Bachelor's Thesis in Finance

STOCKHOLM SCHOOL OF ECONOMICS

A study of the risk-return relationship in the Swedish housing market: evidence from an H-CAPM model

Adrian Imreorow♣ Oscar Schagerström♠

Abstract

This paper investigates the risk-return relationship in the Swedish housing market by testing a housing capital asset pricing model (H-CAPM). The model is applied on one- and two-dwelling houses for permanent living in 238 municipalities between 1982 and 2009. Following the framework of Case, Cotter, and Gabriel (2011), the H-CAPM is a modification of the traditional CAPM in that the aggregate Swedish housing market is used as proxy for systematic risk. The H-CAPM model is further controlled for the inclusion of idiosyncratic risk and housing equivalents of the SMB, HML and momentum factors, as well as a set of common micro- and macroeconomic variables. The time-series and cross-sectional regression results support the single-factor H-CAPM model, and that there is a strong relationship between municipal house price returns and their covariance with the aggregate national housing market portfolio. Moreover, substantial cross-sectional variation is observed, with housing betas ranging from 0.33 to 1.37. The Fama-MacBeth (1973) regressions further suggest that an increase in beta of 0.5 is compensated by an increase in the annual real excess house price return of 2.92%.

Keywords: Housing capital asset pricing model, H-CAPM, housing market, house price returns, risk-return relationship

Tutor: Assistant Professor Laurent Bach

Acknowledgements: We would like to express gratitude to our tutor, Assistant Professor Laurent Bach, for offering us guidance and inspiration throughout the process of writing this thesis. We also want to thank Professor Peter Englund and Anders Nordberg (Riksbanken) for helpful comments, as well as Niclas Sjölund (Statistics Sweden) for providing us with raw data.

♣ 21408@student.hhs.se
♠ 21545@student.hhs.se

Table of contents

1. Introduction

Owner occupied housing has the dual role of providing accommodation and being an investment. The latter purpose is of great importance to both individuals and the economy as a whole since housing accounts for the largest share of wealth in many nations' balance sheets today (Smith and Searle, 2010). Moreover, several studies indicate that changes in house prices have about the same – or even greater – impact on household consumption than changes in the value of other financial assets (Case and Quigley, 2005, Slacalek, 2009). Thus, housing as an investment is of interest not only to the home owner, but also other economic agents such as financial institutions, governments and central banks.

In the investment context, housing shares many common characteristics with equities. Both are risky assets, and similarly to equities, housing rewards investors with both capital gains and implicit dividends for not having to rent. A number of studies have also highlighted that home buyers have increasingly stronger investment motives (see Case and Shiller, 1988, Case and Shiller, 2003). In contrast to other financial assets, housing investments have further been surrounded by the belief that they basically generate stable risk-free real returns (Bostadskreditsnämnden, 2008, Case and Shiller, 2003). Yet, the boom and bust of several housing markets in the last decades, and particularly during the recent financial crisis, have made the press and public more attentive to the risks associated with residential real estate.

In academia related to housing, there has also been a shift in the thematic focus towards risk (Smith and Searle, 2010).[1] The Swedish Central Bank, for example, recently issued a report titled "The Riksbank's inquiry into the risks in the Swedish housing market" (Riksbanken, 2011). One of the topics covered in the report include whether or not the recent decade's sharp increase of Swedish house prices are motivated by fundamental factors. Despite the apparent increase in the focus on risk related to housing investments, surprisingly few studies apply asset pricing models from the finance literature in order to identify the risk-return characteristics. Instead, most studies implement models that include fundamental drivers or a set of macroeconomic variables (see Case and Shiller, 1990 and Chinloy, 1992). Furthermore, substantial cross-sectional differences between submarkets have been observed. Some say that the cross-sectional variation is driven by local variation in fundamentals (Negro and Otrok, 2007, Hiebert and Roma, 2010), while others claim that investment speculation is more relevant (Case and Shiller, 1988).

[1] Between 1991-2000, a negligible proportion of articles in the Journal of Housing Economics focused on risk, whereas in 2001-2008 the proportion had increased to some 15% (Smith and Searle, 2010).

In light of the above, the purpose of this paper is to analyze if there is a risk-return relationship in the Swedish housing market. More specifically we attempt to identify whether or not housing investors are compensated for systematic and idiosyncratic risk. To do so, following Case, Cotter and Gabriel (2011), this paper tests a housing capital asset pricing model (henceforth H-CAPM) on 238 municipalities for one- and two-dwelling houses between 1982 and 2009. This is to our knowledge the first study of its kind on the Swedish housing market. The H-CAPM model is a modification of the traditional CAPM in that the aggregate Swedish housing market is used as the market portfolio proxy. To test the H-CAPM empirically, we run time-series regressions for each municipality in three steps by: (i) testing for the appropriate market portfolio; (ii) controlling for the risk factors of idiosyncratic risk and housing equivalents of the SMB, HML, and momentum factors; and (iii) controlling for common micro- and macroeconomic factors from the housing literature. Finally, we proceed to validate a potential risk-return relationship using the classic Fama-Macbeth (1973) two-step procedure.

The empirical results indicate a strong relationship between municipal house price returns and their covariance with the housing market portfolio. Moreover, substantial cross-sectional variation is observed with housing betas ranging from 0.33 to 1.37. The Fama-MacBeth regressions further suggest that an increase in beta of 0.5 is compensated by an increase in the annual real excess house price return of 2.92%. The H-CAPM model is further robust to the inclusion of the risk factor control variables and the micro- and macroeconomic control variables.

The paper is organized as follows. Section 2 briefly covers previous related literature. Section 3 presents the theoretical framework for the H-CAPM model, followed by the method employed to test the model in Section 4. Section 5 provides a concise presentation of the data used in the empirical study. Results are presented in Section 6. In Section 7, the results and robustness of the H-CAPM model is discussed, followed by conclusions and implications in Section 8.

2. Related literature

In this section we will briefly touch upon related literature that investigates the relationship between house prices and fundamental economic drivers, since some of these variables are included in our control models. However, the main focus will be on papers that have an asset pricing approach towards the housing market.

Several papers investigate house prices in relation to fundamental economic factors. Girouard et al. (2006) review a number of international studies on the role of fundamentals in explaining house prices in 18 OECD countries. They find that the housing stock supply, real disposable income, real interest rate, real wealth, unemployment and demographics to various degrees are key drivers of house price fluctuations. Égert and Mihajlek (2007) come to similar conclusions in a comparative study of 19 OECD countries and eight central and eastern European economies. They find that factors such as GDP per capita, real interest rate, housing credit and demographic factors well explain house prices in the covered countries. Case and Shiller (1990) test for the forecastability of excess house price returns by including a set of commonly used macroeconomic variables. In addition they include two housing specific fundamental metrics: rent over price and construction cost dividend over price. Their conclusion is that increases in the adult population, per capita real income growth and the ratio of construction costs to prices have a significant positive effect on excess returns.

Chinloy (1992) investigates the returns of holding single family housing in the San Fransisco Bay Area. He includes a set of variables that Chen et al. (1986) and Chan et al. (1990) have found to affect security prices and real estate investment trust returns, respectively. Furthermore, Chinloy also controls for the idiosyncratic risk factors income capitalization rate[2] and the condition of the housing market[3]. His results show that only inflation and income capitalization rate explain housing returns. Finally, Chinloy tests the traditional CAPM and reaches the conclusion that although betas are low, housing is not a zero beta asset when using an appropriate lag structure. While not including lags, Davidoff (2007) does not find any relationship between the stock market and housing returns. Moreover, Barry (1980) does not find the CAPM to explain farm real estate returns very well either. Nevertheless, Anderson and Beracha (2010) find a positive relationship between the returns of homes in more than 3000 U.S zip-codes and the stock market. In another study, Jud and Winkler (2002) show that lagged stock market returns have a significant positive impact on MSA house price returns, in addition to a number of other fundamental variables.

Following the ambiguous relationship between housing and the stock market, a few papers have attempted to find alternative proxies for the market portfolio. Sarama (2010) explores the explanatory power of a global and local CAPM model on 10 U.S. cities. The two models differ in the composition of the market portfolio. The global CAPM's market portfolio is the aggregate U.S. household composition of a value- weighted portfolio comprising a stock market index and the aggregate U.S. housing market. The local CAPM model's market portfolio comprises the composition between a stock market index and the excess return on the local housing market.

[2] Measured as the net operating income divided by dollar price for a constant quality house.
[3] Defined as the growth of sales volume for houses.

Sarama concludes that the local CAPM model better explains house price returns. There is further significant heterogeneity in the risk-return relationship across different cities.

Whereas some papers, like the above mentioned, test the time-series relationship between the market factor and the housing market, few conclude any risk-return relationship in the cross-section. A common way of testing the validity of asset pricing models is by looking at the cross-sectional relationship between market betas and returns. This method is applied by Cannon et al. (2006) on U.S. zip code house price returns. They test for the explanatory power of the stock market, idiosyncratic risk[4] and the house price level. The results indicate that there is a positive relationship between both betas and squared betas; median house price returns rise by 3.84 % when beta increases from zero to 0.5. Furthermore, idiosyncratic risk is also priced: every 10 % increase in non-systematic risk is compensated with 1.88% higher return. Finally, the house price level, measured as a Fama-French Small-minus-Big (SMB) factor (see Fama and French, 1992), is also significant.

Case, Cotter and Gabriel (2011) employ a multifactor asset pricing model in their analysis of the risk-return relationship of 151 MSAs in the U.S. market. However, since the stock market does a poor job in explaining housing returns, they define systematic risk as the return of the aggregate U.S. housing market. The model is extended with additional risk factors including idiosyncratic risk, momentum and SMB. Moreover, the robustness of the multifactor model is tested by including control variables that are common in the housing literature. More specifically, changes in employment, foreclosure incidence and affordability are included as control variables. Their results show that the national housing market factor has a significant positive effect on MSA house price returns. The alternative stock market portfolio is not found to be significant. Furthermore, none of the risk factors or the control variables are significant either. After applying the Fama-MacBeth (1973) framework, they conclude that there is a true relationship between risk – as measured by betas – and returns.

3. Theoretical framework

The theoretical framework and method in this paper is inspired by Case, Cotter and Gabriel (2011). Similar to them, we test a housing capital asset pricing model (H-CAPM), which is a modification of the traditional capital asset pricing model (CAPM) as depicted by e.g. Sharpe (1964), Lintner (1965), and Mossin (1966). Our model differs from Case, Cotter and Gabriel in

[4] Defined as the root mean square error of the time-series regressions against the stock market.

the sense that we use different control variables. Moreover, we include dividends in the house price returns and use real returns rather than nominal.[5]

Below we outline the theoretical framework for the H-CAPM model. We then proceed to present other risk factors and control variables used to test the validity of our asset pricing model.

3.1 H-CAPM

The traditional CAPM states that there is a linear relationship between an asset's return and its covariance with the optimally diversified market portfolio.[6] Theoretically, this portfolio includes every single asset available including not only equities but also real estate, bonds, commodities, and any other asset that is held by investors in market equilibrium. Obtaining the returns on all these assets is impossible in practice. The market portfolio is therefore usually proxied using an all equity value-weighted index, such as the Standard & Poor's 500. However, this practice has been criticized since the unobservable market portfolio cannot be proxied by a limited set of assets like a stock market index (Roll, 1977). Attempts have been made to develop broader market portfolios (see Campbell, 1996 and Sarama, 2010). Considering the fact that housing comprises the largest share of private wealth, it is surprising to find so few indices including housing. This fact may explain the poor performance of the stock market in explaining housing returns (see Davidoff, 2007, Case, Cotter and Gabriel, 2011 and Chinloy, 1992).

Our modification of the traditional CAPM arises from the fact that it is applied in a housing context, whereby an aggregate national housing market portfolio is used as proxy for systematic risk. We thus implicitly assume that the household's investment decision is restricted to housing. This is consistent with the equity pricing literature, where investments in equities are assumed to be segmented rather than integrated (Case, Cotter and Gabriel, 2011). Still, it would be preferable to also test a value-weighted index that reflects the aggregate composition between different asset classes. Unfortunately, we could not create such an index since reliable data was not available for our time period. However, a stock market portfolio is included as well for control purposes.

When applying the CAPM framework on owner-occupied housing, it is important to clarify that housing takes the dual role of being both a consumption good (by providing accommodation)

[5] In the theoretical framework of the CAPM, dividends should be included in the individual assets and the market portfolio. In practice, the question of whether or not to include dividends in stock price returns has been shown to be of minor importance due to almost perfect correlation between stock return indices that do and do not include dividends (Bartholdy and Peare, 2004). We decide to include dividends for both the house market index as well as the municipal house price returns. The reason for this is twofold: (i) it is more correct in theory, and (ii) the magnitudes of the regression coefficients are more accurate in an economic sense.

[6] More specifically, given an asset's beta and the risk free rate, the CAPM model explains the expected risk premium for that asset in the following formula: $\mathrm{ER_i} = \mathrm{R_f} + \beta_\mathrm{i}(\mathrm{ER_m} - \mathrm{R_f})$, where $\mathrm{ER_i}$ is the expected return of stock i, $\mathrm{R_f}$ is the risk free rate, $\mathrm{ER_m}$ is the expected return of the optimally diversified market portfolio, and β_i is the asset's beta as denoted by $\mathrm{Cov}(\mathrm{R_i} - \mathrm{R_f}, \mathrm{R_m} - \mathrm{R_f})/\mathrm{Var}(\mathrm{R_m} - \mathrm{R_f})$ (Jagannathan and McGrattan, 2005).

and a financial asset. As an investment, housing shares many common characteristics, but also differences, with regards to other financial assets (Smith and Searle, 2010). Analogously to equities, the returns of owner-occupied homes can be decomposed into capital gains in the form of price appreciation, and implicit dividends received from the net rental value of services that is produced by the house (Englund, Hwang and Quigley, 2002).[7] However, contrary to most other financial assets, housing as an investment is to a large extent illiquid, indivisible, associated with high transaction costs and difficult to hedge (Smith and Searle, 2010). Moreover, annual house prices tend to experience first-order serial correlation, while experiencing negative autocorrelation for lags up to five years (Englund and Ioannides, 1997). Housing is thus complex in its nature, but in our H-CAPM framework we choose to treat it as a financial asset similar to equities.

The standard procedure of verifying a risk-return relationship is to apply cross-sectional analysis on a large set of individual assets. Unfortunately, due to infrequent trades and heterogeneity in attributes it is difficult in practice to calculate price indices for individual houses (Englund, Hwang and Quigley, 2002). However, several studies have noted that there are considerable differences across submarkets (see Negro and Otrok, 2007 and Hiebert and Roma, 2010). Hence, in our study of the risk-return relationship on the Swedish market, we have chosen to use the widest cross-sectional data set available, which is at the municipal level. Note that this inevitably elmininates some of the individual houses' idiosyncratic risk. Nonetheless, municipal level idiosyncratic risk is still retained.

Finally, the rationale for implementing an H-CAPM model in explaining cross-sectional municipal house price returns, rather than to develop a multi-factor model with several explanatory variables is threefold: (i) In accordance with the traditional CAPM, we hypothesize that the H-CAPM model captures all relevant systematic risk, and that idiosyncratic risk and housing equivalents of the SMB, HML, and momentum factors are not priced in market equilibrium. (ii) An alternative approach would have been to decompose the systematic risk into macroeconomic variables. However, we argue that it is difficult to explain all sources of systematic risk by fundamentals. (iii) Even if the underlying factors for the systematic housing market portfolio can be identified, there is an evident tradeoff between proxying systematic risk by a broad set of independent variables, and the simplicity of having one source of systematic risk.

In conclusion, we argue that our H-CAPM model is sufficient and intuitive in explaining the risk-return relationship on the Swedish housing market.

[7] Algebraically, the expression is $R_t = [(P_{t+1} - P_t + d_{t+1})/P_t]$, where R_t is the house price return at time t, P_{t+1} is the house price at time t+1, d_{t+1} is the implied dividend, received by not having to rent, at time t+1.

3.2 Risk factor control variables

In order to test our hypothesis that the risk-return relationship in the Swedish housing market is explained by the single-factor H-CAPM model, we need to control it for additional risk factors as well. This section presents and motivates housing equivalents of the most commonly used risk factors in the equity pricing literature.

3.2.1 Idiosyncratic risk

Housing investments, unlike equities, are to a large extent illiquid, indivisible, associated with high transaction costs, and difficult to hedge (Smith and Searle, 2010). For these reasons, housing owners cannot diversify their holdings and should reasonably be expected to seek compensation for total risk, i.e. for both systematic and idiosyncratic risk (Case, Cotter and Gabriel, 2011). Consequently, the first step in testing the robustness of a single factor H-CAPM is to investigate if such risk is priced.

The results from previous empirical studies have varied, and so have the methods employed to define idiosyncratic risk. In the context of equity markets, Goyal and Santa-Clara (2003) find a positive relationship between lagged average stock variance – which mainly consists of idiosyncratic risk – and the return on the market. However, Bali et al. (2005) show that Goyal and Sata-Clara's results do not hold for an extended sample. Levy (1978) and Malkiel and Xu (2002) show that idiosyncratic risk, defined as mean square errors and root mean square errors respectively, has a significant impact on returns in cross-sectional analyses. The underlying explanation for these results is believed to be that investors do not hold fully diversified portfolios. In the housing context, Cannon et al. (2006) use root mean square errors as proxies for idiosyncratic risk and find a significant positive relationship. In contrast, Case, Cotter and Gabriel (2011) do not obtain any significant results in their asset pricing model.

Similar to several of the studies above, we make use of the residuals in defining the idiosyncratic risk. Since we assume that our market factor captures all systematic risk, by definition only idiosyncratic risk will be left in the residuals. In our time series regressions, we therefore use the absolute value of the residuals in each period, obtained from the single factor H-CAPM regression. The cross-sectional Fama-MacBeth (1973) application further allows us to test for idiosyncratic risk as defined by the root mean square errors.

3.2.2 SMB, HML and momentum risk factors

In the equity asset pricing literature, the single-factor CAPM's ability to capture all risk has been disputed. It has been suggested that risk is multidimensional and thus needs to be proxied using a multifactor model (Fama and French, 1992). In addition to idiosyncratic risk, we therefore also include other common risk factors depicted in the asset pricing literature, namely SMB, HML and momentum (see Fama and French, 1993, and Carhart, 1997). While these factors have been widely discussed in equity pricing, they have generally been overlooked in the context of housing markets.

In equity asset pricing, the SMB factor is believed to capture the higher risk of small companies (Chan and Chen, 1991). A direct parallel to housing would mean that such a risk factor would capture the higher risk of lower priced homes. This analogy is not made in the housing literature, but rather a reversed one. Cannon et al. (2006) include a variant of the SMB because they find a positive relationship between the median house price level in different MSAs and their corresponding returns. Hence, they compute the SMB as the difference between returns in high priced and low priced MSAs. Case, Cotter and Gabriel (2011) apply a similar method. While Cannon et al. obtain significant results, Case, Cotter and Gabriel do not. We define our SMB the same way as Cannon et al. and include it to see if a potential price-risk relationship explains returns across submarkets.

A good alternative for the HML factor has to our knowledge not been implemented in housing asset pricing contexts. We construct a HML factor that is based on the K/T-ratio (purchase price to assessed value ratio). In equity contexts, HML is the ratio of book equity to market equity (BE/ME) and is believed to proxy for differences in return between high BE/ME-ratio "value stocks" and low BE/ME-ratio "growth stocks". The analogy for our K/T-ratio based HML is that municipalities with high average K/T-ratios are growth regions, while municipalities with low average K/T-ratios are value regions. It is believed that value stocks carry premiums because they are distressed (Fama and French, 1996), but it is unclear if this applies to the housing market as well. Nonetheless, we include our version of the factor to see if it is priced. The reader should observe that the K/T-ratio is analogous to a market-to-book ratio rather than a book-to-market ratio and that a potential relationship would thus be reversed.

Carhart (1997) constructed a portfolio – comprising the equal-weighted difference between the top 30% and bottom 30% of mutual funds, ranked on the previous year's returns – and was able to document a momentum effect where past mutual funds performances continued for a year. In the housing context the momentum factor has been largely overlooked, except for Case, Cotter and Gabriel (2011) who fail to find any significant relationship. We include the momentum factor in order to compare our results to Case, Cotter and Gabriel and because it has been shown to have a significant positive effect on returns for real estate investment trusts (Chui, Titman and Wei, 2003, Brounen et al., 2008).

Finally, it is important to note that it would be practically impossible for any investor to replicate the SMB, HML and momentum portfolios since it would require buying a portfolio of houses in several regions. The rationale for including them is instead that the portfolio construction provides a good framework for testing whether there, similar to equities, exist additional risk factors that are priced.

3.3 Micro- and macroeconomic control variables

In equity pricing theory, it is generally acknowledged that a set of state variables drive systematic risk. Chen et al. (1986) identified a number of such variables, which later became the classic arbitrage pricing theory (APT) factors. Analogously, a number of macroeconomic variables have been recognized to drive the variation in aggregate housing markets. Therefore, we include a number of macroeconomic variables as a final control for the H-CAPM. Since idiosyncratic risk reasonably can be expected to be priced in the housing market, we also include two fundamental supply and demand variables at the municipal level. The intuition for including these micro- and macroeconomic variables is to directly target risk factors that have been shown to affect the housing market. Below we outline the theoretical rationale for including each control variable.

3.3.1 Housing supply

Different measures of the housing stock or construction activity are commonly included in housing models. Given no changes in demand, a higher supply of housing should lead to a decrease in price. Abelson et al. (2005) show that an increase in housing stock per capita has a significant negative impact on prices. However, using housing starts instead of the housing stock, Case and Shiller (1990) do not find any significant relationship.

3.3.2 Population

Demographic compositions of different age groups have been shown to have a significant effect on house prices. An increase in the population should exert an upward push in the demand for housing units. Mankiw and Weil (1989) document a significant effect of population growth on house prices and finds that there is a substantial jump in the demand for housing between the ages of 20 and 30. Demand for housing then declines after the age of 40 by approximately one percent per year. Similarly to Mankiw and Weil, Berg (1996) shows in a study on the Swedish housing market that changes in the ratio of people aged 20-44 put upward pressure on house prices, while the age group 45-64 put a downward pressure on house prices. Noteworthy, however, several papers have contrary to the above studies found insignificant or negative effects of population growth on house prices (Hort 1998, Engelhardt and Poterba, 1991). Despite the ambiguous results, we believe that the factor is relevant and thus choose to include it in the control models.

3.3.3 GDP

GDP is a good indicator of the state of the economy and households' income, and as such should provide a good proxy for the demand for housing. Égert and Mihajlek (2007) find that GDP per capita, among other variables, explain house price fluctuations well in eight Central European and Eastern European regions and 19 OECD countries. In a stylized overview of the Swedish housing market in an international perspective, Englund (2011) notes that most international house price studies find a positive relationship between house prices and GDP.

3.3.4 Mortgage rates

Mortgage rates are an important macroeconomic component that affects house prices. Since a majority of housing investments are made with leverage, real house prices should decrease as an effect of rising real mortgage rates. Claussen et al. (2011) show that much of the fluctuations in real Swedish house prices between 1986 and 2010 are attributable to changes in the average after tax real mortgage rate. Girouard et al. (2006) summarize the results of several international housing papers and conclude that all of them find a significant negative effect of real interest rates or mortgage rates on house prices.

3.3.5 Income

Since the level of disposable income is an integral part of housing consumption, it is an important factor determining the demand for housing services (Englund, 2011). Claussen et al. (2011) find that higher real disposable income has a significant positive impact on house prices in the Swedish housing market. Moreover, Girouard et al. (2006) note that several international studies support that real disposable income has a positive effect in explaining house price fluctuations.

4. Method

In order to test the H-CAPM empirically, we divide the analysis into several steps. First we employ a set of time-series regressions, whereby the municipal house price returns are regressed on the two market portfolio proxies. Then, we augment the model by including different sets of risk-factor control variables and micro- and macroeconomic control variables. Finally, we proceed to validate a potential risk-return relationship in the cross-section by implementing the commonly used Fama-MacBeth (1973) two-step procedure.

4.1 H-CAPM

We begin by applying the basic H-CAPM model, where the municipal house price returns are regressed on an aggregate national housing market portfolio:

$$(1)\ R_{i,t}^{Mun} = \alpha_i + \beta_i R_t^{Hmkt} + \varepsilon_{i,t}$$

Where:

$R_{i,t}^{Mun}$ is the real excess house price return, including dividend, over the risk-free rate, in municipality i, at time t.

R_t^{Hmkt} is the real excess return, including dividend, of a value-weighted national housing market portfolio over the risk-free rate at time t.

Thereafter, we apply the traditional CAPM framework, where municipal house price returns are regressed on a stock market return index, which is the commonly used proxy for the market portfolio.

(2) $R_{i,t}^{Mun} = \alpha_i + \beta_i R_t^{Smkt} + \varepsilon_{i,t}$

Where:

R_t^{Smkt} denotes the real excess return of a value-weighted stock market portfolio over the risk-free rate at time t.

4.2 Risk factor control models

We augment the H-CAPM model by separately adding the risk factor variables to regression (1). Finally, we include all independent variables from regressions (3)-(6) in regression (7):

(3) $R_{i,t}^{Mun} = \alpha_i + \beta_i R_t^{Hmkt} + \delta_i s_{i,t} + \varepsilon_{i,t}$

(4) $R_{i,t}^{Mun} = \alpha_i + \beta_i R_t^{Hmkt} + \delta_i SMB_t + \varepsilon_{i,t}$

(5) $R_{i,t}^{Mun} = \alpha_i + \beta_i R_t^{Hmkt} + \delta_i HML_t + \varepsilon_{i,t}$

(6) $R_{i,t}^{Mun} = \alpha_i + \beta_i R_t^{Hmkt} + \delta_i PR1YR_t + \varepsilon_{i,t}$

(7) $R_{i,t}^{Mun} = \alpha_i + \beta_i R_t^{Hmkt} + \delta_{1,i} s_{i,t} + \delta_{2,i} SMB_t + \delta_{3,i} HML_t + \delta_{4,i} PR1YR_t + \varepsilon_{i,t}$

Where:

$s_{i,t}$ is idiosyncratic risk, defined as the absolute value of the residuals from regression (1) for municipality i, at time t.

SMB_t is the equal-weighted average real excess return difference, at time t, between the top 30 percent and the bottom 30 percent of municipalities, ranked on the average purchase price at time t-1.

HML_t is the equal-weighted average real excess return difference, at time t, between the top 30 percent and the bottom 30 percent of municipalities, ranked on the average unadjusted ratio of the purchase price to the assessed value at time t-1.

$\mathrm{PR1Y}_t$ is the momentum factor comprising the equal-weighted average real excess return difference, at time t, between the top 10 percent and the bottom 10 percent municipalities, ranked on the returns at time t-1.

4.3 Micro- and macroeconomic control models

We proceed to augment the model further and include the micro- and macroeconomic control variables separately to regression (1). Then we include all independent variables from regression (8)-(12) in regression (13). In a final step, we include all independent variables from regression (7) and (13) in regression (14):

$$(8)\ R_{i,t}^{Mun} = \alpha_i + \beta_i R_t^{Hmkt} + \delta_i \log(\mathrm{Houses})_{i,t} + \varepsilon_{i,t}$$

$$(9)\ R_{i,t}^{Mun} = \alpha_i + \beta_i R_t^{Hmkt} + \delta_i \Delta \mathrm{Pop}_{i,t} + \varepsilon_{i,t}$$

$$(10)\ R_{i,t}^{Mun} = \alpha_i + \beta_i R_t^{Hmkt} + \delta_i \Delta \mathrm{GDP}_t + \varepsilon_{i,t}$$

$$(11)\ R_{i,t}^{Mun} = \alpha_i + \beta_i R_t^{Hmkt} + \delta_i r_t^{Mortgage} + \varepsilon_{i,t}$$

$$(12)\ R_{i,t}^{Mun} = \alpha_i + \beta_i R_t^{Hmkt} + \delta_i \Delta \mathrm{Inc}_t + \varepsilon_{i,t}$$

$$(13)\ R_{i,t}^{Mun} = \alpha_i + \beta_i R_t^{Hmkt} + \delta_{1,i} \log(\mathrm{Houses})_{i,t} + \delta_{2,i} \Delta \mathrm{Pop}_{i,t} + \delta_{3,i} \Delta \mathrm{GDP}_t + \delta_{4,i} r_t^{Mortgage} + \delta_{5,i} \Delta \mathrm{Inc}_t + \varepsilon_{i,t}$$

$$(14)\ R_{i,t}^{Mun} = \alpha_i + \beta_i R_t^{Hmkt} + \delta_{1,i} s_{i,t} + \delta_{2,i} \mathrm{SMB}_t + \delta_{3,i} \mathrm{HML}_t + \delta_{4,i} \mathrm{PR1YR}_t + \delta_{5,i} \log(\mathrm{Houses})_{i,t} + \delta_{6,i} \Delta \mathrm{Pop}_{i,t} + \delta_{7,i} \Delta \mathrm{GDP}_t + \delta_{8,i} r_t^{Mortgage} + \delta_{9,i} \Delta \mathrm{Inc}_t + \varepsilon_{i,t}$$

Where:

$\log(\mathrm{Houses})_{i,t}$ is the logarithm of the number of completed houses and apartments in municipality i at time t.

$\Delta \mathrm{Pop}_{i,t}$ denotes the population growth for people aged 20-64 in municipality i at time t.

$\Delta \mathrm{GDP}_t$ represents the real per capita GDP growth at time t.

$r_t^{mortgage}$ is the real home mortgage rate at time t.

$\Delta \mathrm{Inc}_t$ is the average work income growth for people aged 20-64 at time t.

4.4 Fama-MacBeth validity test

Since the objective of this paper is to verify a risk-return relationship in the Swedish housing market, we have to investigate the cross-sectional characteristics of the time-series regressions. In a final step of the analysis, we therefore investigate the risk-return relationship between municipal returns and the housing market portfolio by applying the Fama-MacBeth (1973) two-step procedure. In order to avoid the error-in-variables problem, but still keep a large dispersion in the data, it is common to create portfolios on ranked individual betas. However, it has been shown that such a grouping procedure may introduce a bias since positive and negative sampling errors tend to cluster and thus even each other out. A solution to this has been to use beta estimates from individual assets from one period to create portfolios, and then use data from a subsequent period to estimate portfolio betas (Fama and MacBeth, 1973, Black, Jensen and Scholes, 1972). Whereas the cross-sectional width of our data set allows for the creation of portfolios, the limited number of time series observations (N=28) would leave too few degrees of freedom if the periods are sub-divided. Inevitably, this would weaken the ability to make inference. Thus, we choose not to create portfolios and use the whole time period to estimate the asset pricing model coefficients. We then apply the Fama-MacBeth two-step procedure on the entire time span as well.[8] The regression equations are as follows:

First, betas are obtained from re-running regression (1):

$$(1)\ R_{i,t}^{Mun} = \alpha_i + \beta_i R_t^{Hmkt} + \varepsilon_{i,t}$$

Then, the stored beta coefficients are included as independent variables in the two-step procedure:

$$(15)\ R_{i,t}^{Mun} = \gamma_{0,t} + \gamma_{1,t}\beta_i + \varepsilon_{i,t}$$

Finally, as mentioned in the theoretical framework, the root mean square error (RMSE) is used as proxy for idiosyncratic risk, and we therefore include it in regression (15):

$$(16)\ R_{i,t}^{Mun} = \gamma_{0,t} + \gamma_{1,t}\beta_i + \gamma_{2,t}S_i + \varepsilon_{i,t}$$

Where:

S_i is the root mean square error for municipality i from time series regression (1).

5. Data

Our study is performed on annual data for the period between 1982 and 2009 – the longest available data set given our cross-sectional width. The average annualized three month Swedish

[8] More specifically, we use the XTFMB command in STATA. In the first step, a cross-sectional regression is performed for each single period. Then, in the following step, the final coefficient estimates are calculated as the mean of the first step coefficient estimates.

Treasury Bill, obtained from DataStream, is used as the risk free rate in order to calculate excess returns. The CPI, obtained from Statistics Sweden, is used in order to deflate nominal variables to real.

As stated in the theoretical framework, the returns to owning housing can be decomposed into capital gains in the form of price appreciation and dividends received from not having to rent. Data for capital gains is obtained from house price indices.[9] Since house price indices on the municipal level are not available we construct our own using the development of the average K/T ratio (purchase price to assessed value). For each municipality, the average annual K/T-ratio data is retrieved from Statistics Sweden for sold one- and two-dwelling houses used for permanent living. Due to readjustments of the assessed values on several occasions, we chain the K/T-ratios to the base year's assessed value in order to construct the final indices. The original data set contains 290 municipalities but is reduced to 238 after excluding series with missing data or fewer than 30 transactions per year. For the housing market proxy we use Statistics Sweden's real estate price index (FASTPI) for one- or two-dwelling houses for permanent living. Data for the second component of house price returns, dividends, is not possible to estimate on municipal level. Therefore the same national annual dividend is applied to both the aggregate housing market portfolio and all municipalities. The annual national dividend is obtained from a series of computations.[10] First, a gross dividend yield is imputed based on data from Statistics Sweden on the development of a rent-to-house index over time. The original series is a CPI index, but by chaining it to an estimate of the dividend yield in 2008 we get the development of the actual gross yield over the period. Then, estimates for maintenance cost, depreciation and property tax are subtracted from the gross yield each year in order to obtain the net dividend yield. The total returns for the FASTPI and municipality indices are then calculated by adding the national dividend yield in each year. In a final step, the total returns are deflated by CPI to get real total returns.[11]

For the all-equity market proxy, stock market returns including dividends are not available for the whole time period of our study and we therefore use stock returns excluding dividends. The data for the period 1982-2006 is obtained from the Central Bank of Sweden and consists of a general

[9] Several studies attest to the difficulty in estimating house price indices. The measurement problems occur mainly due to heterogeneity in attributes and infrequent trades. According to Eurostat (2010), there are four main methods for calculating house price indices: stratification, the repeat sales method, hedonic regression methods, and the use of property assessment information. The property assessment information method was used by Statistics Sweden prior to 1986 and is the method we employ when calculating municipal house price indices. See Appendix B for further information on the construction of the municipal house price indices.

[10] Appendix B provides an extensive overview on how the national level dividend is calculated.

[11] More specifically, our real house price returns are calculated as $R_t = [(P_{t+1} - P_t + d_{t+1})/P_t] * CPI_{t-1}/CPI_t$, where R_t is the house price return at time t, P_{t+1} is a house price index at time t+1, d_{t+1} is the implied dividend received by not having to rent, at time t+1 and CPI_t is the consumer price index at time t.

index of Swedish stocks. We extend the time series to 2009 using the OMX AFV General Index, which is available from Affärsvärlden. Housing supply is measured as the number of completed houses and apartments using municipal level data from Statistics Sweden. The growth in population between the ages of 20 and 64 is also retrieved from Statistics Sweden. The home mortgage rate is measured using the five year middle mortgage rate for the period 1986-2009, and is downloaded from DataStream. To extend our series back to 1982 we use an extrapolation method whereby the mortgage rates are regressed on the rates of 10 year government bonds, available from the Central Bank of Sweden.[12] Finally, per capita real disposable income is proxied by the average work income growth for full time employees, aged 20-64, using data from Statistics Sweden. Per capita GDP is also available from Statistics Sweden.

The SMB factor is calculated as the equal-weighted average real excess return difference between the top 30 percent minus the bottom 30 percent of municipalities, ranked on the previous year's average purchase price. The HML factor is constructed by taking the equal-weighted average real excess return difference between the top 30 percent minus the bottom 30 percent of municipalities, ranked on the previous year's average K/T-ratios. The momentum factor, PR1Y, is calculated as the equal-weighted average excess return difference between the top 10 percent minus the bottom 10 percent of municipalities, ranked on the previous year's returns.

The data used in the empirical study is considered to be reliable, since it is obtained from large and neutral institutions such as Statistics Sweden and the Central Bank of Sweden. Appendix B further provides an extensive description of the methodology employed and assumptions made in order to construct the municipal indices as well as the national level dividend.

6. Empirical results

Table A.1 provides descriptive statistics for the data used in the empirical study. The average of average municipal real excess returns is lower than the housing market portfolio's average real excess return. The reason for this discrepancy lies in the fact that the housing market returns are based on a value-weighted index, where metropolitan areas with higher returns, such as Gothenburg, Malmoe, and Stockholm are given more weight. Thus, the average real excess return is higher for the housing market portfolio. Notably, the real excess return of the housing market portfolio is 6.33% compared to 8.62% for the stock market portfolio. Recall, however, that the housing market returns include dividends, whereas the stock market returns do not. The housing market portfolio is furthermore considerably less volatile than the stock market portfolio (7.86% compared to 27.77%). The SMB and HML are, both positive on average. The momentum factor,

[12] The regression has an R^2 of 0.95, and is thus a good method of extrapolating the series.

PR1Y, is negative at -1.19%, and thus appears to exhibit a reversal pattern. Per capita GDP growth, the risk free rate, and mortgage rates, all reasonable figures, whereas average real work income growth surprisingly is negative at -1.77%. Population growth is further quite modest at an annual municipal average of 0.32%.

The correlation matrix of the national level variables in Table A.2 provides some interesting preliminary observations. As expected, the stock market's correlation with the housing market portfolio is limited at 0.134. The housing market portfolio is further positively correlated with real per capita GDP growth and real average work income growth, whereas it is negatively correlated with real mortgage rates and the real interest rate. Finally, the risk factors of SMB, HML, and momentum are highly correlated with each other, and with the housing market portfolio. This might indicate that they essentially capture the same type of risk exposure.

Presented in Table A.3 are the results for the two basic CAPM models, the augmented risk factor control models and the micro- and macroeconomic control models. The number of significant municipalities at the 5 % level is given within brackets. Observe that the estimates of the coefficients are averages across all municipalities. The reader should therefore be cautions when drawing specific conclusions from the reported results. They do however provide a good overall picture of the statistical significance for the different variables.

In model (1), where national house price returns are used as the market portfolio, all 238 municipalities have significant coefficients. The average beta value is 0.865, with minimum and maximum values of 0.333 and 1.374 respectively. The adjusted R^2 is fairly high at 0.631 on average and only three intercepts are significantly different from zero.[13] Figure A.5 and Figure A.6 depict two Swedish maps of the geographical dispersion of housing betas and adjusted R^2s respectively, where the values are sorted into quintiles. It is evident from Figure A.5 that the three big metropolitan areas of Gothenburg, Malmoe, and Stockholm have the highest housing betas, whereas the northern parts of Sweden have the lowest betas. By looking at both Figure A.5 and Figure A.6, municipalities with high betas seem to be coupled with high adjusted R^2s and municipalities with low betas appear to experience low adjusted R^2s. This is further supported by Figure A.2 where every tenth percent municipality, ranked on betas, is plotted with its corresponding beta, 95 percent beta confidence interval and adjusted R^2. As is evident, there is a clear trend where betas and the adjusted R^2s follow each other closely. More specifically, the correlation between betas and adjusted R^2s from regression (1) is 0.719.

[13] Since house prices are generally acknowledged to be inert, we also included one lag of municipal house price returns in regression (1). All 238 municipalities were still significant in that specification with very similar adjusted R^2 and housing beta distributions.

When replacing the housing market portfolio with the stock market portfolio as proxy for systematic risk in model (2), it is notable that not a single beta coefficient is significant but that 229 intercepts are significant. Furthermore, the adjusted R^2 drops dramatically to an average of 0.017.

Moving on to the risk factor control models, we note that in model (3), where idiosyncratic risk is included, the housing market portfolio remains statistically significant in all municipalities, while the coefficients for idiosyncratic risk only are significant in 15 municipalities. The average coefficient is further positive at 0.189. The adjusted R^2 does not increase by much in model (3) compared to model (1).

In models (4), (5) and (6), the explanatory power of the SMB, HML and momentum risk factors are tested separately. Interestingly, 63 of 238 municipalities generate significant coefficients for the SMB factor. The HML and momentum factors are less significant than SMB, with significant coefficients in 31 and 39 municipalities respectively. Overall, the housing market portfolio remains robust to the inclusion of the SMB, HML, and momentum factors in models (4)-(6), and is significant in all 238 municipalities. The average adjusted R^2 increases to 0.655 and 0.640 respectively in model (4) and (5). In model (6), however, the adjusted R^2 drops slightly to an average of 0.622.[14]

In the final risk factor control model (7), we test the housing market portfolio's robustness to the inclusion of all risk factors. The housing betas are significant in 236 cases. While the results for idiosyncratic risk are fairly the same, SMB, HML and momentum are significant in 51, 30, and 22 municipalities respectively. The sign and magnitude of the coefficients further remain at approximately the same level, but HML experiences a reversal of its sign and turns positive.

In the augmented micro- and macroeconomic control models (8)-(12), each control variable is separately added to H-CAPM model (1). Throughout these tests, average housing market betas remain in the span of 0.84-0.94. The microeconomic control variables of the logarithm of completed houses and apartments as well as population growth are significant in 12 and 26 cases respectively.[15] The macroeconomic variables of per capita real GDP growth, real mortgage rates and average worker real income growth exert a significant impact on 46, 23 and 26 municipalities respectively. Finally, the housing market portfolio is robust throughout regressions (8) to (12) and

[14] We tested several compositions of the SMB, HML, and momentum factors. More specifically we tested compositions whereby the real excess return difference between the top and bottom 10, 25, 30 and 50 respectively were calculated. The results were statistically very similar and are thus not presented in the paper.

[15] We also tested for the effect of the total population growth, separated population growth into two variables comprising people aged 20-44 and 45-64 respectively, as well as included up to three lags of each variable. The empirical results are robust to all those formations of the population variable.

drops at most to 231 significant cases. Compared to model (1), the average adjusted R^2 increases only slightly to, at most, 0.639 in model (10).

In model (13), where all micro- and macroeconomic control variables are included, the number of municipalities with significant coefficients drops for all variables. The housing market portfolio is still significant in 186 cases. The average adjusted R^2 increases only slightly to 0.637, compared to model (1).

All independent variables, except the stock market portfolio, are included in regression (14). Despite the inclusion of all these variables, the housing market portfolio still exerts a significant positive impact on 174 municipalities. Apart from the housing market portfolio, none of the other variables are particularly significant, with the SMB factor exhibiting the highest number of significant coefficients in only 34 municipalities. Furthermore, the average adjusted R^2, in model (14) compared to model (1), only increases from 0.631 to 0.641.

In the final step of the analysis, we test the validity of the H-CAPM model by implementing a variation of the Fama-MacBeth (1973) procedure in regression (15) and (16). The results are reported in Table A.4 and indicate that the average intercept from regression (15) is not significantly different from zero. Furthermore the average coefficients for the beta imply that, an increase in beta from zero to one yield an increase in excess real returns by 5.846%. The results can further be illustratively understood by looking at Figure A.4, where average municipal returns are plotted against their corresponding housing betas from regression (1). Note that the red dotted line is a reference line drawn from origo. Housing betas are dispersed and quite evenly distributed along the line, indicating a strong risk-return relationship between housing betas and municipal house price returns. Lastly, regression (16) further reinforces the insignificant results for idiosyncratic risk from the time-series regressions, with an average root mean square errors coefficient of -0.080. Moreover, the intercept remains insignificantly different from zero and the average coefficient for housing betas is significant at 5.744%.

7. Discussion

7.1 Results

Corroborating the results of several other papers, we do not find any significant relationship between regional house price returns and the stock market. Although not a single municipal regression produced significant coefficients, most had significant positive intercepts. Theoretically, if the stock market proxies for systematic risk, this would mean that housing offers substantial premiums. Still, we believe that the most plausible interpretation for the results is that all-equity indices are inadequate market portfolio proxies. The results thus support our choice of the aggregate housing market index as a proxy for systematic risk.

Similar to Case, Cotter and Gabriel's (2011) results, we find that the national market factor is highly significant in explaining returns on the municipal level. The Fama-MacBeth regressions furthermore give strong support for the H-CAPM model and indicate that there is a linear relationship between municipal house price returns and their covariance with the aggregate housing market. First, we cannot reject that the intercept is significantly different from zero, which it theoretically should be. Secondly, the slope coefficient from our Fama-MacBeth regression – which should represent the market portfolio's risk premium – is close to the true housing market portfolio's excess return. More specifically, the coefficient is 5.846%, compared to the housing market portfolio's average real excess return for 1982-2009 of 6.334%.

Another interesting observation that emerges when analyzing the results is the apparent relationship between adjusted R^2s and betas from regression (1). As is evident by looking at Figure A.2, as well as Figure A.5 and A.6 there seems to be a clear trend where higher betas are coupled with higher model explanatory power, and low betas are coupled with lower model explanatory power. There is not a clear cut explanation for this pattern. Since housing is both a consumption good and an investment simultaneously, one theory could be that in northern areas with low adjusted R^2 the consumption part plays a more significant role – in other words, housing is not seen as an investment to the same extent. Conversely, in metropolitan areas with high adjusted R^2 speculative behavior among households might be more relevant.

Furthermore, the H-CAPM model appears to be robust to the inclusion of common risk factors from the equity pricing literature, as well as to the inclusion of the micro- and macroeconomic control variables. This is supported by the time-series regressions, where the increase of the adjusted R^2 is small throughout model (3) to (14), implying that apart from the housing market portfolio, other risk factors do not add much to explaining municipal house price returns.

The insignificant results for idiosyncratic risk are in line with Case, Cotter and Gabriel's (2011) results but not with Cannon et al.'s (2006). This is further verified by looking at Figure A.3 and Figure A.4. In Figure A.3 there is substantial variation in the risk-return relationship, whereby some municipalities have considerably higher sharpe ratios (excess real return over standard deviation) than others indicating that municipal idiosyncratic risk exists. Turning to Figure A.4, we note that overall only systematic risk is priced. At first, it may be surprising that idiosyncratic risk is not priced since a majority of households are unable to diversify housing risk and thus could be expected to require compensation for non-systematic risk too. The results do not necessarily question this, but simply imply that idiosyncratic risk is not priced at the municipal level and relative to the national housing market portfolio. Non-systematic risk may, however, be priced on a lower level, e.g. ZIP codes or individual houses.

Moreover, the SMB, HML, and momentum factors are not significant either, indicating that these risk factors are not priced in the housing market at the municipal level. Thus, there doesn't seem to be any analogy for value stocks or growth stocks in the housing market. Neither is there any equivalent to the momentum factor, which is surprising given the annual first-order serial correlation that has been documented in house price returns.

Finally, the inclusion of micro- and macroeconomic variables indicate that they do not have any explanatory power in excess of the aggregate housing market portfolio. The implication of the poor explanatory power of these variables for the H-CAPM model is thus: (i) Per capita GDP growth, mortgage rates, average work income growth, population growth and completed houses and apartments do not exert any impact on municipal house price returns in excess of the housing market portfolio. (ii) The insignificant results for the local supply and demand factors of population growth and completed houses and apartments support the insignificant findings for idiosyncratic risk. Thus, they do not capture local risk.

In conclusion, according to our initial hypothesis, the results from testing the H-CAPM model empirically suggest that mainly systematic risk, as specified by the aggregate housing market, is priced at the municipal level. That is, investors are not compensated for bearing idiosyncratic risk, nor do other risk factors or micro- and macroeconomic variables exert explanatory power. Moreover, the substantial cross-sectional variation of the betas and the level of idiosyncratic risk shed interesting light on the dispersion of risk exposure that households across Swedish municipalities face. Since households to a large extent only own a single house, it is surprising that only systematic risk is priced.

7.2 Robustness

A natural first step in testing the robustness of the H-CAPM is to question the validity of the aggregate housing market portfolio as proxy for systematic risk. As previously noted, betas and adjusted R^2s are positively correlated. Another explanation to our theory that the dispersion in model fit reflects different degrees of speculative behavior, is that metropolitan areas with higher betas comprise a larger part of the value-weighted housing market index. As such, they will naturally be more correlated with it. In the theoretical framework of the CAPM, each asset practically comprises a very small fraction of the market portfolio. It is therefore interesting to see if the results still are robust for formations of the market portfolio whereby areas close to a municipality are excluded from the market portfolio. We therefore begin by testing the H-CAPM's robustness for two alternative market portfolios. The first alternative is a county market portfolio and includes regressing municipal house price returns, in a given county, on a market portfolio proxy comprising the value-weighted house price returns of all other counties.[16] The second alternative is a metropolitan/non-metropolitan market portfolio and includes regressing each municipality in the largest metropolitan counties (Stockholm, Gothenburg and Malmoe) on a market portfolio proxy comprising the value-weighted house price returns of all non-metropolitan counties. Conversely, non-metropolitan municipalities are regressed on an index consisting of only metropolitan counties.[17] The results are presented in Table A.6 and are very similar to our basic H-CAPM model. Our conclusion is therefore that the national housing market portfolio, used in the basic model, is robust to the value-weighting issues mentioned above.

We proceed our robustness test by trying to create a portfolio that better reflects the market portfolio in terms of asset class distribution. We do this by constructing a value-weighted index of the aggregate housing market portfolio and the stock market portfolio from regression (1) and (2) respectively. The weights are constant for the whole period and are equal to 50.1 % in equities and 49.9% in housing (based on OECD data for average household wealth between 1995 and 2006). The results are discouraging: only 12 out of 238 municipality beta coefficients are significant. The implications of the weighted portfolio results are either that the portfolio is wrongly specified, that the H-CAPM is rejected, or that the housing market is segmented from the equity markets. If the last case is true, it means that an all-housing market portfolio should be used as suggested by our basic H-CAPM model.

A next step in analyzing the robustness of our results is to briefly comment on the assumptions and calculations made in order to obtain the house price returns (see Appendix B for an extensive overview). Although the empirical results support the H-CAPM model, it should be noted that the results are sensitive to the construction of our own municipal house price indices, as well as the assumptions related to the national dividend. Table B.2 adds comfort to our municipal K/T-ratio index, which on an aggregate level closely follows Statistics Sweden's FASTPI index. The dividend is calculated on the national level, and we therefore fail to take into account regional variations of dividends. However, this should be of fairly limited importance since dividends fluctuate much less than capital gains, and as such do not affect the variation in total returns to the same extent.

[16] There are 21 counties in Sweden. Each municipality belongs to a county.
[17] The 21 county market portfolios, as well as the two metropolitan/non-metropolitan market portfolios are calculated by aggregating the K/T-ratio indices using the same method as described in Figure B.2.

Furthermore, we believe that our model is well specified since it follows common practice in the equity- and housing literature. Ideally, we would like to have made extensive tests for autocorrelation, but since it is out of the scope of this paper it has been left out.

Some suggestions for further research include creating market portfolio proxies consisting of several asset classes. In addition, it would be interesting to implement an asset pricing model at a lower, e.g. ZIP-code level. The H-CAPM model could also be expanded or modified with other risk factors and micro- and macroeconomic control variables. A final suggestion is to include condominiums in addition to single dwellings, even though such data is not available for an extended time period in Sweden.

8. Conclusion and implications

This paper investigates the risk-return relationship in the Swedish housing market by testing a housing capital asset pricing model (H-CAPM) on municipal level data. The model is a modification of the traditional CAPM in that the aggregate Swedish housing market is used as proxy for systematic risk. The H-CAPM is further controlled for the inclusion of idiosyncratic risk and housing equivalents of the SMB, HML and momentum factors, as well as a set of common micro- and macroeconomic variables. The time-series and cross-sectional regression results support the single-factor H-CAPM model, and that there is a strong relationship between municipal house price returns and their covariance with the aggregate national housing market portfolio. There is further substantial variation across municipalities with housing betas ranging from 0.33 to 1.37. The Fama-MacBeth regressions indicate that an increase in beta of 0.5 is compensated by an increase in the annual real excess house price return of 2.92%.

The results from the H-CAPM model quantify in an intuitive way the systematic risk exposure that different municipalities bear in relation to the aggregate housing market. The results also indicate that investors are not compensated for idiosyncratic risk at the municipal level, despite the fact that households in practice cannot diversify their housing investments. The findings in this paper may thus be useful for households when forming investment portfolios or deciding on the level of leverage, as well as institutions interested in developing housing derivatives for hedging purposes. Moreover, the results are of interest to central banks, municipalities and other policy makers that are concerned with the level of risk exposure that Swedish households are subject to.

References

Abelson, P., Joyeux, J., Milunovich, G. and Chung, D. (2005), "Explaining house prices in Australia: 1970-2003", *Economic Record*, Vol. 81, pp. 96-103.

Anderson, C.W. and Beracha, E. (2010), "Home Price Sensitivity to Capital Market Factors: Analysis of ZIP Code Data", *Journal of Real Estate Research*, Vol. 32, No. 2, pp.161-185.

Bali, T.G., Cakici, N., Yan, X. and Zhang, Z. (2004), "Does idiosyncratic risk really matter?", *Journal of Finance*, Vol. 60, No. 2, pp. 905–929.

Barry, P.J. (1980), "Capital Asset Pricing and Farm Real Estate", *American Journal of Agricultural Economics*, Vol. 62, No. 3, pp. 549-553.

Bartholdy, J. and Peare, P. (2004), "Estimation of expected return: CAPM vs. Fama and French", *International Review of Financial Analysis*, Vol. 14, No. 4, pp. 407-427.

Berg, L. (1996), *Age distribution, saving and consumption in Sweden*. Unpublished paper, Department of Economics, Uppsala University.

Black, F., Jensen, M.C. and Scholes, M.S. (1972), "The Capital Asset Pricing Model: Some Empirical Tests", Jensen, M. (red.), *in Studies in the theory of capital markets*. New York: Praeger Publishers Inc, pp. 79-121.

Bostadskreditnämnden (2008), *Bostaden – en riskfylld tillgång. Marknadsrapport, december 2008*

Bostadskreditnämnden (2009), *Vad bestämmer priset på bostäder?. Marknadsrapport, oktober 2009*

Bourassa S., Hoesli, M. and Sun, J. (2006), "A simple alternative house price index method", *Journal of Housing Economics*, Vol. 15, Vol. 1, pp. 80-97.

Brounen D., Derwall, J., Huij, J. and Marquering, W. (2008), *Do REIT-Fundmanagers Really Perform Better?*. Unpublished paper. Erasmus University, Netherlands.

Campbell, J. (1996), "Understanding Risk and Return", *Journal of Political Economy*, Vol. 104, No. 2, pp. 298-345.

Cannon, S., Miller, N.G. and Pandher, G.S. (2006), "Risk and Return in the U.S Housing Market A cross-Sectional Asset-Pricing Approach", *Real Estate Economics*, Vol. 34, No. 4, pp. 519-552.

Carhart, M.M. (1997), "On Persistence in Mutual Fund Performance", *Journal of Finance*, Vol. 52, No. 1, pp. 57-82.

Case, K and Shiller, R. (1988), "The behavior of home buyers in boom and post-boom markets", *NBER Working Paper 2748, National Bureau of Economic Research*.

Case, K. and Shiller, R. (1990), "Forecasting Prices and Excess Returns in the Housing Market" *Journal of the American Real Estate and Urban Economics Association*, Vol. 18, No., pp. 253–273.

Case, K. and Shiller, R. (2003), "Is There a Bubble in the Housing Market?" *Brookings Papers on Economic Activity*, Vol. 34, No.2, pp. 299-362.

Case, K., Cotter, J. and Gabriel, S. (2011), *Housing Risk and Return: Evidence From a Housing Asset-Pricing Model.* Working Papers 201104, Geary Institute, University College Dublin.

Case, K., Quigley, J., and Shiller, R. (2005), "Comparing Wealth Effects: The Stock Market versus the Housing Market", *Advances in Macroeconomics*, Vol. 5, No. 1, pp. 1-32.

Chan, K.C., Henderschott, P.H. and Sanders, A.B. (1990), "Risk and Return on Real Estate: Evidence from Equity REITs", *NBER Working Paper 3311, National Bureau of Economic Research*.

Chan, K.C. and Chen, N.F. (1991), "Structural and Return Characteristics of Small and Large Firms", *Journal of Finance*, Vol. 46, No. 4, pp.1467-1484.

Chen, N.F., Roll, R., and Ross, S.A. (1986), "Economic Forces and the Stock Market: Testing the APT and Alternative Asset Pricing Theories," *Journal of Business*, Vol. 59, No. 3, 383-403.

Chinloy, P. (1992), "The Returns to Holding Housing", *Journal of Housing Economics*, Vol. 2, No. 4, 310–323.

Chui, A.C.W., Titman, S. and Wei, K.C.J. (2003), "Intra-industry momentum: the case of REITs", *Journal of Financial Markets*, Vol. 6, No. 3, pp. 363-387.

Claussen, C.A., Jonsson, M. and Lagerwall, B. (2010), "A macroeconomic analysis of house prices in Sweden", Sveriges Riksbank (red.), i*n The Riksbank's inquiry into the risks in the Swedish housing market*, Stockholm: Sveriges Riksbank

Davidoff, T. (2007), *Stock prices, housing prices, housing stock prices, and fundamentals.* Working paper, University of California, Berkley.

Égert, B. and Mihajlek, D. (2007), "Determinants of House Prices in Central and Eastern Europe*", Comparative Economic Studies*, Vol. 49, No. 3, pp. 367-388.

Engelhardt G. and Poterba, J. (1991) "House prices and demographic change: Canadian Evidence", *Regional Science and Urban Economics*, Vol. 21. No. 4. - pp. 539-546.

Englund, P. (2011), "Swedish House Prices in an International Perspective", Sveriges Riksbank (red.), *in The Riksbank's inquiry into the risks in the Swedish housing market*, Stockholm: Sveriges Riksbank

Englund, P., Hwang, M. and Quigley, J.M. (2002), "Hedging Housing Risk", *Journal of Real Estate Finance and Economics*, Vol. 24, No. 1-2, pp. 167-200.

Englund P. and Ioannides, Y. (1997), "House Price Dynamics: An International Empirical Perspective", *Journal of Housing Economics*, Vol. 6, No. 2, pp. 119-136.

Eurostat (2010), *Harmonized Indices of Consumer Prices (HICPs)*. Draft Version 2.0.

Fama, E.F. and French, K.R. (1992), "The Cross-Section of Expected Stock returns", *Journal of Finance*, Vol. 47, No. 2, pp. 427-465.

Fama, E.F. and French, K.R. (1993), "Common risk factors in the returns on stocks and bonds", *Journal of Financial Economics*, Vol. 33, No. 1, pp. 3-56.

Fama, E.F. and French, K.R. (1996), ”Multifactor Explanations of Asset Pricing Anomalies”, *Journal of Finance*, Vol. 51, No. 1, pp. 55-84.

Fama, F. and MacBeth, J. (1973), “Risk, return, and equilibrium: Empirical tests”, *Journal of Political Economy*, Vol. 81, No. 3, pp. 607-636.

Girouard, N., Kennedy, M.., van den Noord, P. and André, C. (2006), “Recent house price developments: The role of fundamentals”, *OECD Economics Department Working Papers, No. 475, OECD Publishing.*

Goyal, A. and Santa-Clara, P. (2003), “Idiosyncratic risk matters!”, *Journal of Finance*, Vol. 58, No. 3, pp. 975–1008.

Hiebert, P. and Roma, M. (2010), “Relative House Price Dynamics Across Euro Areas and U.S. Cities. Convergence of Divergence?”, *European Central Bank, Working Paper Series, no. 1206*.

Hort, K (1998), “The Determinants of Urban House Price Fluctuations in Sweden 1968-1994”, *Journal of Housing Economics*, Vol. 7, No. 2, pp. 93-120.

Jagannathan, R. and McGrattan, E.R. (1995), ”The CAPM Debate”, *Federal Reserve Bank of Minneapolis Quarterly Review*, Vol. 19, No. 4, pp. 2-17.

Jud, G. D. and Winkler, D. T. (2002), “The dynamics of metropolitan housing prices”, *Journal of Real Estate Research*, Vol. 23, No. 1/2, pp. 29–45.

Levy, H. (1978), “Equilibrium in an Imperfect Market: A Constraint on the Number of Securities in a Portfolio”, *American Economic Review*, Vol. 68, No. 4, pp. 643-658.

Lintner, J. (1965), “The Valuation of Risk Assets and the Selection of Risky Investments in Stock Portfolios and Capital Budgets”, *Review of Economics and Statistics*, Vol. 47, No. 1, pp.13-37.

Malkiel, B.G. and Xu, Y. (2002), *Idiosyncratic risk and security returns.* Working paper, University of Texas, Dallas.

Mankiw, N.G. and Weil, D.N. (1989), “The Baby Boom, the Baby Bust, and the Housing Market”, *Regional Science and Urban Economics*, Vol. 19, No. 2, pp. 235-258.

Mossin, J. (1966), “Equilibrium in a Capital Asset Market”, *Econometrica*, Vol. 34, No. 4, pp. 768-783

Negro, M.D. and Otrok, C. (2007), “99 Luftballons: Monetary policy and the house price boom across U.S. states”, *Journal of Monetary Economics*, Vol. 54, No. 7, pp. 1962-1985.

Riksbanken (2011), *The Riksbank's inquiry into the risks in the Swedish housing market*, Stockholm: Sveriges Riksbank.

Roll, R. (1977), “A critique of the asset pricing theory's tests Part I: On past and potential testability of the theory”, *Journal of Financial Economics*, Vol. 4, No. 2, pp. 129-176.

Sarama, R.F.(2010), *Asset Pricing and Portfolio Choice in the Presence of Housing.* Ph.D dissertation, Ohio State University, U.S.

Sharpe, W.F. (1964), "Capital Asset Prices: A Theory of Market Equilibrium under Conditions of Risk", *Journal of Finance*, Vol. 19, No. 3, pp. 425-442.

Slacalek, J. (2009), "What Drives Personal Consumption? The Role of Housing and Financial Wealth", *B.E. Journal of Macroeconomics*, Vol. 9, No. 1.

Smith, S.J. and Searle, B.A. (2010), *The Blackwell Companion to the Economics of Housing. The Housing Wealth of Nations*. Companion to the Economics of Housing, United Kingdom: Blackwell Publishing Ltd

Statistics Sweden (1986a), *Fastighetsprisindex (FPI) – Presentation av en ny produkt. FPI 1975-1985*.

Statistics Sweden (1986b), *Fastighetsprisindex (FPI) Småhus 1:a och 2:a kvartalen 1986*. Statistiska Meddelanden P 16 SM 8605.

Wessel, P. and Jennefelt, E. (2007), *Risk and return for single family housing in Sweden*. Unpublished paper, Stockholm School of Economics.

Data sources:
Affärsvärlden, OMX Affärsvärldens Generalindex. Available online: http://bors.affarsvarlden.se/afvbors.sv/site/index/index_info.page?magic=%28cc%20%28info%20%28tab%20hist%29%29%29 [2011-05-01].

Riksbanken, Räntor och aktieavkastningar 1856–2006. Available online: http://www.riksbank.se/templates/Page.aspx?id=26806 [2011-05-01].

Statistics Sweden, Statistikdatabasen. Available online: http://www.ssd.scb.se/databaser/makro/start.asp [2011-05-01].

Thomson Reuters, Datastream [2011-05-01].

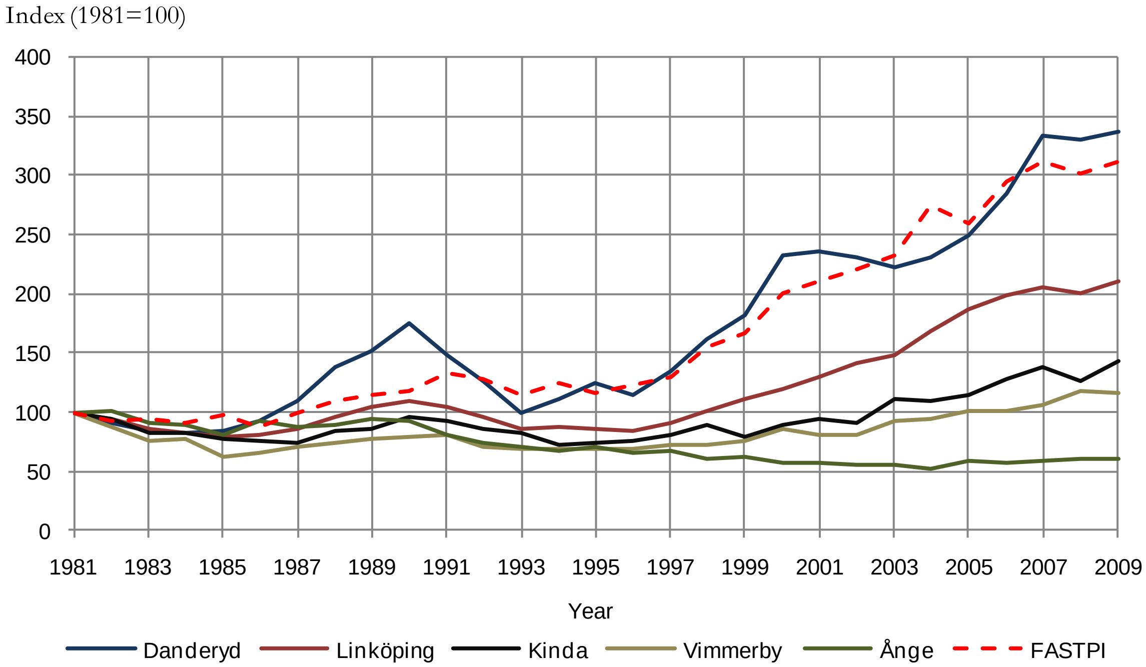
Appendix A

Table A.1: Descriptive statistics for regression variables.

	Obs.	Mean	Median	Std.	Min.	Max.	Kurt.	Skew.
Municipal level variables								
R^{Mun} (%)	6,664	5.665	6.734	8.514	-13.652	20.477	2.821	-0.416
s	6,664	3.813	3.268	2.916	0.206	11.673	3.849	0.969
log(Houses)	6,664	3.597	3.701	1.255	1.175	5.557	2.516	-0.373
ΔPop (%)	6,664	0.304	0.316	1.180	-2.245	2.477	3.263	-0.111
National level variables								
R^{Hmkt} (%)	28	6.334	8.504	7.859	-13.430	15.220	2.795	-0.825
R^{Smkt} (%)	28	8.619	11.030	27.770	-40.690	76.660	2.730	0.254
SMB (%)	28	2.324	2.042	4.149	-6.682	10.640	2.759	-0.169
HML (%)	28	0.773	-0.264	3.520	-4.529	9.039	2.290	0.450
PR1Y (%)	27	-1.194	-2.629	4.399	-7.487	8.315	2.517	0.622
ΔGDP (%)	28	1.859	3.074	2.798	-4.222	5.079	2.662	-0.963
r^{rf} (%)	28	3.432	3.263	2.227	0.409	10.550	4.725	1.084
$r^{Mortgage}$ (%)	28	5.590	5.310	2.073	1.829	9.742	2.357	0.283
ΔInc (%)	28	-1.769	-1.501	4.870	-12.470	6.098	2.439	-0.405

Descriptive statistics for data used to perform the empirical study are reported above. The statistics for municipal level variables comprise average values across municipalities. s is idiosyncratic risk, defined as the absolute value of the residuals from regression (1). log(houses) is the number of completed houses and apartments. ΔPop is defined as population growth for people aged 20-64. R^{Mun} and R^{Hmkt}, are the annual real excess returns, including dividends, over the real average annualized three-month Swedish Treasury Bill r^{rf}. R^{Smkt} is the annual real excess stock market returns, excluding dividends. SMB represents the annual equal-weighted average real excess return difference between the top 30 percent and the bottom 30 percent of municipalities, ranked on the previous year's average purchase price. HML is the annual equal-weighted average real excess return difference between the top 30 percent and the bottom 30 percent ofmunicipalities, ranked on the previous year's average unadjusted K/T-ratio. PR1Y is the annual equal-weighted average real excess return difference between the top 10 percent and the bottom 10 percent of municipalities, ranked on the previous year's returns. ΔGDP is the real per capita GDP growth. $r^{mortgage}$ represents the average annualized real five-year middle mortgage rate. ΔInc is the income growth for the average worker, aged 20-64. Nominal data is deflated to real by the Swedish CPI available from Statistics Sweden. Data for population, completed houses and apartments, and average work income is available from Statistics Sweden. Data for mortgage rates, the risk free rate and per capita GDP is available from Datastream. Stock market returns are available from Riksbanken and Affärsvärlden. The nominal house price returns are calculated as the sum of the capital gain from a house price index and a national level dividend. Data for the aggregate housing market's capital gains is calculated based on the FASTPI index, available from Statistics Sweden. Capital gains for municipalities are computed based on the development of the K/T-ratio (average purchase price to assessed value), available from Statistics Sweden. The national housing dividend is calculated as the average gross rent each year, less depreciation, property tax, and maintenance cost. The dividend is then divided by the previous year's average purchase price to obtain the net dividend yield. The number of municipalities is reduced from 290 to 238 after the exclusion of municipalities with missing data or where the number of transactions is less than 30 for any year. Note that the momentum factor comprises 27 observations, since its formed based on the previous year's returns.

Figure A.1 Yearly indices of real house prices for one- or two dwelling houses for permanent living in five selected municipalities.



The graph depicts the real house price development between 1981 and 2009, where every twentieth percent municipal real house price development is selected for presentation. The real house price index is rebased to 100 in year 1981. Nominal house prices are deflated by the CPI, available from Statistics Sweden. The FASTPI is a real estate price index for one- or two-dwelling house for permanent living, available from Statistics Sweden. Municipal house price indices are calculated based on the development of the K/T-ratio (average purchase price to assessed value). See appendix B for more details on the K/T-ratio index construction.

Table A.2: Correlation matrix for national level regression variables.

	R^{Hmkt}	R^{Smkt}	SMB	HML	PR1Y	ΔGDP	r^{rf}	$r^{Mortgage}$	ΔInc
R^{Hmkt}	1.000								
R^{Smkt}	0.134	1.000							
SMB	0.768	0.123	1.000						
HML	0.599	-0.041	0.827	1.000					
PR1Y	0.440	-0.102	0.710	0.842	1.000				
ΔGDP	0.585	0.383	0.653	0.375	0.240	1.000			
r^{rf}	-0.503	-0.041	-0.188	-0.221	-0.064	0.021	1.000		
$r^{Mortgage}$	-0.356	0.200	-0.101	-0.213	-0.088	0.131	0.875	1.000	
ΔInc	0.774	0.264	0.595	0.401	0.243	0.617	-0.143	0.054	1.000

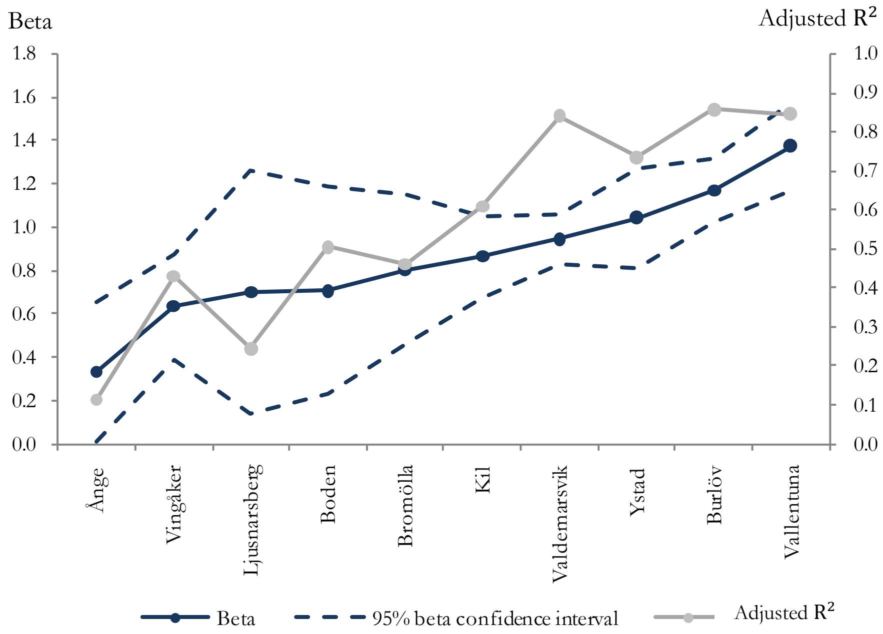
A correlation matrix for the national level variables used in the empirical study is presented above. For variable descriptions, we refer to Table A.1.

Table A.3: Basic and augmented H-CAPM time-series regressions (1)-(14).

	CAPM models		Risk-factor control models					Micro- and macroeconomic control models						
Regression no.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Intercept	0.188	5.516	-0.491	0.129	0.073	-0.053	-0.646	0.110	0.066	0.343	1.822	-0.590	1.418	-0.888
	(3)	(229)	(20)	(3)	(5)	(6)	(15)	(11)	(13)	(11)	(23)	(17)	(56)	(10)
R^{Hmkt}	0.865		0.859	0.961	0.897	0.885	0.936	0.865	0.868	0.925	0.841	0.943	0.913	0.977
	(238)		(238)	(238)	(238)	(238)	(236)	(232)	(237)	(237)	(237)	(231)	(186)	(174)
R^{Smkt}		0.017												
		(0)												
s			0.189				0.203							0.183
			(15)				(21)							(21)
SMB				-0.238			-0.244							-0.065
				(63)			(51)							(34)
HML					-0.119		0.151							0.090
					(31)		(30)							(20)
PR1Y						-0.122	-0.099							-0.155
						(39)	(22)							(16)
log(Houses)								0.021					-0.190	-0.081
								(12)					(19)	(18)
ΔPop									0.768				0.607	0.474
									(26)				(24)	(19)
ΔGDP										-0.289			-0.227	-0.186
										(46)			(27)	(19)
$r^{Mortgage}$											-0.265		-0.088	-0.007
											(23)		(9)	(5)
ΔInc												-0.159	-0.043	-0.107
												(26)	(20)	(22)
β distribution														
Mean	0.865	0.017	0.859	0.961	0.897	0.885	0.936	0.865	0.868	0.925	0.841	0.943	0.913	0.977
Median	0.834	0.015	0.825	0.957	0.883	0.874	0.933	0.875	0.838	0.927	0.801	0.963	0.913	0.966
Min	0.333	-0.062	0.337	0.534	0.468	0.421	0.544	0.140	0.327	0.283	0.313	0.099	0.913	-0.407
Max	1.374	0.100	1.371	1.368	1.378	1.318	1.330	1.427	1.540	1.312	1.475	1.642	0.913	8.353
Adj. R^2 distribution														
Mean	0.631	-0.026	0.639	0.655	0.640	0.622	0.646	0.630	0.635	0.639	0.634	0.635	0.637	0.641
Median	0.644	-0.033	0.645	0.675	0.651	0.639	0.667	0.648	0.643	0.653	0.649	0.646	0.655	0.662
Min	0.114	-0.038	0.108	0.221	0.139	0.138	0.173	0.133	0.084	0.085	0.082	0.081	0.019	0.068
Max	0.921	0.039	0.928	0.960	0.947	0.939	0.954	0.922	0.953	0.926	0.926	0.925	0.948	0.960

Reported above are the regressions results for the CAPM-models (1)-(2), risk factor control models (3)-(7), the micro- and macroeconomic control models (8)-(13), as well as model (14) that includes all independent variables except the stock market portfolio. The reported figures comprise average heteroskedasticity robust regression coefficients as well as the number of municipalities with significant coefficients at the 5% level (within brackets). Reported as well are the β and adjusted R^2 distributions for each model. For a description of the regression variables, we refer to Table A.1. Note that the inclusion of the momentum factor in regression (5), (7) and (14) requires that year 1982 is dropped since the momentum portfolio is formed based on the previous year's returns.

Figure A.2: Relationship between betas and adjusted R^2s.



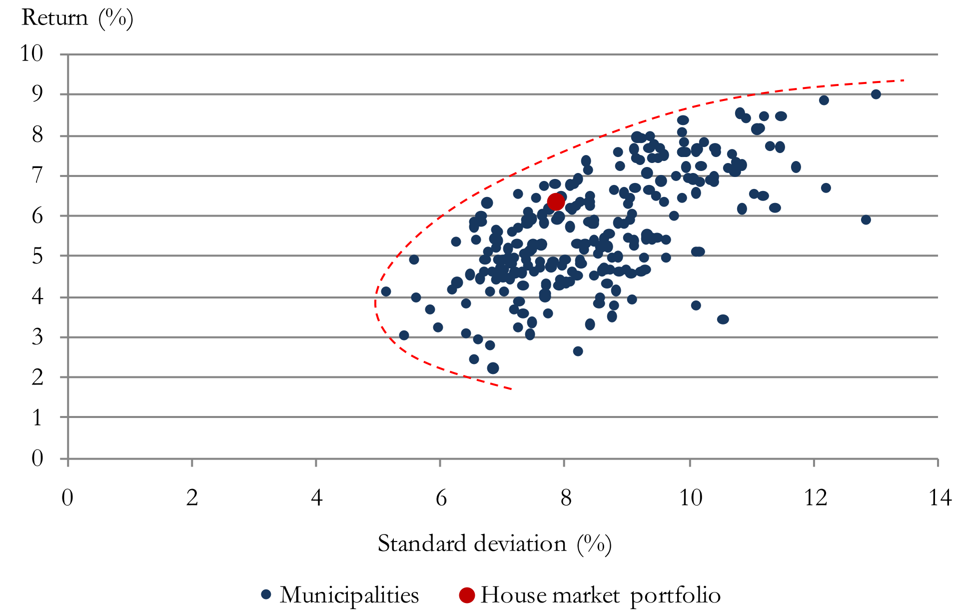
The figure plots every tenth percent municipality beta estimate from regression (1). Plotted are also the 95% confidence interval bands for the beta estimates, as well as the corresponding adjusted R^2s.

Table A.4: Fama-MacBeth two-step procedure.

	Mean	Standard error	t-statistic	p-value
	(15) $R_{i,t}^{Mun} = \gamma_{0,t} + \gamma_{1,t}\beta_i + \varepsilon_{i,t}$			
Intercept	0.610	1.078	0.570	0.577
Beta coefficient	5.846	1.843	3.170	0.004
R^2	0.169			
N	28			
	(16) $R_{i,t}^{Mun} = \gamma_{0,t} + \gamma_{1,t}\beta_i + \gamma_{2,t}S_i + \varepsilon_{i,t}$			
Intecept	1.096	1.003	1.090	0.284
Beta coefficient	5.744	1.832	3.140	0.004
RMSE coefficient	-0.080	0.064	-1.260	0.219
R^2	0.177			
N	28			

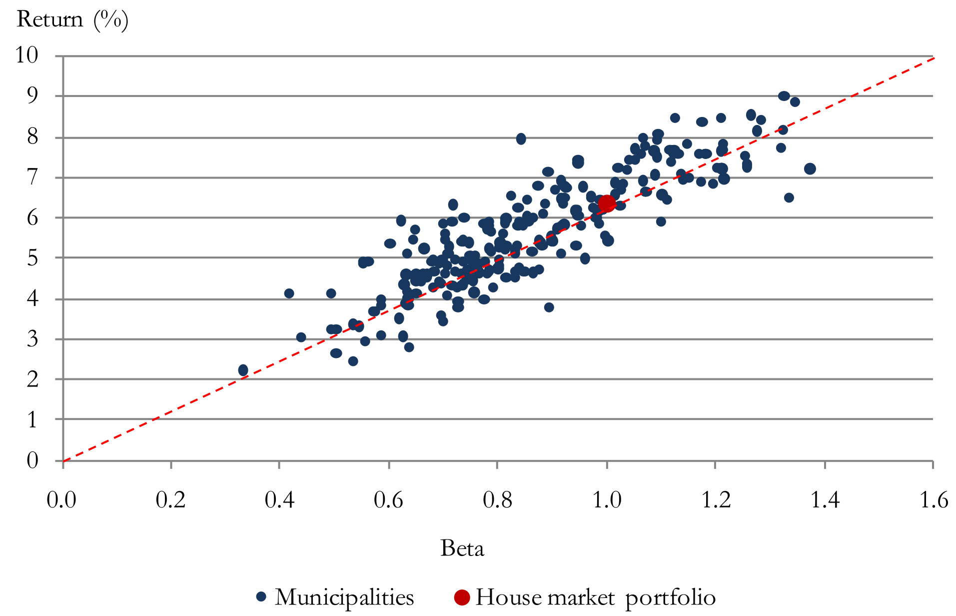
Reported above are the regression results for the Fama-MacBeth validity test regressions. Mean denotes the average coefficients obtained from running regressions (16) and (17) using the Fama-MacBeth two-step procedure. Reported are also the corresponding standard errors, t-statistics and the p-values.

Figure A.3: Risk-return relationship for 238 Swedish municipalities and the housing market portfolio.



The graph shows the average annual real excess returns, including dividends, over the average annualized three-month Swedish Treasury Bill, plotted against the corresponding standard deviation for each municipality and the housing market portfolio, between 1982 and 2009. Note that the dotted red line is a manually drawn reference line resembling the mean-variance efficiency frontier.

Figure A.4: Beta-return relationship for 238 Swedish municipalities and the housing market portfolio.



The graph depicts the average annual real excess return, including dividends, over the average annualized three-month Swedish Treasury Bill, plotted against the corresponding beta, from regression (1), for each municipality and the housing market portfolio, between 1982 and 2009. The housing market portfolio has a beta of one by definition, since it is perfectly correlated with itself. Note that the red dotted line represents a reference line that is manually drawn from origo.

Figure A.5: Geographical dispersion of housing betas from regression (1).

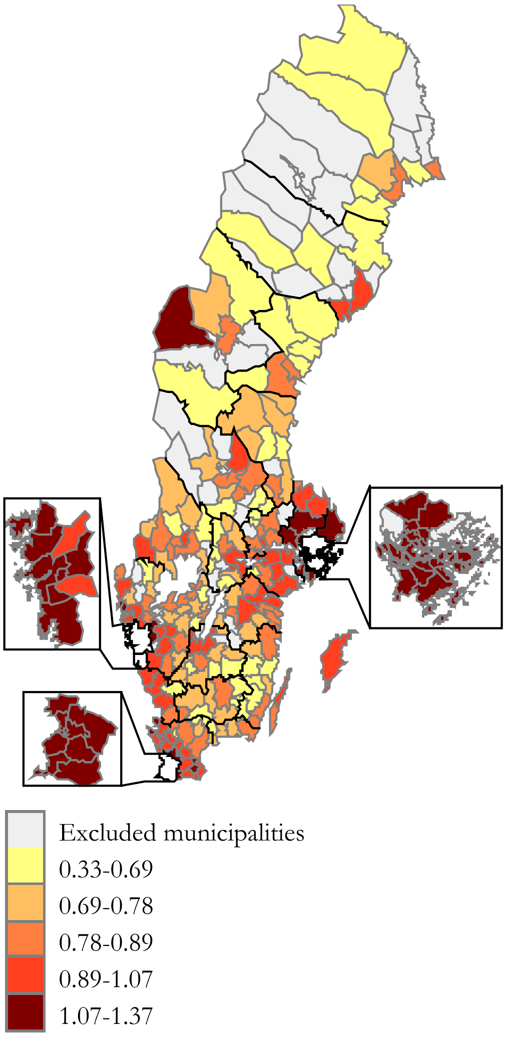


Figure A.6: Geographical dispersion of adjusted R^2s from regression (1).

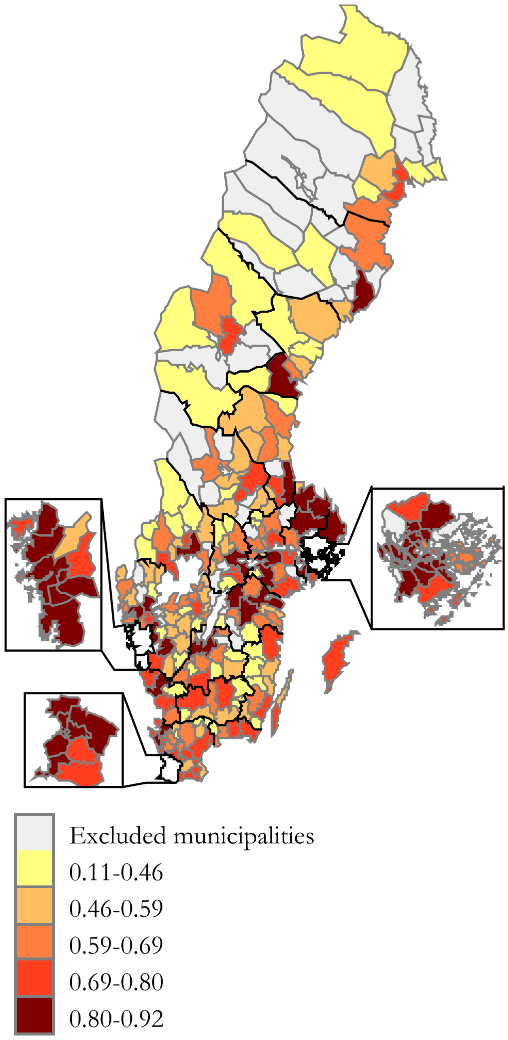


Figure A.4 depicts the geographical dispersion of housing betas from regression (1), sorted into quintiles. Figure A.5 depicts the geographical dispersion of adjusted R^2s from regression (1), sorted into quintiles. The light grey areas represent municipalities with missing data or fewer than 30 transactions for any year.

Table A.5: Market portfolio proxy robustness regressions.

	Alternative market portfolio proxies		
	County	Metropolitan/ Non-metropolitan	Equity-Housing
Intercept	0.053	-0.055	4.545
	(2)	(2)	(186)
$R^{Portfolio}$	0.886	0.903	0.150
	(236)	(238)	(12)
β distribution			
Average	0.886	0.903	0.150
Median	0.833	0.876	0.143
Min	0.273	0.323	0.007
Max	1.473	1.362	0.352
Adj. R^2 distribution			
Average	0.637	0.622	0.041
Median	0.660	0.642	0.036
Min	0.097	0.083	-0.038
Max	0.916	0.926	0.207

The table presents the results from the three robustness regressions for alternative market portfolio proxies. The county market portfolio regressions include regressing each municipality on the aggregate annual excess real returns of all counties but the one in which the municipalities are situated in. There are thus 21 alternative market portfolios, one for each of Sweden's 21 counties. The metropolitan/non-metropolitan regressions include regressing each non-metropolitan municipality on the aggregate annual excess real returns of the metropolitan counties of Stockholm, Malmoe, and Stockholm. Conversely, each metropolitan municipality is regressed on the aggregate annual excess real returns of all counties but the counties of Stockholm, Malmoe, and Stockholm. There are thus two alternative market portfolios for the metropolitan/non-metropolitan market proxy. The equity-housing market portfolio consists of a weighted index between the returns of the housing market portfolio from regression (1) and the stock market portfolio from regression (2). The 21 county market portfolios and the two metropolitan/non-metropolitan market portfolios are calculated by aggregating the K/T-ratio indices using the same method as described in Figure B.2. The equity-housing market portfolio is calculated as a value-weighted index of the aggregate housing market portfolio and the stock market portfolio from regression (1) and (2) respectively. The weights are constant for the whole period and are equal to 50.1 % in equities and 49.9% in housing (based on OECD data for average household wealth between 1995 and 2006).

Table A.6: List of H-CAPM model (1) regression results and the average real excess house price returns for each of the 238 municipalities included in the empirical study.

Municipality	Intercept	Beta	R^2	Average return
0114 Upplands Väsby	-0.715	1.259	0.827	7.263
0115 Vallentuna	-1.493	1.374	0.845	7.211
0120 Värmdö	0.804	1.212	0.677	8.480
0123 Järfälla	-0.466	1.212	0.913	7.213
0125 Ekerö	-0.629	1.258	0.838	7.341
0126 Huddinge	-0.427	1.255	0.847	7.522
0127 Botkyrka	-0.744	1.217	0.841	6.962
0136 Haninge	0.408	1.131	0.792	7.573
0138 Tyresö	-0.002	1.213	0.831	7.683
0160 Täby	-0.635	1.320	0.837	7.725
0162 Danderyd	0.616	1.326	0.628	9.016
0163 Sollentuna	0.067	1.276	0.812	8.152
0180 Stockholm	-0.201	1.325	0.871	8.190
0181 Södertälje	-0.154	1.071	0.802	6.630
0182 Nacka	0.288	1.284	0.849	8.423
0186 Lidingö	0.351	1.347	0.749	8.882
0188 Norrtälje	-0.744	1.196	0.811	6.829
0191 Sigtuna	-0.545	1.174	0.789	6.890
0192 Nynäshamn	-0.606	1.111	0.774	6.434
0305 Håbo	-1.983	1.336	0.876	6.482
0319 Älvkarleby	0.271	0.785	0.485	5.245
0331 Heby	0.937	0.907	0.316	6.681
0360 Tierp	-0.659	0.944	0.813	5.319
0380 Uppsala	-0.377	1.202	0.854	7.239
0381 Enköping	0.143	1.068	0.685	6.910
0382 Östhammar	-0.753	0.999	0.806	5.573
0428 Vingåker	1.096	0.635	0.431	5.117
0480 Nyköping	0.139	1.017	0.787	6.579
0481 Oxelösund	-0.150	0.898	0.556	5.537
0482 Flen	-0.918	1.003	0.690	5.432

Municipality	Intercept	Beta	R^2	Average return
0483 Katrineholm	0.055	0.814	0.855	5.208
0484 Eskilstuna	0.217	0.945	0.840	6.202
0486 Strängnäs	0.188	1.026	0.771	6.685
0509 Ödeshög	0.246	0.747	0.349	4.979
0513 Kinda	1.002	0.704	0.315	5.461
0561 Åtvidaberg	0.388	0.721	0.609	4.957
0562 Finspång	-0.736	0.793	0.640	4.284
0563 Valdemarsvik	-0.830	0.865	0.610	4.651
0580 Linköping	0.865	0.926	0.897	6.732
0581 Norrköping	0.206	0.943	0.910	6.177
0582 Söderköping	0.506	0.838	0.588	5.816
0583 Motala	0.783	0.780	0.871	5.725
0586 Mjölby	0.842	0.784	0.684	5.811
0617 Gnosjö	1.035	0.665	0.347	5.247
0642 Mullsjö	-0.288	0.902	0.524	5.425
0662 Gislaved	0.630	0.709	0.665	5.123
0665 Vaggeryd	0.489	0.856	0.615	5.908
0680 Jönköping	0.715	0.957	0.858	6.775
0682 Nässjö	0.176	0.703	0.667	4.627
0683 Värnamo	1.339	0.739	0.752	6.020
0684 Sävsjö	-0.097	0.629	0.442	3.888
0685 Vetlanda	0.626	0.680	0.580	4.930
0686 Eksjö	0.493	0.694	0.416	4.886
0687 Tranås	0.014	0.766	0.612	4.865
0760 Uppvidinge	0.416	0.664	0.391	4.621
0761 Lessebo	0.040	0.692	0.451	4.423
0763 Tingsryd	0.780	0.711	0.521	5.285
0764 Alvesta	0.248	0.759	0.645	5.057
0765 Älmhult	1.597	0.649	0.476	5.708
0767 Markaryd	-0.124	0.803	0.443	4.964
0780 Växjö	0.621	0.855	0.765	6.037
0781 Ljungby	1.443	0.699	0.693	5.871
0821 Högsby	0.983	0.495	0.303	4.121

Municipality	Intercept	Beta	R^2	Average return
0834 Torsås	-0.331	0.782	0.422	4.621
0840 Mörbylånga	0.719	0.887	0.703	6.339
0860 Hultsfred	0.056	0.504	0.419	3.247
0861 Mönsterås	0.548	0.698	0.583	4.969
0862 Emmaboda	0.133	0.585	0.495	3.840
0880 Kalmar	1.333	0.825	0.793	6.561
0881 Nybro	0.306	0.671	0.648	4.553
0882 Oskarshamn	1.554	0.603	0.558	5.372
0883 Västervik	0.140	0.813	0.717	5.287
0884 Vimmerby	-0.213	0.766	0.439	4.638
0885 Borgholm	-0.067	0.987	0.492	6.185
0980 Gotland	0.959	0.923	0.782	6.804
1060 Olofström	1.480	0.418	0.386	4.126
1080 Karlskrona	0.676	0.789	0.801	5.675
1081 Ronneby	0.756	0.734	0.764	5.407
1082 Karlshamn	1.143	0.703	0.621	5.594
1083 Sölvesborg	1.772	0.719	0.689	6.324
1214 Svalöv	0.447	1.015	0.687	6.875
1230 Staffanstorp	-0.010	1.211	0.879	7.659
1231 Burlöv	0.173	1.169	0.858	7.578
1233 Vellinge	0.535	1.265	0.838	8.549
1256 Östra Göinge	-0.322	0.732	0.544	4.317
1257 Örkelljunga	0.191	0.803	0.460	5.278
1260 Bjuv	-0.184	1.025	0.791	6.311
1261 Kävlinge	0.598	1.117	0.843	7.675
1262 Lomma	0.944	1.175	0.866	8.388
1263 Svedala	0.097	1.183	0.786	7.592
1264 Skurup	-0.419	1.210	0.771	7.245
1265 Sjöbo	0.534	0.919	0.550	6.357
1266 Hörby	0.196	0.989	0.729	6.457
1267 Höör	0.362	0.971	0.636	6.511
1270 Tomelilla	-0.412	1.103	0.725	6.573

Municipality	Intercept	Beta	R^2	Average return
1272 Bromölla	0.643	0.749	0.711	5.385
1273 Osby	1.361	0.552	0.283	4.859
1275 Perstorp	0.641	0.681	0.349	4.952
1276 Klippan	-0.018	0.923	0.657	5.825
1277 Åstorp	0.050	0.947	0.661	6.051
1278 Båstad	1.228	1.067	0.794	7.989
1280 Malmö	0.133	1.214	0.921	7.822
1281 Lund	1.008	1.093	0.863	7.932
1282 Landskrona	1.483	0.892	0.690	7.135
1283 Helsingborg	0.842	1.065	0.887	7.585
1284 Höganäs	0.981	1.072	0.789	7.771
1285 Eslöv	-0.266	1.140	0.799	6.956
1286 Ystad	0.843	1.042	0.736	7.446
1287 Trelleborg	0.555	1.147	0.766	7.822
1290 Kristianstad	1.048	0.853	0.784	6.451
1291 Simrishamn	0.611	1.039	0.575	7.189
1292 Ängelholm	0.782	1.021	0.809	7.248
1293 Hässleholm	0.180	0.788	0.678	5.172
1315 Hylte	1.392	0.644	0.289	5.471
1380 Halmstad	1.352	0.948	0.791	7.354
1381 Laholm	0.817	0.816	0.645	5.985
1382 Falkenberg	0.674	0.916	0.815	6.476
1383 Varberg	1.114	0.917	0.762	6.925
1384 Kungsbacka	0.115	1.181	0.873	7.595
1401 Härryda	0.789	1.052	0.809	7.450
1402 Partille	0.763	1.088	0.874	7.654
1407 Öckerö	1.155	1.095	0.748	8.088
1415 Stenungsund	-0.308	1.152	0.848	6.988
1419 Tjörn	0.496	1.124	0.754	7.614
1421 Orust	0.329	1.030	0.618	6.852
1427 Sotenäs	1.360	1.125	0.608	8.488
1430 Munkedal	-0.011	0.778	0.568	4.917
1435 Tanum	1.443	0.948	0.613	7.446

Municipality	Intercept	Beta	R^2	Average return
1440 Ale	1.032	1.054	0.502	7.705
1441 Lerum	0.584	1.094	0.797	7.516
1442 Vårgårda	0.408	0.971	0.456	6.556
1447 Gullspång	-0.938	0.776	0.486	3.975
1452 Tranemo	-0.228	0.717	0.399	4.313
1460 Bengtsfors	0.325	0.684	0.571	4.657
1461 Mellerud	-0.037	0.695	0.435	4.368
1462 Lilla Edet	-0.229	0.981	0.610	5.988
1463 Mark	-0.023	0.918	0.720	5.794
1465 Svenljunga	-0.252	0.802	0.566	4.827
1466 Herrljunga	-0.271	0.901	0.561	5.434
1470 Vara	-0.168	0.765	0.467	4.681
1471 Götene	0.031	0.836	0.608	5.324
1472 Tibro	-0.019	0.746	0.578	4.707
1473 Töreboda	0.475	0.651	0.470	4.596
1480 Göteborg	0.554	1.125	0.889	7.677
1481 Mölndal	0.277	1.120	0.912	7.370
1482 Kungälv	0.153	1.090	0.839	7.058
1484 Lysekil	-0.127	1.138	0.682	7.081
1485 Uddevalla	0.077	0.976	0.828	6.257
1486 Strömstad	2.609	0.844	0.506	7.954
1487 Vänersborg	-0.272	0.882	0.819	5.313
1488 Trollhättan	0.520	0.866	0.789	6.007
1489 Alingsås	-0.151	1.073	0.917	6.644
1490 Borås	-0.391	0.988	0.851	5.865
1491 Ulricehamn	-0.590	0.833	0.545	4.687
1492 Åmål	-0.327	0.738	0.504	4.347
1493 Mariestad	-0.304	0.863	0.654	5.165
1494 Lidköping	0.945	0.838	0.635	6.251
1495 Skara	0.332	0.749	0.455	5.080
1496 Skövde	0.777	0.737	0.698	5.444
1497 Hjo	-0.650	0.816	0.597	4.518

Municipality	Intercept	Beta	R^2	Average return
1498 Tidaholm	0.592	0.631	0.454	4.591
1499 Falköping	0.346	0.707	0.590	4.823
1715 Kil	0.291	0.805	0.461	5.389
1730 Eda	1.361	0.717	0.364	5.900
1737 Torsby	0.091	0.722	0.407	4.662
1761 Hammarö	0.667	0.922	0.733	6.508
1763 Forshaga	-1.094	0.961	0.715	4.993
1764 Grums	-0.746	0.832	0.579	4.523
1765 Årjäng	-0.104	0.994	0.451	6.189
1766 Sunne	1.991	0.623	0.407	5.935
1780 Karlstad	0.504	0.883	0.871	6.098
1781 Kristinehamn	-0.332	0.754	0.681	4.445
1782 Filipstad	-0.612	0.585	0.495	3.096
1783 Hagfors	-0.644	0.757	0.433	4.149
1784 Arvika	0.943	0.783	0.596	5.906
1785 Säffle	-0.129	0.748	0.709	4.608
1861 Hallsberg	-0.019	0.732	0.701	4.620
1862 Degerfors	-1.226	0.637	0.524	2.809
1863 Hällefors	-0.899	0.627	0.417	3.072
1864 Ljusnarsberg	-0.989	0.700	0.244	3.445
1880 Örebro	0.025	0.999	0.870	6.350
1881 Kumla	-0.027	0.909	0.771	5.731
1882 Askersund	1.354	0.562	0.411	4.916
1883 Karlskoga	0.147	0.634	0.638	4.165
1884 Nora	-0.717	0.851	0.537	4.675
1885 Lindesberg	-0.224	0.745	0.686	4.497
1907 Surahammar	-0.840	0.877	0.623	4.717
1960 Kungsör	-0.713	0.848	0.495	4.656
1961 Hallstahammar	-0.215	0.952	0.687	5.817
1962 Norberg	-0.418	0.620	0.282	3.507
1980 Västerås	1.259	0.874	0.759	6.796
1981 Sala	-0.179	0.879	0.653	5.387
1982 Fagersta	-0.015	0.635	0.400	4.010

Municipality	Intercept	Beta	R^2	Average return
1983 Köping	-0.122	0.877	0.623	5.430
1984 Arboga	-0.323	0.801	0.642	4.753
2026 Gagnef	-0.676	0.728	0.374	3.932
2029 Leksand	0.716	0.814	0.555	5.875
2031 Rättvik	-0.699	0.917	0.484	5.108
2062 Mora	0.123	0.755	0.632	4.907
2080 Falun	0.137	0.815	0.777	5.301
2081 Borlänge	0.467	0.810	0.783	5.595
2083 Hedemora	0.018	0.650	0.512	4.136
2084 Avesta	0.391	0.670	0.471	4.632
2085 Ludvika	0.251	0.659	0.546	4.424
2104 Hofors	-0.809	0.695	0.538	3.593
2121 Ovanåker	-0.828	0.695	0.481	3.575
2132 Nordanstig	-0.823	0.727	0.400	3.784
2161 Ljusdal	-0.317	0.725	0.501	4.278
2180 Gävle	0.962	0.775	0.832	5.872
2181 Sandviken	-0.270	0.785	0.777	4.701
2182 Söderhamn	-0.045	0.682	0.517	4.274
2183 Bollnäs	0.376	0.628	0.606	4.355
2184 Hudiksvall	0.261	0.738	0.673	4.934
2260 Ånge	0.115	0.333	0.114	2.225
2262 Timrå	-0.551	0.841	0.679	4.774
2280 Härnösand	0.055	0.572	0.579	3.679
2281 Sundsvall	-0.076	0.833	0.844	5.198
2282 Kramfors	0.266	0.438	0.380	3.040
2283 Sollefteå	-0.943	0.534	0.388	2.439
2284 Örnsköldsvik	0.324	0.651	0.580	4.446
2309 Krokom	-0.051	0.760	0.635	4.760
2313 Strömsund	-0.530	0.503	0.202	2.656
2321 Åre	-1.067	1.100	0.432	5.901
2361 Härjedalen	-0.180	0.635	0.315	3.844
2380 Östersund	0.467	0.848	0.744	5.836
2401 Nordmaling	-1.880	0.895	0.464	3.787

Municipality	Intercept	Beta	R^2	Average return
2462 Vilhelmina	-0.143	0.545	0.232	3.309
2480 Umeå	-0.065	0.984	0.903	6.170
2481 Lycksele	0.111	0.494	0.261	3.243
2482 Skellefteå	0.275	0.585	0.660	3.984
2514 Kalix	-0.592	0.557	0.419	2.936
2523 Gällivare	0.032	0.575	0.373	3.675
2560 Älvsbyn	-0.027	0.535	0.290	3.365
2580 Luleå	0.590	0.839	0.792	5.907
2581 Piteå	1.411	0.553	0.591	4.916
2582 Boden	-0.416	0.708	0.505	4.066
2583 Haparanda	-0.165	0.831	0.395	5.101
2584 Kiruna	0.335	0.670	0.312	4.579

Appendix B

1. Construction of K/T-ratio indices

In order to construct the municipal house price indices, we implement the same assessment-based method that Statistics Sweden used for calculating house price indices prior to 1981 (Statistics Sweden, 1986a). To calculate the indices, annual data is gathered on average K/T-ratios, average assessed value changes, average assessed values for transacted houses, as well as the number of transactions in each municipality. The data is available, for sold one- or two- dwelling houses for permanent living in 290 municipalities, from Statistics Sweden. We exclude municipalities with missing values or fewer than 30 transactions in any year. This leaves us with a data sample of 238 municipalities. Below, we elaborate further on the variables included and the sampling methodology and adjustments that we have made in order to calculate the K/T-ratio based indices.

1.1 K/T-ratio

The K/T-ratio reflects the ratio between the purchase price and the assessed value of a property. Two houses with the same assessed value can be viewed as similar in terms of qualitative as well as regional characteristics, and provides a good basis for overcoming the heterogeneity bias. The K/T-ratio thus depicts at what multiple, to the assessed value, a property has been sold for. Since all houses in Sweden are given an assessed value, the K/T-ratio can be viewed as a standardized measure of this multiple. Thus, by comparing the development of K/T-ratios over time for the houses sold in each municipality, an estimation of the price fluctuations of prices over time, for relatively comparable objects, can be constructed (Statistics Sweden, 1986a).

1.2 Assessed value changes

The Swedish Tax Agency (Skatteverket) regularly assesses the values of the Swedish housing stock. The assessed value should reflect 75% of the market price of the house. Between 1981 and 2009, the Swedish Tax Agency made assessments in 1990, 1996, 2003, 2006, and 2009 (Statistics Sweden). Data on assessed value changes for municipalities is not available for 1990. In order to not miss nine years of data, we estimate the 1990 adjustments by dividing the average assessed value for the houses sold 1990-2005 over the average assessed value for houses sold 1981-1989 for each municipality. More specifically, we estimate the 1990 assessed value change by using the average assessed value, and the number of transactions for each municipality in the following way:

$$\mathrm{AV}_{\mathrm{i,1990}} = \left[\sum_{t=1990}^{1995} \frac{\mathrm{N}_{\mathrm{i,t}} * \mathrm{AV}_{\mathrm{i,t}}}{\mathrm{N}_{\mathrm{i,T}}}\right] \Bigg/ \left[\sum_{t=1981}^{1989} \frac{\mathrm{N}_{\mathrm{i,t}} * \mathrm{AV}_{\mathrm{i,t}}}{\mathrm{N}_{\mathrm{i,T}}}\right]$$

Where:

$\mathrm{AV}_{\mathrm{i,1990}}$ is the assessed value change 1990 in municipality i.
$\mathrm{N}_{\mathrm{i,t}}$ is the number of transactions in municipality i at time t.
$\mathrm{AV}_{\mathrm{i,t}}$ is the averaged assessed value in municipality i at time t.
$\mathrm{N}_{\mathrm{i,T}}$ is the total number of transactions for the summarized time period.

The above method is subject to potential measurement biases, but due to the limitations in data, and the large number of transactions in each municipality, we do believe that it is the best approximation available. The problem with using this method in order to estimate the change in the adjusted value on municipality level is evident. The adjustment is supposed to reflect changes in assessed values for the whole housing stock in each municipality. Our estimation is, however, only based on the average assessed value change for the houses sold in 1990-2005 compared to 1981-1989. Suppose for instance, that in the period of 1981-1989, mostly houses with high assessed values in a municipality were sold, whereas the opposite was true 1990-1995. We would then be faced with a downward bias in the aggregate adjustment on municipal level and underestimate the true change in the average assessed value for the whole housing stock in the municipality.

1.3 Chaining the K/T-ratio house price index

The municipality K/T-ratio indices are constructed by using the above annual data, between 1981 and 2009, on average K/T-ratios, as well as changes in assessed value (1990, 1996, 2003, 2006, and 2009). The assessed value changes are needed because house prices have generally been trending upwards along with assessed values. Whenever an assessed value change is made, it reflects the general increase in the price level of houses. Thus, the K/T-ratio drops in magnitude when a reassessment is made. In order to correctly depict the development of the K/T-ratio over time, this has to be accounted for. Technically, it means that we undo the reassessments so that the different sub-periods are chained. Consequently, the adjusted K/T-ratio reflects the development of the purchase price in relation to the base year's assessed value for each municipality. To illustrate we use the following formula:

$$\frac{K^a}{T_{i,t}} = \frac{K}{T_{i,t}} * \left(\frac{AV_{i,T}}{AV_{i,1981}}\right)$$

Where:

$\frac{K^a}{T_{i,t}}$ = The average adjusted K/T-ratio, for transacted houses, in municipality i at time t, where t=1981, 1982, 1983, …, 2009.

$\frac{K}{T_{i,t}}$ = The average unadjusted K/T-ratio, for transacted houses, in municipality i at time t, where t=1981, 1982, 1983,…, 2009.

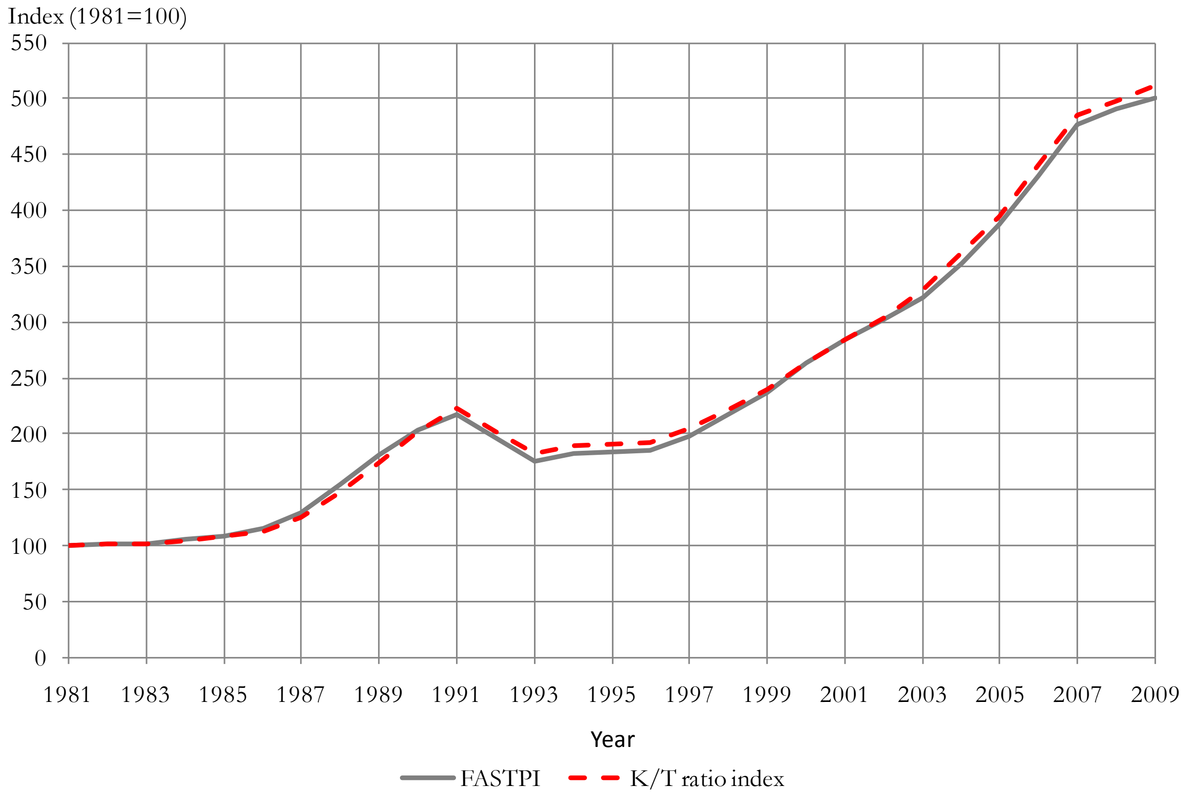
$\frac{AV_{i,T}}{AV_{i,1981}}$ = The average assessed value in municipality i at time T over the average assessed value in municipality i in 1981, where T=1990, 1996, 2003, 2006, 2009. E.g. in year 1995, one assessed value change has been made and the unadjusted K/T-ratio is multiplied by $\frac{AV_{i,1990}}{AV_{i,1981}}$, and in 1998 two assessed value changes has been made and the unadjusted K/T-ratio is multiplied by $\frac{AV_{i,1990}}{AV_{i,1981}} * \frac{AV_{i,1996}}{AV_{i,1990}}$.

Table B.1: Nominal K/T-ratio index calculation example for the Stockholm municipality.

Municipality: 0180 Stockholm						
Year	$\frac{K}{T_{i,t}}$	$\frac{AV_{i,T}}{AV_{i,1981}}$	$\frac{K^a}{T_{i,t}}$	Index (1981=100)	Assessed value changes	
1981	1.49	1.00	1.49x1.00=1.49	100	1981	1.00
…	…	…	…	…	1990	2.07
2002	3.25	1.00x2.07x1.08=2.24	3.25x2.24=7.27	487	1996	1.08
2003	1.46	1.00x2.07x1.08x2.20=4.92	1.46x4.92=7.18	481	2003	2.20
2004	1.59	1.00x2.07x1.08x2.20=4.92	1.59x4.92=7.82	524	2006	1.19
2005	1.74	1.00x2.07x1.08x2.20=4.92	1.74x4.92=8.56	573	2009	1.46

The table shows an example for the Stockholm municipality on how the K/T-ratio indices are constructed. $K/T_{i,t}$ is the average unadjusted K/T-ratio for transacted houses. $K^a/T_{i,t}$ is the average adjusted K/T-ratio for transacted houses. $AV_{i,T}/AV_{i,1981}$ is the assessed value change multiplier used to inflate the index based on each municipality's base year assessed value. The assessed value changes for 1996, 2003, 2006 and 2009 reflects the Swedish Tax Authority's adjustments in assessed values, while the 1990 assessed value changes is estimated based on the average assessed value change for transacted houses. The index is finally constructed by rebasing the base year's adjusted K/T-ratio to 100. All data used to calculate the K/T-ratio indices are available from Statistics Sweden.

Figure B.2: FASTPI and K/T-ratio index comparison.



The graph depicts a comparison between the FASTPI index and an aggregated house price index based on our 238 municipal K/T-ratio indices. As is evident, the two methodologies yield comparatively similar indices. The comparison adds comfort to our choice of sampling methodology and adjustments for both calculating the municipality indices on the basis of K/T-ratios, as well as using a proxy for the K/T-adjustment in 1990.

The FASTI is calculated as a chained Laspeyres index. In each municipality, the houses are divided into twelve categories based on their assessed values. For each category an average purchase price is calculated. The index is calculated as follows (Statistics Sweden, 1986b):

$$I(t-1,t) = [\sum_i \sum_j (N_{i,j,t-1} * \bar{p}_{i,j,t}) \Big/ \sum_i \sum_j (N_{i,j,t-1} * \bar{p}_{i,j,t-1})] * 100$$

Where:

$N_{i,j,t-1}$ is the number of houses in region i, in assessed value category j, at time t-1.

$\bar{p}_{i,j,t-1}$ is the average purchase price of houses, in region i, in assessed value category j, at time t-1.

The aggregated K/T-ratio index is calculated similarly to the equal-weighted method for aggregating sale price appraisal ratio (SPAR) indices, suggested by Bourassa et al. (2006):

$$I(t-1,t) = \left[\frac{\sum_i K/T^a_{i,t} * N_{i,t}}{N_t} \Big/ \frac{\sum_i K/T^a_{i,t-1} * N_{i,t-1}}{N_{t-1}}\right] * 100$$

Where:

K/T^a_i is the adjusted K/T-ratio for municipality i at time t.

$N_{i,t}$ is the number of transaction in municipality i at time t.

N_t is the total number of transactions in all municipalities at time t.

An alternative, to the equal-weighted method for aggregating the K/T-ratio index, would be to use the value-weighted method described by Bourassa et al. (2006), but due to limitations in our data set we could not employ that method.

2. National dividend estimation

In this section we explain how we estimate the net dividend yield. First the gross dividend yield is calculated as rents over the previous year's price. Then property tax, depreciation and maintenance cost over the previous year's price is subtracted in order to arrive at the net dividend yield(see e.g. Bostadskreditsnämnden, 2009, Chinloy, 1992 and Case and Shiller, 1990).

2.1 Rent

Calculating the gross dividend yield requires imputing a rent, which is equal to the costs of renting similar houses. However, data for renting one- or two dwelling houses is very limited. We therefore choose to base our imputed rent on the costs for renting rented housing. Unfortunately, such data is not available for our entire time span. However, consumer price indices for rents and houses are available. We use these to create an index of the evolution of average rents over average house value. By setting the base year to a year for which data is available for the average rent and median house price, it is possible to extrapolate the rent-to-price ratio for the entire period. This is a method which the Swedish National Housing Credit Guarantee Board (Bostadskreditsnämnden) has previously employed (Bostadskreditsnämnden, 2009). We set the base year to 2008, when the average gross rent to price is 3.23%. However, since rented housing is generally smaller than owner-occupied houses, we make an upward adjustment of the gross dividend yield using a step-up factor (see Sarama, 2010). The average floor space between 2006 and 2009 for rented and owner occupied housing is 71 and 137 square meters respectively (data obtained from Statistics Sweden). This gives a step-up factor of 1.9 (137 divided by 71). Thus our adjusted gross dividend yield for 2008 is 6.13 %.

$$\mathrm{Div_t} = \left[\frac{\mathrm{CPI_t^{Rent}}}{\mathrm{CPI_{t-1}^{House}}} \Big/ \frac{\mathrm{CPI_{2008}^{Rent}}}{\mathrm{CPI_{2007}^{House}}}\right] \times \frac{\mathrm{P_{2008}^{Rent}}}{\mathrm{P_{2007}^{House}}} \times 1.9$$

Where:
$\mathrm{Div_t}$ is the gross national dividend yield at time t.
$\mathrm{CPI_t^{Rent}}$ represents the CPI for rent at time t.
$\mathrm{CPI_{t-1}^{House}}$ is the CPI for house prices at time t-1.
$\mathrm{P_{2008}^{Rent}}$ is the average national rent in 2008.
$\mathrm{P_{2007}^{House}}$ is the average purchase price of a house at time t-1.

2.2 Property tax

Because of changed tax legislation on several occasions during our time period, property taxes have varied considerably both in size and nature. Data on property taxes for 1991-2009 is obtained from Bostadskreditsnämnedn (2009). For the period between 1981 and 1990 both the property tax and the assessed values, which the tax was applied on, were linked to the tax subject. The average property tax was during this period 2 % but deductible against an average marginal tax rate of 50 %, which makes the effective rate 1 % (Wessel and Jennefelt, 2007). Then there was a large tax reform in 1990 in which it was decided that assessed values should equal to 75 % of the market value. The property tax rate was set to 1.5% and remained at this level until 2001, with the exception of 1996-1997 when it was 1.7%. In 2001, the rate was lowered to 1 %. Finally, the tax was abolished in 2008 and replaced by a municipal fee which is equivalent to an old property tax rate of 0.5%. Before the property tax rate is subtracted it has to be deflated by the aggregate average unadjusted K/T-ratio. The unadjusted K/T-ratio is aggregated in the same way as described in Figure B.2. The adjustment is required because the dividend yield is applied on the adjusted K/T-ratio indices, whereas the property tax rate is based on assessed values.

$$\mathrm{Adj.\,Property\ Tax_t} = \frac{\mathrm{Property\ Tax_t}}{\mathrm{K/T_t}}$$

Where:
$\mathrm{Adj.\,Property\ Tax_t}$ is the property tax in percent at time t.
$\mathrm{K/T_t}$ is the aggregate average K/T-ratio for the 238 municipalities in our data sample market at time t.

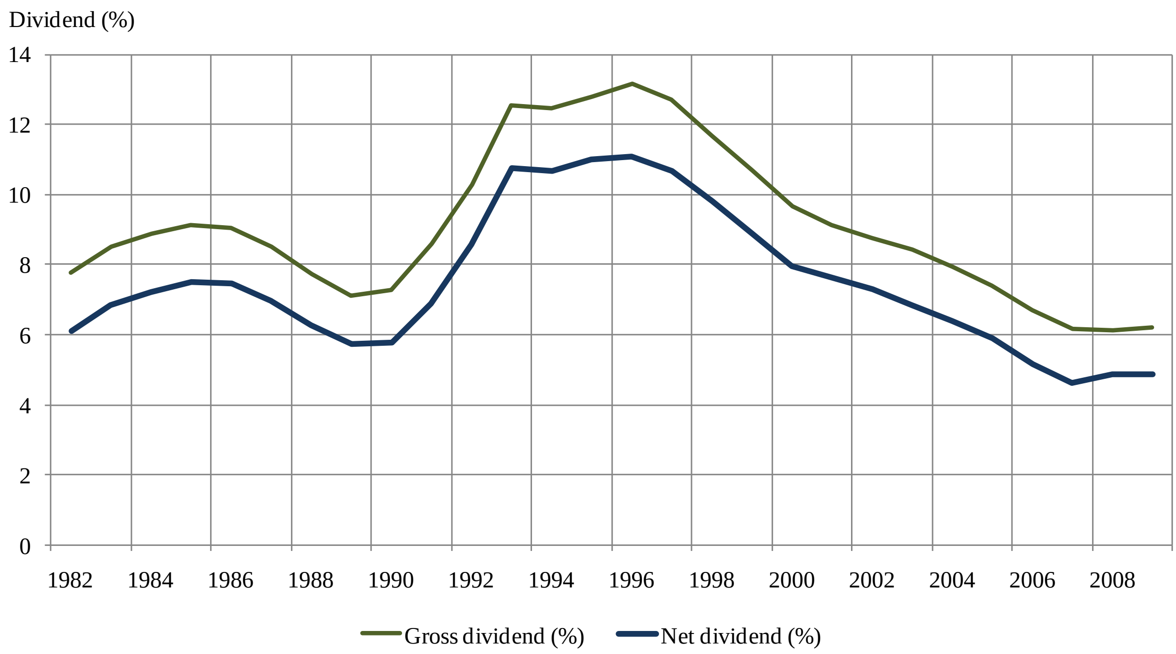
2.3 Depreciation

Housing derives its value from both land and buildings. The former is traditionally not depreciated, but the latter is. As labor and material costs for constructing buildings can be assumed to be fairly similar across a country, the large differences between housing prices in different geographical areas usually comes from the attractiveness of the land. Applying a flat depreciation rate on total housing value would therefore most likely overstate depreciation costs for expensive housing and understate for cheap ones. However, we have not found any good data to separate between depreciable and non-depreciable housing value. Instead we choose to apply a method used by Wessel & Jennefelt (2007) in which we assume that there is an equal split between land and buildings. Furthermore, buildings are assumed to last for 100 years, meaning that the final depreciation rate applied on the total housing value is 0.5%.

2.4 Maintenance cost

The maintenance cost is estimated based on data from Statistic Sweden's annual Household Expenditure Report (HUT, Hushållens utgifter). Data is available for the period 2003-2009. Maintenance and reparation expenditure are defined as those that keep the house in its original condition and includes both material and services costs (COICOP identifier 043). In addition, we include costs for other services that are associated with living in the house (COICOP Identifier 044). Unfortunately, housing types other than owner occupied houses could not be filtered out from the data. Therefore, expenditure made by households living in condominiums is reflected in the numbers as well. These costs differ in some ways from those of houses, but overall we believe the data reflects the true costs. A maintenance rate is obtained by dividing the total expenditure per household by the average value of houses sold in Sweden that year. For the period 2003-2009, the average maintenance rate was 0.55%. This rate is applied on the whole period we analyze, i.e. between 1982 and 2009.

Figure B.3: Implied nominal gross and net dividend yield



The graph depicts the national nominal gross and net dividend yield development between 1982 and 2009. The net dividend is calculated as the gross dividend less property tax, depreciation and maintenance costs.