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THE RELATIONSHIP BETWEEN MACROECONOMIC FACTORS AND THE PRICE OF TENANT-OWNED REAL ESTATE IN PREMIER URBAN AREAS

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Abstract

This thesis analyzes the relationship between macroeconomic factors, such as interest rates and asset prices, and the price of tenant-owned real estate in Sweden's three major cities, Stockholm, Gothenburg and Malmoe. We use the average price per square meter as the dependant variable, which is analyzed in a trend-stationary model covering monthly observations for the time period April 2003 to January 2007. We find that the short term interest rate has a weak positive relationship to prices, whereas the longer maturity interest rate has a weak negative impact on prices, implying that households are perhaps more concerned about the long-term interest rate forecasts rather than the current levels. It seems like the overall state of the economy and price developments in the stock market play important roles in understanding what influence the changes in real estate prices.

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1. INTRODUCTION

The prices of tenant-owned real estate situated in premier urban areas[1] in Sweden's three major cities, Stockholm, Gothenburg and Malmoe, has increased dramatically in recent years. The average price per square meter, the most commonly used valuation instrument for real estate of this kind, has in a few years increased with double digit figures annually. It is safe to say that this price growth is far higher than that for other kind of residential real estate and inflation, but it is harder to identify the reasons for this development. (Mäklarsamfundet 2007)

A natural way to begin to assess the problem is to look at the basics of supply and demand where the number of people moving to the specific areas far exceeds the number of people moving out, combined with a relatively small number of new homes being built in the rather densely populated urban centres (SCB 2007:1). The phenomenon can probably also be explained by the current business cycle with high levels of GDP, economic growth and relatively balanced levels of unemployment and inflation. But can these factors solely explain why this type of real estate has increased so rapidly in recent years?

The issue of the price development in the tenant-owned real estate market in Sweden has been given considerable attention in the media and many analysts suggest that the sector is overheated and that a sudden and sharp drop in prices can occur in the near future. This extensive debate has put pressure on the Swedish Central Bank, The Riksbank, to increase their instrumental rate, the repo rate, in order to reduce the risk of a bubble in the real estate sector. The initial answer from The Riksbank has been that the price development within premier real estate is already accounted for in the broad Consumer Price Index, CPI, which is the main index used when determining the instrumental interest rate. As a result of this, The Riksbank advocates that no extra measures should be taken on their part in order to fine tune this relatively small part of the overall Swedish economy. (Srejber 2002)

However, the real estate sector as a whole is indeed one of the most important sectors from The Riksbank's point of view. First, real estate companies are the single largest borrowers from Swedish banks with more than 15% of the total outstanding loans. Secondly, real estate is used as collateral in more than 50% of the cases when a loan is granted in Sweden. The health of the real

[1] The main variable analyzed in the paper is the prices of tenant-owned real estate in premier urban locations in Sweden. The legal name in Swedish is "Bostadsrätt" and it has many similarities with other types of ownership used internationally. It is however not exactly the same as neither the American co-op nor the British 100-year lease system. The paper will therefore use "tenant-owned real estate" or just "real estate" when referring to the dependent variable. Appendix 2 contains a detailed description of the dependent variable.

estate sector is therefore an important indicator of the strength of the Swedish economy in general and thus a sector of great interest for the monetary policy makers at The Riksbank. (Srejber, 2002)

The perspective of this thesis is that of a monetary policy body, such as The Riksbank. Although several different variables will be tested the focus will be on the price adjusting power of the central bank through their instrumental interest rate. It would certainly be interesting to analyze many perspectives in a thorough manner but in order to achieve tangible results the paper will focus on the perspective of the central bank. However, this thesis does not give recommendations on whether or not a central bank should try to control this type of price development through monetary policy.

In this thesis we will analyze and try to answer the question;

> *To what extent can macroeconomic factors such as the activity in the economy, the stock market development, demographical changes and especially the central bank's instrumental interest rate influence the prices of tenant-owned real estate in premier urban regions in Sweden?*

The main purpose of this study is to examine the relationship between The Riksbank's instrumental interest rate and prices of tenant-owned real estate. Several variables will be included as references in the econometric model presented in Chapter 3, but the main scope will be to analyze how The Riksbank can influence the prices of this particular asset class. We hope that this thesis will add to existing research by providing new perspectives on the interplay between the monetary policy and the prices of specific real estate from a government point of view. The explicit real estate data used in our model has never been analyzed in an academic setting before, despise the fact that it is intensely debated in the media and society as a whole.

We conclude that the interest rate has a mixed relationship with real estate prices. An increase in the short-term rate does not seem to reduce the upward trend of real estate prices, whereas the longer maturity interest rate has a weak negative correlation to prices. The variables that appear to have the most significant relation to real estate prices are the stock market index and measurements of economic development in society such as employment and a proxy for GDP.

The paper is structured in the following way; Chapter 2 provides the theoretical framework of the monetary transmission mechanism, the interest rate channel, the relationship between interest rates and asset prices as well as the connection between real estate prices and economic activity. Chapter 3 presents the method used in our study, the statistical data and our variables as well as

the reason for including them. Chapter 4 describes the actual data from the study and Chapter 5 will analyze the results. The main conclusions are summarized in Chapter 6 and critique as well as suggestions for further research is briefly touched upon in Chapter 7. A complete compilation of the statistical tests and model specifications as well as a detailed definition of the dependent variable and possible model extensions can be found in the Appendices, which concludes the thesis.

2. THEORETICAL FRAMEWORK

The theoretical framework on which we build this thesis revolves to a large extent on the central bank's instrumental interest rate and the mechanics of its implementation. In Sweden the instrumental interest rate, the repo rate, is set by an independent central bank, The Riksbank. Since 1995, The Riksbank has had as its monetary policy objective to keep inflation, measured in terms of CPI, at a two percent level with a tolerance range of +/- one percent (The Riksbank 2007:1). An adjustment to the repo rate has a direct effect on the shortest interest rate, the overnight interest rate; whereas longer maturity interest rates adjust to the repo rate depending upon how the underlying expectations are formed. According to Romer & Romer (1994) the central bank can also affect asset prices, the exchange rate and the quantity of money by changing the repo rate. Consequently, through the repo rate monetary policy can influence the interest rate that apply for the public and thereby also affect aggregated demand and resource utilization in the economy.

Given this reasoning, is it in the central bank's interest to take changes in real estate prices into consideration, and should such an action be targeted towards aggregated demand or real estate prices specifically? In the following sections we will outline the mechanics of the interest rate channel of monetary policy, work through the theories connecting monetary policy to asset prices as well as have a look at previously performed studies.

2.1 Monetary Transmission Mechanism

The monetary transmissions mechanism refers to the way in which the central bank can affect inflation and the rest of the economy through the instrumental rate. The monetary transmission mechanism relies on two premises. First, it explicitly assumes that monetary policy is conducted through interest rate targeting, which is currently the case in Sweden. Secondly, the monetary transmission mechanism assumes that monetary policy effects are primarily transmitted through aggregated demand. The process is complicated due to the fact that the public's expectations on future policy affect the outcome of the monetary actions taken by the central bank. (Hörngren 1995)

The mechanism itself works through several interacting channels and varies both in terms of impact and lag length (Mishkin 2001). Most literature, for example Woodford & Walsh (2003) as well as Hörngren (1995), regard three channels as the core of the monetary transmission mechanism, namely; the *interest rate channel,* the *credit channel* and the *exchange rate channel*. In this

essay we will focus on the interest rate channel because it describes the process in which monetary policy effect households' investments and consumption. Other papers, such as Mishkin (2001), address the importance of stock markets and real estate prices through which monetary policy can affect the economy.

2.1.1 The Interest Rate Channel

The transmission mechanism through the interest rate channel has been a standard economic feature in monetary policy since the Keynesian model was introduced in economical literature. The traditional Keynesian schematic view of the process triggered by a monetary tightening policy is an increase in real interest rates resulting in a higher cost of capital, in turn leading to a fall in investments and ultimately causing aggregated demand and output to decline. (Mishkin 1995)

Former senior advisor to the Swedish Riksbank, Lars Hörngren (1995), accredit the interest rate channel the most direct effect of a changed repo rate. An increase in the repo rate will almost instantaneously result in an increase in the short-term rates. Market participants will then invest in shorter maturities to a larger extent, creating a shortage in demand for longer maturities. Borrowers looking for long-term loans will then in effect need to offer higher interest rates to attract investors. The more prolonged the interest rate hike is expected to last, the more pronounced will the effect on long-term interest rates be. The higher long-term interest rate will make saving more attractive and hence change the households consumption behavior. Apart from a decline in household consumption, the increase in interest rates also brings about a fall in financial and real asset prices. Therefore, the combined effect of an interest rate increase will be a decrease in aggregated demand and, all other things being equal, result in a downward pressure on inflation.

Whether one chooses to think of the interest rate channel in terms of the traditional Keynesian scheme or in terms of credit markets, investments will decline as real interest rates increase (Mishkin 1995).

2.2 Interest Rates and Asset Prices

According to Mishkin (2001) and Giuliodori (2005) asset prices also play a vital role in the transmission of interest rates. Few researches have tried to identify the relative importance of the individual channels of the monetary transmission mechanism, quite surprisingly given the last decades' large fluctuations in asset prices in many industrialized countries. Mishkin (2001) argues

that although asset prices, such as stocks and real estate, have an important impact on aggregated demand in the economy, the optimal policy response would be different given the nature of each individual shock thereby making it practically impossible to adjust the monetary policy appropriately. As a result, Mishkin (2001) favors a hands off approach by the central bank.

Bernanke and Gertler (2001) also address the question whether or not central banks should respond to asset price movements. The main result of their study is that central banks should only take asset price swings into consideration when setting the policy interest rate if the effect of asset prices reflects on the bank's inflation forecast.

2.2.1 Real Estate Prices

Giuliodori (2005) suggests a number of reasons why central banks and economists should place particular emphasis on real estate prices. First, real estate represents a significant portion of net wealth in the private sector in most European economies. Secondly, while other financial assets are mostly held by the wealthier part of the population, real estate ownership is more evenly distributed among the population, therefore making real estate a better asset class to base studies on transmission mechanism on. Finally, and according to Giuliodori (2005) more importantly, housing is generally used as collateral in the loans market and therefore the link between other channels in the monetary transmission mechanism is stronger for residential assets making it a potential amplifying channel of monetary policy. In the study by Giuliodori (2005) designed to test how real estate prices respond to interest rate shocks in the economy the main result showed that, in economies where the mortgage and housing market is regarded as competitive, interest rate shocks had a significant effect on residential prices. It also strengthens the hypothesis that asset values tend to amplify the effects of policy shifts on consumption.

The Riksbank declared that it does not take house prices into consideration other than through the influence increased real estate prices has on households wealth and hence on private consumption (Rosenberg 2004).

2.2.2 Stock Prices

In an article by Mishkin (2001) fluctuations in stock markets, which are affected by the interest rate and hence monetary policy, have important impacts on the economy. Mishkin (2001) refers to four different channels through which the stock market affects the economy. First, through the stock markets effect on investments and secondly through firm balance sheet effects. Thirdly and fourthly by affecting households through wealth and liquidity effects. In this paper we are mostly

interested in the effects of stock markets on private consumption and in particular real estate prices.

By having a positive effect on the stock market, expansionary monetary policy raises the value of households' financial wealth, in which a major component is common stock. Modigliani's life cycle model (Modigliani 1972 and Friedman 1980) states that households' consumption is a function of their lifetime resources, i.e. lifetime wealth. Therefore, as households' financial wealth increases as a result of raising stock markets, consumption and aggregated output in the economy rises as well.

2.3 Real Estate Prices and Economic Activity

A number of papers study the relationship between real estate prices and economic activity. Girouard and Blöndal (2002) examines the role of real estate prices in influencing private consumption and residential investments in OECD countries. They find that real estate price increases, as well as deregulations in the mortgage market, had a significant positive impact on households consumption through wealth effects.

In a study by Ahearne *et al.* (2005) house prices[2] and economic activity are found to be highly pro-cyclical, with movements in housing prices associated with both changes in monetary policy and economic performance. However, there are difficulties determining the interaction causality between house prices, economic activity and monetary policy, due to the fact that inflation targeting central banks' respond to inflation expectations that come from economic activity, in which house prices are one component. Ahearne *et al.* (2005) conducted the study on a global set of industrialized countries[3], including Sweden, where they examined to what degree macroeconomic variables lead or lag the development in house prices. Ahearne *et al.* (2005) found that stock prices move closest to the development of real estate prices among variables such as real GDP, inflation, nominal policy interest rate and real personal consumption growth, although stock prices tends to have larger volatility over time than house prices. In their study, the interest rate and inflation were factors that tended to lead the development of house prices, with the

[2] Single family house price index for each individual country in the study, i.e. for Australia, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, the Netherlands, New Zealand, Norway, Spain, Sweden, Switzerland, the United Kingdom, and the United States, respectively.

[3] The sample comprises Australia, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, The Netherlands, New Zealand, Norway, Spain, Sweden, Switzerland, The United Kingdom and The United States.

nominal policy interest rate declining as house prices increased. Economic activity, measured either as GDP, consumption or the output gap, showed a positive correlation with house prices.

In addition to the global study of industrialized countries performed by Ahearne *et al.* (2005), Ball (2004) has conducted comparable studies on European data reaching similar results. Ball also points to the importance of local supply and demand circumstances as explanations to the development of real estate prices.

The results of previous studies indicate that we should expect a negative correlation between real estate prices and variables such as nominal interest rates and inflation, whereas we should expect a positive correlation to variables such as asset prices, GDP and consumption. In the following section we discuss different variables in more length and thereafter present the model we have chosen to examine.

3. METHODOLOGICAL CONSIDERATIONS

The objective of this part of the thesis is to introduce and explain the choice of method in detail as well as variables used in order to examine our problem. An econometric regression model will be used in order to analyze how different factors influence the price of tenant-owned real estate. The method is inspired by similar studies conducted first and foremost in the USA where many different types of econometric models were used, all with their respective strengths and weaknesses. The perspective in Aheme *et al.* 2005, where we found plenty of macroeconomic insights, is rather general and a substantial amount of variables are tested. Our thesis have a similar but somewhat more concentrated angle where the variables are tested in one model along with a stronger focus on the instrumental interest rate. In the following text the choice of variables and econometric model are explained, along with the reasons for excluding a few adjacent factors.

3.1 Variables and Data Collection

The data in our study comprise monthly observations from April 2003 to January 2007 of economic and demographic data, all based on Swedish observations except for the proxy of the price development in the forest industry, which is a European measurement. The reason why we do not have a longer time period is because it is the maximum length for which the data on tenant-owned real estate has been collected in Sweden on other than a yearly basis.[4]

In the following sub-sections we explore each variable in more detail in addition to discussing the reasons behind excluding other variables from the model.

3.1.1 Tenant-Owned Real Estate Prices

The basis for our study on real estate prices in premier urban areas in Sweden are monthly data on average prices per square meter in the municipals of Stockholm, Gothenburg and Malmoe. The time series cover monthly observations over the period April 2003 to January 2007. The data has been made available to us by Mäklarstatistik, a Swedish confederation of real estate agents comprising about 70 percent of the total Swedish market.[5]

[4] Data on yearly basis for tenant-owned real estate has been collected by Mäklarstatistik since 1996.

[5] Mäklarstatistik's statistics cover all real estate mediated by real estate agents affiliated with Mäklarsamfundet, as well as all property sold in the private market through registration with the Swedish Land and Registration Authority.

Usually econometric studies of real estate prices are conducted using aggregated data over all properties sold, including farm houses, commercial real estate, agriculture property and so on (Girouard and Blöndal 2002 and Ahearne *et al.* 2005). The data we use has been made exclusively available for our study and is composed only of tenant-owned real estate in the inner-regions of Stockholm, Gothenburg and Malmoe.[6]

There are three reasons why we chose not to use aggregate house prices and yearly observations. First, we want to explore the relationship between the short-term market interest rate and tenant-owned real estate in the regions that have witnessed the largest price increases over the last couple of years. Secondly, we believe it is interesting to examine real estate in these specific regions since it is heavily debated in the media. Thirdly, we want to examine real estate prices without the influence of commercial real estate, rural real estate and holiday homes because of the higher degree of mortgages in the chosen real estate group, indicating a closer relationship to interest rates.

The variable used in our study is the logarithm of the de-trended average price per square meter in all regions.

In figure 1 the price development in the regions we study are plotted against time. From the graph it is obvious that the increase in prices has been considerable during the last couple of years.

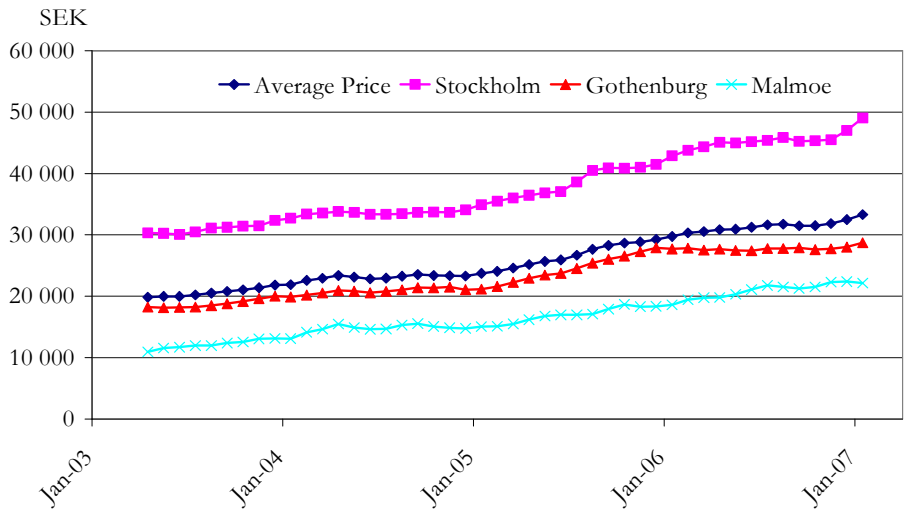


Fig 1. Price levels per square meter in Stockholm, Gothenburg, Malmoe and Average. (Source: Mäklarstatistik 2007)

[6] Stockholm: *Vasastan-Kungsholmen, Östermalm* and *Södermalm*; Gothenburg: *Centrum*; Malmoe: *Centrum Väst*

3.1.2 Short-Term Interest Rate

The relationship between the interest rate and asset price movements has been explored in the previous chapter. We have chosen to include the 3-month STIBOR[7] as our short-term interest rate in the model. The rational being that it is the shortest of maturities usually quoted by banks on private mortgages. Also, the 3-month STIBOR adjusts almost instantaneously to changes in the repo rate, and as shown in figure 2, the correlation between the repo rate and the 3-month STIBOR is almost 99 percent.[8] As discussed in the theory section the 3-month STIBOR also incorporates the markets expectations about future interest rate paths, expectations that to a large extent mirror the expectations households have on their future borrowing cost.

The data series used in our study is the logarithm of the de-trended observations for the 3-month STIBOR.

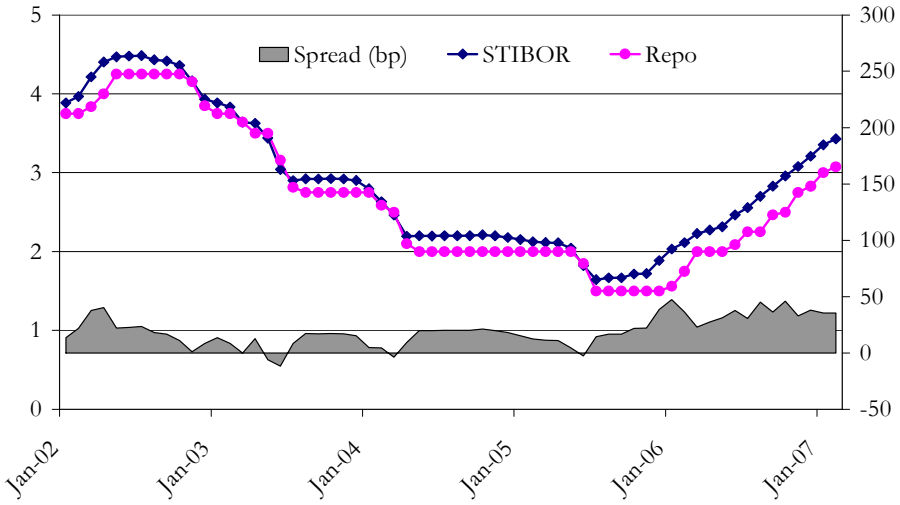


Fig 2. Levels of 3-month STIBOR, repo rate and spread (Source: The Riksbank 2007:2)

3.1.3 Activity Index

The development of the economy in general is probably one of the most influential factors when prices are decided in the real estate market. The most commonly used measurement for this indicator is the GDP which measures the monetary value of all the finished goods and services produced within a country's borders for a specific time period. It includes all private and public consumption, government outlays, investments and exports, less imports, which occur

[7] Stockholm Interbank Offered Rate

[8] See Appendix 1

within a defined territory and is thus a very broad indicator for the state of the economy. The GDP in Sweden is measured by Statistics Sweden, a government body, on a quarterly basis. However, since the dependent variable is measured on a monthly basis another variable would be preferable.

The Activity Index, also measured by Statistics Sweden, is a weighted index consisting of different indicators that is produced to reflect the monthly change in the GDP. Technically it shows the monthly change in the total economy compared to the preceding month, enumerated to an annual figure. The index is calculated in fixed, season adjusted prices and illustrates the change in the economic activity. The reason for using the Activity Index rather than the GDP is that the Activity Index is a better fit for our specific dependent variable since it is based on monthly variations at the same time as it is more up to date compared to the relatively slowness of the GDP. The choice of variable to illustrate the overall status of the economy can certainly be argued.

The data series used in our study is the logarithm of the de-trended observations for the Activity Index.

3.1.4 SAX All Share Index

To capture the wealth and consumption effects due to changes in stock prices we add the SAX All Share index to our model. As discussed in section 2.2.2 stocks represent the majority of household's financial wealth which is used both as collateral and payment of housing. Therefore, we have chosen to include the stock markets performance in our model. We have chosen to use the SAX All Share index since it reflects the movements of all shares registered on the Stockholm Stock Exchange and therefore serves well as a proxy for the movements of households' financial wealth in the regions we wish to examine.

The data series used in our study is the logarithm of the de-trended observations for the SAX All Share Index.

3.1.5 Employment

The issue of employment can be analyzed from two different perspectives. The first point of view is to analyze the percentage of a population that are currently employed on a regular basis. This rate would be measured as the part of a population that are capable to work that actually has a job. This parameter excludes children, senior citizens and people that are retired. The

second way to look at employment is to analyze the unemployment rate, i.e. the number of people that are capable to work and that wants to work that are unemployed.

The choice of perspective is naturally a result of the issue at hand. If real estate in relatively poor neighbourhoods are analyzed the second perspective could very well be of great interest when possible rents are determined. However, the price structure of the dependent variable in this thesis, relatively high priced tenant-owned real estate, is probably more dependent of the number of employed.

The employment data consists of the logarithm of the de-trended monthly observations measured in thousands of employed in Sweden for the age category 16-64 years.

3.1.6 Construction of New Real Estate

As a part of our model we want to capture the effect that demographic changes have on real estate prices. In addition to population growth and employment, the number of new apartments has an important impact on the aggregated supply of property within a region. It is therefore important not only to look at population numbers when considering the supply and demand of real estate, but also include factors that change the quantity of property available. Although we do not believe that the quantity of newly developed real estate is large within our regions of interest, the fact that new real estate are built in close connection to these regions may influence the price of real estate.

The construction data originally consisted of quarterly observations for the three individual areas, Stockholm, Gothenburg and Malmoe. The data comprise all newly built apartments within each area. In the study we interpolated the data to obtain the total number of newly constructed real estate in all regions combined for each month. Finally, we use the logarithm of the de-trended monthly observations.

3.1.7 Population Growth

The population development in an area is certainly an important indicator of the demand, and thus the price structure, of real estate. The number of people living in an area at a specific point in time is decided by several factors which include the number of newborn children, mortality rate and both streams of relocation. A variable that does not capture the whole picture, for example only adding newly born children and subtracting the number of deceased, will not give a satisfying result and this is the reason why we use a total population index rather than separated population variables.

The population data used has been interpolated from quarterly observations of the total population of the municipals[9] Stockholm, Gothenburg and Malmoe. The data used is the logarithm of the de-trended average population size in the three regions.

3.1.8 The 10-year Government Bond Interest Rate

The Swedish 10-year Government Bond mirrors the markets expectations on short-term interest rate movement across time. Therefore it serves as a good proxy for expectations of future interest rates in the economy. We believe that households not only consider the short-term interest rate when deciding on how much to borrow, but also form expectations about future interest rates. As a result of this we think that it is reasonable to add the 10y Government Bond to our model.

The data series used in our study is the logarithm of the de-trended observations for the 10-year Government Bond.

3.1.9 Forest Prices

A reasonable question when prices increase steadily within an asset class is where the money fuelling the development comes from. Internal factors, such as increased debt levels or profits from real estate that are used to purchase new real estate, are definitely important variables but external capital put into the market are even more interesting in the long run. A possible external cash flow can be the one created when Swedish forest owners sell their land and move into urban areas, bringing their profits with them and fuelling the real estate sector. To test for this hypothesis a new variable has been created – Pulp Index. It measures the price development of forest products and should as a result of this be positively correlated with the dependent variable.

The data series used are the logarithm of the de-trended monthly observations for the Western European Pulp Index traded on the Chicago Mercantile Exchange. (CME 2007)

3.1.10 Excluded variables

The fact that the following variables are not included in our model does not suggest that they are not important or have a possible significant relationship to real estate prices. However, what it does imply is that the possible effect of them is already captured by an included variable or that the variable in question is not available in such detail as we require.

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[9] Municipal, *Swedish: "Kommun"*

The Repo Rate

Changes in the repo rate have an almost instantaneous effect on the short-term market rates. The strong correlation with the short-term rates and the fact that banks usually quote their mortgages against the 3-monthy STIBOR is reason enough for us to exclude the repo rate from our model. Including both the repo rate and the 3-month STIBOR would result in severe multicollinearity problems.

The Output Gap

The output gap effectively measures economic activity as the difference between the current output and output at full capacity. Hence, the output gap is a good proxy for economic activity. In Sweden output gap numbers are released on a quarterly basis. Therefore, we have chosen to include Statistics Sweden's Activity Index instead, which effectively measures the same macroeconomic fluctuations and is available in monthly observations.

Profits from sold real estate

The Swedish tax system, which makes it possible to postpone profits from divested real estate, probably works a catalyst in the real estate market. Profits are often used when new real estate are acquired, but this factor can unfortunately not be included as a variable due to the lack of reliable data.

3.2 Econometric Specification

In this section we will discuss the model specification and the implications it has on our study. For the interested reader, full statistical results and explanations can be found in Appendix 1.

Empirical studies of time series data pose several challenges on the econometric specification. First, analysis of time series data assumes that the data variables are stationary, implying that the time series have constant mean and variance over time. In Appendix 1, we have plotted our variables against time and it is clear that the unedited variables are not stationary; hence we have non-stationary time series'. The problem with non-stationary time series data in statistical studies is that it is not possible to generalize the results found in one study to other time periods. This implies that a study using our unedited data would only be significant to the specific time period, hence the correlation among the variables from April 2003 to January 2007.

Secondly, non-stationary time series exhibit either a stochastic or deterministic trend. Broadly speaking, if a trend is not predictable we call it a stochastic trend otherwise we call it a

deterministic trend. A deterministic trend has the following properties. Consider the following time series Y_t.

$$Y_t = \alpha_1 + \alpha_2 t + \alpha_3 Y_{t-1} + \mu_t$$

If $\alpha_1 \neq 0, \alpha_2 \neq 0, \alpha_3 = 0$, we obtain:

$$Y_t = \alpha_1 + \alpha_2 t + \mu_t$$

The specification above is called a trend stationary process. By running regressions for each variable against time we obtain the mean and the average increase over time. The process of removing the estimated mean and increase for each point in time is called de-trending and the edited time series obtained is now stationary.

Table 1 shows mean and standard deviation for each of the unedited variables. The variables with the smallest fluctuations are the *Activity Index*, *Employment* and *Population*, i.e. the variables expected to have the strongest deterministic trend over time. As previously discussed all of our unedited data appears to be non-stationary implying that the series contains a unit root.[10] After performing a Dickey-Fuller test[11] for each variable, which can be found in Appendix 1, it is clear that we cannot reject the null hypothesis that the time series contains a unit root for seven out of eight variables. Hence, we chose to specify our model using trend stationary time series', i.e. de-trended time series' in the form specified above.

Table 1. The mean and standard deviation of each unedited variable

Variable	Mean	Std. Deviation	Std. Deviation as % of mean
Tenant-owned real estate	25 830	4 216	16.32%
3-month Stibor	2.44	0.51	20.86%
Activity Index	111.55	4.62	4.14%
SAX All Share Index	247.46	61.71	24.94%
Employment	4 268	79.37	1.86%
Construction	182.17	69.44	38.12%
Population	507 039	4 793	0.95%
10y Government Bond	4.00	0.56	14.12%
Pulp Index	531.20	60.11	11.32%

[10] A time series that contains a unit root is said to be non-stationary, i.e. it contains a stochastic or deterministic trend.

[11] A Dickey-Fuller test concludes whether a unit root is present in an autoregressive model. It is named after the statisticians D. A. Dickey and W. A. Fuller, who developed the test in the 1970s. The test statistic and hypothesis is outlined in greater detail in Appendix 1.

After considering the effects of different econometric specifications we have decided to use a trend stationary framework and to specify our model as follows:

$$\ln \Pr ice_t = \beta_1 + \beta_2 \ln STIBOR_t + \beta_3 \ln Activity_t + \beta_4 \ln SAX_t + \beta_5 \ln Employment_t + \beta_6 \ln Construction_t + \beta_7 \ln Population_t + \beta_8 \ln GovtBond + \beta_9 \ln PulpIndex_t + \varepsilon_t \quad (1)$$

One could always argue that more variables should be added, because clearly the mechanisms driving the development of prices are complex. As in all econometric models the number of variables must be carefully chosen to balance the trade-off between overfitting and underfitting the model (Gujarati 2003). Overfitting a model, hence including one or more irrelevant explanatory variables, still makes the OLS[12] estimators unbiased and consistent. However, the variance of the model coefficients will increase, thereby making the coefficients less precise. On the other hand, excluding a relevant variable, i.e. underfitting of the model, makes the model biased and inconsistent providing little guidance about the true relationship. Notice that the two specification errors generate different results. If we include an extra variable the model is still coherent with the original model, although the results may be less strong. Deducting a variable that should be included will in effect render a model that is wrong. In conclusion, it is therefore better to include too many variables than too few.

The data variables will be examined using a log-linear OLS framework. That is, the coefficients of the explanatory variables are interpreted as elasticises and not as marginal effects as in linear models. For example, this implies that if the SAX All Share index increases by one percent, tenant-owned real estate, on average, will increase by β_4 percent, given that all other variables are held constant. (Gujarati 2003)

[12] *Ordinary Least Squares*

Table 2 provides the name and specification for all variables used in our study.

Table 2. Variables used in the statistical analysis

Variable	SPSS name	Functional form	Source
Tenent-owned real estate	No trend Price	De-trended logarithm of Price	Värderingsdata/Mäklarstatistik
3-month STIBOR	No trend STIBOR	De-trended logarithm of STIBOR	The Riksbank
Activity Index	No trend Activity	De-trended logarithm of Activity	Statistics Sweden, SCB
SAX All Share Index	No trend SAX	De-trended logarithm of SAX	OMX
Employment	No trend Employment	De-trended logarithm of Employment	Statistics Sweden, SCB
Construction	No trend Construction	De-trended logarithm of Construction	Statistics Sweden, SCB
Population	No trend Population	De-trended logarithm of Population	Statistics Sweden, SCB
10y Government Bond	No trend GovtBond	De-trended logarithm of 10y Government Bond	The Riksbank
Pulp Index	No trend Pulp	De-trended logarithm of Pulp Index	The Chicago Mercantile Exchange

3.3 Causality Considerations

The most obvious problem when analyzing the relationship between asset prices and an instrumental interest rate is the issue of causality. In this context it is important to remember that the actual purpose of the rate is to control the asset price development, not the other way around. As a result of this, it should be the interest rate that moves before asset classes and it is consequently interesting to analyze.

A simple and linear definition of causality between two variables ca be stated as;

If x is a necessary cause of y; then the presence of y necessarily implies the presence of x. The presence of x, however, does not imply that y will occur.

In our case the perspective is that the instrumental rate (y) causes the change in asset prices (x), and that the real estate prices do not imply a change in the interest rate. The problem with this definition is the deterministic relation between the variables. That *"the presence of y necessarily implies the presence of x"* is not viable in our model since a rate change is not automatically followed by an adjustment in real estate prices under all circumstances.

An alternative definition is the following;

If x is a sufficient cause of y, then the presence of x necessarily implies the presence of y. However, another cause z may alternatively cause y. Thus the presence of y does not imply the presence of x.

In this example a third variable (z) can cause the changes in real estate prices and the causality between the interest rate (y) and the real estate prices (x) is not guaranteed. The notion that many different variables affect a macroeconomic phenomenon is natural and the number of z;s are probably close to infinite.

A third definition of causality can be stated as;

If x is a cause of y, then the presence of x implies the presence of y. However, x can also cause y. Thus, the direction of causality can not be established.

The core of the problem regarding the concept of instrumental interest rates is which variable that influences which. A central bank changes the rate as a result of the price development, and the price development respond to interest changes. The bilateral causality is obvious and natural in the sense that a substantial change in one variable will have an affect on the other. The problem is to assess if the first movement is a result of a previous change in the other variable.

Although regression analysis captures the relationship between the dependant variable and the explanatory variables it does not necessarily imply causality. In regressions involving time series data time does not run backwards. Therefore, it is possible to say that if event A happens before event B, then A can possible influence B. The opposite is however not true, event B cannot affect A. This is roughly the idea behind the Granger causality test.[13] To investigate the causality between two time series variables the following pair of regressions are estimated;

$$\text{I}: \; Y_t = \sum_{i=1}^{n} \alpha_1 X_{t-1} + \sum_{j=1}^{n} \beta_j Y_{t-j} + u_{1t}$$

$$\text{II}: \; X_t = \sum_{i=1}^{n} \alpha_1 Y_{t-1} + \sum_{j=1}^{n} \beta_j X_{t-j} + u_{2t}$$

Each of the regressions above are estimated two times. For example, regression (I) is first regressed including both lagged variables (unrestricted regression) and then regressed excluding the lagged values of X (restricted regression). The null hypothesis is $H_0 : \sum \alpha_i = 0$, that is, the lagged variable do not belong in the regression and we do not have a causal relationship. To test

[13] Granger causality is a technique for determining whether one time series is useful in forecasting another. Ordinarily, regressions reflect "mere" correlations, but Clive Granger, who won a Nobel Prize in Economics, argued that there is an interpretation of a set of tests as revealing something about causality. A time series X is said to Granger-cause Y if it can be shown, usually through a series of F-tests on lagged values of X (and with lagged values of Y also known), that those X values provide statistically significant information about future values of Y.

the hypothesis we perform an F-test, which follows the *F*-distribution with *m* and *(n-k)* degrees of freedom: [14]

$$F = \frac{(RSS_R - RSS_{UR})/m}{RSS_{UR}/(n-k)}$$

Since we are interested not only in the relationship between the variables but also the direction of the causality, a number of Granger tests will be performed. This will enable us to get a picture of how our independent variables can be used as predictors of future real estate price movements.

[14] *m* is equal to the number of lagged *X* terms (in regression I) and *k* is the number of parameters estimated in the unrestricted regression. *RSS* is the *residual sum of squares* for the restricted and unrestricted regression, respectively.

4. EMPIRICAL FINDINGS

The explanatory effect of our variables on the dependent variable, tenant-owned real estate, is outlined in table 3.[15] The model, specified in section 3.2 as regression model (1), has an R-square[16] of 0.453 and four out of eight explanatory variables are significant at a 10% level. The R-square value of 0.453 is rather high for a trend-stationary model, indicating that the model predicts approximately 45% of the variability in the dependant variable.

Table 3. Results from model specification (1)

Variable	Coefficient	P-value
Constant	0.000	0.899
3-month Stibor	0.076	0.060*
Activity Index	1.887	0.047**
SAX All Share Index	0.292	0.001***
Employment	0.616	0.025**
Construction	-0.035	0.152
Population	2.027	0.626
10y Government Bond	-0.075	0.174
Pulp Index	-0.037	0.730
R-square	0.453	
Adjusted R-square	0.334	

* *Significant at a 10% level*
** *Significant at a 5% level*
*** *Significant at a 1% level*

First of all, the intercept or constant has a coefficient of zero as expected in a trend-stationary model since the mean goes to zero when the time series' are de-trended.

Among the significant variables, which are the *3-month STIBOR, Activity Index,* the *SAX All Share Index* and *Employment,* the *SAX All Share Index* is the most significant followed by *Employment* and the *Activity Index*. All significant variables, except *3-month STIBOR*, have the expected sign, whereas the *3-month STIBOR* has a significant positive relationship to the dependant variable. Of the significant variables, an increase in the *Activity Index* has the greatest effect on the dependant variable with an elasticity of 1.887, implying that for each percentage increase in economic activity the prices of tenant-owned real estate in our regions increases by 1.887%. Among the other significant variables, real estate prices on average increase 0.616% for an increase of one

[15] All complementary statistical data can be found in Appendix 1.

[16] R^2, or goodness of fit, measures the proportion or procentage of the total variation in Y explained by the regression model. An important property of R^2 is that it is a non-decreasing function of the number of explanatory variables, i.e. by including additional variables the goodness of fit in the model increases by definition.

percent in *Employment*, 0.292% for a one percent increase in the *SAX All Share Index* and finally 0.076% for a one percent increase in the *3-month STIBOR*.

The non-significant variables in the model are; *Construction, Population,* the *10y Government Bond* and the *Pulp Index*. *Construction* and the *10y Government Bond* are slightly significant, whereas *Population* and the *Pulp Index* are highly insignificant. The *Pulp Index* variable also has the wrong sign as the price of real estate is expected to increase as the price of other asset classes, in this case forest or pulp, increases.

One could argue that the model would benefit from excluding the *Pulp Index* and *Population* variables. To test the robustness of the other variables a regression excluding *Pulp Index* and *Population* has also been tested;

$$\ln \Pr ice_t = \alpha_1 + \alpha_2 \ln STIBOR_t + \alpha_3 \ln Activity_t + \alpha_4 \ln SAX_t + \alpha_5 \ln Employment_t + \alpha_6 \ln Construction_t + \alpha_7 \ln GovtBond + e_t \quad (2)$$

The results of model specification (2) are presented in table 4.

Table 4. Results from model specification (2)

Variable	Coefficient	P-value
Constant	0.000	0.899
3-month Stibor	0.060	0.037**
Activity Index	1.854	0.035**
SAX All Share Index	0.298	0.000***
Employment	0.621	0.020**
Construction	-0.037	0.051*
10y Government Bond	-0.088	0.068*
R-square	0.447	
Adjusted R-square	0.362	

* *Significant at a 10% level*
** *Significant at a 5% level*
*** *Significant at a 1% level*

Estimating model (2) provides us with a model that has an R-square of 0.447, which is insignificantly higher than that of model (1). Although, for comparison across models it is better to look at adjusted R-square[17], which takes into account the use of the different number of explanatory variables in the two models. The adjusted R-square is 0.362 and 0.334 for model (2) and (1), respectively. In model (2) all variables are significant at a 10% level. But the *3-month STIBOR* still has a positive relationship to real estate prices. As in model (1), the *Activity Index* has the greatest impact on our dependant variable followed by *Employment*.

[17] Adjusted R^2, is the goodness of fit adjusted for the degrees of freedom within the model.

The coefficients of the variables included in both models change marginally between the models, indicating that the excluded variables, *Pulp Index* and *Population*, represent random noise without explanatory power. Due to the risk of underfitting our model, we have chosen to keep model specification (1) as our primary model.

The Granger test results of model (2) are summarized in table 5 and 6. We notice that we have a bilateral causality between the price of tenant-owned real estate, the *Activity Index* and the *10-year Government Bond* both when we test for the one month and three months lag. All other variables are to be considered independent, i.e. we can not determine the causality between them.

Table 5. Causality amongst the variables in model (2), one month lag length.

Direction of causality	Number of lags	F value	Decision
Stibor → Price	1	0,84	Do not reject
Price → Stibor	1	1,08	Do not reject
Activity → Price	1	2,94*	Do not reject
Price → Activity	1	5,96**	Reject
SAX → Price	1	1,15	Do not reject
Price →SAX	1	2,14	Do not reject
Employment → Price	1	0,24	Do not reject
Price → Employment	1	0,01	Do not reject
Construction → Price	1	0,67	Do not reject
Price → Construction	1	0,82	Do not reject
10y Govt Bond → Price	1	9,47***	Reject
Price → 10y Govt Bond	1	6,75**	Reject

* *Significant at a 10% level*
** *Significant at a 5% level*
*** *Significant at a 1% level*

Table 5. Causality amongst the variables in model (2), three months lag length.

Direction of causality	Number of lags	F value	Decision
Stibor → Price	3	0,36	Do not reject
Price → Stibor	3	1,89	Do not reject
Activity → Price	3	3,24**	Reject
Price → Activity	3	5,89**	Reject
SAX → Price	3	0,04	Do not reject
Price →SAX	3	1,02	Do not reject
Employment → Price	3	0,00	Do not reject
Price → Employment	3	0,25	Do not reject
Construction → Price	3	0,02	Do not reject
Price → Construction	3	0,80	Do not reject
10y Govt Bond → Price	3	5,67**	Reject
Price → 10y Govt Bond	3	10,98***	Reject

* *Significant at a 10% level*
** *Significant at a 5% level*
*** *Significant at a 1% level*

5. ANALYSIS AND DISCUSSION

This part of the thesis will analyze the results and answer the most important question from the introduction chapter, namely;

> *To what extent can macroeconomic factors such as the activity in the economy, the stock market development, demographical changes and especially the central bank's instrumental interest rate influence the prices of tenant-owned real estate in premier urban regions in Sweden?*

In order to do this in a clear and consistent manner the analysis is divided to reflect the different variables that influence the development of real estate prices.

5.1 The Influence of Interest Rates

The relationship between interest rates and real estate prices has been discussed and studied in great detail and can be seen both in the perspective of The Riksbank or as the interplay between two asset classes, real estate and credit. Previous research, such as Giuliodori (2005), points to the fact that real estate prices tend to have an amplifying effect on household investments thereby contributing to an increase in consumption and inflation. For households the most direct effect of an increase in interest rates comes from higher borrowing costs, since the majority of households in our specific regions borrow a large part of the cost when buying their home. Empirical studies, such as Ahearne *et al.* (2005), find that for longer time periods the interest rate across all maturities tend to lead the development of real estate prices, i.e. have a negative relation to real estate prices.

The results from our study are two-folded. On the one hand we have a negative relationship between the 10-year government bond and tenant-owned real estate. Although not as robust as we expected, the negative relationship shows that households' expectations on future interest rates, captured by the 10-year bond, has a considerable impact on the prices of tenant-owned real estate in our regions. The 3-month STIBOR on the other hand has a stronger but positive relation to prices, implying that households are less concerned with the short-term effects of higher interest. A possible explanation could be that the instrumental interest rate has been historically low during our time period and that households therefore are less concerned about the changes in the short-term interest rate and more concerned about the future level of it. This could in part explain the difference we observe between the short and long-term interest rates. Another explanation could be that the long-term interest rate better fits the time horizon on which households base their investment decisions. It is reasonable to believe that households

estimate the time for which they intend to live in a certain tenant-owned real estate to more than a couple of months or a year. Thus, the longer maturity interest rates capture the relation households have to real estate prices in a better way than short-term interest rates.

In model (2) the two interest rate variables are both significant but have rather small elasticities compared to the other variables. This suggests that within our sample the interest rate is not the most important factor. The positive relationship found between real estate and the 3-month STIBOR suggests that The Riksbank would have limited possibilities of influencing the price level of real estate in the short-run, should it decide to intervene. Based on the results of our study, The Riksbank has a greater chance of influencing real estate prices by managing expectations about future interest rate levels. By communicating interest rate projections as part of its *Monetary Policy Report* and openly discussing policy considerations The Riksbank are working towards further openness and in turn a better chance of managing households' expectations.

5.2 The Influence of Assets Prices and Economic Activity

The notion presented in earlier research that financial assets and the general development of the economy can have a valid impact on real estate prices turned out to have significant bearing in our model. The proxies used in the regression model for these two factors were the *SAX All Share Index* and the *Activity Index*. Earlier research advocated that these factors should be positively correlated with real estate prices through the rather natural logic that the financial strength of the consumer increases if these variables increase.

The activity of the economy was in fact the most influential factor with an elasticity of almost 2. It is quite expected that the activity index has a key impact on such a large part of the economy as the residential real estate sector constitutes. The decision to buy an apartment is probably one of the largest financial commitments a citizen makes during his or her lifetime. A healthy economy not only makes it possible to acquire this kind of premier real estate but also makes it psychologically viable in a long-term perspective since the risk of rapid asset price depreciation is less likely in a strong economy. The debt levels and financing arguments in the current real estate market indicate that consumers are not expecting a price decline similar to that of other significant personal investments such as automobiles, where price depreciation is more or less inevitable. It is very feasible to suggest that the high activity level in the economy has a major role in this kind of reasoning.

The de-trended stock market coefficient is significant on a 1% level which is a statistically noteworthy result. The effect on the dependent variable is not as large as the activity variable but still almost 0.3, which suggest that a 1% increase in the *SAX All Share Index* would increase the real estate prices with 0.292%. Profits made in the stock market, realized or not, can consequently be an essential part of the explanation of the price development of real estate.

Findings from earlier research points in the same direction and the results are hardly astonishing, but the strength of the correlation is nevertheless interesting as an indicator for the dependent variable and as support for further studies.

5.3 The Influence of Demographics

Apart from interest rate levels and asset prices, tenant-owned real estate display a relationship to changes in demographics such as the employment and population changes. Looking at our results we see that changes in employment is one of the more influential and significant factors. One can suspect that an increase in employment should coincide with a general upswing in the economy, which would trigger an increase in real estate prices and therefore the positive relationship come as no surprise. Although we believe that employment within the regions we study is very high, fluctuations in employment result in variations in consumers buying power and therefore also in real estate prices. So even though the effect of increased employment may not have a direct effect on prices within the studied regions, real estate prices will nevertheless increase due to the overall increase in demand. Clearly, trying to determining the causality of this is very difficult.

Population changes certainly have an effect on real estate prices but due to different reasons this does not show in our results. The fact that the population data is collected on a quarterly basis for the municipals, therefore no capturing all variations to the extent we need, could be one problem. Another possible explanation could be that the increase in population from one time period to another is practically constant across our sample, thus when the time series is de-trended it creates a variable with small or illegible variations.

5.4 The Causality Problem

The test results from the analysis section show that there is a bilateral causality relationship between the dependent variable and both the activity in the economy as well as the long term interest rate. The idea of bilateral causality is that two variables influence each other over time,

which would imply that the price of real estate follows the development in the economy to some extent and that the activity in the economy is affected by the real estate prices at the same time. The same idea would apply to the long term government bond interest rate. The result is not surprising since real estate buyers certainly evaluate the status and forecasts of the economy, and both the *Activity Index* and the *10-year Government Bond* are good proxies for this. On the same token it is not impossible to see how these two variables are influenced by real estate prices; the activity index through the GDP development and the long maturity bond through the long term outlook of the economy.

The remaining variables are considered to be independent towards the dependent variable. This does not imply that the correlation or the significance of the variables is pointless, but that the causality between the variables cannot be determined.

6. CONCLUSIONS

In this paper our main purpose has been to analyze to what extent macroeconomic factors can influence the development of tenant-owned real estate in premier urban regions. The variables comprise a selection of interest rates and asset prices as well as demographical factors such as population and construction of new real estate.

To examine the relationship we have used trend stationary time series' in a log-linear OLS framework. The dependent variable has been the average square meter price for tenant-owned real estate in the urban regions of Stockholm, Gothenburg and Malmoe. Two econometric models has been analyzed, the second analyzing a selection of the significant variables from the first model.

The variables that appear to have the most significant relationship to real estate prices are factors that are frequently used as indicators of the state of the economy, such as the stock market development and the economic activity. An increase in the short-term interest rate does not seem to reduce the upward trend of real estate prices, whereas the longer maturity interest rate has a weak negative impact on prices. This implies that households are less concerned with short-term effects of higher interest rates and more concerned about the expectations of future interest rate levels. Demographical factors such as population are certainly important, but the variable in our model fails to add explanatory power, perhaps due to specification errors or our limited time period.

7. CRITIQUE AND SUGGESTIONS FOR FURTHER RESEARCH

As stated in section 3.3 the issue of causality could be a problem, especially when analyzing the relationship between instrumental interest rates and asset prices. The Granger test shows the causality links in the model with the result that the dependent variable has a bilateral causality both with the long-term interest rate and the economic activity. The result is that it is hard to verify the deterministic power of the independent variables which leads to a weaker model.

The length of the time series used in the model is rather short in a macroeconomic setting. 46 observations are not necessarily too few, but given the fact that the data only cover four years can constitute a problem. The reason for this deficiency is, as stated in previous chapters, that the data covering the specific type of real estate simply does not exist to the extent needed. Other types of real estate, or assets for that matter, could certainly have been analyzed but that would have neglected our focus of research; how The Riksbank can influence the most widely discussed real estate type in Sweden.

Plenty of international research has been conducted regarding the relationship between instrumental interest rates and real estate. The academic research in Sweden has on the other hand been limited. The problem with previous studies, from our point of view, is that the term real estate is treated as generic where tenant-owned apartments, commercial space, agricultural properties and rental buildings often are bundled into one index which leads to indistinct results. A suggestion for further research within this area is thus to be more specific regarding the different asset classes covered combined with a longer time span.

Since the relationship between interest rates and the price of tenant-owned real estate is rather weak in our model it would be interesting to investigate it further. This can be done using the model in our thesis, but with variations in the specification of the interest rate variables.

An interesting specification would be to add the interest rate variables in levels, since we believe that households are not only interested in the changes in interest rates but also the level of it. Although the real interest rate might not be different for a nominal interest rate of four or twelve percent, the higher level will perhaps discourage households from borrowing since the interest nevertheless is higher in nominal terms. To examine this specification, as well as a couple of others, we have tested possible model extensions in Appendix 3. The results are similar to the ones we reached in chapter 4, but possibly it shows that the data of tenant-owned real estate can be used for further research of the interaction between real estate and interest rates.

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APPENDICES

APPENDIX 1 – COMPLETE STATISTICAL RESULTS

Correlation between repo rate and 3-month STIBOR

Variable	Mean (%)	Correlation
Repo	2.678	98.9
STIBOR	2.872	

Sequence charts of all variables versus time

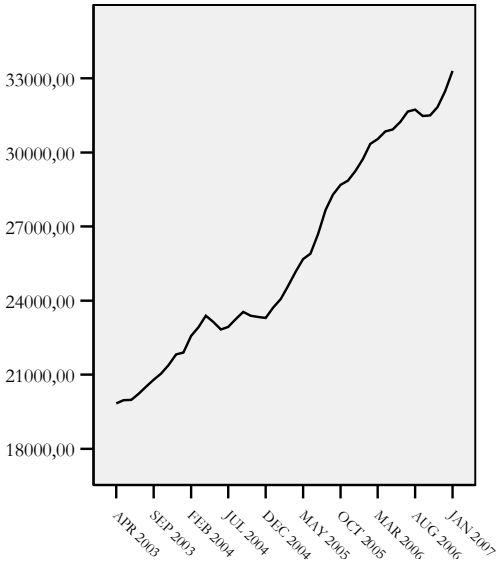


Fig. 3 Price level of tenant-owned real estate versus time

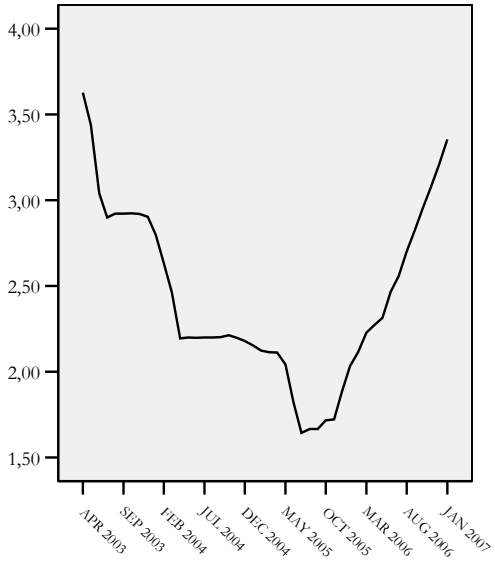


Fig. 4 Level of the 3-month STIBOR versus time

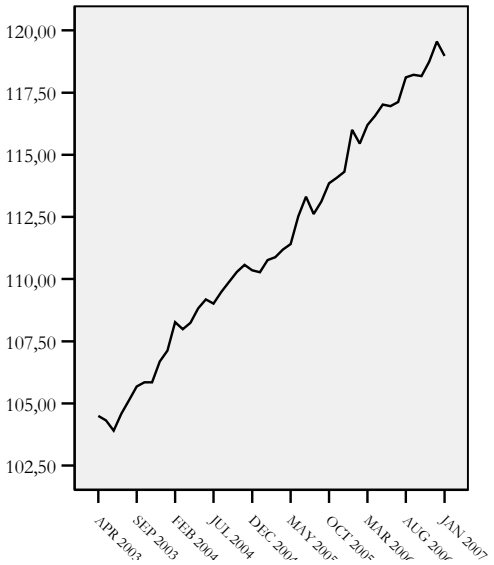


Fig. 5 Level of Activity Index versus time

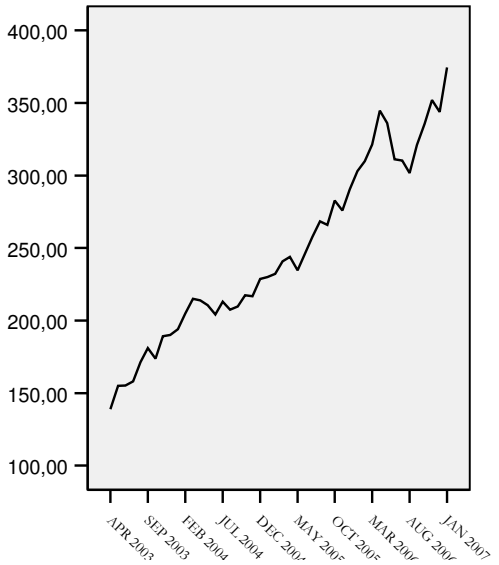


Fig. 6 Level of the SAX All Share Index versus time

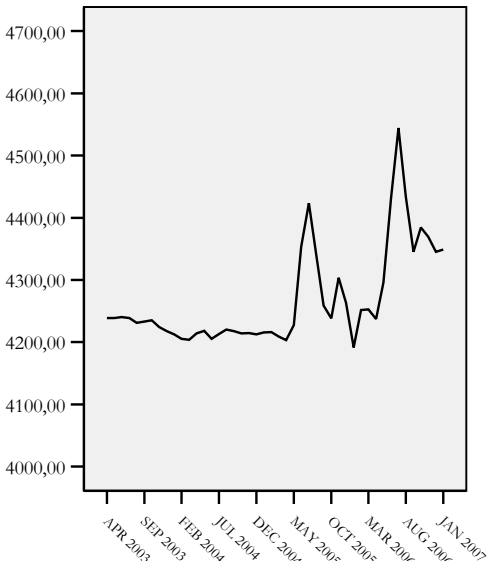


Fig. 7 Level of employment in Sweden versus time

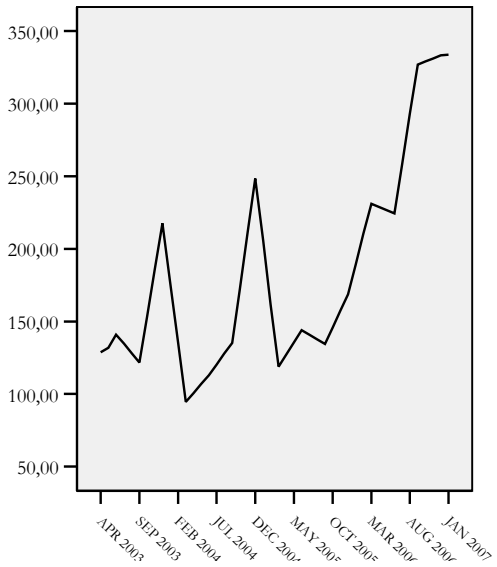


Fig. 8 Level of new construction versus time

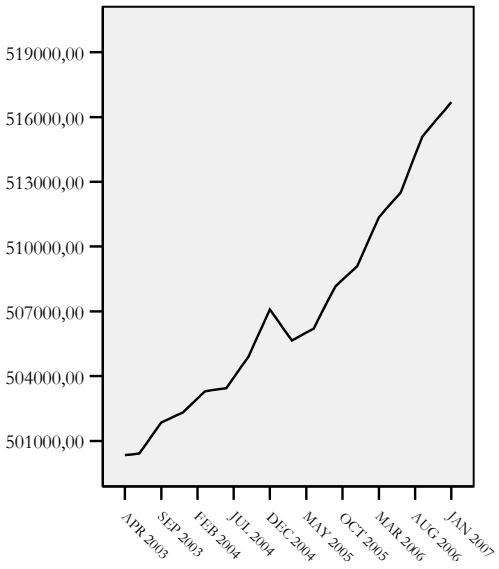


Fig. 9 Level of average population versus time



Fig. 10 Level of the 10year Govt. Treasury Bond versus time

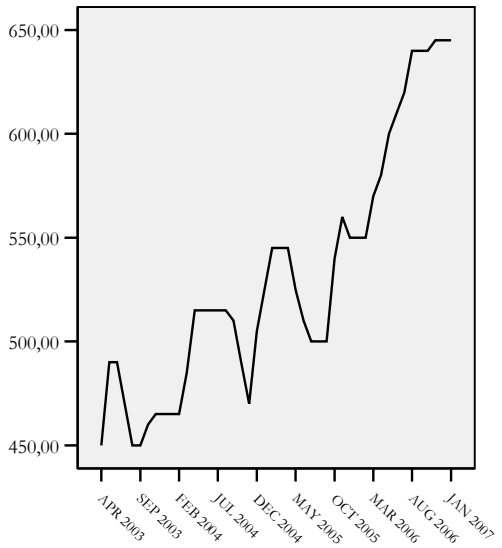


Fig. 11 Level of the European Pulp Index versus time

Unit root test for all variables

All tests use the equation:

$$\Delta Y_t = \beta_0 + \beta_1 T + \beta_2 Y_{t-1} + u_t$$

The t-value for β_2 is used as the test statistic. The null hypothesis $H_0 : \beta_2 = 0$ (i.e. the series contains a unit root) is rejected if the observed *t* value is < -3,519.

Table 7. Dickey-Fuller test for Price including constant and trend

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1551.374	975.545		1.590	.119
	Time	27.293	16.612	1.257	1.643	.108
	Lag_Price	-.074	.053	-1.070	-1.399	.169

Table 8. Dickey-Fuller test for 3-month STIBOR including constant and trend

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-.159	.085		-1.873	.068
	Time	.006	.001	.688	5.787	.000
	Lag_Stibor	-.000310	.029	-.001	-.011	.992

Table 9. Dickey-Fuller test for Activity Index including constant and trend

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	52.409	13.484		3.887	.000
	Time	.175	.045	4.755	3.869	.000
	Lag_Activity	-.505	.131	-4.751	-3.865	.000

Table 10. Dickey-Fuller test for SAX All Share Index including constant and trend

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	44.701	16.850		2.653	.011
	Time	1.355	.539	1.702	2.513	.016
	Lag_SAX	-.294	.119	-1.670	-2.465	.018

Table 11. Dickey-Fuller test for Employment including constant and trend

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1364.234	468.382		2.913	.006
	Time	1.385	.677	.368	2.046	.047
	Lag_Employment	-.327	.112	-.524	-2.917	.006

Table 12. Dickey-Fuller test for Construction including constant and trend

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	6.181	9.796		.631	.531
	Time	.629	.364	.361	1.729	.091
	Lag_Construction	-.094	.072	-.271	-1.298	.201

Table 13. Dickey-Fuller test for Population including constant and trend

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	11475.452	23341.295		.492	.626
	Time	16.759	16.462	.663	1.018	.314
	Lag_Population	-.023	.047	-.316	-.485	.630

Table 14. Dickey-Fuller test for 10-year Government Bond including constant and trend

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	.230	.316		.728	.471
	Time	-8.13E-005	.003	-.006	-.029	.977
	Lag_Govtbond	-.062	.065	-.213	-.943	.351

Table 15. Dickey-Fuller test for 10year Pulp Index including constant and trend

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	75.078	38.351		1.958	.057
	Time	.772	.390	.667	1.980	.054
	Lag_PulpIndex	-.169	.088	-.647	-1.921	.062

The test statistics are summarized in table 16. In all but one of the cases $t_{obs} > t_{critical} = -3.519$, hence we cannot reject the null hypothesis of a unit root in a majority of the time series analyzed.

Table 16. Unit root test summary

Variable	t	Critical value	Summery
Price	-1.399	-3.519	Possibly contains a unit root
Stibor	-0.011	-3.519	Possibly contains a unit root
Activity	-3.865	-3.519	Do no contain a unit root
SAX	-2.465	-3.519	Possibly contains a unit root
Employment	-2.917	-3.519	Possibly contains a unit root
Construction	-1.298	-3.519	Possibly contains a unit root
Population	-0.485	-3.519	Possibly contains a unit root
GovtBond	-0.943	-3.519	Possibly contains a unit root
PulpIndex	-1.921	-3.519	Possibly contains a unit root

Since all but one of the time series' contains a unit root we consider the variables non-stationary and therefore need to be de-trended before analysis.

De-trending of time series

Consider the following time series $\ln Y_t$.

$$\ln Y_t = \alpha_1 + \alpha_2 t + \alpha_3 \ln Y_{t-1} + \mu_t$$

If $\alpha_1 \neq 0, \alpha_2 \neq 0, \alpha_3 = 0$, we obtain, $\ln Y_t = \alpha_1 + \alpha_2 t + \mu_t$

The specification above is called a trend stationary process. In table 15 the individual time series' estimated mean and slope are showed.

Table 17. Summary of intercept and mean of the individual trend stationary processes

Variable	Intercept	Slope
Ln Price	9.866	0.012
Ln Stibor	0.959	-0.004
Ln Activity	4.641	0.003
Ln SAX	5.005	0.019
Ln Employment	8.338	0.001
Ln Construction	4.702	0.019
Ln Population	13.120	0.001
Ln GovtBond	1.555	-0.007
Ln PulpIndex	6.903	0.007

By removing the trend at each point in time of all time series' we obtain the data we finally use.

Simple and partial correlations

Table 18. Simple correlation for de-trended logarithms of all variables

		Prices	Stibor	Activity	SAX	Employ-ment	Construc-tion	Popula-tion	10y Govt bond	Pulp Index
Price	Pearson Correlation	1	.027	.342(*)	.421(**)	.117	-.197	-.018	.034	-.066
	Sig. (2-tailed)		.858	.020	.004	.439	.190	.904	.821	.664
	N	46	46	46	46	46	46	46	46	46
Stibor	Pearson Correlation	.027	1	.174	-.179	.303(*)	.725(**)	.881(**)	.663(**)	.585(**)
	Sig. (2-tailed)	.858		.248	.234	.041	.000	.000	.000	.000
	N	46	46	46	46	46	46	46	46	46
Activity	Pearson Correlation	.342(*)	.174	1	.269	-.024	.089	.287	.424(**)	.039
	Sig. (2-tailed)	.020	.248		.071	.872	.558	.053	.003	.798
	N	46	46	46	46	46	46	46	46	46
SAX	Pearson Correlation	.421(**)	-.179	.269	1	-.436(**)	-.172	-.091	.156	-.190
	Sig. (2-tailed)	.004	.234	.071		.002	.254	.550	.301	.207
	N	46	46	46	46	46	46	46	46	46
Employ-ment	Pearson Correlation	.117	.303(*)	-.024	-.436(**)	1	.189	.248	.107	.160
	Sig. (2-tailed)	.439	.041	.872	.002		.208	.096	.481	.288
	N	46	46	46	46	46	46	46	46	46
Construc-tion	Pearson Correlation	-.197	.725(**)	.089	-.172	.189	1	.790(**)	.498(**)	.212
	Sig. (2-tailed)	.190	.000	.558	.254	.208		.000	.000	.156
	N	46	46	46	46	46	46	46	46	46
Popula-tion	Pearson Correlation	-.018	.881(**)	.287	-.091	.248	.790(**)	1	.693(**)	.457(**)
	Sig. (2-tailed)	.904	.000	.053	.550	.096	.000		.000	.001
	N	46	46	46	46	46	46	46	46	46
10y Govt bond	Pearson Correlation	.034	.663(**)	.424(**)	.156	.107	.498(**)	.693(**)	1	.550(**)
	Sig. (2-tailed)	.821	.000	.003	.301	.481	.000	.000		.000
	N	46	46	46	46	46	46	46	46	46
Pulp Index	Pearson Correlation	-.066	.585(**)	.039	-.190	.160	.212	.457(**)	.550(**)	1
	Sig. (2-tailed)	.664	.000	.798	.207	.288	.156	.001	.000	
	N	46	46	46	46	46	46	46	46	46

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

Table 19. Partial correlation between de-trended lnPrice and de-trended lnSTIBOR controlling for all other variables

Control Variables			No trend Price	No trend Stibor
No Trend Activity & No trend SAX & No trend Employment & No trend Construction & No trend Population & No trend 10y Govt bond & No trend Pulp Index	No trend Prices	Correlation	1.000	.304
		Significance (2-tailed)	.	.060
		df	0	37
	No trend Stibor	Correlation	.304	1.000
		Significance (2-tailed)	.060	.
		df	37	0

Table 20. Partial correlation between de-trended lnPrice and de-trended lnActivity controlling for all other variables

Control Variables			Prices no trend	No Trend Activity
No trend Stibor & No trend SAX & No trend Employment & No trend Construction & No trend Population & No trend 10y Govt bond & No trend Pulp Index	Prices no trend	Correlation	1.000	.321
		Significance (2-tailed)	.	.047
		df	0	37
	No Trend Activity	Correlation	.321	1.000
		Significance (2-tailed)	.047	.
		df	37	0

Table 21. Partial correlation between de-trended lnPrice and de-trended lnSAX controlling for all other variables

Control Variables			Prices no trend	No trend SAX
No trend Stibor & No Trend Activity & No trend Employment & No trend Construction & No trend Population & No trend 10y Govt bond & No trend Pulp Index	Prices no trend	Correlation	1.000	.507
		Significance (2-tailed)	.	.001
		df	0	37
	No trend SAX	Correlation	.507	1.000
		Significance (2-tailed)	.001	.
		df	37	0

Table 22. Partial correlation between de-trended lnPrice and de-trended lnEmployment controlling for all other variables

Control Variables			Prices no trend	No trend Employment
No trend Stibor & No Trend Activity & No trend SAX & No trend Construction & No trend Population & No trend 10y Govt bond & No trend Pulp Index	Prices no trend	Correlation	1.000	.359
		Significance (2-tailed)	.	.025
		df	0	37
	No trend Employment	Correlation	.359	1.000
		Significance (2-tailed)	.025	.
		df	37	0

Table 23. Partial correlation between de-trended lnPrice and de-trended lnConstruction controlling for all other variables

Control Variables			Prices no trend	No trend Construction
No trend Stibor & No Trend Activity & No trend SAX & No trend Employment & No trend Population & No trend 10y Govt bond & No trend Pulp Index	Prices no trend	Correlation	1.000	-.234
		Significance (2-tailed)	.	.152
		df	0	37
	No trend Construction	Correlation	-.234	1.000
		Significance (2-tailed)	.152	.
		df	37	0

Table 24. Partial correlation between de-trended lnPrice and de-trended lnPopulation controlling for all other variables

Control Variables			Prices no trend	No trend Population
No trend Stibor & No Trend Activity & No trend SAX & No trend Employment & No trend Construction & No trend 10y Govt bond & No trend Pulp Index	Prices no trend	Correlation	1.000	-.081
		Significance (2-tailed)	.	.626
		df	0	37
	No trend Population	Correlation	-.081	1.000
		Significance (2-tailed)	.626	.
		df	37	0

Table 25. Partial correlation between de-trended lnPrice and de-trended lnGovtBond controlling for all other variables

Control Variables			Prices no trend	No trend 10y Govt bond
No trend Stibor & No Trend Activity & No trend SAX & No trend Employment & No trend Construction & No trend Population & No trend Pulp Index	Prices no trend	Correlation	1.000	-.222
		Significance (2-tailed)	.	.174
		df	0	37
	No trend 10y Govt bond	Correlation	-.222	1.000
		Significance (2-tailed)	.174	.
		df	37	0

Table 26. Partial correlation between de-trended lnPrice and de-trended lnPulp controlling for all other variables

Control Variables			Prices no trend	No trend Pulp Index
No trend Stibor & No Trend Activity & No trend SAX & No trend Employment & No trend Construction & No trend Population & No trend 10y Govt bond	Prices no trend	Correlation	1.000	-.057
		Significance (2-tailed)	.	.730
		df	0	37
	No trend Pulp Index	Correlation	-.057	1.000
		Significance (2-tailed)	.730	.
		df	37	0

Table 27 summarizes the simple and partial correlations to the dependant variable.

Table 27. Summary of simple and partial correlations to the dependant variable

Variable	Simple correlation	Partial Correlation
Stibor	0.027	0.304
Activity	0.342	0.321
SAX	0.421	0.507
Employment	0.117	0.359
Construction	-0.197	-0.234
Population	-0.018	-0.081
GovtBond	0.034	-0.222
PulpIndex	-0.066	-0.057

The above results indicate that it is reasonable to build a trend stationary model. There are however some correlation coefficients that appears to be rather small or of the wrong sign. For example the 3-month STIBOR. This can be an indicator that our data set is too small or that

some of the variables should be excluded from our model. We have decided to keep all variables to avoid underfitting the model.

Model estimation (1)

Table 28. SPSS output from the estimation of the trend stationary log-linear model:

$$\ln \Pr ice_t = \beta_1 + \beta_2 \ln STIBOR_t + \beta_3 \ln Activity_t + \beta_4 \ln SAX_t + \beta_5 \ln Employment_t + \beta_6 \ln Construction_t + \beta_7 \ln Population_t + \beta_8 \ln GovtBond_t + \beta_9 \ln PulpIndex_t + \varepsilon_t$$

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.673(a)	.453	.334	.02143445	.703

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.014	8	,002	3,826	,002(a)
	Residual	.017	37	.000		
	Total	.031	45			

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	.000	.003		.127	.899		
	No trend Stibor	.076	.039	.584	1.940	.060	.163	6.123
	No trend Activity	1.887	.917	.302	2.059	.047	.688	1.454
	No trend SAX	.292	.082	.552	3.579	.001	.622	1.609
	No trend Employment	.616	.263	.331	2.338	.025	.737	1.358
	No trend Construction	-.035	.024	-.332	-1.462	.152	.288	3.478
	No trend Population	-2.027	4.123	-.157	-.492	.626	.146	6.853
	No trend 10y Govt bond	-.075	.054	-.294	-1.387	.174	.330	3.033
	No trend Pulp Index	-.037	.106	-.064	-.348	.730	.437	2.291

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions								
				(Constant)	No trend Stibor	No trend Activity	No trend SAX	No trend Employ-ment	No trend Construc-tion	No trend Popula-tion	No trend 10y Govt bond	No trend Pulp Index
1	1	3.642	1.000	.00	.01	.00	.00	.01	.01	.01	.02	.01
	2	1.628	1.496	.00	.00	.10	.17	.10	.00	.00	.02	.00
	3	1.025	1.885	.78	.00	.00	.00	.00	.00	.00	.00	.01
	4	.864	2.053	.00	.00	.26	.00	.23	.01	.00	.00	.18
	5	.839	2.083	.03	.00	.12	.01	.11	.12	.01	.01	.13
	6	.507	2.679	.00	.00	.28	.55	.46	.00	.00	.01	.00
	7	.247	3.839	.01	.10	.09	.17	.00	.02	.03	.83	.08
	8	.155	4.849	.01	.21	.11	.10	.08	.77	.07	.10	.54
	9	.092	6.289	.16	.67	.04	.00	.00	.07	.88	.01	.03

Multicollinearity

R^2 and *t* rations:	R^2 = 0.453 and four out of eight elasticises are significant at a 10 percent level. Low sign of multicollinearity.
Pair-wise correlations among regressors:	One pair-wise correlation is above 0.80 (STIBOR-Population) indicating that there might be some multicollinearity. The correlation between construction and population is quite high (0.790). No other alarming correlations exists. Low sign of multicollinearity.
Conditions indexes:	All condition indexes, except the first which is equal to 1 by definition, are well below 10 meaning that the level of multicollinearity in the model is low.
Tolerance values and VIF:	None of the tolerance values are below 0.1 (or VIF > 10). The parameter with the lowest value is Population (0.146) and the second lowest value is STIBOR (0.163) indicating that these parameters show signs of weak involvement in multicollinearity.

Conclusion: The multicollinearity is rather weak in this model. STIBOR and Population seems to be most involved.

Scatterplot of predicted values vs. residual, model (1)

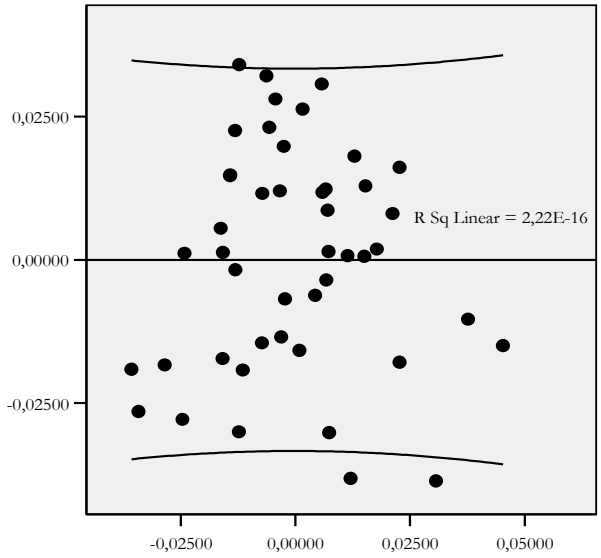


Fig. 12 Scatterplot of model (1), predicted values vs. residual

There is clearly no sign of heteroscedasticity since the residuals are equally scattered across the predicted values.

Model estimation (2)

Table 29. SPSS output from the estimation of the trend stationary log-linear model:

$$\ln \Pr ice_t = \alpha_1 + \alpha_2 \ln STIBOR_t + \alpha_3 \ln Activity_t + \alpha_4 \ln SAX_t + \alpha_5 \ln Employment_t + \alpha_6 \ln Construction_t + \alpha_7 \ln GovtBond_t + e_t \quad (2)$$

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.669(a)	.447	.362	.02098033

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.014	6	.002	5.261	.000(a)
	Residual	.017	39	.000		
	Total	.031	45			

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	.000	.003		-.068	.946		
	No trend Stibor	.060	.028	.458	2.158	.037	.315	3.173
	No Trend Activity	1.854	.849	.297	2.184	.035	.769	1.300
	No trend SAX	.298	.077	.563	3.891	.000	.677	1.477
	No trend Employment	.621	.255	.334	2.432	.020	.751	1.332
	No trend Construction	-.037	.019	-.350	-2.009	.051	.466	2.147
	No trend 10y Govt bond	-.088	.047	-.344	-1.879	.068	.422	2.368

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions						
				(Constant)	No trend Stibor	No Trend Activity	No trend SAX	No trend Employment	No trend Construction	No trend 10y Govt bond
1	1	2.466	1.000	.00	.04	.02	.00	.02	.05	.04
	2	1.620	1.234	.00	.00	.11	.18	.11	.00	.02
	3	1.000	1.570	1.00	.00	.00	.00	.00	.00	.00
	4	.837	1.716	.00	.01	.39	.01	.32	.09	.00
	5	.510	2.199	.00	.00	.35	.55	.43	.02	.03
	6	.360	2.616	.00	.01	.11	.21	.10	.49	.46
	7	.206	3.456	.00	.93	.02	.04	.02	.34	.44

Multicollinearity

R^2 and *t* rations:	R^2 = 0.447 and all elasticises are significant at a 10 percent level. No sign of multicollinearity.
Conditions indexes:	All condition indexes, except the first which is equal to 1 by definition, are well below 10 meaning that the level of multicollinearity in the model is low.
Tolerance values and VIF:	None of the tolerance values are below 0.1 (or VIF > 10). The parameter with the lowest value is STIBOR (0.315) and the second lowest value is 10y Government Bond (0.422) indicating that none of the parameters are involved in multicollinearity.

Conclusion: The multicollinearity is rather weak in this model.

Scatterplot of predicted values vs. residual, model (2)

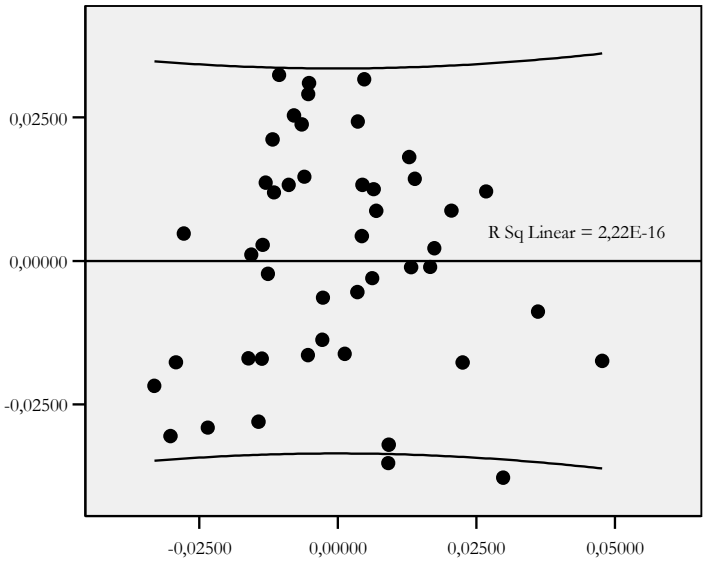


Fig. 13 Scatterplot of model (2), predicted values vs. residual

There is clearly no sign of heteroscedasticity since the residuals are equally scattered across the predicted values.

APPENDIX 2 – EXPLANATION OF THE DEPENDENT VARIABLE

Our dependant variable – *tenant-owned real estate* – consists, before de-trending, of the average price per square meter for real estate in the Swedish urban districts of; Kungsholmen, Vasastan, Östermalm and Söder in Stockholm, Centrum in Gothenburg and Centrum Väst in Malmoe. The dependant variable is collected as monthly observations from April 2003 to January 2007, a total of 46 observations.

Figures 14-16 shows where the districts we have chosen to analyze are located.

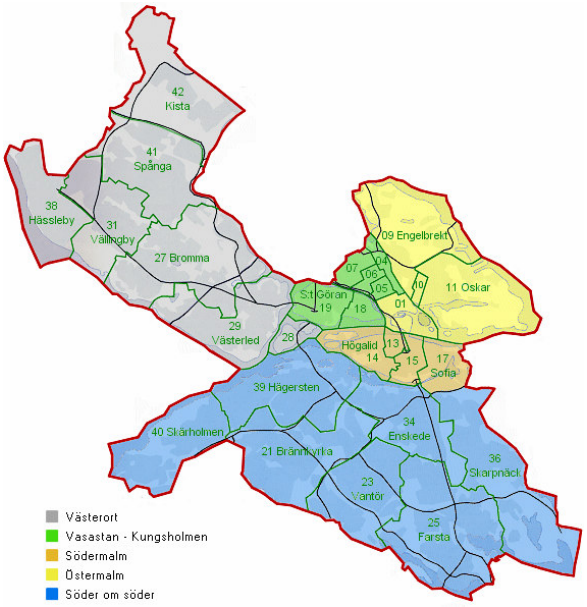


Fig. 14 Districts in Stockholm

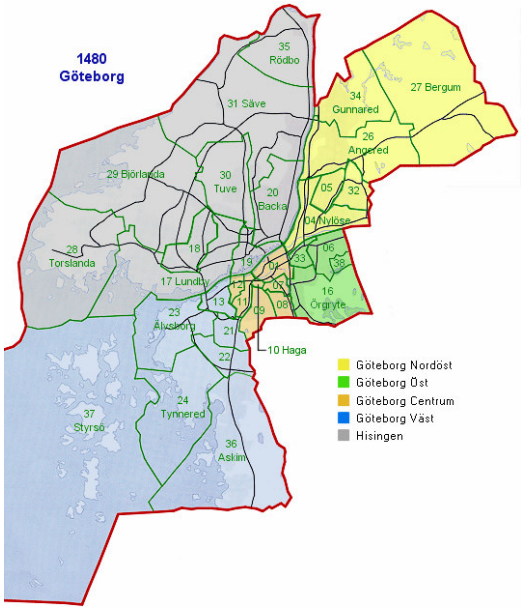


Fig. 15 Districts in Gothenburg

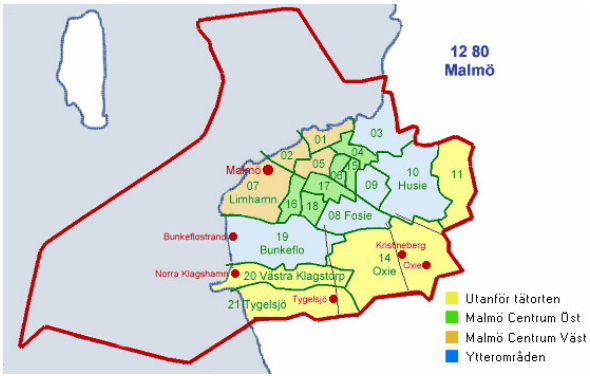


Fig. 16 Districts in Malmoe

APPENDIX 3 – POSSIBLE MODEL EXTENSIONS

As discussed in chapter 7, we are interested in investigating the relationship between prices of tenant-owned real estate and the interest rates in greater detail. To do this we have tested other models as an extension to our two primary models in order to capture the effects of different econometric specifications. In this section we briefly outline the models tested and the results of them.

I $$\ln \Pr ice_t = \beta_1 + \beta_2 STIBOR_t + \beta_3 \ln Activity_t + \beta_4 \ln SAX_t + \beta_5 \ln Employment_t + \beta_6 \ln Construction_t + \beta_7 \ln Population_t + \beta_8 GovtBond + \beta_9 \ln PulpIndex_t + \varepsilon_t$$

Difference to model (1): The interest rate variables are de-trended in levels, i.e. not in logarithmic scale.

Results: Similar to model (1) in terms of sign, significance and magnitude.

II $$\ln \Pr ice_t = \beta_1 + \beta_2 (GovtBond_t - STIBOR_t) + \beta_3 \ln Activity_t + \beta_4 \ln SAX_t + \beta_5 \ln Employment_t + \beta_6 \ln Construction_t + \beta_7 \ln Population_t + \beta_8 \ln PulpIndex_t + \varepsilon_t$$

Difference to model (1): Future interest rate expectations are captured by the difference between de-trended *10y Government Bond* and *3-month STIBOR*.

Results: Similar to model (1) in terms of sign, significance and magnitude. The new variable has small significant coefficient.

III $$\ln \Pr ice_t = \beta_1 + \beta_2 \ln(GovtBond_t - STIBOR_t) + \beta_3 \ln Activity_t + \beta_4 \ln SAX_t + \beta_5 \ln Employment_t + \beta_6 \ln Construction_t + \beta_7 \ln Population_t + \beta_8 \ln PulpIndex_t + \varepsilon_t$$

Difference to model (1): Future interest rate expectations are captured by the log of the difference between *10y Government Bond* and *3-month STIBOR*. The interest rate variables are not de-trended.

Results: The new variable is not significant. The other variables have similar signs and significance as in model (1).

IV $$\ln \Pr ice_t = \beta_1 + \beta_2 (GovtBond_t - STIBOR_t) + \beta_3 \ln Activity_t + \beta_4 \ln SAX_t + \beta_5 \ln Employment_t + \beta_6 \ln Construction_t + \beta_7 \ln Population_t + \beta_8 \ln PulpIndex_t + \varepsilon_t$$

Difference to model (1): Future interest rate expectations are captured by the difference between *10y Government Bond* and *3-month STIBOR*. The interest rate variables are not de-trended.

Results: The new variable is not significant. The other variables have similar signs and significance as in III.