Overvaluation in the housing market and its effect on the performance of listed real estate companies

A study focused on Sweden

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Abstract

In the years 2007-2015 prices for flats in Sweden increased with approximately 80%. Simultaneously, the Swedish real estate index, SX8600PI, increased with 77%, outperforming the OMXSPI by 33%. This paper examines whether a potential overvaluation in the housing market in Sweden can explain some of the abnormal return of Swedish listed real estate companies. Further, the study is extended to include the Danish market. We consider 11 Swedish listed real estate companies and 5 Danish during Q2 2007 – Q1 2015. We regress the abnormal returns over the difference in fundamental and actual house prices. In addition, we examine lagged effects by regressing the abnormal returns over the difference in fundamental and actual house prices the previous quarters. We find explanatory value in the Swedish market but not in the Danish. Based on the results from the Swedish market, investors could, if concluding that the housing market is currently overvalued, increase the probability to obtain abnormal returns the upcoming four quarters by investing in Swedish listed real estate companies.

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Keywords**:** fundamental housing value, real estate, Swedish housing market, housing bubble, Fama-French Three-Factor Model

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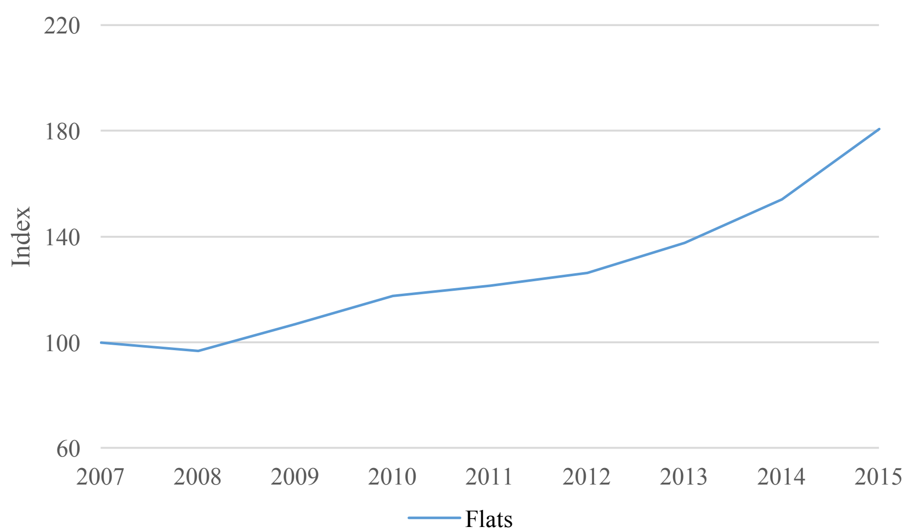
1. Introduction

During the past decades, the Swedish housing market has experienced a rapid growth. In the years 2007-2015 prices for flats in Sweden increased with approximately 80%, as seen in Figure 1. This dramatic increase led to immense speculation regarding a potential bubble in the Swedish housing market. Simultaneously, extraordinary low interest rates, resulting in low mortgage rates compared to historical standards, have led to increased debt levels of Swedish households. These debt levels have contributed to an overvalued housing market according to reports by Ölcer and van Santen (2016) and the European Systematic Risk Board (2016). In the years 2012-2015, the Swedish real estate index, SX8600PI, outperformed the Stockholm all-share index, OMXSPI, by almost 40%, as seen in Figure 2. This thesis aims to answer the following question:

Could a potential overvaluation in the housing market in Sweden explain some of the abnormal return of Swedish listed real estate companies?

We extend the study to include the Danish market, where house prices have not increased nearly as much as in Sweden. In Denmark, the estimated mispricing in the housing market is small during the considered time period. Because of limited data on estimated fundamental housing values, we were not able to test our model on other countries.

Figure 1: Real prices for flats in Sweden 2007 – 2015 (2007=100)



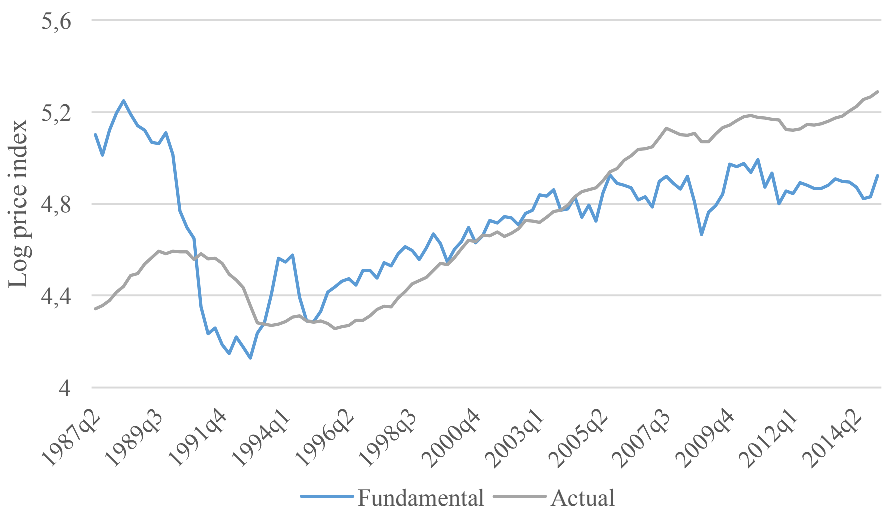
Source: Statistics Sweden (SCB)

Figure 2: Development of SX8600PI and the OMXSPI 2007 – 2015 (2007=1)

Source: NASDAQ OMX

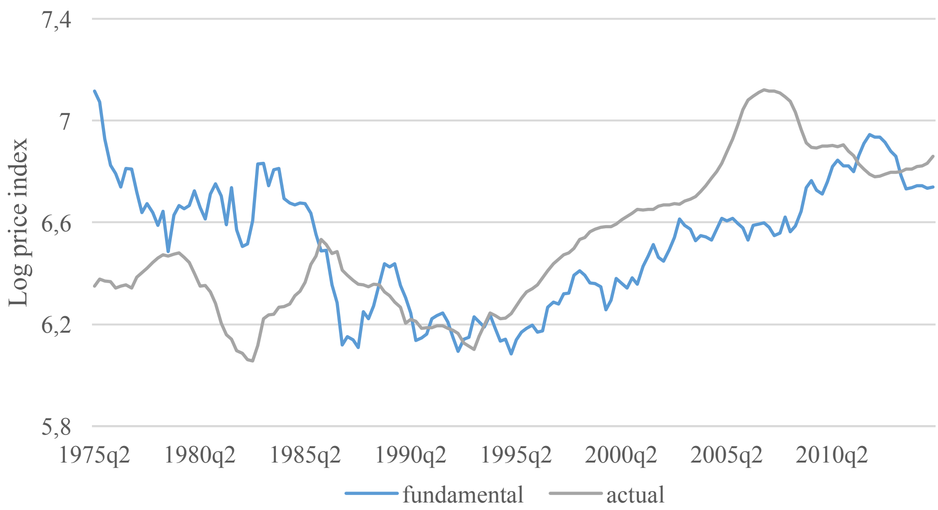
To determine whether the housing market is currently over- or undervalued, an estimated fundamental value must be attained. In our thesis, we have determined this value by using the results from a regression model presented in the paper by Bergman and Sørensen (2016). Their model estimates the fundamental value of the housing market in an economy. This value can be compared with actual house prices and thereby determine whether the market is over- or undervalued. Bergman and Sørensen's findings suggest that actual house prices in Sweden have been above the fundamental values since Q3 2004, as seen in Figure 3. In Denmark, on the other hand, their findings suggest that the housing market has been valued close to its fundamental values since 2007, shown in Figure 4.

Figure 3: Swedish fundamental and actual house prices 1987 – 2015



Source: Bergman and Sørensen (2016)

Figure 4: Danish fundamental and actual house prices 1975 – 2015



Source: Bergman and Sørensen (2016)

As far as we are concerned, this kind of research has not been conducted before. However, studies using fundamental housing value data have been applied in different contexts during recent years. Hiebert and Sydow (2011) use data on fundamental values to analyze unexpected housing returns. Hott and Jokipii (2012) use similar data to investigate whether consistently low interest rates can result in a residential real estate bubble. Our research, on the other hand, uses fundamental housing values in a completely different context. No research has been conducted to examine whether deviations from fundamental values in the housing market affect abnormal returns of real estate companies. Other research within the area examine how real estate prices and stock prices move together. A study conducted by Daniel C. Quan (1999) find significant relationships between stock prices and real estate prices, with joint data from several countries.

We exclude companies with more than 20 % of net revenue generated from foreign countries in 2014. We consider quarterly returns for 11 listed real estate companies on the Stockholm Stock Exchange with observations ranging from Q2 2007 to Q1 2015. For the Danish market, we consider 5 listed real estate companies in the same time period. Due to limited data availability, this study does not consider the observed companies' different degrees of exposure towards the commercial versus residential real estate markets. This would be an interesting aspect for further investigation.

In order to answer the main question, we conduct an Ordinary Least Squares regression, assuming company and time fixed effects. As the dependent variable, we use the adjusted abnormal returns of real estate companies. Mispricing in the housing market is the independent variable.

We find that mispricing in the housing market in Sweden has explanatory value for the adjusted abnormal returns of Swedish listed real estate companies. Testing for the Danish market, we find no explanatory value. This thesis provides proof that the more overvalued the housing market is in Sweden, the higher the abnormal returns of Swedish listed real estate companies will be. Furthermore, we show that there exist lagged effects, i.e. overvaluation in the Swedish housing market has explanatory value for each of the following four quarter's abnormal returns. In practice, this implies that investors are able to increase the probability to achieve abnormal returns the upcoming quarters if they invest in Swedish listed real estate companies when Bergman and Sørensen`s (2016) model indicates that the housing market in Sweden is overvalued.

It should be noted that, in order to ensure the validity of our results, a similar study that considers a larger number of companies and a longer time period should be conducted. Another issue is that we do not test how listed real estate companies are affected when the housing market is undervalued. As mentioned, the housing market in Sweden has been overvalued during the entire time span considered in this thesis. The Danish housing market has, on the other hand, been valued closely in line with its fundamental value. Hence, we cannot draw any conclusions whether our study is applicable when the housing market is undervalued.

The paper is structured as follows. We begin by providing background on the topic, followed by relevant research, including relevant economic theories and previous empirical work within the area. We then demonstrate the nature of the datasets and the methodology used in this research. Subsequently, we show our results, our conclusion, and finally used references and appendix.

2. Background

In recent years, the discussion regarding a possible housing bubble in Sweden has received a lot of attention. In this section, we start by discussing a possible bubble in the Swedish and the Danish housing market. Subsequently, we mention some important characteristics of the real estate industry.

2.1 Potential bubble in the Swedish housing market

The European Systematic Risk Board (ESRB) presented a report in November 2016 about vulnerabilities in the residential real estate sector. Regarding the Swedish market, they point out that the combination of the rapid increase of residential real estate prices and the increasing household indebtedness should be taken as a serious warning signal. In the report, the ESRB focus on key ratios such as loan-to-value and debt-to-disposable income. Regarding the latter, Swedish household's debt-to-disposable income ratio has increased with nearly 10 % during 2012-2015. The ESRB also point out that house prices in Sweden has increased more than disposable income in recent years. Furthermore, they state that the Swedish residential real estate market appears to be overvalued by as much as 24 %. The report does not mention any concerns about a housing bubble in Denmark, although prices are nearly at an all-time high.

The Swedish housing market is, and has for a long time been, determined by excess demand. This, in combination with the strong purchasing power of Swedish households are, according to Turk (2015), some of the factors that explain the tremendous price rush in the housing market in recent years. In Denmark, on the other hand, after a long period of dramatic price increases, there was a sharp decrease in 2007-2009. Since 2010 however, prices have started to recover and by 2015, they had almost reached its former peak, see figure 5 presented in *Appendix B – Graphs and tables*.

As Figure 3 indicates, the Swedish housing market has been overvalued compared to its fundamental value since Q3 2004. If the fundamental values used in the study are estimated correctly, this would be a strong indicator that there has been a housing bubble in Sweden since the end of 2004. Data for the Danish market, presented in Figure 4, show that the Danish housing market was overvalued between 1994 and 2011. In 2011, the values started to diverge, and during 2011 – 2015, the actual prices have been valued approximately in line with the fundamental value.

2.2 The real estate industry

The real estate sector can be divided into two sub-categories, commercial and residential. Residential real estate contains the industries where the end customers are private individuals and use the properties for living purposes. In commercial real estate, the customers are corporations and associations which use the real estate for commerce, i.e. industrial, offices, retail etc., DiPasquale and Wheaton (1992). The real estate companies used in our study have different degrees of exposure towards the different sub industries. Some companies are more exposed towards residential real estate whilst others are more dependent on commercial real estate. We are, as previously mentioned, only focusing on deviations from fundamental values within the residential real estate industry. Clearly, this affects our results.

To eliminate this problem, we could have chosen to exclude companies with large revenue streams from commercial real estate. However, doing this would have meant a large reduction of our sample size. For that reason, we chose to keep the firms within the population. With that said, according to Geltner et al. (2010) many of the factors that drives profitability in the commercial real estate market are similar to the ones affecting the residential. Economic factors such as interest rates affect both industries in similar ways. Thus, the effect an overvalued housing market has on residential real estate might be very similar to the effect it has on the commercial.

3. Previous literature

This section consists of two parts. In the first part, we explain the Fama-French Three Factor-Model and the Vector Auto Regression Model used in our study. In the second part, we present research on real estate bubbles and empirical studies conducted using fundamental housing values.

3.1 Relevant economic theories

Fama-French Three-Factor Model

The Fama-French Three-Factor Model, introduced by Fama and French (1992) is an asset pricing model that explains financial returns by three different risk factors. It is an extension of the traditional Capital Asset Pricing Model (CAPM) which explains a company's financial return with the risk and return of the market. The Fama-French model extends the CAPM by adding the factors Small Minus Big (SMB) and High Minus Low (HML). According to Fama and French (1992), these factors explain more than 90% of financial returns of companies in a diversified portfolio, tested on the NYSE. The Fama-French Three-Factor Model is country-specific. It is constructed by going long and short in six value weight portfolios. The formula is presented below:

$$R_{t_i} = \alpha + \beta_{MRKT_i} * R_{MRKT_{t_i}} + \beta_{SMB_i} * R_{SMB_{t_i}} + \beta_{HML_i} * R_{HML_{t_i}} \tag{1}$$

The market factor explains financial returns with the risk of the equity market which contains all listed companies in the market. The SMB factor captures the risk of small sized companies (small market capitalization). The HML factor captures the risk of growth companies (low book value of equity to market capitalization). The Fama-French Three-Factor Model incorporates the SMB factor by going long in three small size company portfolios and going short in three large size company portfolios. The average return of these portfolios is the SMB factor. The formula is presented below:

SMB = 1/3 (Small Value + Small Neutral + Small Growth) - 1/3 (Big Value + Big Neutral + Big Growth) (2)

The model incorporates the HML factor by going long and short in the following portfolios:

$$HML = 1/2\ (Small\ Value + Big\ Value) - 1/2\ (Small\ Growth + Big\ Growth) \tag{3}$$

The Value portfolios are portfolios consisting of companies with high book-to-market and Growth portfolios are portfolios consisting of companies with small book-to-market. The average return of these portfolios is the HML factor.

The Vector Auto Regression Model

The Vector Auto Regression Model (the VAR-model), described by Hill et al. (2011), is a forecasting model. The model is built on the Autoregressive Model (the AR-model). The AR-model is used to study time varying processes where one variable's value is dependent of its own- and the error term's (the stochastic term's) previous values. Both the AR- and VAR-model forecast future values as linear interdependencies between several time series.

The VAR-model extends the AR-model by allowing more than one variable to change. The VAR-model typically treats all variables as endogenous but it can be altered to allow for some variables to be exogenous.

The only data required to build a VAR-forecasting model is the variables between which the model-builder believes there exist interdependencies. Subsequently, the model-builder attempts to find each variable's dynamic structure, by creating an equation for how each variable evolve over time, depending linearly on its own and other variables in the model's, including the error term's, lagged values. The VAR-model is built using vectors of lagged values.

There are two different types of VAR-models; Structural VAR-model and Reduced-form VAR-model. The structural VAR-model is the model concerned in this thesis. Structural VAR-modelling is commonly used to test structural hypothesis by altering the model until the null-hypothesis is rejected. The error term in a Structural VAR-model is treated and denoted as structural shocks to the model.

3.2 Relevant empirical research

Real estate bubbles

Garber (2000) describes housing bubbles as movements in the housing market which cannot be explained by fundamentals. Previous research have tried to determine whether there has been a housing bubble in different markets during different times. Mikhed and Zemčík (2009) try to conduct this analysis by using fundamental factors such as mortgage rates, building costs, population etc. to analyze if changes in US house prices can be justified by these factors. In their paper, they discover that the real estate prices have taken long swings from their fundamental values for long periods of time, creating both over- and undervalued markets.

Previous research suggest several reasons for why these housing bubbles emerge. One interesting explanation could be that of herding behavior brought up by Avery and Zemsky (1998). They propose that when an economy faces several uncertainties, these combined uncertainties can overwhelm the price mechanisms and by so, making phenomena's such as price bubbles possible. Another potential explanation could be something referred to as positive feedback discussed in the paper by Zhou and Sornette (2006). They explain positive feedback as when the market has recently been going up (or down), it tends to continue that trend. They argue that this positive feedback could be one of the contributing factors for speculative bubbles in the housing market.

Fundamental housing values

Studies using fundamental housing value data have been applied in different context in recent years. When estimating fundamental housing values, factors such as disposable income, mortgage rates, building costs, population etc. are commonly used. These factors are used to estimate the discounted value of expected future rent and thus deriving a fundamental value. In recent studies, a model much similar to the dividend-discount model based on asset prices introduced by Campbell and Shiller (1988a,1988c) has been used.

Several studies using these fundamental housing values have been published in recent years. Hiebert and Sydow (2011) use fundamental housing values to analyze unexpected housing returns in the euro area. Hott and Jokipii (2012) use them to investigate whether low interest rates during long times can cause housing bubbles. Their results provide strong evidence that there is a robust connection between housing bubbles and low interest rates.

Bergman and Sørensen (2016) use comparable factors in order to set up an empirical model much similar to the dividend-discount model. This is done to estimate the fundamental value of a housing market. They are, instead of dividends, discounting future imputed rents. To estimate the future imputed rents they use the VAR-model. In brief, the VAR-model defines variable values as a linear model of their past values. The VAR-model is further described under *Relevant economic theories*. The variables Bergman and Sørensen are using in the VAR-model are the following:

i. Price of a unit of owner-occupied housing

ii. Rent on both owner-occupied and rental housing

iii. Aggregate real disposable income

iv. Aggregate real housing stock

v. Depreciation rates

vi. Nominal mortgage interest rates

vii. Expected rate of consumer price inflation

viii. Tax rate on both capital income and property

ix. User cost premium for risk and credit constraints (constant)

Bergman and Sørensen test their model on the Swedish and Danish market, providing empirically significant results. Furthermore, they compare their estimated fundamental values to actual house prices in Denmark and Sweden in order to find potential over- or undervaluation. This data, measuring the over- or undervaluation on the housing market, is the data applied in this thesis.

4. Data

In this section, we state the notations and the datasets used in this thesis.

4.1 Notations

The following notations are used:

$Mispricing_{t_s}$ = Mispricing in the Swedish housing market at time t

R_{t_s} = Stock return for a Swedish company in Sweden period t

AR_{t_s} = Abnormal return for a Swedish company period t

$R_{SMB_{t_s}}$ = Fama French's Small minus Big portfolio return in Sweden period t

$R_{HML_{t_s}}$ = Fama French's High minus Low portfolio return in Sweden period t

$R_{MRKT_{t_s}}$ = Fama French's market (OMXSPI) portfolio return in Sweden period t

$R_{f_{t_s}}$ = Quarterly risk free rate (10 Year Swedish Treasury Bond return) at time t

$Mispricing_{t_d}$ = Mispricing in the Danish housing market at time t

R_{t_d} = Stock return for a Danish company period t

AR_{t_d} = Abnormal return for a Danish company period t

$R_{SMB_{t_d}}$ = Fama French's Small minus Big portfolio return in Denmark period t

$R_{HML_{t_d}}$ = Fama French's High minus Low portfolio return in Denmark period t

$R_{MRKT_{t_d}}$ = Fama French's market (OMXCGI) portfolio return in Denmark period t

$R_{f_{t_d}}$ = Quarterly risk free rate (10 Year Danish Treasury Bond return) at time t

$AR_{MRKT_{t_s}}$ = Abnormal return of the market portfolio in Sweden at time t

$AR_{MRKT_{t_s}}$ = Abnormal return of the market portfolio in Sweden at time t

ε_k = Error term

s = Swedish company

d = Danish company

4.2 Datasets

The primary dataset in this study has been provided by Michael Bergman from his and Sørensen's (2016) paper on estimated historic fundamental and market prices for the housing market in Sweden.[1] This data contains quarterly observations and consequently we consider quarterly data for all variables. Other primary data is quarterly adjusted stock prices (adjusted for stock splits, new emissions, etc) for 11 Swedish listed real estate companies. In our secondary dataset, we consider equivalent data for the Danish market, for 5 Danish listed real estate companies.

Firms with more than 20% of net revenue from foreign countries in 2014 have been excluded because an overvalued domestic housing market would have a much smaller effect on these companies. Unfortunately, eliminating these companies decreased our sample size.

If the company in question has two share classes, the most liquid is considered.[2] In both our primary and secondary dataset, all firms have been listed on a Swedish or Danish stock exchange during the full time period considered, which is Q2 2007 until Q1 2015.

This data is complemented with data for returns of the three factor portfolios included in the Fama-French Three-Factor Model, for Sweden and Denmark respectively, in order to calculate abnormal returns. The factor portfolio returns are High Minus Low, Small Minus Big and the Market factor and were imported from the AQR library, where returns are computed using hypothetical portfolios. For more details regarding the Fama-French Three-Factor Model, see *Relevant economic theories*. Furthermore, data on 10 Year Swedish Government bonds (SE GVB 10Y), and 10 Year Danish Government bonds (DK GVB 10Y), collected from the Swedish Riksbank, and Thomson Reuters' Datastream, are included in the full dataset.

[1] Bergman and Sørensen have received the data of market prices from Statistics Sweden (SCB) and Statistics Denmark.

[2] This data is collected from Thomson Reuters' Datastream

The companies considered in Sweden are:

Atrium Ljungberg AB, Castellum AB, Catena AB, Diös Fastigheter AB, Fabege AB, Fast Partner AB, Heba Fastighets AB, Hufvudstaden AB, Kungsleden AB, Wallenstam Byggnads AB and Wihlborgs Fastigheter AB.

The companies considered in Denmark are:

Admiral Capital AS, Blue Vision AS, Jeudan AS, Nordicom AS and TK Development AS.

It should be noted that we consider the Swedish and the Danish datasets separately.

5. Methodology

In the following paragraphs we start by explaining our methodology, presenting our dependent and independent variables. Then, we discuss sample issues and robustness tests. Lastly, we explain how we have conducted our OLS regressions.

5.1 Variables

5.1.1 Dependent variable

The dependent variable in our main regression is the quarterly adjusted abnormal return of the real estate companies in the respective dataset. The adjusted abnormal return is the adjusted stock increase, further adjusted for the return explained by the Fama-French Three-Factor Model and the risk free rate. For in detail methodology, see *Appendix A – Computing abnormal returns.*

The Swedish market:

$$R_{t_s} = \frac{(P_{t_s} - P_{t-1_s})}{P_{t-1_s}} \tag{4}$$

$$AR_{t_s} = R_{t_s} - (\beta_{SMB_s} * R_{SMB_{t_s}} + \beta_{HML_s} * R_{HML_{t_s}} + \beta_{MRKT_s} * R_{MRKT_{t_s}}) - r_{f_{t_s}} \tag{5}$$

The Danish market:

$$R_{t_d} = \frac{(P_{t_d} - P_{t-1_d})}{P_{t-1_d}} \tag{6}$$

$$AR_{t_d} = R_{t_d} - (\beta_{SMB_d} * R_{SMB_{t_d}} + \beta_{HML_d} * R_{HML_{t_d}} + \beta_{MRKT_d} * R_{MRKT_{t_d}}) - r_{f_{t_d}} \tag{7}$$

The beta for each company and each of the three factors used in the Fama-French Three-Factor Model is computed using linear regression for the period Q2 2007 - Q1 2015 in both Sweden and Denmark.

5.1.2 Independent variable

The independent variable used in our regressions is mispricing in the housing market (*Mispricing)* which is the difference of the natural logarithm of the indexed actual and fundamental prices of the housing market, assuming a price elasticity of one. The fundamental values of the Swedish and Danish housing markets used in this study is a result of the regression model by Bergman and Sørensen (2016), further described under *Relevant empirical research*. The reason we use this data is twofold. Firstly, the Swedish Institute of Economic Research (Konjunktursinstitutet) recommended us to use it. Secondly, the Swedish Institute of Economic Research use a similar model to determine the fundamental value of the housing market. Unfortunately, we were not able to acquire the Swedish Institute of Economic's data because they did not want their results to be published.

$$\begin{aligned} Mispricing_{t_s} &= Log(Indexed\ Swedish\ actual\ house\ price) \\ &\quad - Log(Indexed\ Swedish\ fundamental\ house\ price) \end{aligned} \tag{8}$$

$$\begin{aligned} Mispricing_{t_d} &= Log(Indexed\ Danish\ actual\ house\ price) \\ &\quad - Log(Indexed\ Danish\ fundamental\ house\ price) \end{aligned} \tag{9}$$

As seen by equations 8 and 9, *Mispricing* is the logarithmic indexed market value minus the logarithmic indexed fundamental value. Consequently, should the *Mispricing* variable be positive, the housing market in question was overvalued at that time. Furthermore, it should be noted that the variable *Mispricing* is a proxy and should not be considered as a definitive value of mispricing in the Swedish and the Danish housing market.

5.2 Selection bias and other sample issues

One of this study's main robustness problems is the time span considered. As seen in Figure 6 presented in *Appendix B – Graphs and tables*, the Swedish housing market has been overvalued during the entire timespan considered. Hence, we do not know if this study would provide similar results in Sweden when the housing market is undervalued. The reason we do not consider a longer time period is because it would have meant a severe reduction of our sample size. In contrast to the Swedish market, the Danish housing market has not been consistently overvalued. Instead, as seen in Figure 7 presented in *Appendix B – Graphs and tables*, the Danish housing market has been valued approximately in line with its fundamental value. The sample size in Denmark is small, which could be one reason why we might not obtain significant results.

Another potential problem with our robustness is that the real estate companies included in our study have different amount of exposure towards the different sub-categories within the real estate industry. The companies highly exposed towards residential real estate might be affected by mispricing in the housing market in a higher degree than the companies highly exposed towards commercial real estate. One way to reduce this potential bias would be to solely include companies with high exposure towards residential real estate. However, we decided to consider all real estate companies because otherwise the sample size would have been reduced too much. On the other hand, the commercial real estate market might be overvalued as well. The current extraordinary low interest rates is, according to Bergman and Sørensen (2016), one contributing factor to overvaluation. Furthermore, according to DiPasquale and Wheaton (1992) the interest rates affect both the residential and the commercial real estate markets in similar ways.

A possible sample selection bias is that we only consider listed real estate companies. No unlisted companies are included in the study. Consequently, the adjusted abnormal returns we use in our regressions are affected by investors' expectations. When there is a boom in the housing market, investors could potentially believe that real estate companies should generate excess returns. Assuming this is the case, investors would rush to invest in real estate companies even though they have not seen any proof of higher future cash flows or decreased risk.

Another potential sample selection bias is that we do not consider companies that have been admitted to listing, or have been delisted during the considered time period. Companies that have been delisted could have been delisted because of a buyout. Buyout firms normally target companies with improvement potential. This implies that companies with great growth potential could have been excluded from our sample. Moreover, not including firms that were admitted for listing during the time period also imply this, since newly listed firms are less mature.[3]

[3] An IPO imply requirements for additional capital, which could mean greater investment- and thus growth-possibilities

5.3 Regressions

5.3.1 Assumptions

To test our hypothesis we run an Ordinary Least Squares regression, assuming both company fixed effects and time fixed effects. This implies that observations are treated as if they were non-random. It is reasonable that the abnormal return of company *x* in period *t* is correlated with company *x*'s abnormal return in period *t-1, t-2* etc. In other words, we believe that some companies perform better than others. Thus, we use company fixed effects. Regarding time fixed effects, it is reasonable that the state of the economy affects companies' abnormal returns. For instance when there is a boom in the economy, companies should perform better than in a recession. Hence, the abnormal return of company *x* in period *t* should correlate with the abnormal return of company *y* in period *t*. We initially ran the regression without fixed effects, and obtained significantly higher p-values than when fixed effects are included.

5.3.2 Regressions for the Swedish market

First, we test for the Swedish market and run the following primary regression:

$$AR_{t_s} = \beta_0 + \beta_{Mispricing_s} * Mispricing_{t_s} + \varepsilon_k \tag{10}$$

We also run the following regressions in order to find potential lagged effects:

$$AR_{t_s} = \beta_0 + \beta_{Mispricing_s} * Mispricing_{t-1_s} + \varepsilon_k \tag{11}$$

$$AR_{t_s} = \beta_0 + \beta_{Mispricing_s} * Mispricing_{t-2_s} + \varepsilon_k \tag{12}$$

$$AR_{t_s} = \beta_0 + \beta_{Mispricing_s} * Mispricing_{t-3_s} + \varepsilon_k \tag{13}$$

$$AR_{t_s} = \beta_0 + \beta_{Mispricing_s} * Mispricing_{t-4_s} + \varepsilon_k \tag{14}$$

5.3.3 Regressions for the Danish market

In addition, we run equations 15-19 for the Danish market in order to test our model when the housing market is valued close to its fundamental value.

$$AR_{t_d} = \beta_0 + \beta_{Mispricing_d} * Mispricing_{t_d} + \varepsilon_k \tag{15}$$

$$AR_{t_d} = \beta_0 + \beta_{Mispricing_d} * Mispricing_{t-1_d} + \varepsilon_k \tag{16}$$

$$AR_{t_d} = \beta_0 + \beta_{Mispricing_d} * Mispricing_{t-2_d} + \varepsilon_k \tag{17}$$

$$AR_{t_d} = \beta_0 + \beta_{Mispricing_d} * Mispricing_{t-3_d} + \varepsilon_k \tag{18}$$

$$AR_{t_d} = \beta_0 + \beta_{Mispricing_d} * Mispricing_{t-4_d} + \varepsilon_k \tag{19}$$

In order to validate that our model-assumptions hold we run a number of tests, mostly for the residuals. We test for outliers, normal distribution of residuals and heteroscedasticity. No outliers are identified in the Swedish dataset. One outlier is identified in the Danish dataset, which is removed. Furthermore, we find that residuals in both datasets are normally distributed. We find no indications of heteroscedasticity in the Swedish dataset. Both the Breusch-Pagan test and the White's test indicate homoscedasticity. In the Danish dataset however, the tests for heteroscedasticity are somewhat ambiguous. The White's test indicates heteroscedasticity while the Breusch-Pagan test indicates homoscedasticity. Due to the ambiguity we use robust standard errors in the Danish regressions to adjust for potential heteroscedasticity. For details, see *Appendix C - Test of model assumptions.*

5.3.3 Robustness test

In order to validate the result from our primary regression, and provide evidence that our results are specific for real estate companies, we run an additional regression. In this regression, we examine whether *Mispricing* in Sweden has explanatory value for the abnormal return of the Swedish all-share index (OMXSPI). The abnormal return of the OMXSPI is computed in the same manner as the adjusted abnormal return for the original dataset. However, since the market factor is the OMXSPI, only the Small Minus Big and the High Minus Low is adjusted for.

The regression is presented below:

$$AR_{t_{MRKT_s}} = \beta_0 + \beta_{Mispricing_{MRKT_s}} * Mispricing_{t_s} + \varepsilon_k \tag{20}$$

where

$$AR_{t_{MRKT_s}} = R_{t_{MRKT_s}} - (\beta_{SMB_{MRKT_s}} * R_{t_{SMB_s}} + \beta_{HML_{MRKT_s}} * R_{t_{HML_s}}) - r_{f_{t_s}} \tag{21}$$

The abnormal return of OMXSPI is, as in the main regression, regressed on the independent variable *Mispricing*. Should we find that *Mispricing* has no explanatory value for the abnormal return of OMXSPI, and we have explanatory value in our original regression, then we provide evidence that the results for our main regression in Sweden are industry specific.

6. Results

The following paragraphs will start by presenting summary statistics. Subsequently, we present the main results from our main OLS regressions in Sweden and Denmark. Further, we show the results for lagged effects in the Swedish market. Finally, we present our main robustness check.

6.1 Summary statistics

Summary descriptive statistics for both the Swedish and the Danish dataset are presented below. Comparing Table 1 and Table 2 there are some apparent differences between the two datasets. Firstly, the Swedish dataset is much larger than the Danish, 341 observations in comparison to 154. This is a potential problem since the sample size in Denmark might be too small. For instance, we see that the standard deviation of the *AR* is much smaller in Sweden than in Denmark. Secondly, studying the differences between Table 1 and Table 2, we see that the abnormal return of Swedish listed real estate companies are on average positive, while the abnormal return of Danish listed real estate companies are on average negative, 0.0238 in comparison to -0.0509. Lastly, we see that the average *Mispricing* is much larger in Sweden than in Denmark, 0.2308 in comparison to 0.1191. Potentially, this has great implications for the results obtained from the regressions for the two markets. Another interesting observation from Table 1 is that the minimum of *Mispricing* is positive. In other words the Swedish housing market is estimated to have been consistently overvalued during the considered time period. This is not the case in Denmark where the minimum of *Mispricing* is negative, meaning that the housing market has been undervalued.

Table 1: Summary statistics Sweden

Variable	Obs.	Mean	Std. Dev.	Min	Max
AR	341	0.0238	0.1399	-0.5226	0.4694
Mispricing	341	0.2803	0.0686	0.1704	0.4349

Note: The dataset consists of observations from 11 Swedish listed real estate companies for the time period Q2 2007 - Q1 2015. The abnormal return (*AR*) is the adjusted quarterly stock return, further adjusted for the Fama-French Thee-Factor Model. This data is obtained from Reuter's Datastream and the AQR Library. *Mispricing* is the logarithmic difference between indexed actual and fundamental housing values. The data on indexed actual prices is in turn received from Statistics Sweden and data on the indexed fundamental values are results of the VAR-model presented in the paper by Bergman and Sørensen (2016).

Table 2: Summary statistics Denmark

Variable	Obs.	Mean	Std. Dev.	Min	Max
AR	154	-.0509	.2267	-0.8227	0.8285
Mispricing	154	.1191	0.2049	-0.1552	0.5682

Note: The dataset consists of observations from 5 Danish listed real estate companies for the time period Q2 2007 - Q1 2015. The abnormal return (*AR*) is the adjusted quarterly stock return, further adjusted for the Fama-French Thee-Factor Model. This data is obtained from Reuter's Datastream and the AQR Library. *Mispricing* is the logarithmic difference between indexed actual and fundamental housing values. The data on indexed actual prices is in turn received from Statistics Sweden and data on the indexed fundamental values are results of the VAR-model presented in the paper by Bergman and Sørensen (2016).

6.2 Regression results

6.2.1 Results for the Swedish housing market and its implications

Analyzing the results of our main regression for the Swedish market, presented in Table 3, it is evident that mispricing in the housing market in Sweden has explanatory value for the abnormal return of listed real estate companies in Sweden. We find that the variable *Mispricing* has explanatory value for *AR*, with significance at the 1 % level. The positive beta of (+)1.923, shows that the more overvalued the housing market is in Sweden, the higher the adjusted abnormal return of Swedish listed real estate companies will be. As a result of these findings, we can conclude that overvaluation in the Swedish housing market explains some of the abnormal returns of Swedish listed real estate companies. It should be noted that we have studied a time interval when the Swedish housing market has been consistently overvalued. Thus, we cannot ensure that we would see the same relationship when the housing market is undervalued. It should be noted that although we only consider a time when the housing market is overvalued, we consider observations in times when the economy in general was in a recession (financial crisis 2007-2009). Consequently, we include observations from when the firms in our sample, on average, did experience negative returns.

Table 3: Main regression results in Sweden

Variable	AR
Mispricing	1.923***
	(0.284)
Constant	-0.478***
	(0.0869)
Observations	341
R^2	0.495

Note: The table shows the results of our main regression in Sweden. Mispricing in the Swedish housing market (*Mispricing*) explains abnormal returns (*AR)* of Swedish listed real estate companies, with significance at the 1 % level. Abnormal return is the adjusted quarterly stock return, further adjusted for the Fama-French Thee-Factor Model. Mispricing is the logarithmic difference between indexed actual and fundamental housing value. The regression includes company fixed effects and time fixed effects. Standard errors are reported within the parentheses. ***, ** and * represent statistical significance at the 1 %, 5% and 10 % levels, respectively.

6.2.2 Results for the Danish housing market and its implications

An interesting extension to our previous analysis of the uninterruptedly overvalued Swedish market is the result from our secondary regression on the Danish market. As the high p-value indicates, presented in Table 4, we see that mispricing in the Danish housing market has no explanatory value for the abnormal returns of Danish listed real estate companies. Worth noting is that the Danish housing market has seen a different development than the Swedish. Firstly, in 2007-2008, the Danish housing market saw a sharp decline in prices. In Sweden, on the other hand, there has barely been a price decrease at all during the examined period, seen in Figure 3. Secondly, the Danish housing market has been valued approximately in line with its fundamental value for most of the time period considered, seen in Figure 7 presented in *Appendix B – Graphs and tables*. In Sweden, on the contrary, we see a rather large spread, seen in Figure 6. These differences provide room for speculation on whether they are the cause of the dissimilar results generated when testing for the Swedish and the Danish market.

The insignificant results from the regression on the Danish market raise the question whether the model is applicable on markets that do not look like Sweden did during the considered time period, e.g. markets that are not experiencing a potential housing bubble. Mispricing in the housing market should explain some of listed real estate companies' abnormal returns. However, when the housing market is barely mispriced, as in Denmark during the considered time period, it seems reasonable that mispricing in the housing market should not explain abnormal returns. As previously mentioned, we do not study an undervalued housing market, since the Swedish market was overvalued and the Danish close to its fundamental value. Consequently, we cannot ensure whether we would receive explanatory value when actual house prices are lower than their fundamental value. Extending our study to include an undervalued housing market would provide further depth to the analysis.

However, the fact that we do not see explanatory value in Denmark could be due to the fact that we only consider 5 companies and 154 observations compared to Sweden where we look at 11 companies and 341 observations. Another possible explanation is that *Mispricing* only has explanatory value for abnormal returns of real estate companies in Sweden but not in Denmark, regardless whether the housing market is overvalued or not. Nevertheless, more likely, the reason is that the housing market in Denmark was barely mispriced during the considered time period.

Table 4: Main regression results in Denmark

Variable	AR
Mispricing	0.363
	(0.226)
Constant	-0.0585
	(0.0834)
Observations	154
R^2	0.329

Note: This table shows the results of our regression in Denmark. Mispricing in the housing market (*Mispricing*) in Denmark has no explanatory value for abnormal returns (*AR)* of Danish listed real estate companies. Abnormal return is the adjusted quarterly stock return, further adjusted for the Fama-French Thee-Factor Model. *Mispricing* is the logarithmic difference between indexed actual and fundamental housing value. The regression includes company fixed effects and time fixed effects. Robust standard errors are used to adjust for potential heteroscedasticity. Robust standard errors are reported within the parentheses. ***, ** and * represent statistical significance at the 1 %, 5% and 10 % levels, respectively.

6.2.3 Lagged effects

After receiving explanatory value for the main regression in Swedish market, we are interested in whether *Mispricing* can explain abnormal return for the real estate companies in the future, e.g. if *Mispricing* has some lagged effects. To test this, we run regressions 11-13 in Sweden, and regressions 15-17 in Denmark. Studying tables 5-8, it is evident that *Mispricing* in Sweden has explanatory value for abnormal returns of Swedish listed real estate companies the following four quarters, with significance at the 1 % level. As a result of these findings, we can conclude that overvaluation in the housing market in Sweden explains some of the abnormal returns in the present quarter as well as abnormal returns the upcoming four quarters.

The fact that we see explanatory value for the next quarters provide one additional aspect to our results. Since one can obtain the current *Mispricing* in the Swedish housing market, using actual prices and Bergman and Sørensen's model to estimate fundamental values, one can explain some of the abnormal return of Swedish listed real estate companies the upcoming four quarters. Using this information, one could invest in Swedish listed real estate companies when the Swedish housing market is overvalued according to Bergman and Sørensen's model and consequently increase the probability to obtain abnormal returns. However, the limited data availability on current house prices and the complexity of Bergman and Sørensen's model make this analysis difficult for retail investors.

Table 5: Lagged effects in Sweden one quarter ahead

Variable	AR
$Mispricing_{t-1}$	1.249***
	(0.185)
Constant	-0.315***
	(0.0646)
Observations	341
R^2	0.495

Table 6: Lagged effects in Sweden two quarters ahead

Variable	AR
$Mispricing_{t-2}$	1.781***
	(0.263)
Constant	-0.542***
	(0.0958)
Observations	341
R^2	0.495

Table 7: Lagged effects in Sweden three quarters ahead

Variable	AR
$Mispricing_{t-3}$	2.131***
	(0.315)
Constant	-0.520***
	(0.0928)
Observations	341
R^2	0.495

Table 8: Lagged effects in Sweden four quarters ahead

Variable	AR
$Mispricing_{t-4}$	3.336***
	(0.493)
Constant	-0.810***
	(0.134)
Observations	341
R^2	0.495

Note: The tables show the results from our lagged effect regressions in Sweden. As the p-values indicate, mispricing in the Swedish housing market (*Mispricing*) explains abnormal returns (*AR)* of Swedish listed real estate companies for all of the four upcoming quarters. The results are significant at the 1 % level. Abnormal return is the adjusted quarterly stock return, further adjusted for the Fama-French Thee-Factor Model. The variables $Mispricing_{t-1}$, $Mispricing_{t-2}$, $Mispricing_{t-3}$ and $Mispricing_{t-4}$ are the logarithmic difference between indexed actual and fundamental housing value the previous four quarters. The regressions includes company fixed effects and time fixed effects. Standard errors are reported within the parentheses. ***, ** and * represent statistical significance at the 1 %, 5% and 10 % levels, respectively.

6.3 Robustness test

After concluding that we reject the null-hypothesis, we want to determine whether our results are specific for the real estate sector or if they hold for the stock market in general. In other words, we want to examine whether overvaluation in the housing market has explanatory value for the stock market in general. To test this, we run the regression presented in equation 20. As seen in Table 9, *Mispricing* has no explanatory value for the abnormal return of the market (OMXSPI) since the p-value is greater than 0.1. From these findings, we can conclude that the results seem to be specific for the real estate sector in relation to the market in general. Nevertheless, we cannot reject the possibility that this relationship holds for other specific sectors as well, e.g. the construction industry.

Table 9: Regression results of OMXSPI

Variable	AR_Market
Mispricing	-0.138
	(0.218)
Constant	0.0597
	(0.0661)
Observations	31
R^2	0.006

Note: This table shows the results of our main robustness test. By running this regression we test whether the results from our main regression in Sweden are specific for the real estate sector. This table shows that mispricing in the Swedish housing market (*Mispricing*) has no explanatory value for the abnormal return of OMXSPI. This indicates that the results obtained in our main regression on the Swedish market are specific for the real estate industry. Standard errors are reported within the parentheses. ***, ** and * represent statistical significance at the 1 %, 5% and 10 % levels, respectively.

7. Conclusion

This paper aims to examine whether a potential overvaluation in the housing market in Sweden can explain some of the abnormal return of Swedish listed real estate companies. Further, we extend our study and test also for the Danish market. As seen under *Results*, we find that mispricing in the Swedish housing market has explanatory value for abnormal returns of Swedish listed real estate companies. Consequently, we reject the null-hypothesis. In the Danish market, on the other hand, we find no explanatory value. It should be noted that house prices in Denmark have not deviated from their fundamental values nearly as much as in Sweden during the considered time period. This could be why we do not receive explanatory value in Denmark.

Another interesting finding is the results from the regressions testing lagged effects in Sweden. In addition to generating explanatory value for abnormal returns the matching quarter, we obtain similar results for each quarter the following year. We show that mispricing in the Swedish housing market has explanatory value for the following four quarter's abnormal returns. This is interesting because of its implications for potential investment opportunities. For instance, if one were to invest in listed real estate companies in Sweden at a time where the Swedish housing market is overvalued according to Bergman and Sørensen‘s model, one should increase the probability to receive abnormal returns.

Due to the limited sample size and short time horizon, it is hard to distinguish to what extent we can apply our results for the Swedish market to other markets and other time periods. It is possible that we would not find the same relationship in an economy where the housing market has been undervalued. In our test on the Danish market, we consider a period with small deviations between market and fundamental values. This, in combination with the insignificant results from the Danish market, raise the question whether our results from the Swedish market are only applicable on an overvalued housing market. However, the sample size in Denmark might be insufficient. Thus, we cannot draw this conclusion definitely.

Further research

As previously noted, we consider a time period when the housing market is overvalued in Sweden and close to fundamental values in Denmark. Consequently, we cannot draw any conclusions whether our results hold when the housing market is undervalued. Extending the research to include periods when the housing market is undervalued would further develop the study and its implications. Moreover, we use a rather small sample size of 11 companies in

Sweden and 5 in Denmark. A study that examines a larger number of firms, preferably including additional markets than Sweden and Denmark, would provide increased depth to our analysis. Another interesting issue for further research is to add a variable that measures whether the commercial real estate market is over- or undervalued. In this study, we consider the explanatory value of mispricing in the residential real estate industry. As mentioned, real estate companies are commonly exposed to both commercial and residential real estate. Thus, it might be possible to receive a higher explanatory value if a variable of mispricing in commercial real estate were to be added.

Furthermore, even though the Fama-French Three-Factor Model explains most of the returns in a diversified portfolio, to use the Fama-French Five-Factor Model could potentially increase the precision of this study. Hence, it would be interesting for further research to include the additional two factors *Robust minus Weak* and *Conservative minus Aggressive* when computing abnormal returns.

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Appendix

Appendix A – Computing abnormal returns

Added notations

y = Year term

q = quarter

m = month

i = company or market in a country

Computing abnormal returns for real estate companies

We compute adjusted quarterly returns for company i in the following manner:

$$R_{t_i} = \frac{(P_{t_i} - P_{t-1_i})}{P_{t-1_i}} \tag{22}$$

These adjusted quarterly returns are then computed by deducting the returns explained by the Fama-French Three-Factor Model. Small minus Big returns, High minus Low returns and the risk free rate are deducted:

$$AR_{t_i} = R_{t_i} - (\beta_{SMB_t} * R_{SMB_{t_i}} + \beta_{HML_t} * R_{HML_{t_i}} + \beta_{MRKT_t} * R_{MRKT_{t_i}}) - r_{f_t} \tag{23}$$

The beta for each company and the three factors used in the Fama-French Three-Factor Model is computed using linear regression for the period Q2 2007 - Q1 2015 in both Sweden and Denmark.

Beta regressions in Sweden

β_{SMB_S} is estimated by the following regression:

$$R_{t_S} - r_{f_{t_S}} = \beta_0 + \beta_{SMB_S} * R_{SMB_{t_S}} + \varepsilon_k \tag{24}$$

β_{HML_S} is estimated by the following regression:

$$R_{t_S} - r_{f_{t_S}} = \beta_0 + \beta_{HML_S} * R_{HML_{t_S}} + \varepsilon_k \tag{25}$$

β_{MRKT_s} is estimated by the following regression:

$$R_{t_s} - r_{f_{t_s}} = \beta_0 + \beta_{MRKT_s} * R_{MRKT_{t_s}} + \varepsilon_k \quad (26)$$

Beta regressions in Denmark

β_{SMB_d} is estimated by the following regression:

$$R_{t_d} - r_{f_{t_d}} = \beta_0 + \beta_{SMB_d} * R_{SMB_{t_d}} + \varepsilon_k \quad (27)$$

β_{HML_d} is estimated by the following regression:

$$R_{t_d} - r_{f_{t_d}} = \beta_0 + \beta_{HML_d} * R_{HML_{t_d}} + \varepsilon_k \quad (28)$$

β_{MRKT_d} is estimated by the following regression:

$$R_{t_d} - r_{f_{t_d}} = \beta_0 + \beta_{MRKT_d} * R_{MRKT_{t_d}} + \varepsilon_k \quad (29)$$

Because only monthly data on the Fama French factor's portfolios return are available, the quarterly Fama French factors are constructed by computing returns on returns for each month (every quarter).

$$R_{SMB_{qt_i}} = (1 + R_{SMB_{m_{t_i}}}) * \left(1 + R_{SMB_{m_{t-1_i}}}\right) * \left(1 + R_{SMB_{m_{t-2_i}}}\right) * \left(1 + R_{SMB_{m_{t-3_i}}}\right) - 1 \quad (30)$$

$$R_{HML_{qt_i}} = (1 + R_{HML_{m_{t_i}}}) * \left(1 + R_{HML_{m_{t-1_i}}}\right) * \left(1 + R_{HML_{m_{t-2_i}}}\right) * \left(1 + R_{HML_{m_{t-3_i}}}\right) - 1 \quad (31)$$

$$\begin{aligned} R_{MRKT_{qt_i}} = {} & (1 + R_{MRKT_{m_{t_i}}}) * \left(1 + R_{MRKT_{m_{t-1_i}}}\right) * \left(1 + R_{MRKT_{m_{t-2_i}}}\right) \\ & * \left(1 + R_{MRKT_{m_{t-3_i}}}\right) - 1 \end{aligned} \quad (32)$$

The risk free rate is annual return and quarterly risk free rate has been estimated by dividing the annual risk free rate by four.

$$R_{f_{q_t}} = \frac{R_{f_{y_t}}}{4} \tag{33}$$

Computing abnormal returns for OMXSPI

The abnormal returns of OMXSPI is computed in a similar way as for the real estate companies, with the difference that the market factor is not deduced.

$$AR_{t_{MRKT}} = \beta_0 + \beta_{Mispricing_{MRKT}} * Mispricing_t + \varepsilon_k \tag{34}$$

where

$$AR_{t_{MRKT}} = R_{t_{MRKT}} - (\beta_{SMB_{MRKT}} * R_{t_{SMB}} + \beta_{HML_{MRKT}} * R_{t_{HML}}) - r_f \tag{35}$$

The SMB- and HML betas for the market are computed using linear regression for the period Q2 2007 - Q1 2015.

$\beta_{SMB_{MRKT}}$ is estimated by the following regression:

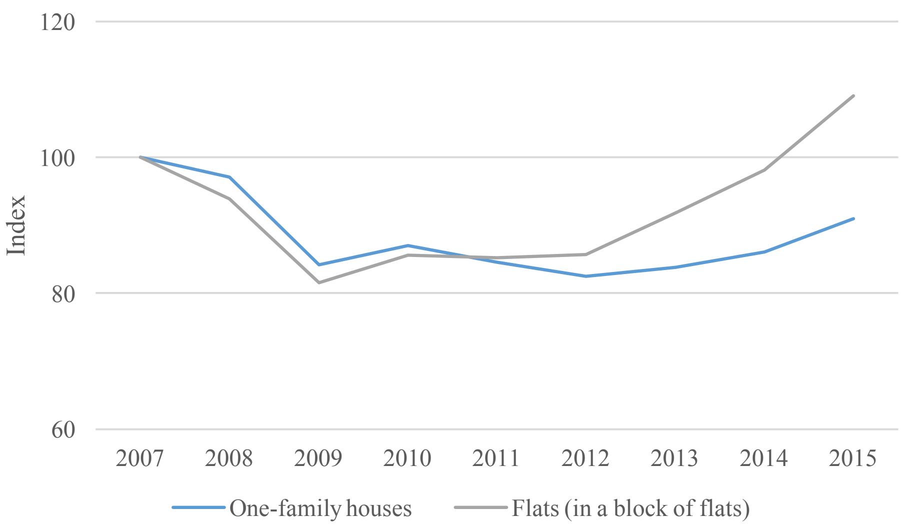
$$R_{t_{MRKT}} - r_f = \beta_0 + \beta_{SMB_{MRKT}} * R_{t_{SMB}} + \varepsilon_k \tag{36}$$

$\beta_{HML_{MRKT}}$ is estimated by the following regression:

$$R_{t_{MRKT}} - r_f = \beta_0 + \beta_{HML_{MRKT}} * R_{t_{HML}} + \varepsilon_k \tag{37}$$

Appendix B – Graphs and tables

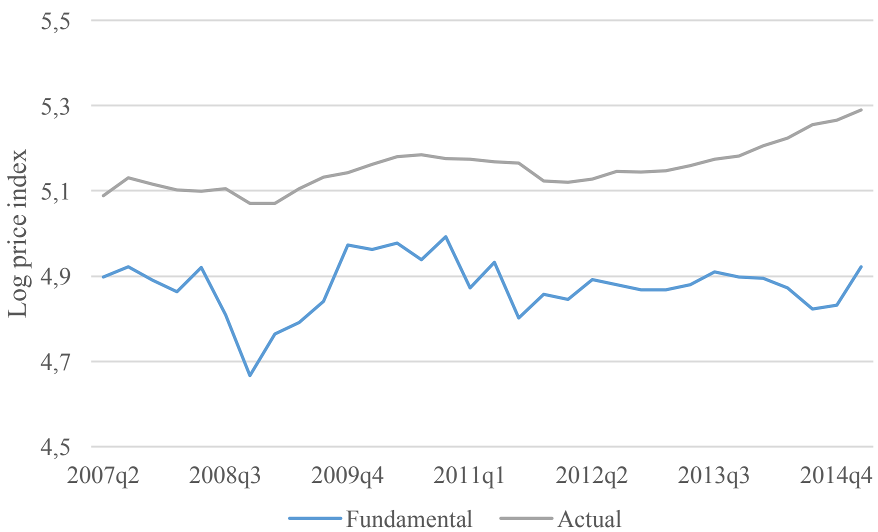
Figure 5: Danish real house prices 2007 – 2015 (2007=100)



Source: Statistics Denmark

Note: This figure presents an index of real house prices in Denmark. The data was received from Statistics Denmark.

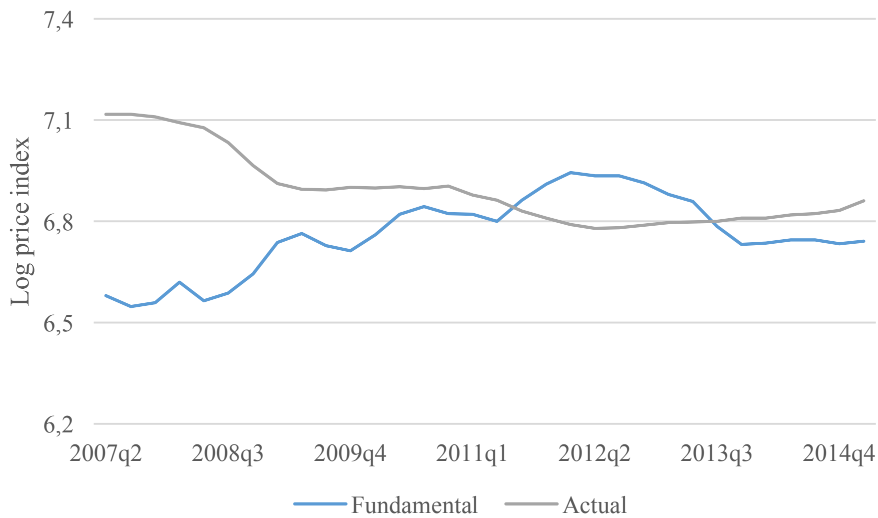
Figure 6: Swedish fundamental and actual house prices Q2 2007 – Q1 2015



Source: Bergman and Sørensen (2016)

Note: This figure presents the natural logarithm of indexed actual- and estimated fundamental housing values in Sweden. The difference is mispricing in the housing market. The fundamental values are the results of a VAR-model presented in the paper by Bergman and Sørensen (2016). The actual housing values were received from the same report.

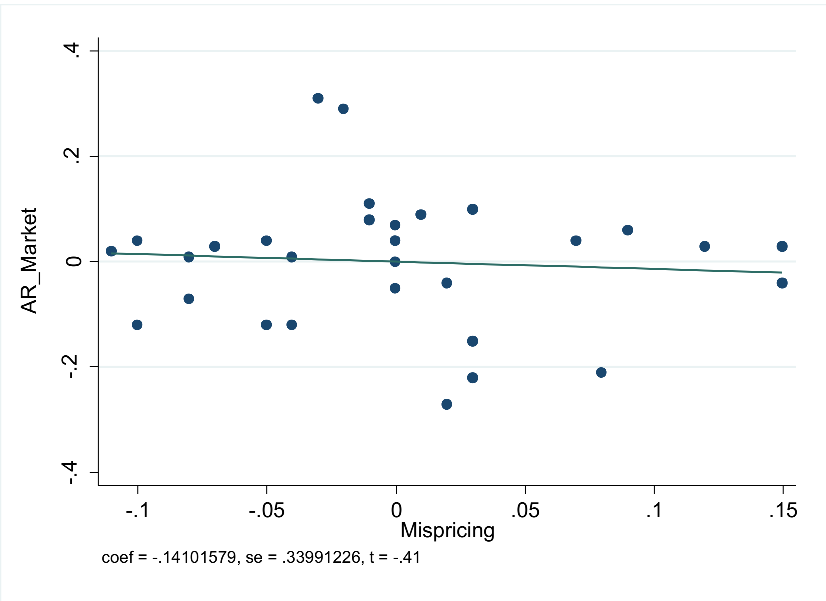
Figure 7: Danish fundamental and actual house prices Q2 2007 – Q1 2015



Source: Bergman and Sørensen (2016)

Note: This figure presents the natural logarithm of indexed actual- and estimated fundamental housing values in Denmark. The difference is mispricing in the housing market. The fundamental values are the results of a VAR-model presented in the paper by Bergman and Sørensen (2016). The actual housing values were received from the same report.

Figure 8: Regression results of OMXSPI



Note: *Mispricing* in Sweden does not explain any of the abnormal returns of OMXSPI.

Table 10: Lagged effects in Denmark one quarter ahead

Variable	AR
$Mispricing_{t-1}$	-0.065
	(0.198)
Constant	0.154*
	(0.0906)
Observations	154
R^2	0.330

Table 11: Lagged effects in Denmark two quarters ahead

Variable	AR
$Mispricing_{t-2}$	-0.008
	(0.151)
Constant	0.146
	(0.0948)
Observations	154
R^2	0.329

Table 12: Lagged effects in Denmark three quarters ahead

Variable	AR
$Mispricing_{t-3}$	-0.003
	(0.169)
Constant	0.151
	(0.0940)
Observations	154
R^2	0.329

Table 13: Lagged effects in Denmark four quarters ahead

Variable	AR
$Mispricing_{t-4}$	-0.024
	(0.155)
Constant	0.152
	(0.0933)
Observations	154
R^2	0.329

Note: The tables show the results from our lagged effect regressions in Denmark. As the p-values indicate, mispricing in the Danish housing market (*Mispricing*) does not explain abnormal returns (*AR)* of Danish listed real estate companies for all of the four upcoming quarters. Abnormal return is the adjusted quarterly stock return, further adjusted for the Fama-French Thee-Factor Model. The variables $Mispricing_{t-1}$, $Mispricing_{t-2}$, $Mispricing_{t-3}$ and $Mispricing_{t-4}$ are the logarithmic difference between indexed actual and fundamental housing value the previous four quarters. The regressions includes company fixed effects and time fixed effects. Robust standard errors are reported within the parentheses. ***, ** and * represent statistical significance at the 1 %, 5% and 10 % levels, respectively.

Appendix C – Test of model assumptions

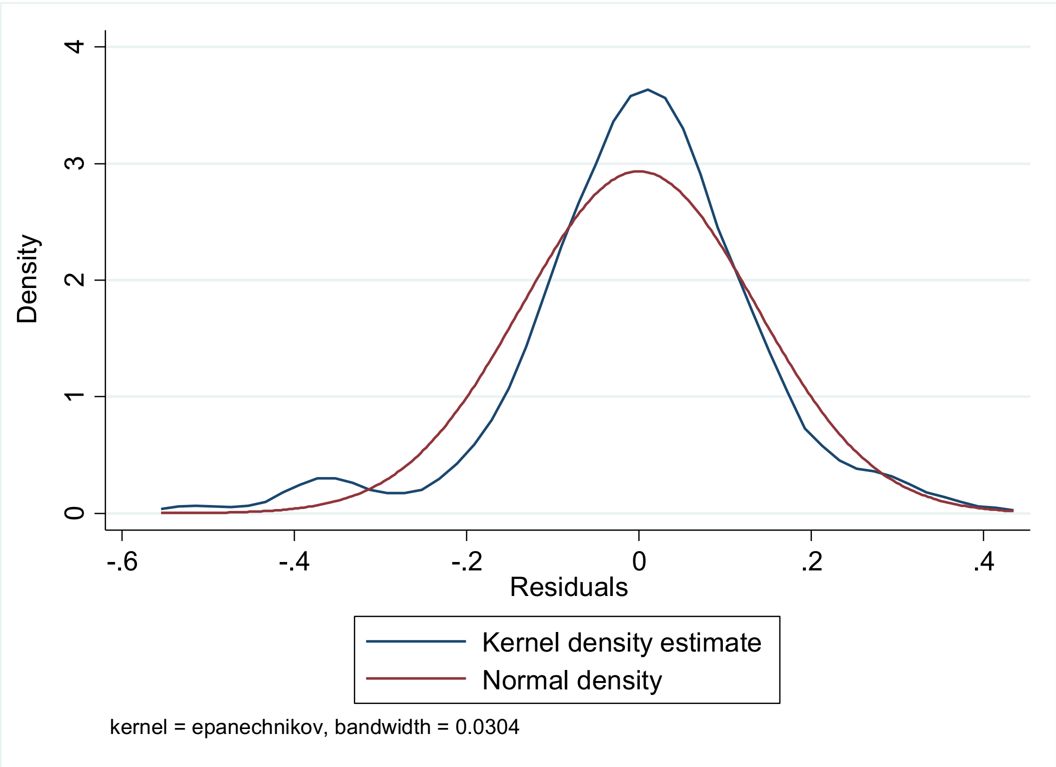
Sweden

Table 14: Shapiro-Wilk W test for normal data

Variable	Obs.	W	V	z	Prob>z
r	341	0.96367	8.672	5.102	0.000

Note: This table shows the Shapiro-Wilk W test for normal data, which tests whether the residuals of the main regression in Sweden (see equation 15) is normally distributed. As seen by the p-value, the residuals are at a 99 % confidence level following a normal distribution.

Figure11: Kernel Density test Sweden



Note: This figure shows the Kernel density estimate of the residuals in the Swedish main regression (see equation 10) and the normal density for the residuals in the Swedish main regression. The plot indicates that the residuals are normally distributed.

Table 15: Cameron & Trivedi's decomposition of IM-test (the Whites's test)

Source	chi2	df	p
Heteroscedasticity	3.16	2	0.2059
Skewness	5.86	1	0.0154
Kurtosis	10.31	1	0.0013
Total	19.33	4	0.0007

Note: This is Cameron & Trivedi's decomposition of IM-test (the Whites's test) for the Swedish dataset, which tests for heteroscedasticity. The test indicates that the data is homoscedastic.

Table 16: Breusch-Pagan / Cook-Weisberg test for heteroscedasticity

chi2(1) = 0.80
Prob > chi2 = 0.3703

Note: This is the Breusch-Pagan / Cook-Weisberg test for heteroscedasticity. Ho is constant variance. The test indicates that the data is homoscedastic. Variables are fitted values of *AR*.

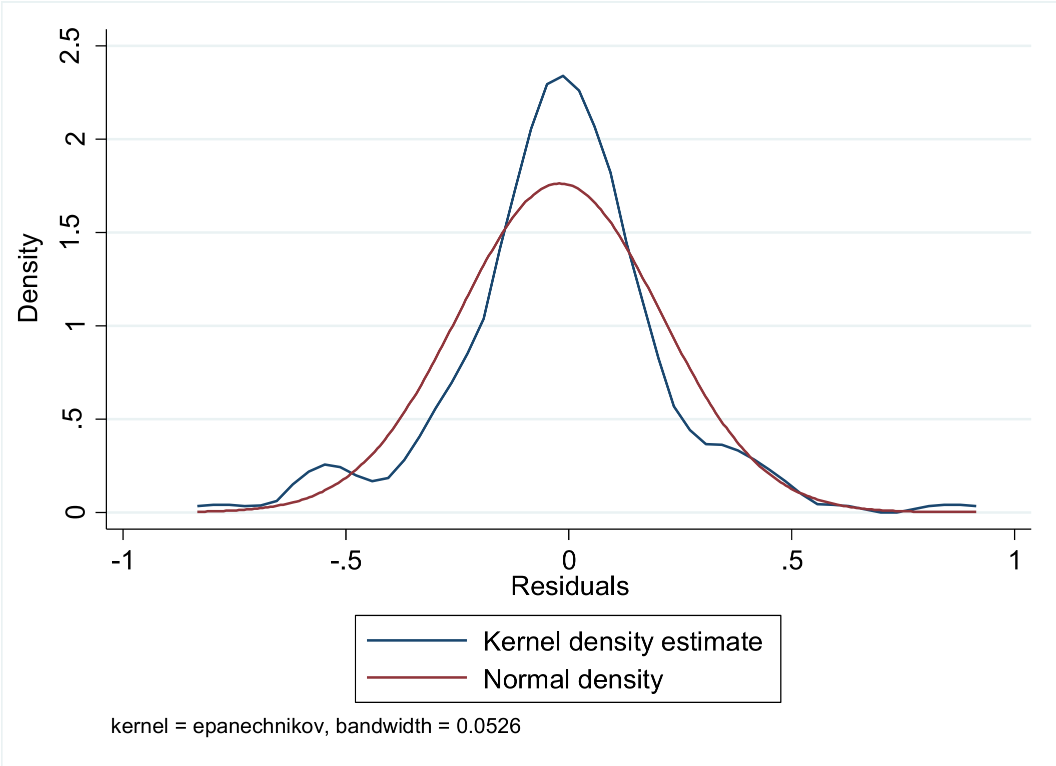
Denmark

Table 17: Shapiro-Wilk W test for normal data

Variable	Obs.	W	V	z	Prob>z
r	154	0.96408	4.275	3.298	0.00049

Note: This table shows the Shapiro-Wilk W test for normal data, which tests whether the residuals of the main regression in Denmark (see equation 15) is normally distributed. As seen by the p-value, the residuals are at a 99 % confidence level following a normal distribution.

Figure 12: Kernel Density Estimate Denmark



Note: This figure shows the Kernel density estimate of the residuals in the Danish main regression (see equation 15) and the normal density for the residuals in the Danish main regression. The plot indicates that the residuals are normally distributed.

Table 18: Cameron & Trivedi's decomposition of IM-test (the Whites's test)

Source	chi2	df	p
Heteroscedasticity	39.50	2	0.0000
Skewness	0.64	1	0.4219
Kurtosis	33.19	1	0.0000
Total	73.33	4	0.0000

Note: This is Cameron & Trivedi's decomposition of IM-test (the Whites's test) for the Danish dataset, which tests for heteroscedasticity. The test indicates that the data is heteroscedastic.

Table 19: Breusch-Pagan / Cook-Weisberg test for heteroscedasticity

chi2(1) = 0.01
Prob > chi2 = 0.9312

Note: This is the Breusch-Pagan / Cook-Weisberg test for heteroscedasticity. Ho Constant variance. The test indicates that the data is homoscedastic. Variables are fitted values of *AR*.

Appendix D – Beta regression results

Sweden

Table 20: Three-Factor model Betas, Atrium Ljungberg Q2 2007 – Q1 2015

Variable	(1) Adj_R_Atrium	(2) Adj_R_Atrium	(3) Adj_R_Atrium
SMB	1.090***		
	(0.317)		
HML		1.052***	
		(0.337)	
Adj_R_Market			0.412**
			(0.157)
Constant	0.0250	0.00928	0.00445
	(0.0212)	(0.0213)	(0.0222)
Observations	31	31	31
R^2	0.290	0.251	0.192

Note: Standard errors are reported within the parentheses. ***, ** and * represent statistical significance at the 1 %, 5% and 10 % levels, respectively.

Table 21: Three-Factor model Betas, Castellum Q2 2007 – Q1 2015

VARIABLES	(1) Adj_R_Castellum	(2) Adj_R_Castellum	(3) Adj_R_Castellum
SMB	0.703**		
	(0.276)		
HML		0.909***	
		(0.268)	
Adj_R_Market			0.424***
			(0.118)
Constant	0.0216	0.0114	0.00647
	(0.0185)	(0.0169)	(0.0167)
Observations	31	31	31
R^2	0.183	0.284	0.308

Note: Standard errors are reported within the parentheses. ***, ** and * represent statistical significance at the 1 %, 5% and 10 % levels, respectively.

Table 22: Three-Factor model Betas, Catena Q2 2007 – Q1 2015

VARIABLES	(1) Adj_R_Catena	(2) Adj_R_Catena	(3) Adj_R_Catena
SMB	0.192		
	(0.597)		
HML		-0.0250	
		(0.620)	
Adj_R_Market			-0.367
			(0.269)
Constant	-0.0253	-0.0280	-0.0236
	(0.0400)	(0.0391)	(0.0380)
Observations	31	31	31
R^2	0.004	0.000	0.060

Note: Standard errors are reported within the parentheses. ***, ** and * represent statistical significance at the 1 %, 5% and 10 % levels, respectively.

Table 23: Three-Factor model Betas, Diös Q2 2007 – Q1 2015

VARIABLES	(1) Adj_R_Dios	(2) Adj_R_Dios	(3) Adj_R_Dios
SMB	0.930**		
	(0.354)		
HML		1.048***	
		(0.359)	
Adj_R_Market			0.542***
			(0.153)
Constant	0.0388	0.0254	0.0190
	(0.0237)	(0.0227)	(0.0216)
Observations	31	31	31
R^2	0.192	0.227	0.303

Note: Standard errors are reported within the parentheses. ***, ** and * represent statistical significance at the 1 %, 5% and 10 % levels, respectively.

Table 24: Three-Factor model Betas, Fabege Q2 2007 – Q1 2015

VARIABLES	(1) Adj_R_Fabege	(2) Adj_R_Fabege	(3) Adj_R_Fabege
SMB	1.703***		
	(0.409)		
HML		1.320***	
		(0.477)	
Adj_R_Market			0.710***
			(0.201)
Constant	0.0487*	0.0242	0.0158
	(0.0274)	(0.0301)	(0.0284)
Observations	31	31	31
R^2	0.374	0.209	0.301

Note: Standard errors are reported within the parentheses. ***, ** and * represent statistical significance at the 1 %, 5% and 10 % levels, respectively.

Table 25: Three-Factor model Betas, Fast Partner Q2 2007 – Q1 2015

VARIABLES	(1) Adj_R_Fast	(2) Adj_R_Fast	(3) Adj_R_Fast
SMB	1.852***		
	(0.371)		
HML		1.758***	
		(0.411)	
Adj_R_Market			0.721***
			(0.193)
Constant	0.0721***	0.0455*	0.0370
	(0.0248)	(0.0259)	(0.0273)
Observations	31	31	31
R^2	0.462	0.387	0.325

Note: Standard errors are reported within the parentheses. ***, ** and * represent statistical significance at the 1 %, 5% and 10 % levels, respectively.

Table 26: Three-Factor model Betas, Heba Q2 2007 – Q1 2015

VARIABLES	(1) Adj_R_Heba	(2) Adj_R_Heba	(3) Adj_R_Heba
SMB	0.305		
	(0.239)		
HML		0.584**	
		(0.230)	
Adj_R_Market			0.395***
			(0.0873)
Constant	0.0137	0.00926	0.00460
	(0.0160)	(0.0145)	(0.0123)
Observations	31	31	31
R^2	0.053	0.182	0.414

Note: Standard errors are reported within the parentheses. ***, ** and * represent statistical significance at the 1 %, 5% and 10 % levels, respectively.

Table 27: Three-Factor model Betas, Hufvudstaden Q2 2007 – Q1 2015

	(1)	(2)	(3)
VARIABLES	Adj_R_Hufvudstaden	Adj_R_Hufvudstaden	Adj_R_Hufvudstaden
SMB	0.00190		
	(0.235)		
HML		0.118	
		(0.243)	
Adj_R_Market			0.250**
			(0.0990)
Constant	0.0128	0.0128	0.00979
	(0.0158)	(0.0153)	(0.0140)
Observations	31	31	31
R^2	0.000	0.008	0.181

Note: Standard errors are reported within the parentheses. ***, ** and * represent statistical significance at the 1 %, 5% and 10 % levels, respectively.

Table 28: Three-Factor model Betas, Kungsleden Q2 2007 – Q1 2015

	(1)	(2)	(3)
VARIABLES	Adj_R_Kungsleden	Adj_R_Kungsleden	Adj_R_Kungsleden
SMB	1.414***		
	(0.371)		
HML		1.220***	
		(0.414)	
Adj_R_Market			0.626***
			(0.176)
Constant	0.0186	-0.00174	-0.00911
	(0.0249)	(0.0261)	(0.0249)
Observations	31	31	31
R^2	0.334	0.231	0.303

Note: Standard errors are reported within the parentheses. ***, ** and * represent statistical significance at the 1 %, 5% and 10 % levels, respectively.

Table 29: Three-Factor model Betas, Wallenstam Q2 2007 – Q1 2015

	(1)	(2)	(3)
VARIABLES	Adj_R_Wallenstam	Adj_R_Wallenstam	Adj_R_Wallenstam
SMB	1.192***		
	(0.355)		
HML		1.385***	
		(0.349)	
Adj_R_Market			0.639***
			(0.154)
Constant	0.0530**	0.0359	0.0284
	(0.0238)	(0.0220)	(0.0217)
Observations	31	31	31
R^2	0.280	0.352	0.373

Note: Standard errors are reported within the parentheses. ***, ** and * represent statistical significance at the 1 %, 5% and 10 % levels, respectively.

Table 30: Three-Factor model Betas, Wihlborgs Q2 2007 – Q1 2015

	(1)	(2)	(3)
VARIABLES	Adj_R_Wihlborgs	Adj_R_Wihlborgs	Adj_R_Wihlborgs
SMB	0.903***		
	(0.283)		
HML		0.842***	
		(0.304)	
Adj_R_Market			0.387***
			(0.135)
Constant	0.0407**	0.0277	0.0231
	(0.0190)	(0.0191)	(0.0191)
Observations	31	31	31
R^2	0.259	0.210	0.221

Note: Standard errors are reported within the parentheses. ***, ** and * represent statistical significance at the 1 %, 5% and 10 % levels, respectively.

Denmark

Table 31: Three-Factor model Betas, Admiral Q2 2007 – Q1 2015

VARIABLES	(1) Adj_R_Admiral	(2) Adj_R_Admiral	(3) Adj_R_Admiral
SMB	0.0984		
	(0.817)		
HML		-0.375	
		(0.609)	
Adj_R_Market			0.262
			(0.317)
Constant	-0.0309	-0.0383	-0.0379
	(0.0496)	(0.0435)	(0.0429)
Observations	31	31	31
R^2	0.000	0.013	0.023

Note: Standard errors are reported within the parentheses. ***, ** and * represent statistical significance at the 1 %, 5% and 10 % levels, respectively.

Table 32: Three-Factor model Betas, Bluevision Q2 2007 – Q1 2015

VARIABLES	(1) Adj_R_Bluevision	(2) Adj_R_Bluevision	(3) Adj_R_Bluevision
SMB	1.359		
	(2.136)		
HML		-1.210	
		(1.597)	
Adj_R_Market			0.0215
			(0.845)
Constant	0.0598	0.00459	0.0187
	(0.130)	(0.114)	(0.114)
Observations	31	31	31
R^2	0.014	0.019	0.000

Note: Standard errors are reported within the parentheses. ***, ** and * represent statistical significance at the 1 %, 5% and 10 % levels, respectively.

Table 33: Three-Factor model Betas, Jeudan Q2 2007 – Q1 2015

VARIABLES	(1) Adj_R_Jeudan	(2) Adj_R_Jeudan	(3) Adj_R_Jeudan
SMB	0.156		
	(0.287)		
HML		0.175	
		(0.214)	
Adj_R_Market			0.178
			(0.108)
Constant	0.00695	0.00435	-0.000494
	(0.0174)	(0.0153)	(0.0147)
Observations	31	31	31
R^2	0.010	0.023	0.085

Note: Standard errors are reported within the parentheses. ***, ** and * represent statistical significance at the 1 %, 5% and 10 % levels, respectively.

Table 34: Three-Factor model Betas, Nordicom Q2 2007 – Q1 2015

VARIABLES	(1) Adj_R_Nordicom	(2) Adj_R_Nordicom	(3) Adj_R_Nordicom
SMB	-0.521		
	(1.095)		
HML		-0.461	
		(0.819)	
Adj_R_Market			0.547
			(0.419)
Constant	-0.110	-0.100*	-0.103*
	(0.0665)	(0.0585)	(0.0568)
Observations	31	31	31
R^2	0.008	0.011	0.055

Note: Standard errors are reported within the parentheses. ***, ** and * represent statistical significance at the 1 %, 5% and 10 % levels, respectively.

Table 35: Three-Factor model Betas, TK Development Q2 2007 – Q1 2015

VARIABLES	(1) Adj_R_TKDevelopment	(2) Adj_R_TKDevelopment	(3) Adj_R_TKDevelopment
SMB	0.659		
	(0.677)		
HML		0.00861	
		(0.516)	
Adj_R_Market			0.710***
			(0.236)
Constant	-0.0315	-0.0512	-0.0623*
	(0.0411)	(0.0368)	(0.0319)
Observations	31	31	31
R^2	0.032	0.000	0.238

Note: Standard errors are reported within the parentheses. ***, ** and * represent statistical significance at the 1 %, 5% and 10 % levels, respectively.