjustment clause is chosen. A hypothetical equivalent was defined for all leases which were not fully index adjusted, and the present value of all leases was solved using the ex-post observed outcomes of the CPI. Hence, allowing the equilibrium base rent to be solved for the whole sample.

The rents of the leases in our dataset are subject to a range of different indexation clauses. Most are tied to changes in CPI on either a yearly or quarterly basis (90.8% of the sample), either allowing downward adjustments or not. Other leases increase the rent with a fixed percentage (6.5%) or are fixed without any change in rent (2.7%). These latter leases without indexation are almost exclusively short leases, mainly due to Swedish lease regulations restricting indexation for leases shorter than three years (SFS 1974:994).

5.1.3 The Effective Age of Buildings

The effects caused by property quality on lease rent can be controlled using the age and depreciation of the building. Instead of employing an ocular inspection of the property, the physical condition will be determined using the effective age of the building. Effective age, in contrast to actual age – which defines the year which the structure was built, also considers the building's management and its measures. An appraiser presents the effective age based on the building's utility and physical wear and tear.

The level of depreciation can be derived from three causes, a building's; age, level of maintenance, and functional obsolescence (Baum and McElhinney 2000).[6] In practice, the effective age could in some cases be the actual age of the building, while in others, it could be more, or less, than the actual age. The appraised (effective) age will reflect the true remaining life for the property. Hence, data about a building's effective age during the signed period is needed for the model.

On the Swedish property market, effective age, referred to as "värdeår" in Sweden, is of importance when calculating the property tax of a building. Moreover, it is determined externally by an appraiser from the Swedish Tax Agency. Therefore, data will be supplied, in some instances, directly from the Swedish Tax Agency, and in others, from the property owner itself.

5.2 Variables and Descriptive Statistics

5.2.1 Rent and Rent Equivalents

The contracted rent in Swedish leases are generally signed as a base rent, however, on top of the base rent, additional supplements for utilities are added. The utilities paid for are, e.g., electricity, cooling, ventilation, and telecommunications, while heating and water are generally included. Moreover, the property tax is usually paid by the tenant, often charged in relation to the leased area. Furthermore, due to the increased costs for the tenant associated with their office relocation, rental discounts during the start of the lease period is not uncommon. The rental discount if often in the form of a deduction of the rent paid, specified to an amount and period.

Regarding the rental discounts and utility surcharges, it is expected they would affect the rent levels in different directions. For example, a lease with low base rent and a high surcharge for utilities would be of the same value as an "everything included" lease with the same cost. Therefore, an increase in utility cost would affect the base rent downward, and the addition of

[6] Functional obsolescence is the depreciation caused by changed function of the asset, relative to its intended purpose.

a rental discount would affect the base rent upward. Hence, it is our view that the rent should be seen in its entirety – taking to account the base rent, sub-charged utilities, and possible discounts. Therefore, in order to determine the rent for leases with different levels of rental discounts and utility surcharges, a cash flow is needed to be calculated during the contracted period.

If the lease is signed with a term of three years or more, the parties may agree on a flexible rent - which is often of frequent occurrence. The parties may in such case, for instance, tie the rent to an index. As the value of a contract differs depending on the index clause used, the rents in the dataset are not directly comparable. To handle the issue of different index clauses, one option could be to run regressions on each subsample or, in order to keep the degrees of freedom high, include a dummy for each clause. However, we believe that the various structures of the individual clauses create quite different expectations of the future development of the rent levels. Therefore, a rent equivalent was calculated for each lease, working under the logic that the total cash inflow and outflows are what matters for landlords and tenants - utility surcharges and rent discounts were also considered in the rent equivalents. What is specified as base rent, utility surcharge, and discounts, could be of importance in a dispute about reasonable rent levels from a legal standpoint, but not in the economic meaning. What is paid by the tenant is what the landlord earns for the leased space. What is specified as rent, utilities, or discounts, is not of relevance for this study, instead, the rent will be viewed in its entirety by looking at the *total* amount paid for the office premise.

However, in the dataset, the rent and utilities are specified as an amount to be paid per year, while the rent discount is presented as a total amount. However, as the period and distribution of the discount are not disclosed in the dataset, a simplification is needed. Therefore, in the creation of rent equivalents, the rent discount is assumed to be evenly distributed over the lease term. This might not be true for some observations, as discounts are commonly given at the beginning of the contracted lease. However, this assumption is seen as the most advantageous solution under the circumstances.

Using both observed changes in the CPI and future inflation forecasts, a discounted present value was calculated to the time the lease started. Optimally, it should have been the date the lease got signed to capture the extent of the expectations fully. Unfortunately, our dataset lacks information on when leases were signed.

Historical changes in the CPI will work as a proxy for the inflation expectations at the time of signing the lease. This method is used in previous research, as by Gunnelin and Soderberg (2003), to create more comparable observations and increase the sample size. However, our dataset also contains recently signed leases that reach into the future where the actual changes are not yet observed. Therefore, future inflation forecasts, compiled on behalf of The Riksbank of Sweden, are used (Prospera 2019). While forecasts can be very uncertain as predictions, here instead it serves the purpose in reflecting *the lessor's uncertainty* regarding future rent changes at the signing of the lease.

By examining zero-coupon government bonds of different maturities, a risk-free rate can be retrieved by matching the maturity of each lease. However, Sweden and many other countries have had a low interests rate environment for the past few years, derived from the thriving economy. For example, the five-year Swedish treasury bond has since 2015 been within half a point from zero per cent, with negative rates for some periods. The two- and three-year treasury bonds have been even further down in the negative values (Nasdaq 2019).As can be observed in Figure 10 below, these rates differ at the most around half a point but are often closer than so. The similarity in rates indicates that even though a risk-free rate matching the maturity of each lease can be retrieved, the impact of the different rates would be small. Meanwhile, the inflation rate has been low, with an average below one per cent annually since 2012, only recently risen toward the stated inflation goal of two per cent (SCB 2019a).

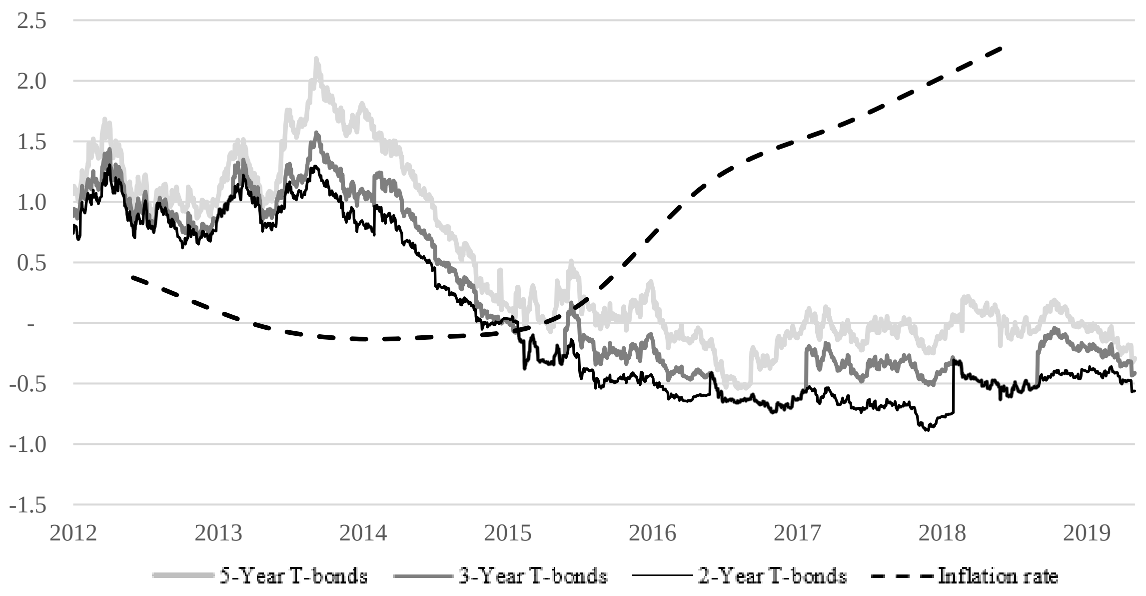

Figure 10. The rate of Swedish 2-, 3-, and 5-year government bond and an approximated inflation rate during 2012 to 2019. (SCB 2019a, Nasdaq 2019)

It seems unreasonable to believe that any landlord would use a negative discount rate for expected lease payments. Hence, for our model, negative rates impose a slight problem in the choice of discount rate. Furthermore, the default risk of a tenant is seen as the risk in each lease cash flow. This risk could, in theory, be estimated using the credit rating of each tenant. Unfortunately, the dataset does not provide this information nor the name of the tenant, making a varying risk premium unfeasible. However, both Gunnelin and Soderberg (2003) and Webb and Fisher (1996) found the choice of discount rate has little impact on the regression results. Therefore, to ensure the choice of discount rate has as little impact in our dataset, regressions were conducted with rent equivalents calculated at different rates, varying from zero to ten per cent. The result from the regressions presented no particular change in neither size of coefficients nor t-values. Given the low interest rates, low inflation rate, and uncertain risk conditions, in conjunction with how arbitrary the choice seems to be, the rent equivalents are calculated using a fixed discount rate of two per cent.

5.2.2 Term of Leases

Our sample contains mostly contracts signed with either a three- or five-year term. Some contracts are signed with a term shorter than three years, making them subject to other rental regulations – an effect which must be considered when defining the model.

Table 1. Distribution of leases over lease length with year rounded up. A lease of one year is here representing leases up to twelve months, two years represent leases of 13-24 months, and so forth.

Year	1	2	3	4	5	6	7	8	9	10	11	20	Total
2012	9	3	30	26	28	10	1	3				1	111
2013	17	9	86	39	30	20	3	4	1				209
2014	22	13	68	39	39	23	8	1		1	2		216
2015	27	6	61	43	52	23	3					2	217
2016	13	8	94	28	40	27	2	2		2		1	217
2017	32	11	93	33	47	13	9	1	1	4			244
2018	16	11	85	24	33	19	4	1	1	1			195
2019	9	11	49	11	16	3							99
Total	145	72	566	243	285	138	30	12	3	8	2	4	1508
Share	10%	5%	38%	16%	19%	9%	2%	1%	0%	1%	0%	0%	100%

Due to the sparse and scattered data on leases of seven years or longer, the regression results are more susceptible to variations in these observations. Therefore, since the number of observations with a term over six years is few, some regressions will be conducted with these excluded as outliers.

After the change in rent regulation in the late ‘80s, which prohibited index clauses for leases shorter than three years, an increase in the average lease length could be observed (Gunnelin and Soderberg 2003). In our sample, the average term is slightly above three years, but it seems to be declining over the time period investigated, as can be observed in Figure 11 below. One explanation for this is the increased demand for more flexible leases beginning to show its effect. However, the sample size for 2012 and 2019 are only half as large as the rest of the years, making the result in those years more susceptible to outliers. In turn, affecting the curve and its interpretation.

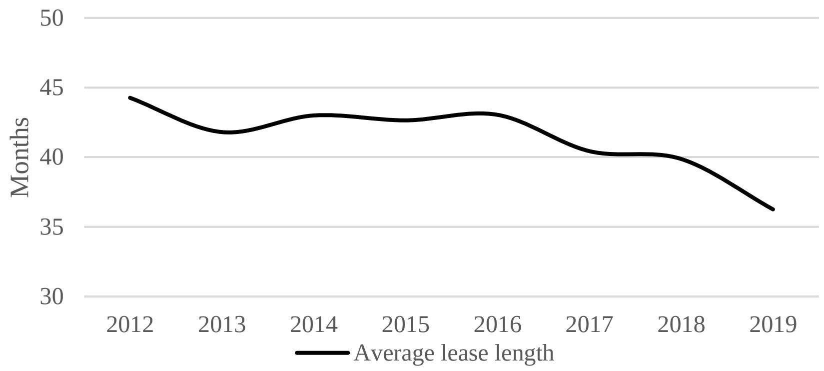

Figure 11. The average lease length of contracts in our sample per year.

5.2.3 Term Structure

The relationship under investigation in this study is between rents and term, i.e. how the lease length affects the rent level for each contract. In our sample, a naïve relationship can be reviewed by looking at the average rents for all leases of specific lengths. This naïve relationship is presented in Figure 12 and Figure 13 below, in an interval where our dataset contains observations for all years.

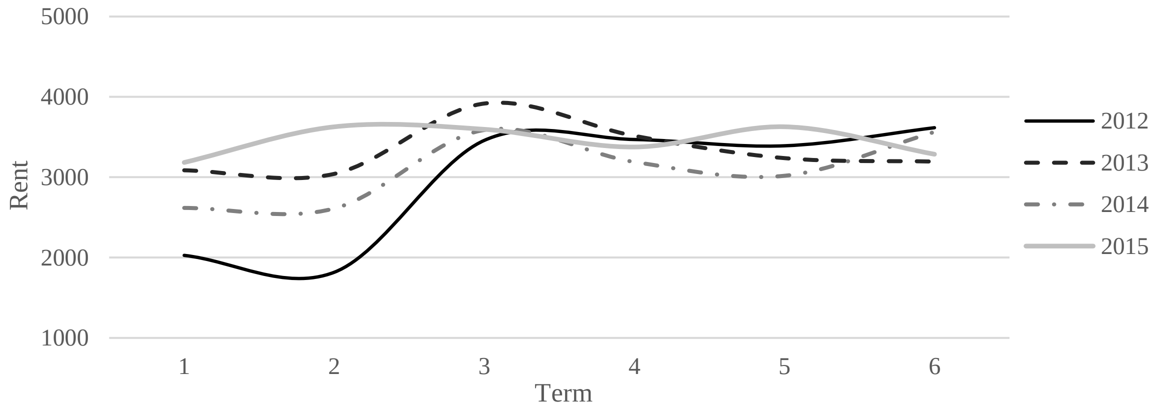

Figure 12. The average rent per lease term of contracts (rounded to year) in our sample per year, 2012-2015.

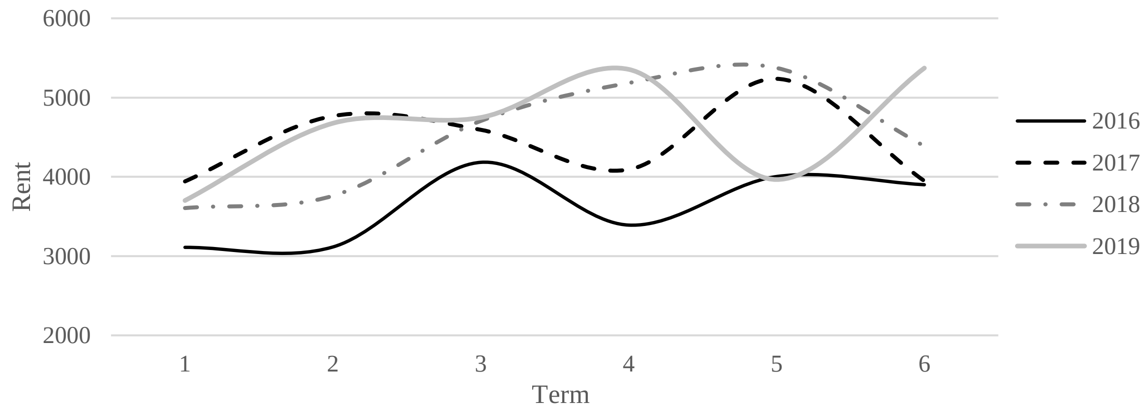

Figure 13. The average rent per lease term of contracts (rounded to year) in our sample per year, 2016-2019.

These naïve relationships do not explain much as they simply state an average of rent without regard to any of the other variables. Further, this procedure groups together leases of vastly different character into the same. For example, a three month and a one-year contract are grouped, even though they are expected to be considerably dissimilar. Hence, the effect term structures have on rent will be mainly found through the regression.

5.2.4 Industry Sector

Each lease has been categorised into one of the nine defined industry sectors. It is noteworthy to mention that the tenant industry categorisation does not indicate what type of activity is present in the lease, but instead, it denotes the primary business of the signing corporation itself. Moreover, all observations in our sample, as mentioned before, are leases of office premises.

Table 2. Distribution of tenant industry sector.

Category	Industry categorisation	*n*	Average lease length
1	Consumer goods	129	46.0
2	Finance	121	41.8
3	Health service	78	36.5
4	IT	54	39.7
5	Industrial	245	42.6
6	Media & Entertainment	73	36.7
7	Public services	160	40.9
8	Services	507	43.7
9	Other	141	45.7
-	Total	1508	42.6

The vast majority of contracts in our sample are signed by corporations active in the service sector, while the IT sector is the second most common. Surprisingly, similar average lease length can be seen between the nine different sectors. A hypothesis would be that different sectors have different preferences on flexibility in relation to the nature of the industry and present market characteristics; however, for our sample, this is observed not to be true.

5.2.5 Negotiation Type and Submarkets

Earlier mentioned regulations protecting the tenant in a renegotiation entails that the landlord must offer to renew the lease at current market rent. With new leases, the landlord can demand any rent as that level becomes market rent when accepted by a tenant. Therefore, the type of negotiation is expected to impact rent levels. The type of negotiation occurring in a contractual situation may, therefore, have a dramatic effect on both parties bargaining position, making it an essential factor to control in the model. In our data set, information exists if leases are signed as; a new lease, a renegotiation with a present tenant, or an up-renting in the same property.[7]

Distribution of negotiation type can be seen in Table 3 below. In our model, due to up-renting being a type of renegotiation with a present tenant, it will, from now on, be referred to as a renegotiation. Even though up-renting is legally defined as a new lease, and not subject to the regulations of renegotiation, it is still expected to be greatly influenced by the current rental agreement.

The geographical characteristic of the lease, and its corresponding property, will be characterised according to its neighbourhood amenities and ranking of the area. The rank will be determined using the submarket rank provided by Newsec through Datscha – a third-party provider of information and analysis for commercial properties. The geographical characteristics of the Stockholm market can be seen in Figure 8 on page 19. The Stockholm market has been divided into submarket corresponding to one of five ranks. Distribution of our sample using these submarkets can be seen in Table 4.

Table 3. Distribution of negotiation type.

Renegotiation type	*n*	Share
New lease	570	37.8%
Renegotiation	695	46.0%
Up-renting	244	16.2%
Total	1 508	100.0%

Table 4. Distribution of submarket rank.

Submarket rank	*n*	Share
AA	524	34.7%
A	193	12.8%
B	654	43.4%
C	109	7.2%
D	28	1.9%
Total	1 508	100.0%

The prime determinant, when distributing and ranking each submarket, will be office rent. Historical average base rent four our whole sample, divided into submarket rank, can be viewed in Figure 14 below.

[7] Up-renting is a negotiation with a present tenant where the goal is to rent additional area in the same property.

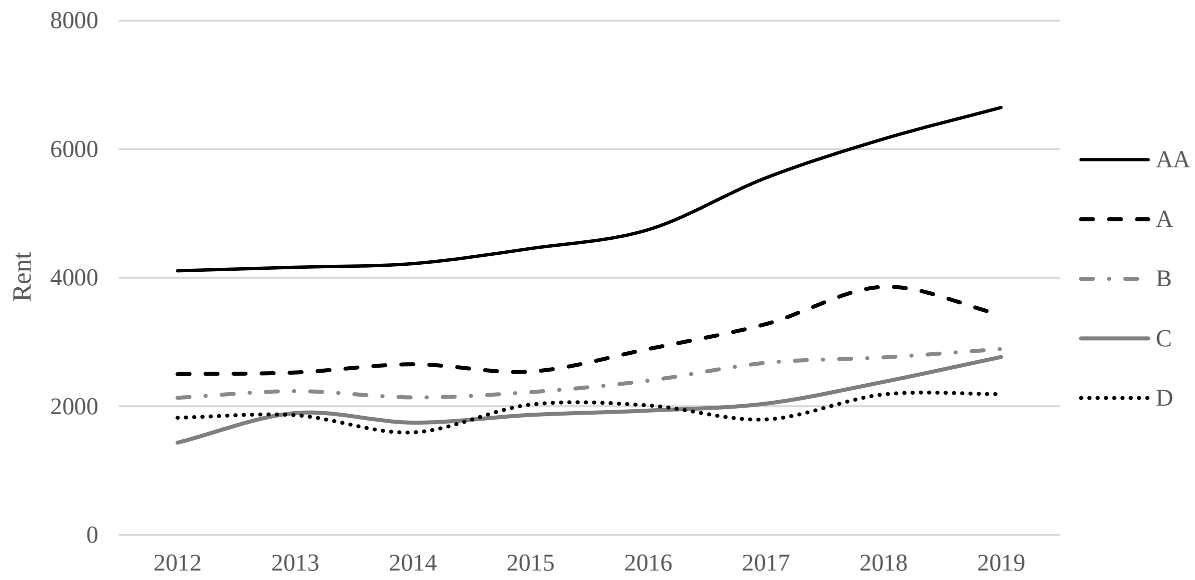

Figure 14. Historical average base rent levels of office leases in our sample, categorised into locational ranking AA through D.

5.2.6 Option Clause

As opposed to the sample used by Gunnelin and Soderberg (2003), and more in line with the research of Bond et al. (2008) and Fang and Ruichang (2009), our sample contains a share of option clauses. The increased use of option clauses on the Stockholm market could be explained by the increased demand for flexibility required by the tenants – also viewed as an essential part mentioned in the outlook for the Swedish rental market. In our sample, 15.9% are signed with an option clause. The option clause can either be of the nature to vacate; a part, or the whole leased area, during the contracted period.

5.2.7 Tenant Improvement

The amount of money invested as tenant improvement connected to a lease agreement will indicate the quality of the leased office space. The quality of the leased office will, to some extent, be explanatory in the level of the chosen base rent. As noted by Gunnelin and Soderberg (2003), ideally, observed contracts rents should be adjusted for tenant improvement clauses. Previous research exploring this field has empirically lacked this type of information. However, our data set contains information about the invested amount in tenant improvement. We can, therefore, control for the effect the investment has on rent levels, while the variable also could function as a proxy for the quality of the space.

For our model, a tenant improvement is defined as a contract for which the office is renovated as; speculation before the initiated negotiation, contracted in the negotiation, or part of a bigger investment in the property, e.g., a renovation or new construction. The dataset contains information about the sum invested by the landlord in each lease, as well if the lease is part of a larger investment, not only tied to the specific lease. The share of observations being subject to a tenant improvement in our sample is 56.7%.

If a tenant improvement occurs in conjunction with a signed lease, the agreed term of the contract is expected to have been influenced by the investment decision. The rational decision of a landlord when investing in an office renovation is to have the investment retrieved during the contracted period. Therefore, the agreed investment decision should entail a longer contract term for leases signed in newly tenant improved offices. When analysing the data, the average term for tenant improved offices is 4.1 years, versus 2.8 years for offices which are leased as is.[8] Further investigation of this phenomenon reveals an almost linear relationship between the invested amount per square meter and the lease term. In Figure 15 below, this relationship can be observed.

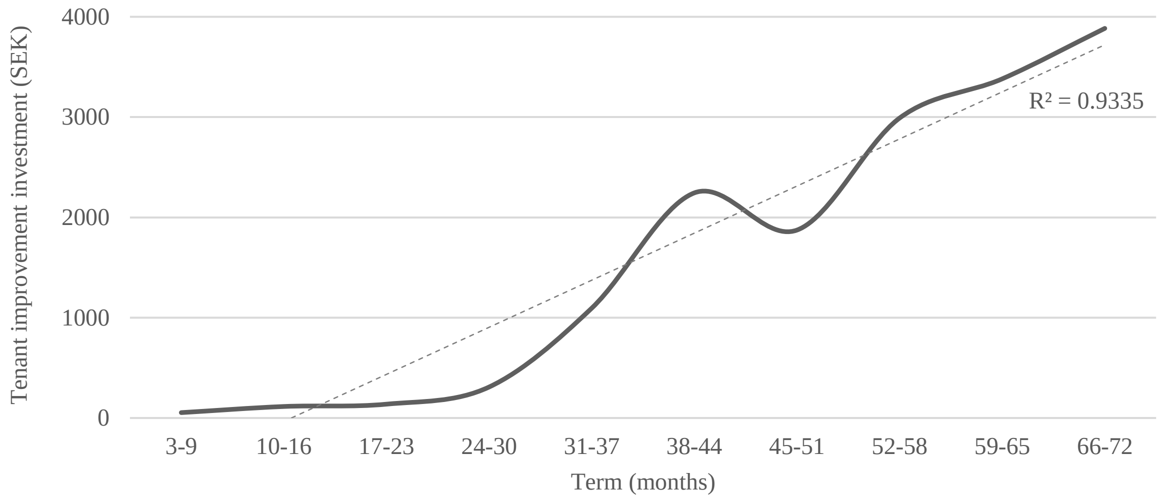

Figure 15. The relationship between tenant improvements and lease term in our sample. A linear trendline is fitted, and its R-squared presented.

Given how clear this relationship seems to be, the effect from the variable tenant improvement must be correctly controlled to avoid omitted variable bias in all variables associated with the term. Since this study aims to look into the effect of the lease term and term structures, makes this addition crucial for the model. Therefore, tenant improvement is added to the model as a continuous variable to reduce noise in the term variable. Additionally, an extra variable is used, indicating whether the office has been improved as a part of a larger investment or project. This separate variable is needed due to these types of investments are not directly connected to the signed lease, and can, therefore, not be accurately valued and accounted.

5.2.8 Definition of Variables

The variables in the dataset explained above is to enter the regression in various ways. Tabulated below are all the available variables described with their unit specified.

[8] In contrast, 3.9 years if only including lease with a term up until six years, versus 2.7 years for offices leased as is.

Table 5. Definition of variables.

Variable	Description	Value	Parameters
Rent	Rent per square meter. All contracts are in Swedish Kronor.	Rent/sqm/year	1
Rent_eq	Rent equivalent per square meter, adjusted for contracted indexation, discounted to the start date of contract. All contracts are in Swedish Kronor.	Rent/sqm/year	1
Size	Leased area in the contract as square meters.	Square meters	1
Util	Rent utility equivalent per square meter, adjusted for contracted indexation, discounted to the start date of contract. Does not enter the regression but is used to compute the variable Rent_eq.	Util/sqm/year	1
Disc	Rent discount equivalent per square meter, adjusted for contracted indexation, discounted to the start date of contract. Does not enter the regression but is used to compute the variable Rent_eq.	Disc/sqm/year	1
Age	Effective age of the building for which the lease was signed, as determined by the assessment authority during the contracted period.	Years	1
Index	The level for which the lease is subject to automatic rent increases. Can either be fixed or connected CPI. Does not enter the regression but is used to compute the variable Rent_eq.	Value	1
Term	Length of the lease period in months.	Months	1
TenImp	Amount invested as tenant improvement by the landlord. Either as speculation in advance or contracted in the negotiation. Amount in thousands of Swedish Kronor.	Cost/sqm	1
Proj	Dummy if the lease is connected to a a bigger investment in the property as a renovation or new construction.	Dummy	1
Opt	Option clause dummy. If the option exist to vacate, a part, or the whole contracted area during the leased period.	Dummy	1
Reneg	Renegotiation dummy. If the contract is signed as a renegotiation, new lease, or up-renting, with previous tenant, Reneg = 1.	Dummy	1
$Ind_{1\text{-}8}$ = [Ind_1,…,Ind_8]	Industry categorization dummy set. The industry of the company which signed the lease, categorized into 9 different sectors. Ind_1 = 1 for leases contracted by a company in the commodities sector, otherwise the value becomes zero, etc.	Dummy vector	8
$Rank_{AA\text{-}C}$ = [$Rank_{AA}$,…,$Rrank_C$]	Location rank dummy set, $Rank_{AA}$ = 1 for leases in a property located in a district ranked AA, otherwise the value becomes zero, etc.	Dummy vector	4
$Year_{13\text{-}19}$ = [Y_{13},…,Y_{19}]	Time dummy set, Y_{13} = 1 for leases contracted during year 2013, otherwise the value becomes zero, etc.	Dummy vector	7
$Year_{12\text{-}19}$ = [Y_{12},…,Y_{19}]	Time dummy set, Y_{12} = 1 for leases contracted during year 2012, otherwise the value becomes zero, etc.	Dummy vector	8

Table 6. Descriptive statistics of the full sample and the subsample for the CBD area.

Data set	*n*	Variable	Mean	Std. Dev.
Full sample	1 508	*Rent*	3 317.57	1 466.47
		Rent_eq	3 907.69	1 692.50
		Size	800.06	1 674.58
		Age	32.21	19.60
		TenImp	1.78	3.06
		Proj	0.04	0.19
		Opt	0.16	0.37
		Reneg	0.62	0.49
		Term	42.59	20.18
CBD Subsample	524	*Rent*	4 925.01	1 104.18
		Rent_eq	5 746.97	1 294.44
		Size	711.73	1 851.58
		Age	30.27	14.97
		TenImp	2.18	3.38
		Proj	0.02	0.15
		Opt	0.18	0.38
		Reneg	0.66	0.47
		Term	43.60	18.37

Correlations between the variables showed that most variables have low correlation bar, with a few exceptions. The rank variable is correlated with the dependent variable rent, as could be expected, because the variable itself examines the rent levels for the lease and corresponding submarket rank. Otherwise, tenant improvement is somewhat correlated to both the renegotiation and term variables. The relationship with term has been discussed above, and the relation to renegotiation is quite apparent, as investments logically should be less common in lease extensions, with or without new conditions. Overall, the rest of the correlations are low. However, a low correlation does not guarantee the regression model is safe from multicollinearity between independent variables.

Table 7. Correlation matrix of the variables entering the regression.

	Rent	*Size*	*Age*	*TenImp*	*Rank*	*Opt*	*Reneg*	*Term*	*Industry*	*Year*
Rent	1.00									
Size	-0.09	1.00								
Age	0.01	-0.05	1.00							
TenImp	0.13	-0.03	0.01	1.00						
Rank	0.77	-0.03	-0.02	0.07	1.00					
Opt	-0.03	0.04	-0.04	-0.01	0.04	1.00				
Reneg	0.02	0.10	0.01	-0.32	0.09	0.04	1.00			
Term	0.05	0.15	-0.09	0.38	0.00	0.11	-0.17	1.00		
Industry	-0.24	0.08	0.06	-0.08	-0.21	-0.03	-0.01	-0.04	1.00	
Year	0.31	0.04	0.06	-0.06	0.00	-0.16	0.09	-0.05	0.04	1.00

5.3 Outliers and Non-Relevant Observations.

The dataset initially contained almost 1 700 observations that had to undergo some sorting and cleaning before it could be used in the regressions. Firstly, the dataset was excluded from faulty data. Such data were corrections of previous inputs; observations with negative rents, and observations incorrectly registered as offices. Secondly, the dataset was cleared of any leases starting before 2012 or later than 2019.

As the aim of this study is to investigate term structures, it is of importance that the leases are similar in how they are constructed regarding lease length and rents. Therefore, leases not bound in time was removed, i.e. leases signed until further notice. These type leases cannot have a term structure to examine as the rent is not tied to any fixed length. In order to capture the price landlord puts on flexibility of this kind, a fixed term could have been added. However, these leases are unique in several respects, and are, therefore, not considered to be comparable with the rest of the sample. Due to similar reasons of comparability, leases shorter than three months were also excluded as they are considered to be outliers of the sample and hard to find a term structure in.

Furthermore, just as term structures are dependent on a fixed term, it also needs a fixed rent. Therefore, leases with percentage rents based on the revenue of the tenant were excluded. This type of rent is common with stores and restaurants but, luckily, quite irregular with office leases.

5.4 Limitations

The data to be used presents two limitations which are of interest to discuss. First, the investigate time period does not contain any severe market crash. The office market analysed, as explained earlier, has been on an upward trend for almost a decade. Having different market conditions present during the investigated period could potentially benefit the analysis and discussion of the term structures. However, even though no crash is present, doubt about future market trends and conditions has been, which was covered in the outlook chapter in this report. Thus, the result of this research will still have relevance and contribution to the field of term structure of interest rates and the making of rental indices.

Second, the size of the sample presents another limitation. In our data, the full sample amounts to a total of 1 508 observations during the investigated eight-year period. The size of the sample may present restrictions to conduct certain analyses and subsamples. Moreover, having a small sample also makes the data very susceptible to outliers, for example, leases signed with a term of two, or greater than seven years, might have an impact on the regression result. Although, in our case, having a sample of 1 508 observation are considered good enough to represent the population.

6 Result and Analysis

6.1 Regression Model

In order for the linear regression to show any non-linear relationships between variables, the dependent variable is transformed using the natural logarithm (e = 2.71828) as a base, creating a log-linear model.

$$\log Y = \beta_0 + \beta_i X_i + \varepsilon_i \tag{9}$$

While allowing for linear relationships to show, it also creates an easy interpretation. After estimating the coefficient $\hat{\beta}$, the independent variable $\log Y$ will be expected to increase with $\hat{\beta}$ units for every unit increase in the variable X. In turn, this denotes that the untransformed Y will be increased with a multiple of $e^{\hat{\beta}}$. As $e^{\hat{\beta}}$ approximately equals $1 + \hat{\beta}$ for small numbers, the value of the coefficient $\hat{\beta}$ can be interpreted as a percentage. Therefore, an increase of one unit in X increases Y with $\left(100 * \hat{\beta}\right)$ per cent (Benoit 2011). In the case of this study, Y represent the rent of lease contracts, which depends on a number of variables.

In previous studies, the importance of varying the term structure over the analysed period has shown to be of concern. Hence, a variable is needed which can deal with interaction effect – an interaction variable. An interaction variable should be used when expectations of a relation between variables exist, and the effects might indicate that a third variable influences. For this model, the interaction effect is expected to be between term and year, as the two independent variables, and rent, as the dependent.

The interactions effect should also be analysed using a second-order variable component. Adding this allows the interaction to produce a curvature, hence, enabling it to determine the shape of the term structure for that corresponding year.

Hence, this leads to the following model:

$$\begin{aligned} \ln Rent\_eq_i = {} & \beta_0 + \beta_1 Size_i + \beta_2 Age_i + \beta_3 TenImp_i + \beta_4 Proj_i + \beta_5 Opt_i \\ & + \beta_6 Reneg_i + \boldsymbol{\beta_7} Rank_{AA-C,i} + \boldsymbol{\beta_8} Ind_{1-8,i} + \boldsymbol{\beta_9} Year_{13-19,i} \\ & + \boldsymbol{\beta_{10}} Year_{12-19,i} \cdot Term_i + \boldsymbol{\beta_{11}} Year_{12-19,i} \cdot Term_i^2 + \varepsilon_i \end{aligned} \tag{10}$$

Where the coefficients $\boldsymbol{\beta_7}$ up until $\boldsymbol{\beta_{11}}$ are vectors of parameters. Moreover, due to perfect multicollinearity, the vectors $\boldsymbol{\beta_7}$, $\boldsymbol{\beta_8}$, and $\boldsymbol{\beta_9}$ needs a reference category. The reference points, and therefore default dummies, is as follows; $\beta_6 Rank_{D,i}$, $\beta_7 Ind_{9,i}$, and $\beta_8 Year_{12,i}$. Hence, the values given by the remaining coefficient in the vector will be in relation to the excluded one – the reference point.

6.2 Regression Results

The following regressions were conducted on the natural logarithm of equalised rents per square meter as the dependent variable. The first regression (regression I) is using the full sample, but only allowing for the possibility of a linear term structure. The second regression (regression

II) uses only contracts with a lease term of up to six years and includes the quadratic term to allow for the term structure shapes proposed by Grenadier (1995). Lastly, the third regression (regression III), uses the subsample for the CBD area. This regression uses the model from the second regression and only leases up to six years, leaving 498 observations. The rank dummy set is omitted as the CBD area is defined in the same way as the AA location rank. The overall fit of the regressions is decently high for all models at around 70 per cent.

Table 8. Results of regressions on the log of rents. Values within parenthesis are probabilities for t-tests and F-tests. "*" denotes significance on a 10% level, "**" on a 5% level, and "***" on a 1% level.

	Regressions								
	I			II			III		
Dependent Variable	ln Rent_eq			ln Rent_eq			ln Rent_eq		
Independent Variables									
Intercept	7.346	(0.000)	***	7.120	(0.000)	***	6.928	(0.000)	***
Size	- 0.000017	(0.000)	***	- 0.000018	(0.000)	***	- 0.000019	(0.000)	***
Age	0.00072	(0.028)	**	0.00059	(0.064)	*	- 0.00127	(0.007)	***
TenImp	0.00640	(0.001)	***	0.00760	(0.001)	***	0.00963	(0.005)	***
Proj	- 0.02368	(0.431)		0.00547	(0.869)		- 0.05077	(0.086)	*
Option	- 0.0012	(0.933)		- 0.0048	(0.734)		0.0076	(0.633)	
Reneg	- 0.0268	(0.056)	*	- 0.0141	(0.319)		- 0.0338	(0.086)	*
$Rank_{AA}$	0.875	(0.000)	***	0.859	(0.000)	***			
$Rank_{A}$	0.359	(0.000)	***	0.346	(0.000)	***			
$Rank_{B}$	0.203	(0.000)	***	0.192	(0.000)	***			
$Rank_{C}$	- 0.049	(0.315)		- 0.068	(0.208)				
Ind_1	0.087	(0.003)	***	0.080	(0.007)	***	- 0.049	(0.156)	
Ind_2	0.132	(0.000)	***	0.115	(0.000)	***	0.033	(0.198)	
Ind_3	0.046	(0.171)		0.043	(0.192)		- 0.041	(0.098)	*
Ind_4	0.092	(0.001)	***	0.076	(0.006)	***	- 0.059	(0.046)	**
Ind_5	0.015	(0.702)		- 0.018	(0.632)		- 0.067	(0.100)	
Ind_6	0.041	(0.286)		0.024	(0.519)		- 0.106	(0.005)	***
Ind_7	0.051	(0.091)	*	0.046	(0.119)		- 0.075	(0.012)	**
Ind_8	0.087	(0.001)	***	0.080	(0.001)	***	- 0.010	(0.646)	
$Year_{13}$	0.195	(0.031)	**	0.371	(0.080)	*	1.679	(0.077)	*
$Year_{14}$	0.112	(0.171)		0.236	(0.218)		1.746	(0.066)	*
$Year_{15}$	0.213	(0.010)	**	0.337	(0.068)	*	1.649	(0.082)	*
$Year_{16}$	0.280	(0.001)	***	0.417	(0.038)	**	1.374	(0.149)	
$Year_{17}$	0.414	(0.000)	***	0.600	(0.001)	***	1.848	(0.052)	*
$Year_{18}$	0.408	(0.000)	***	0.356	(0.130)		1.413	(0.142)	
$Year_{19}$	0.573	(0.000)	***	0.690	(0.000)	***	1.653	(0.081)	*
$Year_{12}Term$	0.00349	(0.012)	**	0.0174	(0.030)	**	0.0668	(0.093)	*
$Year_{13}Term$	- 0.00000	(1.000)		0.0041	(0.491)		0.0012	(0.805)	
$Year_{14}Term$	0.00169	(0.011)	**	0.0080	(0.062)	*	- 0.0073	(0.077)	*
$Year_{15}Term$	0.00074	(0.340)		0.0084	(0.019)	**	0.0028	(0.406)	
$Year_{16}Term$	0.00121	(0.157)		0.0079	(0.114)		0.0203	(0.001)	***
$Year_{17}Term$	0.00077	(0.298)		0.0041	(0.246)		0.0007	(0.852)	
$Year_{18}Term$	0.00220	(0.100)		0.0186	(0.013)	**	0.0314	(0.002)	***
$Year_{19}Term$	- 0.00055	(0.724)		0.0073	(0.173)		0.0211	(0.000)	***

Table 8. Continued.

$Year_{12}Term^2$				- 0.000164	(0.067)	*	- 0.000662	(0.097)	*
$Year_{13}Term^2$				- 0.000052	(0.442)		- 0.000064	(0.331)	
$Year_{14}Term^2$				- 0.000067	(0.202)		0.000096	(0.051)	*
$Year_{15}Term^2$				- 0.000098	(0.026)	**	- 0.000037	(0.383)	
$Year_{16}Term^2$				- 0.000089	(0.111)		- 0.000234	(0.002)	***
$Year_{17}Term^2$				- 0.000036	(0.403)		0.000028	(0.573)	
$Year_{18}Term^2$				- 0.000192	(0.022)	**	- 0.000366	(0.006)	***
$Year_{19}Term^2$				- 0.000102	(0.160)		- 0.000223	(0.000)	***
R^2	0.735			0.747			0.673		
Adjusted R^2	0.729			0.740			0.646		
F	164.13	(0.000)	***	148.72	(0.000)	***	38.14	(0.000)	***
n	1508			1449			498		

6.2.1 Interpretation of the Coefficients

Size

The results show the variable *Size* as having a significant impact and have a very slight negative effect on rent levels. A negative value would seem logical given that the marginal increase of each extra square meter should be lower with larger spaces compared to smaller. However, with a coefficient of -0.0018% in regression II, the effect on rents is negligible, and it can be viewed as an almost perfectly linear relation. In perspective, the regression result indicates that an increase in the leased area of 1000 m^2 would lower the rent per square meter with merely 1.8%.

Age

The effective building age is also significant and slightly positive in the full sample regressions I and II. Although, logical reasoning could maintain that older buildings should be of worse quality and therefore should have a negative impact on rents. However, keep in mind that the variable *Age* is the effective age of the building, determined by construction year and timing of refurbishments. Therefore, it could be a skewed measurement and unfit as a proxy for building quality. While the coefficient is significant, it is also low enough to have a negligible effect on rent levels. One theoretical explanation could be that it is the effect of some multicollinearity with locational aspects, since the Stockholm CBD often is characterised of having older buildings. This claim is supported by a negative coefficient for age in the results from regression III, on the CBD subsample. However, the coefficient still has a negligible effect, even though it is significant.

Furthermore, when looking closer on the sample, the CBD has one of the lowest averages in the variable *Age*, which contradicts that explanation.[9] However, the variable age is the effective age, not only considering refurbishments. Concludingly, not much can be said about the impact

[9] Average effective building age in the sample by location ranking, in years: AA = 30.3, A = 44.9, B = 28.8, C = 37.7, D = 40.0

building age has on rent levels. The quality of the office space is probably much more dependent on other factors, such as tenant improvement investments.

Tenant improvement

Tenant improvement investments seem to have an impact on the rent levels since the coefficient is significant; however, the effect appears to be very small. As the variable was entered as the invested amount in thousands, the coefficient tells us that the rent level is increased with 0.76% for each thousand invested in the office by the landlord. As a reference, the mean investment in the sample was at SEK 3 300 per square meter, resulting in a 2.5% increase in rent. For the CBD subsample, the coefficient is somewhat larger at 0.96%. However, when put into a larger perspective, an investment can also lead to lower operating costs, resulting in an even larger effect on the net operating income. In turn, an increase in net operating income reflects in the property value. As much larger investments are not uncommon in the sample, this effect could reach up to 20% higher rents. However, the model forces the tenant improvement effect into a linear relationship and interpretations in the extremes should be restrained.

Due to the previously observed relationship between tenant improvements and term, it is of interest to examine how the model reacts to other ways of including the variable *Tenant improvement* investments. Thus, the same model as regression II and III was run, but with a dummy stating if there had been an investment or not. The variable was still significant with a coefficient stating investments increases the rent level with about 8% for the full sample and 4% in CBD. The results indicate either that it could work well as a proxy for quality of the office space, or that the landlord requires a higher rent to compensate for the investment. The full results of this model can be observed in the appendix. However, this version of the model changes the significance and shapes of the term structures, which seems to prove that a relationship between these variables exists.

Furthermore, it states that term structures can be influenced by omitted variable bias when tenant improvements are not controlled. As the only way of finding omitted variable bias is to investigate what happens when it is included, this variable of great value to the study of term structures. However, it is hard to tell if using a continuous variable for the invested amount is the best way to manage this relationship. Perhaps an interaction variable between term and tenant improvement could control this relationship in a better manner.

Project

Additionally, the variable *Proj* states whether the office had been improved as a part of a more substantial investment or project. It was anticipated to explain some observations where the leased area was just refurbished, but not as a direct tenant improvement. Therefore, it was to function as another indication of the quality of the space. However, the coefficient did not become significant in the full sample regressions. For the CBD subsample, the coefficient states that leases included in larger project have a 5% lower rent. This result is surprising as this variable was supposed to represent a better quality of the office. However, there is some overlap with the tenant improvement variable, where some leases are both a part of a larger investment as well as tenant improved. Moreover, only 1% of the observations in this subsample are part of larger projects, making this coefficient very vulnerable to variations in those observations.

Furthermore, the question remains if tenant improvements and more extensive projects work as an indication of the quality for the office. Another explanation could be that its effect on rent reflects the landlord's desire to get returns on their investment. Ultimately, the model would likely improve by the inclusion of an objective assessment of the office quality. However, a tenant's willingness to pay a certain level of rent also depends on their own subjective opinion of the quality of the space. Seemingly, there is no perfect way of handling this issue.

Option

The dummy variable *Opt*, controlling for break options, showed to be insignificant in all regressions. In general, the inclusion of such clauses can be seen as rare in Sweden, but, in this sample, the occurrence was quite common. Therefore, it was somewhat expected to have an impact. However, these break options were formed quite differently, with different kinds of consequences when used. Hence, the difficulty in extracting the effect from a dummy variable. Conversely, if the compensation when exercising an option is priced right, the option itself should not have an impact on the rent level.

However, break options do also have an implication on the term of the contract and, in turn, the term structure. If a tenant is allowed to leave the contract before the end of the contract, the exact lease term is unclear. Maybe the term could be weighted with a probability of the tenant using the option. Although, then the penalties for using the option must also be accounted for.[10]

Renegotiation

Due to the regulations regarding the security of tenancy, the coefficient for *Renegotiations* was expected to be negative. An existing tenancy restrains the landlord to only demand rents reflecting the current market level, which is derived from other leases of similar spaces. Meanwhile, with a new lease, the only limit to the rent level is what the tenant is willing to pay for the leased space. Therefore, it was expected to be higher rent levels for new leases. However, the effect seems to be smaller than expected, since the coefficient proved to be insignificant in the full sample. On the other hand, in the CBD subsample, the coefficient was found to be significant at about 3%. Thus, this difference in rent between negotiation type is also of economic significance in the CBD, as three per cent contribution to market value can be quite substantial. As the current rent levels reach about SEK 8 000 per square meter (as seen later in the rent indices), this seemingly small percentage can impact the total cash flow of the property quite considerably.

6.2.2 Dummy Sets

Rank

For the first of the dummy sets, the results for location ranking shows to have a large impact on rents, as could be expected. Due to the interpretation of percentages in a log-linear model only

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[10] As this procedure is deemed to be outside the scope of this study, a regression was run without the observations containing break options. This showed no significant effect on the term structures or the other coefficients.

functioning for low coefficients, these coefficients need to be transformed to understand their magnitude correctly. However, no regard to the error term is taken in these naïve interpretations. According to the results in regression II, rents in the CBD ($Rank_{AA}$) are approximately 136% higher than the omitted location ranking of $Rank_D$. As expected, the size of the coefficient is decreasing for lower location ranks. In the second-best ranked location, $Rank_A$, rents are approximately 41% higher, and for $Rank_B$ its approximately 21% higher than $Rank_D$. Lastly, the rent levels for $Rank_C$ cannot be verified to be significantly different from the excluded rank. As regression III only included observations from the CBD, the rank dummy set was omitted. Instead, the result regarding the CBD's rent levels can be observed when compared to the rent levels of the full sample. These indices are presented later in the report.

Industry

Regarding the tenant industry categorisation, the results are varying. Since the category "Other" (Ind_9) was excluded due to multicollinearity, all results relate to this category. What is of interest with dummy sets like this one is how they relate to each other. In the full sample, most of the industries had positive coefficients, meaning these specific industries have higher rents than "Other". Controversially, this was inversed in the CBD subsample with mostly negative coefficients. However, the coefficients for the industries related to each other similarly in both samples, disregarding how they relate to the excluded variable. Furthermore, not all results were significant and cannot be said to be separated from the reference category. For significance, the result also differed between the samples. Consumer goods, Finance, IT, and Services produced significant results in the full sample, while in regression III, the coefficients for Health services, IT, Media and entertainment, and Public services was significant. Only the industry category IT was significant in both regressions; however, with vastly different effect. Concludingly, if ranked from highest to lowest with regard to significance, some interpretation of the difference between the sectors can be made. The highest rents can be observed in leases with tenants within the Finance, Consumer goods, or Service sector, as they rank the highest amongst the set in both regressions. Meanwhile, Health services, Public services, and Media and entertainment, seem to rank the lowest.

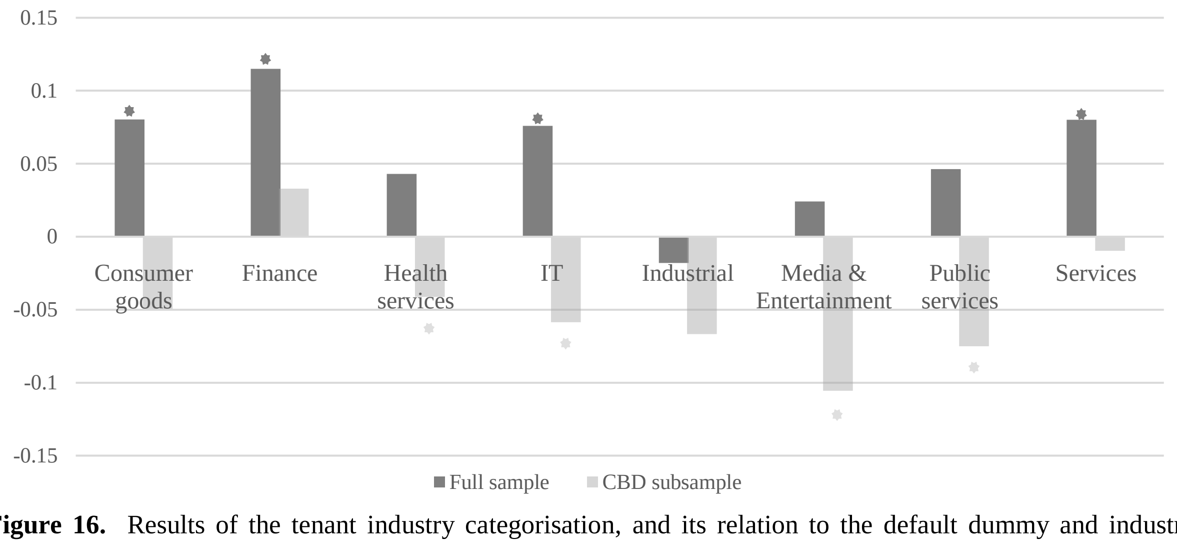

Figure 16. Results of the tenant industry categorisation, and its relation to the default dummy and industry categorisation "Other". Values derived from regression II and III. "*" denotes significance on the 10% level.

Year

As for the dummy set only including the year, its interpretation on its own is limited as it also affects both the interaction variable sets. Therefore, the impact from the year also depends on the size of the coefficient *Term*, creating the term structures later presented. Since the model controls for the term of the lease in the interaction variables, the coefficients for *Year* represent the change of rents in contracts where the lease length is zero. For many of the coefficients in all regressions, the result is significant. However, as this study is only conducted on leases which are longer than three months, the interest in this result is low.

For any further interpretations, the three dummy sets *Year*, $Year_t Term$, and $Year_t Term^2$ should be examined and interpreted in union. For example, the coefficient for year 2018 is lower than many of the other years, while the coefficients for the interaction terms are larger. Hence, for certain terms, the rent levels of 2018 will be higher than those with larger coefficients within the *Year* dummy set. Therefore, the reasoning regarding the remaining variables is brought up when examining term structures and rent indices below.

6.2.3 Term Structures

Regression I only included the first interaction variable between year and term and, therefore, only allowing for a linear term structure. However, only two years showed to have significant results, 2012 and 2014. Both years had a positive relationship between term and rent. Still, the overall fit of the regression is high, and when term squared in regression II is included, it does only provide a marginal improvement of the fit.

However, the model is still expected to perform better than the first, since it allows for all three term structure shapes to appear. The improved performance cannot be read directly from the regression results above, as the effect from term comes from two different interaction variables. One or both individual coefficients can be insignificant for one year, but still has a significant impact when examined jointly. Therefore, all years are tested if their combined influence on rents is significantly different from zero. The tests were done through a series of Wald tests for each year; the results can be observed in Table 9 below. The null hypothesis of being jointly equal to zero could be rejected in four of the years in the full sample regression (II), and five of the years in the CBD regression (III).

In a linear rational expectations model, which studies the uncertainty of individuals' and firms' expectations about future economic conditions when interpreting the significance of the term structures, an essential part is to distinguish between statistical significance and economic significance. For these types of models, the economic significance is not dependent on having statistical significance, and it is even clearly acknowledged that the models are inherently misspecified (Engsted 2009). However, statistical tests are not without value in economic scientific research. When interpreting the regression result, having a significant term structure for every year is not expected. During individual years, when the term structure is flat, a statistical insignificance of the term effect will be found. In other words, no term structure exists for the given year, due to the market valuing length of tenure equally for all lengths.

Table 9. Wald Test for joint significance among the linear and quadratic term variables on the results from regression II and III.

Year	p-values	Term structure (if significant at 10% level)		p-values	Term structure (if significant at 10% level)
	Full sample (regression II)			*CBD subsample (regression III)*	
2012	(0,016)	Upward sloping	***2012***	(0,215)	
2013	(0,711)		***2013***	(0,005)	Downward sloping
2014	(0,032)	Upward sloping	***2014***	(0,104)	
2015	(0,063)	Upward sloping	***2015***	(0,682)	
2016	(0,279)		***2016***	(0,003)	Single humped
2017	(0,250)		***2017***	(0,001)	Upward sloping
2018	(0,036)	Single humped	***2018***	(0,002)	Single humped
2019	(0,372)		***2019***	(0,000)	Single humped

All term structures are then presented in Figure 17 to Figure 20 as second-degree polynomial functions, responding to the results of the regression models above. However, as the rent is presented in its original form, the result had to be transformed back to their non-logarithmic state. The fitted values were generated using equation (8), with the error term included in the transformation to reduce bias in the predictions.

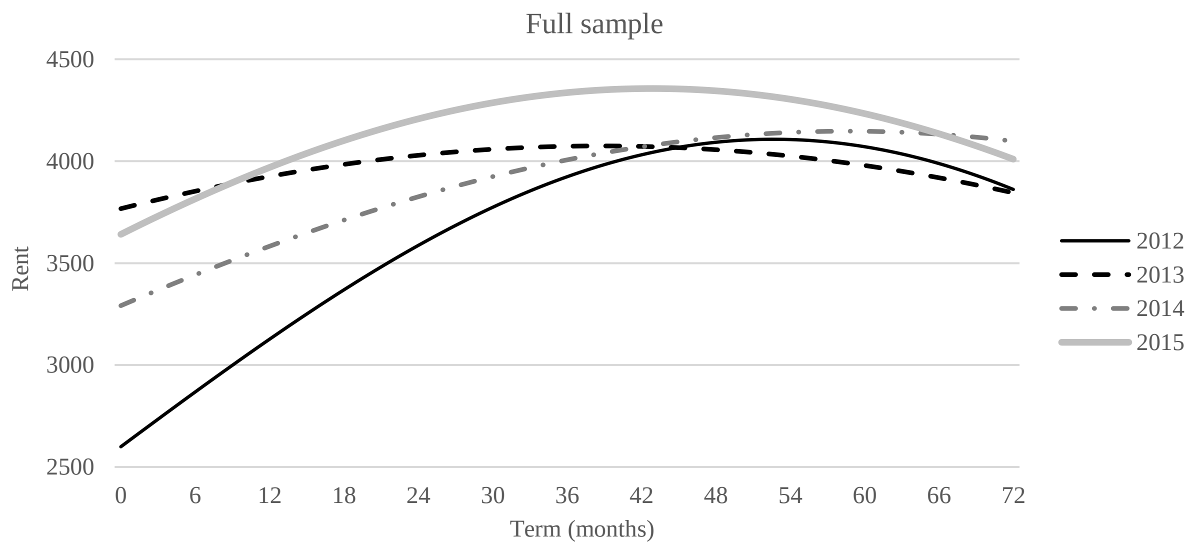

Figure 17. Regression II term structures. Rent as a function of lease length in full sample, years 2012-2015.

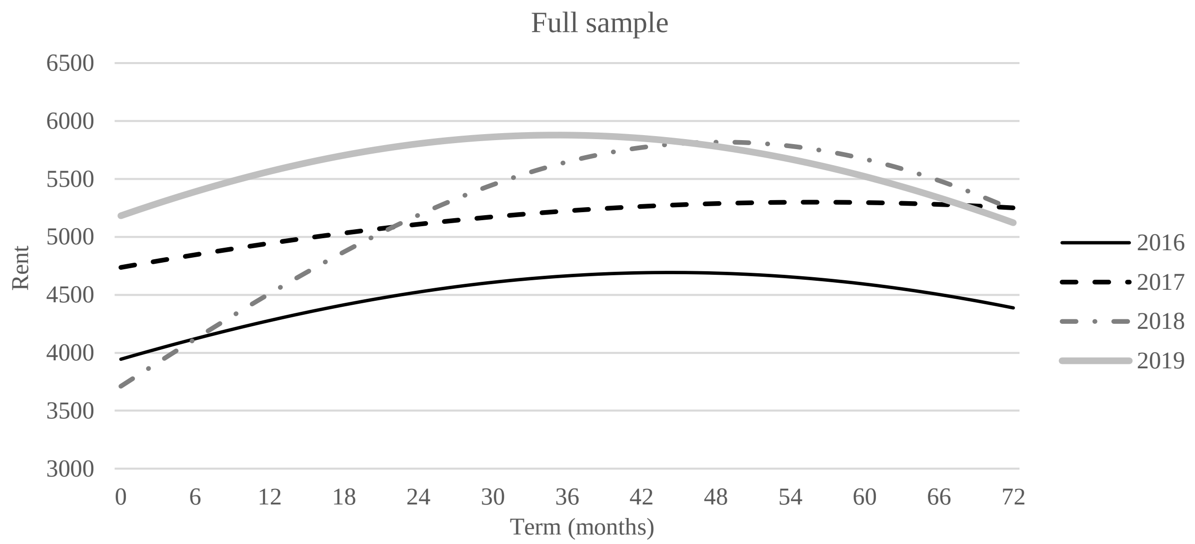

Figure 18. Regression II term structures. Rent as a function of lease length in full sample, years 2016-2019.

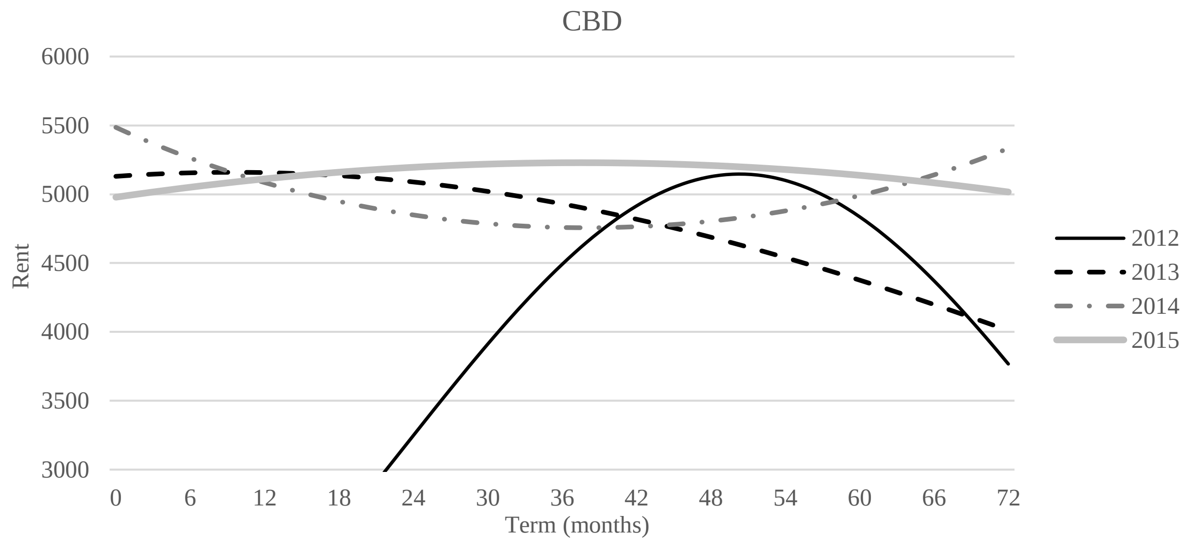

Figure 19. Regression III term structures. Rent as a function of lease length in the CBD, years 2012-2015.

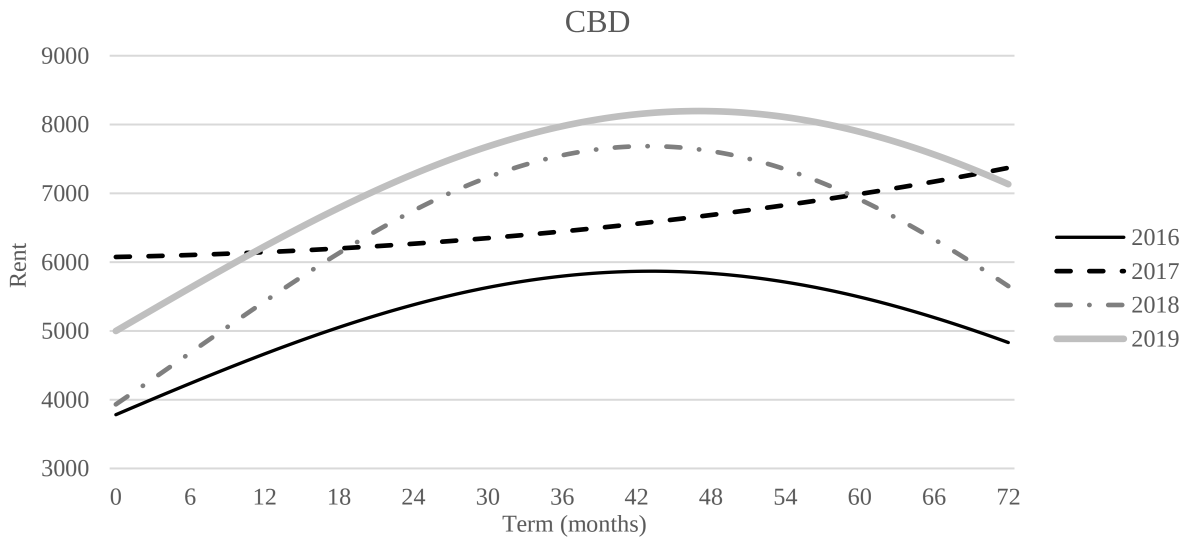

Figure 20. Regression III term structures. Rent as a function of lease length in the CBD, years 2016-2019.

The term structures for all years are plotted, both for the full sample regression II and the CBD sample regression II. However, not all are shown to have a significant effect on rent levels, as Table 9 explained. Many of the insignificant term structures are quite flat in the interval plotted, for example, the three of the curves in Figure 18. In general, there are only small differences between the different years when examining the full sample. Essentially, all curves slope upward, while only one significant result is evaluated to be single-humped.

However, in the results for the regression run in the CBD, the term structures differ quite a lot between the years. Although not significant, the term structure for 2012 distinguishes itself quite a bit with a narrow curve and low rent levels for short leases. This result is probably caused by having too few observations from that year, making the curve very susceptible to outliers. Further, in CBD, the only significant downward sloping term structure appeared in the year 2013. The slope would indicate that the landlord or the market expected some downturn of the market, this explained by their action of letting to a lower rent if the tenant was willing to sign up for longer leases. Perhaps this was a reaction to the recent drastic change in the inflation rate; it had just dropped from three to zero in only one year. This change could have given an expectation of a shift in the economy. However, if that was the case, it cannot be observed in the term structures of the full sample. For 2013, the slope of the term structure is, although modest, upward in the interval. Even though it is not significant, the adjacent years are. These term structures are all sloping upward, i.e. with no indication of any disbelief in the market. If this means the downward result for the CBD in 2013 is an inadequate representation of the actual market anticipation, or if it was a reaction to the recent economic changes, is hard to prove. A similar reaction can be interpreted from the 2018 term structures. Here, single humped slopes were found in both regression II and III. With the current global uncertainties and impending economic shift, there are expectations that the market studied also will turn before long.

Another interpretation of these term structures can be to analyse which lease term resulted in the highest rent for each year. In other words, the number of months yielding the peak of the curve in its interval, making the derivative function zero. The lengths vary slightly between the investigated term structures in the full sample, even though they all have similar shapes. If we look at the full sample results, for example, the highest rent in 2013 occurs at lease lengths around 39 months, while it occurs at 59 months for the subsequent year. However, the maximum and average rent levels within the interval barely differentiate between the two. Whether there is a real difference between these max points years is hard to prove. However, since these term structures are predetermined to be quadratic curves, not too much should be read into the lease length where the maximum can be found. All max points are presented in the table below, where the inconsistent results can be observed.

Table 10. The lease term (in months) which results in the highest rent levels per year for the full sample (regression II) and the CBD subsample (regression III).

Year	***2012***	***2013***	***2014***	***2015***	***2016***	***2017***	***2018***	***2019***
Full sample	52.5	38.5	59.0	43.0	44.0	56.0	48.5	35.0
CBD Subsample	50.0	9.0	0.0	37.0	43.5	72.0	43.0	47.0

In order to test if quadratic polynomial shapes are a good fit for these term structures, we also tried a semi-parametric model for each year. The benefit is that an exact shape of the term structure can be found, instead of forcing it into a specific form. Although, making this transformation also presents the risk of overfitting the model. The results of semi-parametric models for the full sample are presented in appendix B. Unfortunately, there were not enough observations in this sample to try a semiparametric model for the CBD subsample. These results can then be compared to the term structures above. While some bear a resemblance to their parametric counterparts, most years show that the regression model forces the term structure into the quadratic polynomial forms. However, for certain years, such as 2018, the semi-parametric fits the curve to a shape quite similar to the quadratic single-humped slope above. Other years, such as 2019, resulted in a flat term structure in both of the models when taking the significance into account. This strengthens the result of 'no result' in the 2019 full sample term structure.

Previously, in chapter 5.2.3, the average rent per lease term was plotted. The semi-parametric regression model essentially does the same, but with regard to the rest of the parameters included in the dataset. Therefore, some of these naïve curves are very similar in shape to the semi-parametric models, as could be expected. However, even though their form is largely the same, they often differ in magnitude. This difference in magnitude simply indicates that the rest of the parameters included in the regression model does more to explaining the rent levels in those years.

6.3 Rent Indices

From the results given above, rent indices were created for leases with lengths of three or five years, as they are the most common in our dataset – and, therefore, also in practice. Indices for both the full sample as well as the CBD subsample are illustrated in Figure 21 below. In both samples, a comparison created by the annual average term for each year is also plotted. The indices are calculated from the results of regression II and III, where the rest of the variables are set to their sample averages to represent a typical lease contract. While the full sample indices are closer to each other than the CBD counterparts, there is still some variance between the leases. This difference can be seen as further evidence that the effects of the term structures should be properly considered when creating hedonic rent indices.

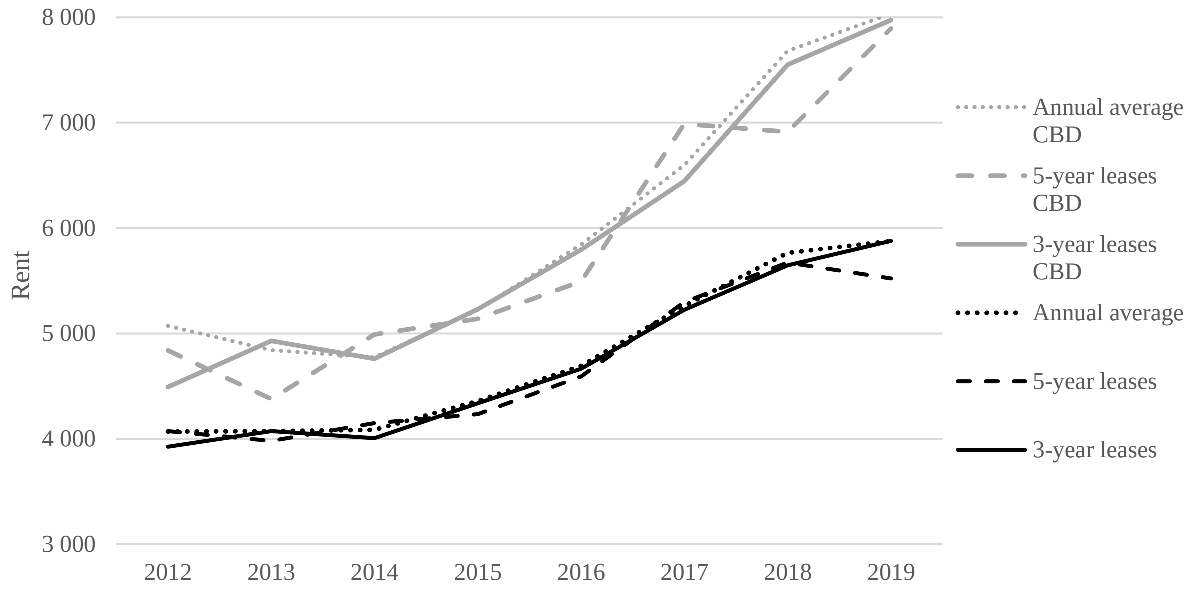

Figure 21. Rent indices created from the regression results for three- and five-year leases for both the full sample and the CBD subsample. A rent index based on the annual average lease length for each year is also presented.

These indices of office rent levels from the full sample are rather similar to the property price index presented in Figure 6, which is logical since property valuation is often based on the asset cash flow - increased rents grow the property price. Hence, these curves should, in theory, follow each other. At least under the assumption that supply is restricted. Otherwise, new construction is being triggered at high enough rental levels, which would restrict the growth in rent levels.

Moreover, the CBD indices can be compared to the average base rent year for submarket rank AA, presented earlier in Figure 14. Some similarities can be observed, as expected, with similar curves. However, when all variables are controlled for in the regression and calculated with the rent equivalents, the rent indices were more turbulent in the first two years of the investigated period. The naïve index decreased while the specific three and five-year indices increase one year and decrease the other. Meanwhile, the average base rents slightly increased over this period, showing the difference of controlling for all.

The indices visualised above are also presented in Table 11, where the year to year change is described as percentages. In the full sample, some particular years are of interest. For example, between 2012 and 2013, the change in three-year leases was at 3.8%, while it was -2.3% for five-year leases. This phenomenon of opposing signs is then repeated the following year, but inversed, and finally, a sizable difference in the year of 2015. These occurrences coincide with the years we found significant term structures.

Furthermore, the only downward term structure occurs in 2013 for the CBD regression. That year, and the following, contains the decline observed in the CBD indices. This indicates that the term structures found in this study do change according to the then existing conditions on the market, but might not predict the future long term changes very well.

The full sample term structures for 2014 and 2015 are both upward, just as 2016 and 2017 for the CBD subsample. These years were all followed by rises in the indices, which indicates the leases was signed with correct expectations of the future. However, since the rents almost only increase during period investigated, the forecasting capacity of the term structures is hard to evaluate further. With single humped results in 2018, it indicates there is an expectation of a future decline in the market. However, in the CBD, the next year was upward again. How this will be reflected in future rent indices remains to be seen. Though, our sample does not include full data for 2019 – as the full year has not passed at the time this study was made, with more complete data, there could occur a more apparent term structure in the full sample or perhaps a term structure more conforming with the expectations of 2018.

Table 11. Estimated rent changes according to the rental indices created from the term structures.

	Full sample (regression II)			CBD (regression III)		
Year	Average rent in sample	Estimated three-year leases	Estimated five-year leases	Average rent in sample	Estimated three-year leases	Estimated five-year leases
2013	0.12%	3.81%	-2.26%	-4.52%	9.79%	-9.52%
2014	0.29%	-1.64%	4.21%	-1.44%	-3.48%	14.02%
2015	6.66%	8.24%	2.09%	9.47%	9.88%	2.95%
2016	7.72%	7.55%	8.49%	11.87%	10.85%	6.91%
2017	12.10%	12.02%	15.32%	12.90%	11.21%	27.26%
2018	9.61%	8.09%	7.09%	16.46%	17.18%	-1.11%
2019	1.91%	4.09%	-2.64%	4.58%	5.60%	14.22%

6.4 Analysis and Discussion

In the regression analysis, the risk of potential biases arises. The data used in the regression analysis was supplied by a single landlord. Using data only provided from a single landlord presents the risk of the gathered sample not being representative of the population –the Stockholm office market. However, the data supplied seem to follow the trendline of rent levels present for the rest of the market, indicating representative data. Moreover, another potential bias is the misspecification of the proper regression model used for the variables under analysis. Potentially, other shapes of the term structure could exist than those presented by Grenadier (1995, 2005). Although, the simplicity and the practical use of the presented model are good enough for the purpose of this report – show the slope of the term structure. A semi-parametric model, which was also conducted in this report, runs the risk of overfitting the result. Meanwhile, the result from the linear regression, argued to be underfitting, might adequately capture the underlying structure of the data – which might be true in this case, motivated by the high coefficient of determination obtained.

What creates the term structure is a balance between the expected market movements, the security of the cash flow, and other factors. While there might be valid anticipation of a market with rising rent levels, where it is beneficial to renegotiate more often, signing short leases comes with the risk of getting a vacancy. However, a rising market is often associated with declining vacancy rates. Therefore, the value of a locked cash flow is less important in a rising market. On the other hand, if there are expectations of a declining market, a stable cash flow is far more valuable.

Moreover, there is much more work associated with short leases, with frequent renegotiations and new lettings. With long leases there is more time for the day to day operations for both landlords and tenants. With the recent demand for flexibility, in both area and lease term, this increased workload is willingly compensated for in coworking agreements. However, this study does not investigate that kind of flexibility, as all leases are standard office lettings of minimum three months. However, since most term structures slope upward, it seems as the type of flexibility we can observe in this sample is not priced relatively high.

7 Summary and Conclusion

This paper has investigated the relationship between rent and lease maturity for office leases, following earlier empirical research of Gunnelin and Soderberg (2003), Bond et al. (2008), and Fang and Ruichang (2009). Data from 1 508 office lease in the Stockholm market, contracted during the period 2012-2019, were used in a regression to estimate initial lease rates, holding other hypothesised characteristics constant. Compared to previous empirical research, our model included the addition of a proxy variable for office quality, containing information about investment amount as tenant office improvement, and if the lease was signed in a project property. Moreover, several models were used to estimate the shape of the term structure; linear, quadratic, and semi-parametric.

A significant term structure was found for 4 out of 8 years for the full sample, and 5 out of 8 for the subsample comprising of leases signed in the CBD. Anticipated lease term on the Swedish market is between 3 to 5 years, consequently, making the term structure estimation more volatile due to clustered short-term leases. Concludingly, at least half of the term structures gave significant results, showing it has some legitimacy in an office rent regression. It gives some further evidence to the reasoning that the market adjusts the price after lease length, according to future market expectations. Additionally, the expectations shown in the term structures does coincide with most of the short-term rent changes observed in this sample. However, if their expectations are accurate long-term forecasts of market changes are beyond this study.

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9 Appendix

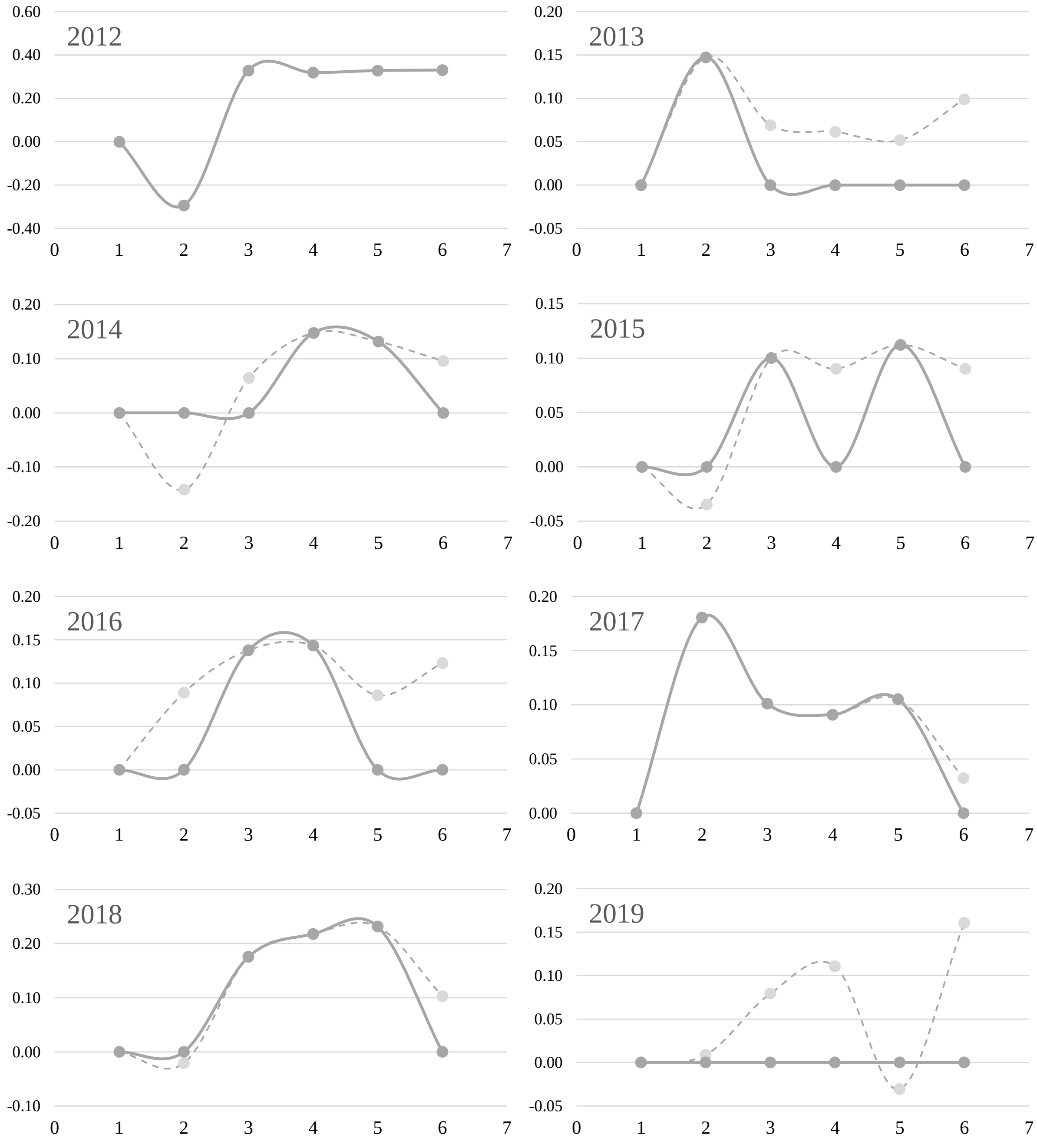
A. Further Regressions

Table A1. Regression results of using tenant improvement as a dummy instead of a continuous variable.

	Regressions					
	Full Sample			CBD		
Dependent Variable	ln Rent_eq			ln Rent_eq		
Independent Variables						
Intercept	7,103	(0,000)	*	6,890	(0,000)	*
Size	- 0,000018	(0,000)	*	- 0,000020	(0,000)	*
Age	0,00072	(0,024)	*	- 0,0011	(0,018)	*
TenImp_dum	0,0802	(0,000)	*	0,0370	(0,036)	*
Option	0,0030	(0,835)		0,0131	(0,407)	
Reneg	- 0,0022	(0,872)		- 0,0468	(0,004)	*
$Rank_{AA}$	0,862	(0,000)	*	- 0,054	(0,134)	
$Rank_{A}$	0,344	(0,000)	*	0,038	(0,156)	
$Rank_{B}$	0,195	(0,000)	*	- 0,034	(0,175)	
$Rank_{C}$	- 0,057	(0,278)		- 0,063	(0,041)	*
Ind_1	0,069	(0,016)	*	- 0,057	(0,193)	
Ind_2	0,108	(0,000)	*	- 0,098	(0,012)	*
Ind_3	0,046	(0,158)		- 0,088	(0,006)	*
Ind_4	0,066	(0,016)	*	- 0,007	(0,743)	
Ind_5	- 0,018	(0,633)		1,721	(0,075)	*
Ind_6	0,018	(0,619)		1,804	(0,062)	*
Ind_7	0,042	(0,149)		1,707	(0,077)	*
Ind_8	0,078	(0,002)	*	1,429	(0,141)	
$Year_{13}$	0,375	(0,074)	*	1,890	(0,051)	*
$Year_{14}$	0,257	(0,175)		1,458	(0,137)	
$Year_{15}$	0,344	(0,060)	*	1,697	(0,079)	*
$Year_{16}$	0,425	(0,033)	*	0,069	(0,091)	*
$Year_{17}$	0,608	(0,001)	*	0,001	(0,878)	
$Year_{18}$	0,370	(0,112)		- 0,009	(0,047)	*
$Year_{19}$	0,706	(0,000)	*	0,001	(0,782)	
$Year_{12}Term$	0,0173	(0,030)	*	0,019	(0,004)	*
$Year_{13}Term$	0,0027	(0,642)		0,000	(0,986)	
$Year_{14}Term$	0,0058	(0,173)		0,031	(0,002)	*
$Year_{15}Term$	0,0065	(0,073)	*	0,021	(0,000)	*
$Year_{16}Term$	0,0063	(0,210)		- 0,001	(0,093)	*
$Year_{17}Term$	0,0026	(0,448)		- 0,000	(0,368)	
$Year_{18}Term$	0,0170	(0,022)	*	0,000	(0,022)	*
$Year_{19}Term$	0,0062	(0,248)		- 0,000	(0,888)	
$Year_{12}Term^2$	- 0,00017	(0,054)	*	- 0,00021	(0,007)	*
$Year_{13}Term^2$	- 0,00004	(0,566)		0,00004	(0,462)	
$Year_{14}Term^2$	- 0,00005	(0,369)		- 0,00035	(0,006)	*
$Year_{15}Term^2$	- 0,00008	(0,080)	*	- 0,00022	(0,001)	*
$Year_{16}Term^2$	- 0,00007	(0,194)		- 0,00000	(0,928)	
$Year_{17}Term^2$	- 0,00002	(0,601)		- 0,00002	(0,539)	

$Year_{18}Term^2$	- 0,00018	(0,033)	*	- 0,00010	(0,004)	*
$Year_{19}Term^2$	- 0,00010	(0,176)		- 0,00022	(0,000)	*
R^2	0,751			0,664		
Adjusted R^2	0,744			0,638		
F	149,69	(0,000)	*	37,10	(0,000)	*
n	1449			498		

B. Semiparametric Models



Figures B1-B8. The coefficients for term structures from semiparametric models in full sample, leases up to 6 years. Dummies were used for term of the contract, rounded to years. Solid line only includes significant values (10% level), dashed line shows term structure without regard to significance.

C. Submarkets and Corresponding Rank

Table C1. List of all submarkets in the municipality of Solna, Stockholm, and Sundbyberg. Categorised into locational ranks according to Newsec, published through the 3rd party database Datscha.

Municipality	Rank	Submarket
Solna	A	Arenastaden
Solna	A	Frösunda
Solna	A	Solna Business Park
Solna	B	Haga norra
Solna	B	Järva
Solna	B	Solna Strand
Solna	C	Bergshamra
Solna	C	Solna Centrum
Solna	D	Solna övriga kommunen
Stockholm	AA	Västra CBD
Stockholm	AA	Östra CBD
Stockholm	A	Gamla Stan
Stockholm	A	Kungsholmen
Stockholm	A	Norrmalm
Stockholm	A	Södermalm - Slussen
Stockholm	A	Östermalm
Stockholm	B	Alvik
Stockholm	B	Globen
Stockholm	B	Kista
Stockholm	B	Marievik/Liljeholmen
Stockholm	B	Norra Station - Rosalagstull
Stockholm	B	Vasastaden
Stockholm	B	Värtahamnen/Frihamnen
Stockholm	B	Västra Kungshomen
Stockholm	B	Övriga Kungsholmen
Stockholm	B	Övriga Södermalm
Stockholm	B	Övriga Östermalm
Stockholm	C	Djurgården
Stockholm	C	Essingeöarna
Stockholm	C	Hammarby Sjöstad
Stockholm	D	Söderort
Stockholm	D	Västerort
Sundbyberg	A	Sundbyerberg Centrum
Sundbyberg	B	Rissne/Hallonbergen
Sundbyberg	B	Sundbyerberg Allén
Sundbyberg	D	Sundbyerberg övriga kommunen

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