Stockholm School of Economics
Bachelor's Thesis in Finance

RISK, PRICE LEVEL AND RETURN IN THE SWEDISH HOUSING MARKET: A PANEL AND CROSS-SECTIONAL ANALYSIS

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ABSTRACT

This thesis carries out an asset-pricing analysis of the Swedish single family house market. Using both cross-sectional and panel data on municipality level we investigate the role of volatility and price level in explaining housing returns. In the cross-sectional regressions, we derive returns from an adjusted price measure, the K/T-ratio, and find weak evidence of a positive risk-return relationship. In the panel regressions, we obtain returns from an investor model and by using municipality fixed effects we unveil a negative risk-return relationship. Contrary to these ambiguous results, we find some evidence that propose a positive price level effect on return.

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Acknowledgements: We would like to thank our tutor Cristian Huse for his excellent inputs while writing this thesis, and Per-Olov Edlund, for his invaluable advice in the field of economic statistics.

Key words: Risk; Return; Price level; Single-family housing; Sweden

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1 INTRODUCTION

Real estate bears the twofold role of consumption and investment. For many Swedish families, the house they live in makes up a substantial part of their private wealth and is thereby their largest single investment. When considering when and what house to purchase, buyers are often concerned by the investment potential of the property, e. g. the rate of return. While financial economists have had a long interest in the role of risk and return of financial assets[1], the primary focus in the literature revolve around equity and stock portfolios and less emphasis has been put on housing as an asset for investment. Housing is, however, comparable to equities in the sense that it can offer two forms of payment to the investor. Whereas the compensation for equities comes in the shape of dividends and price returns, this is analogous to rents and house price returns in the real estate market. On the other hand, because partial ownership is rare, it is not possible to eliminate the unsystematic risk associated with the structure and location of the house, implying that housing is practically not diversifiable. Thereby offer price for a house with riskier returns, compared to an otherwise similar house, should be lower but also have a higher expected return.

As of 2008, 57.2% of the Swedish residents lived in a single-family housing, which is considered to be an either detached, row or linked houses.[2] House prices are a common subject of debate in the media and general public, where the risk the housing investment carries is discussed as the possible burst of a "housing bubble". Consequently, it is the recent housing bubbles around the world and the price development in Swedish housing market that has inspired us to focus on the role of housing as an asset for investment. Nevertheless, Case et al (2005) find that changes in housing prices have a larger and more important impact in influencing household consumption than that of the changes in stock market prices, thereby making the question of risk and return of housing an important issue also from a macroeconomic perspective.

When investing in an asset in financial markets, it is commonly recognized that there should be a positive risk and return relationship. We ask ourselves:

Is there a positive relationship between risk, price level and return in the Swedish single-family housing market?

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[1] For example, Campbell and Hentschel (1992).
[2] SCB, "Bostads- och byggnadsstatistisk årsbok 2010", p47

1.1 PURPOSE

The purpose of this study is to apply an asset-pricing analysis and empirically examine a possible risk and return trade-off in the Swedish single-family housing market. We also include market price to examine price level effects. First, we decompose house price returns into risk and price level to investigate the two variables impact on the return using a cross-sectional model. Second, we include a set of assumptions that affect the house investment and apply fixed effects in a panel data model to get a better investment picture. With our study we hope to shed light on the potential of investing in Swedish property.

Readers should pay attention to that we use two separate ways to estimate housing returns in the cross-sectional and panel data models.

1.2 CONTRIBUTION

This paper builds upon studies of the risk-return relationship of financial assets and extends the analysis to the Swedish housing. To our knowledge, this is the first attempt to apply a cross-section on risk, return and price level for the aggregate Swedish housing market. Furthermore, we extend an investor model constructed by Wessel and Jennefelt (2007) by analyzing it in a panel.

1.3 STUDY OUTLINE

In *Section 2* we present some previous research in our field of study. *Section 3* gives an introduction to the theoretical framework used in our models. In *Section 4*, we explain the cross-sectional and panel data regressions which are used in our study, and we present the computation method of our variables. *Section 5* presents the results from our statistical analysis and *Section 6* concludes our results. *Section 7* gives a short discussion regarding our results. *Section 8* gives a couple of suggestions for further studies and in *Section 9* we present limitations to our analysis. *Section 10* shows our references and in the appendices in *Section 11* we explain assumptions made, data, sampling method, detailed results and an overview of our regression testing.

2 PREVIOUS LITERATURE

The majority of research in this field of study examines the U.S. housing market. Crone and Voith (1999) observe appraiser files data on repeat sales from 1971–1996 and investigate the joint consumption-investment decision to see whether this link negates the risk-return relationship. First they find that increased risk leads to a higher return but also that the risk-return tradeoff is negated by the consumption-investment link regarding the magnitude of the house investment.

Cannon et al (2006) carries out an asset-pricing analysis using cross-sectional regression on zip code level data in the U. S. metropolitan single family housing market. They study whether housing returns can be explained by volatility, price level, stock market return and idiosyncratic volatility. They find a positive relationship between housing returns and volatility where a 10% increase in volatility leads to a 2.48% increase in annual housing returns and that there is a positive but diminishing price effect. These results are robust to metropolitan statistical area clustering effects and differences in socioeconomic variables. In addition, it is showed that stock market risk is priced directionally in the housing market.

The Swedish market for single family housing is studied by Wessel and Jennefelt (2007), who find a positive relationship between risk and return. They construct a cross-sectional investor model that adjusts for differences in sizes and standards for houses based on assessed values and account for opportunity cost of renting, maintenance cost, depreciation, property tax and transaction costs. For five and ten year investments, they find that a 10% increase in volatility leads to a 7.42% and 3.30% increase in return respectively. Furthermore, they find that the risk of investing in metropolitan areas is higher than in non-metropolitan areas but also that the metropolitan areas render higher returns. They conclude by showing that risk adjusted return in metropolitan areas is higher than in non-metropolitan.

On the other hand, Dolde and Tirtiroglu (1997) look at time-varying housing returns and volatilities in the United States. They find a negative relationship between conditional variance and returns in Connecticut but a positive relationship in San Francisco. But their goal is to test the information diffusion in these two housing markets.

Lu Han (2009) show through a 4-quarter moving window of average real housing returns and volatility that house price indices in the San Jose and Santa Clara area in the U.S. reflect a strong positive relationship between return on housing and its related volatility. In contrast, the opposite relationship is found in Pittsburgh.

When examining the efficiency of the U.S. market for single family housing, Case and Shiller (1989), find that year-to-year house price changes tend to be followed by changes in the same direction the subsequent year. In addition, predictable changes in the real interest rate do not seem to be incorporated in the prices. This leads to the conclusion that the market is not efficient and that there exists a profitable trading strategy for individuals that are free to time their investment in housing. However, price changes on individual homes do not seem to be very forecastable.

Using U.S. and international panel data, Case et al (2001) find strong evidence that variations in housing market wealth has an impact upon consumption in the developed countries. According to their model, an immediate increase by 10% in housing wealth increases consumption by 0.4% for

U.S. states. In contrast, they also find that financial wealth has no effect. Their results propose that changes in housing wealth should be considered to have a large and more important effect on household consumption in the developed countries compared to changes in the stock market.

Using a restricted error-correction model of real house price changes on Swedish panel data, Hort (1998) finds that movements in income, user costs and construction costs have significant impact on real house prices. Furthermore, the estimates of the dynamic equation demonstrate a rich autoregressive structure in real house prices. An adjustment to the long-run relationship is also quite swift. Finally, fluctuations in real house prices are well explained by development in fundamental demand conditions, but they are also consistent with speculative behavior.

On a general level, most researchers seem to agree on the real estate's ability to offer a hedge against inflation and that real assets present protection against the negative effects of unexpected inflation. In addition, real estate returns have a low correlation with returns of financial assets. These are the primary reasons why real estate is included in many portfolios. Regarding the risk-return relationship, however, researchers have found diverse results, making it an interesting subject of study in the Swedish housing market.

3 THEORY

We hereby list the underlying theoretical framework that we use when empirically studying the data.

3.1 RETURN

Return is calculated using the annual arithmetic return:

$$r_{arithmetic} = \frac{r_{t+1} - r_t}{r_t} = \frac{r_{t+1}}{r_t} - 1 \quad (1)$$

The average arithmetic return is calculated using the formula:

$$\bar{r}_{arithmetic} = \frac{1}{n}\sum_{i=1}^{n} r_{arithmetic} \quad (2)$$

The average annualized return is determined by the geometric average rate of return:

$$r_{geometric} = \left(\prod_{i=1}^{n}\left(1 + r_{arithmetic,i}\right)\right)^{\frac{1}{n}} - 1 \quad (3)$$

3.2 RISK

The unbiased estimator of the population standard deviation is used to compute the volatility of the house price returns, which we consider as the risk:

$$\sigma = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(ret_i - \overline{ret})^2} \tag{4}$$

The volatility measures the variation in returns from the expected return value. With a higher volatility, the spread of returns will have a larger range. Accordingly, a low volatility would imply that the returns do not fluctuate considerably around the mean.

Nevertheless, the standard deviation might not be the best measure for risk because it makes an asset with positive but significantly fluctuating returns look risky. Likewise, an asset with constant negative returns would have a standard deviation of zero. The implication is that all changes, despite direction, are treated as risk. The investor is usually only concerned about the downside of risk, when returns are below the average or negative, and not by the upside or gain. Thereby other risk measures, such as Value at Risk (VaR), might also be applicable for measuring risk in the housing market.[3] However, we have chosen the volatility as risk measure, which is most common, for our models.

3.3 PRICE LEVEL

Average house prices across municipalities present a substantial positive skew.[4] To handle this problem we use the natural logarithm of average house prices, $ln(Price)$, to get a comparatively symmetrical distribution. This reduces the problem of nonlinearity, which is important because we assume linearity in the relationship between the response variable and the predictors in our regressions.

3.4 USING FIXED EFFECT ESTIMATION

It is reasonable to believe that each municipality has its own unobserved, individual and time-invariant features that could influence our independent variables, price level and volatility. One example of such a difference could be the geographical location, which affect house prices for each municipality but do not change over time. It is hard to get a correct measure of these omitted and unobserved variables, but if they are not taken into account they could impact and bias our regression results.

[3] Jorion, P. (2006) "Value at Risk: The New Benchmark for Managing Financial Risk", 3rd edition, McGraw-Hill.
[4] Specifically, 2.287, which can be seen in the figure 2 in the appendices.

By exploiting the time-dimension of our panel data we therefore control for unobserved characteristics through fixed effects, extracting coefficients that applies to all municipalities and are separated from each municipality's individual characteristics. We create dummy-variables for each municipality, assuming that these parameters estimate the unobserved effects. Thereby we obtain better estimates of the effects of volatility and price level on return.

3.5 ORDINARY LEAST SQUARES

When applying our regressions, we use the Ordinary Least Squares method with the Gauss-Markov assumptions MLR. 1-5, for the multiple regressions used in the cross-section, and FE. 1-7 for the fixed-effect used in the panel data regressions.[5]

[5] Wooldridge, J.M. (2009),"Introductory Econometrics: A Modern Approach", 4th Edition, South-Western, p503 and p104

4 DATA

4.1 STATISTICS SWEDEN'S HOUSE PRICE MEASURES

Our main source of data is Statistics Sweden, an administrative organization who supplies all sorts of users with statistics for decision making, debate and research. Whereas the organization provide several different measures of the price development for single family housing, not all of them are useful.

4.1.1 REAL ESTATE PRICE INDEX

The Real Estate Price Index is calculated by separating real estate's into several classes based on assessed value and applies a system of weighting to produce an index. However, the weakness of the index is that it needs a certain amount of transactions to be reliable. Thereby it is not possible for Statistics Sweden to calculate the index on municipality level or by month, thereby not applicable in our study.

4.1.2 AVERAGE HOUSE PRICES

Simply the average house transaction prices at municipality level by year. The weakness with this measure is that the properties that are included in the market for single family housing are very different in their characteristics. They differ with regard to location, standard and size and it could be the case that, for one year, only large houses in attractive neighborhoods are sold. Comparing prices year-on-year in such a scenario would be misleading since the properties are not comparable and would not reflect the actual price development in a particularly good way.

4.1.3 THE K/T RATIO

Using the K/T ratio is the simplest and most correct way, according to Statistics Sweden, to compare prices across municipalities.[6] It is the quotient between the transaction prices (K) and the assessed values (T) of properties. It reflects how much more than the assessed value the buyer paid for the house. Since every property has an assessed value, this can be seen as a standardized measure "excess price". By comparing K/T ratios over time, users can obtain an estimate of the price development in a municipality. Furthermore, this measure does not need the same amount of transactions to be reliable. Nevertheless, when comparing K/T ratios over time the user has to be aware of that they are based upon the general assessment of assessed value which occurs, at earliest, one year before the presented K/T ratio. For example, coefficients calculated between 1990 and 1995 are based on assessed values from 1990 and so on. The assessed values were calculated by the Swedish authorities in 1981, 1990,

[6] SCB, "Hur mäter man prisutvecklingen på småhus?"

1996, 2003, 2006. Thereby, the user has to account for changes in general assessment of assessed values over the period where comparison is made. To get an understanding of what a property value is at present, the user can multiply the K/T ratio by the assessed value of a property to get an estimate of the market value.

Given Statistics Sweden's confidence regarding the K/T ratio as well as the use of it by Wessel and Jennefelt (2007), we believe that it is the most reliable measure for price development at a municipality level. **Therefore, we use the K/T ratio, instead of average purchase prices, for our return and volatility calculations.**

4.2 SAMPLING

4.2.1 SINGLE FAMILY HOUSING DEFINITION

The real estate we look at is one- or two-dwelling buildings for permanent living. These buildings are defined as building established for one or two families, including complementary buildings such as garage, storage and other minor buildings.

4.2.2 GATHERING DATA

The following data was gathered based on yearly figures from Statistics Sweden for one- and two-dwelling buildings, by municipality and over the time period 1981-2008:

- Number of transaction.
- Average purchase price, in 1'000 SEK.
- Average assessed values, in 1'000 SEK.
- Average Purchase-price-coefficient. We call this the K/T-ratio.

Other data gathered from Statistics Sweden:

- Average useful floor space per dwelling. Figures were only measured in 2003 and this is what we use as a proxy for the whole period.
- Average maintenance and repair cost. We used the measure per square meter in multi-dwelling buildings in the private category for the period 1992-2008.[7]
- Average monthly rent fee per dwelling. Gathered from figures of dwelling for rented and co-operative society dwellings for the period 1992-1998 and only for rented dwellings between 1999-08.[8]

[7] SCB, "Bostads- och byggnadsstatistisk årsbok 2010", p174
[8] SCB,"Bostads- och byggnadsstatistisk årsbok 2010", p169

4.2.3 SAMPLING METHOD

Our original data set contained 290 municipalities. When collecting our data we have excluded the municipalities that do not have observations for the full time-series or municipalities that, at some year, had less than 30 transactions. Thereby we can assume transactions within municipalities to be diversified, preventing us from getting misguiding outliers. After exclusion, the sample consists of 238 municipalities. The excluded municipalities are widespread all over Sweden and only 2.41% originated from metropolitan areas.

4.2.4 RELIABILITY OF DATA

We believe that the reliability of the data gathered from Statistics Sweden can be defined as high given that the institution has no private interests.

5 METHOD

Information regarding our data and sampling is found in the appendices.

5.1 ADJUSTED K/T-RATIO

As stated above, the K/T-ratio is the purchase price divided by assessed value of a property at the date of sale. We use an adjusted K/T-ratio instead of average real estate purchase prices to obtain improved measures of return and volatility. In other words, we estimate purchase price, P_t, with the adjusted K/T-ratio Z^*_t. We therefore overcome some of our sampling problems concerning heterogeneity and get a better measure of the price development. The adjustment is made to take into consideration the fact that the assessed values only get assessed every sixth year, by setting 1981 as a static base year.

The measure is formed by multiplying the K/T-ratio computed by Statistics Sweden with the average assessed value divided by the average assessed value in base year 1981. The formula can be seen below.

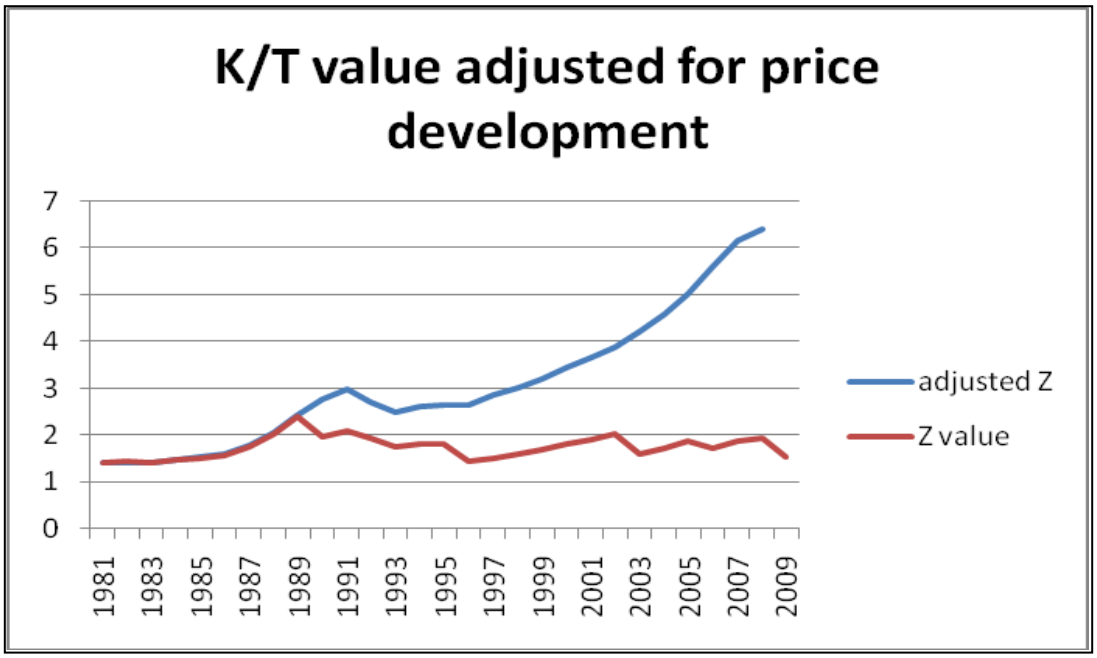
$$Z^*_{i,t} = Z_{i,t} \times \frac{AV_{i,t}}{AV_{i,81}} \tag{5}$$

where

- $Z^*_{i,t}$ is the adjusted K/T-ratio for municipality *i* in year *t*,
- $Z_{i,t}$ is the K/T-ratio for municipality *i* in year *t* as computed by Statistics Sweden,
- $AV_{i,t}$ is the average assessed value for municipality *i* in year *t*,
- $AV_{i,81}$ is the average assessed value for municipality *i* in base year 1981.

Adjusting the K/T-ratio from the one Statistics Sweden reports prevents us from getting a flat, misleading price development. Nevertheless, it allows us to make comparison over time periods with different assessed values for properties. The difference is illustrated in figure 1.

Figure 1. Showing the aggregate average adjusted and original K/T-ratios over the time period 1981-2008.



5.2 CROSS-SECTIONAL REGRESSION ON HOUSING RETURNS

For the yearly time-series 1982-2008, mean annual returns and price levels are calculated for each municipality. Annual returns are computed from underlying $Z^*_{i,t}$ values seen in equation (5). Price level is represented by the average of the natural logarithm of mean house prices for each year. They are then collapsed into means for each municipality. The corresponding volatility for a municipality is calculated using the standard deviation of the annual returns. The data set forms a cross-section across municipalities i = 1,…, n (n = 238) . Returns are decomposed using the cross-sectional regression below to study the role of volatility and price level on returns to housing investment.

$$r_i = \alpha_0 + \alpha_1 Vol_i + \alpha_2 lnPrice_i + \varepsilon_i \quad (6)$$

where

- r_i is the average annual return for the $Z^*_{i,t}$-priced house in each municipality,
- Vol_i is the return volatility for the $Z^*_{i,t}$-priced house for each municipality over the years 1982-2008,
- $lnPrice_i$ is the average of the natural logarithm of house prices (in SEK 000s),
- ε_i is the error term.

5.2.1 QUINTILE PORTFOLIOS

We separate the municipalities into five portfolios ranked by the natural logarithm of the average house market prices (Price Quintile = 1, 2,…, 5) and apply the cross-sectional regression for each quintile. This is done to see how the independent variables explain return with regard to market segment.

5.2.2 CLUSTERING EFFECTS

By defining zip codes into neighborhoods, Goetzmann et al (1998) find that property prices fluctuate together, even though they are separated in space, as long as they are perceived by the market as substitutes for each other. We thereby want to see if our return-volatility-price level relationship is robust to clustering effects. We use Local Labor Markets (LLMs), computed by Statistics Sweden based on commuting patterns for workers, as a proxy for municipality clustering.[9] All municipalities belong to one of the total of 75 LLMs, which give 74 dummy variables in the cross-sectional regression. The reasoning behind this is that houses in these LLMs are perceived by the market as substitutes since people within them are still able to commute to their workplace.

5.3 PANEL DATA

When calculating return and volatility for the panel data, an investor model is constructed to take into account factors that affect homeowners when investing. The following section describes how return and volatility is generated using the investor model.

5.3.1 HOLDING PERIODS

When generating the underlying data set, we use both 10-year and 5-year investment horizons in two different panel data sets. Annualized return and volatility are calculated for the horizons with different initial periods of investment. Starting at 1981 we get, for each municipality, 18 investment periods built on 10 years each, and 23 investment periods built on 5 years each.

5.3.2 CONSTRUCTING THE PRICE INDEX

To be able to calculate return and volatility, the assumptions listen below are incorporated with the adjusted K/T-ratio to give a price index for each municipality over our time period 1981-2008. Table 1 explains the assumptions that have been make when we account for factors that affect the buying, holding and selling of the house.

[9] SCB, “Metoden att skapa Lokala Arbetsmarknader”.

Table 1. Overall house investment assumptions and transactions costs.

Overall assumptions[10]	**(% figures are an assumed proportion of house value)**
Depreciation	0,5% yearly
Maintenance and Operating cost	1,17% yearly
Opportunity gain of not renting	6,28% yearly (a homeowner is assumed to gain from not having to rent)
Loan	We assume investors take no loans
Time of enter/exit	Investment take place in the beginning of a year, sale in the end of a year
Property tax	1% yearly
Insurance	We assume that investors have no insurance costs
Inflation	We do not take into account inflation in our assumptions
Tax Shield	We do not take into account any gains from a tax shield
Interest payments	Since there is no loan we do not take into account interest payments
Transaction costs	
Background check	We do not take into account any background check cost when investing
Inspection cost	We do not take into account any inspection cost when investing
Duty stamp	1,5% paid at time of investment
Real estate agent fee	3% at time of sales

To incorporate these factors we construct a price index, computed in three steps. First, we generate the annual capital return using the formula below.

$$Annual\ capital\ return = \ Cap(r_{i,t}) = \frac{Z^*_{i,t+1}}{Z^*_{i,t}} - 1$$

Second, we calculate the annual return on investment having incorporated the surrounding factors of opportunity gain, maintenance- and operational cost, depreciation and property tax using the following formula. Percentage figures are an assumed proportion of house value.

$$ret_{i,t} = \left(\frac{Z^*_{i,t+1}}{Z^*_{i,t}} - 1\right) + (og_t - mc_t - \partial_t) - \frac{(Assessed\ value_t * taxrate_t)}{property\ value_t} \quad (9)$$

where

- og_t is the yearly opportunity gain in percent,
- mc_t is the yearly maintenance cost in percent,
- ∂_t is the yearly depreciation in percent,
- $\frac{(Assessed\ \ value_t * taxrate_t)}{property\ \ \ value_t}$ is the $Property\ tax$ in percent,
- t is continuous as $t = 1982, \dots, 2008$

[10] For a detailed explanation, see appendices.

In the third and final step we generate the price index for each municipality in a regular way. We use 1981 as our base year and continue up to 2008:

$$Index(1981)_i = 100$$

$$Index_{t,i} = 100 * [(1 + ret_{82,i}) * \dots * (1 + ret_{08,i})]$$

where

- t is continuous as $t = 1982, \dots, 2008$
- i is the municipality (n=1,…, 238)

5.3.3 GENERATING RETURN, VOLATILITY AND PRICE LEVEL

Next, we use the price index to calculate the yearly annualized returns for a house investment on each of our two investment horizons. At the time of sale the return is affected by the fee that the investor has to pay to the real estate agent. At the time of investment the return is affected by the duty stamp that the investor has to pay when registering the house at the district court. Therefore, the 5-year investor obtains larger transaction costs in proportion to return than the 10-year investor.

$$Yearly\ return\ on\ investment = \sqrt[(x-k)]{\frac{[Index\ (T=x)]*(1-ma)}{[Index\ (T=k)]*(1-s)}} - 1 \qquad (11)$$

where

- k is the time of investment,
- x is the time of sale,
- ma is the real estate agent fee,
- s is the duty stamp.

The risk accompanied by a certain investment period is measured using the volatility. Price level is measured by the natural logarithm of mean house price in the first year of investment.

In total, we get two panel data sets, one for the 10-year horizon, containing 18 investment periods and 4284 observations for return and volatility, one for the 5-year horizon, containing 23 investment periods and 5473 observations of volatility and return. Both panel data sets are balanced. For summary statistics see Table 16 and 17 in appendices.

5.4 PANEL REGRESSIONS ON HOUSING RETURNS

Having the two panel data sets we can study the relationship of our independent variables and the return both by holding municipality- and year specific effects fixed. In our first setup we use only the binary dummy variables for each municipality, getting the following model:

$$ret_{i,t} = \beta_0 + \beta_1 Vol_{it} + \beta_2 lnPrice_{it} + \beta_3 mun2 + \cdots + \beta_{241} mun238 + u_{it} \quad (7)$$

where

- $ret_{i,t}$ is the return for municipality *i* in year *t*,
- β_0 is the intercept for municipality 1,
- $\beta_1 Vol_{i,t}$ is the volatility for municipality *i* in year *t*,
- $\beta_2 lnPrice_{i,t}$ is the price level for municipality *i* in year *t*,
- mun * is the binary dummies for each municipality (n=2,3,…, 238),
- $u_{i,t}$ is the error term.

By using this model we hope to capture and proxy the unobserved municipality specific variables that, if excluded, would create omitted variable bias. We therefore get a pure estimate of the impact of volatility and price level on return. This fixed effects model let each municipality have its own intercept that is constant over time and it allows the unobserved effects to be correlated with our independent variables since they are now included in the form of municipality dummies.

Factors captured in the municipality dummies could be geographical features, attitudes, abilities and interest in buying single family houses. It is reasonable to believe that these factors change to a large extent between different municipalities. Also, we assume that the changes of these factors are negligible or nonexistent looking over our time horizon setup.

5.5 MODEL TESTING

All models have been subjected to extensive testing. For further details see appendices.

6 EMPIRICAL FINDINGS

6.1 CROSS-SECTIONAL REGRESSIONS ON HOUSING RETURNS[11]

Table 2 shows regression results for the aggregate housing market. Regressing returns on volatility using model (6) we find that the estimated volatility coefficient is statistically significant at 0.141.[12] However, volatility alone has a very low explanatory power. By including price level (B) we get a statistically significant but higher coefficient for the volatility at 0.180 and a price level effect of 0.030. This implies that a 10% increase in risk would lead to a 1.80% rise in return and that a house with a market value of 2.000,000 SEK compared to a house of 1,000,000 SEK would earn an additional 2.10% return. This is calculated by 0.0303*[ln(2000)-ln(1000)]. The explanatory power has increased substantially, implicating that a large proportion of the returns can be explained by the price level.

Table 2. Cross-sectional regression of housing returns on volatility and price level.

	(A) Estimate	(B) Estimate
Volatility	0.141**	0.180***
	(0.0517)	(0.0295)
lnPrice		0.0303***
		(0.00160)
Intercept	0.0458***	-0.148***
	(0.00494)	(0.0113)
N	238	238
R^2	0.030	0.692
adj. R^2	0.026	0.689
RMSE	0.0150	0.00845

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

We now rank the housing market consisting of 238 municipalities into five portfolios based on their average price level. Model (6) excluding lnPrice is estimated for each price quintile (Table 3). For most municipalities, low price level corresponds to a low population density (residents per square kilometer, 2008[13]). Accordingly, quintile number 5 contains most of the municipalities in Sweden that are classified as metropolitan areas, i.e. Stockholm, Gothenburg and Malmo and their suburbs.[14] More specifically, 38 out of the 47 observations in this quintile are classified as metropolitan. Furthermore, quintile 4 include larger cities such as Landskrona, Borås and Trelleborg, but also many

[11] See appendices for descriptive statistics.
[12] This first approach is somewhat similar to the one applied by Cannon et al (2006)
[13] SCB, "Description of the population in Sweden 2008"
[14] SCB, "Geography in statistics – regional divisions in Sweden 2005"

municipalities that surround larger cities or lie in the outskirts of, but are not classified as, metropolitan areas.

We now get higher estimates of the coefficients in all quintiles. Furthermore, the trend seems to be that there is a higher explanatory power in our model when prices get higher. This would imply that an asset pricing model would have a stronger explanatory value in (i) highly priced submarkets and (ii) highly populated submarkets. If we assume that most of the municipalities in the upmost two quintiles belong to metropolitan areas or are up-and-coming metropolitan areas we can conclude that a risk-return relationship can be explained better in metropolitan markets. A possible interpretation is that the risk-return relationship is varying from positive to negative in the some submarkets, resulting in lower explanatory power of the model when applied to aggregate data. In addition, Urbanization might drive the relationship so that urban areas experience a more solid risk-return trade-off.

As a result, it may be the case that scarcely populated areas of Sweden, where demand for real estate is lower, experience a risk-return linkage that is more randomly distributed and affected by municipality fixed effects which reduce the explanatory power of the model for the full data set.

Interpreting why the volatility coefficients are not monotonic across quintiles, as we might expect, is hard. The metropolitan submarkets in quintile 5 might be saturated and if quintile 4 then represents up-and-coming metropolitan areas, this might implicate that it contain increasingly saturated submarkets which are still volatile, but offer a higher reward for the risk taken.

Table 3. Cross-sectional regression of housing returns on volatility by market segment.

	QPrice=1 Estimate	QPrice=2 Estimate	QPrice=3 Estimate	QPrice=4 Estimate	QPrice=5 Estimate
Volatility	0.195**	0.274**	0.170***	0.337***	0.252***
	(0.0705)	(0.0879)	(0.0405)	(0.0559)	(0.0530)
Intercept	0.0227**	0.0278***	0.0397***	0.0377***	0.0532***
	(0.00725)	(0.00745)	(0.00397)	(0.00463)	(0.00510)
N	48	48	47	48	47
R^2	0.109	0.196	0.214	0.335	0.277
adj. R^2	0.090	0.178	0.196	0.321	0.261
RMSE	0.00987	0.00832	0.00771	0.00888	0.00563

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

By including price level we again get a higher explanatory power of the model (Table 4). Although all estimates for volatility are significant, the coefficients have changed with the most noticeable decline in the highest and lowest price quintiles. Price effects are significant in three price quintiles (1, 3 and 5) and generally the effect seems to decline with higher price level. It should be noticed that whenever the price level coefficient is not significant, the volatility coefficient is higher. Thereby price level effects might be incorporated in the volatility coefficient.

Table 4. Cross-sectional regression of housing returns on volatility and price by market segment.

	QPrice=1 Estimate	QPrice=2 Estimate	QPrice=3 Estimate	QPrice=4 Estimate	QPrice=5 Estimate
Volatility	0.253***	0.280**	0.166***	0.335***	0.173**
	(0.0645)	(0.0922)	(0.0359)	(0.0549)	(0.0578)
lnPrice	0.0379***	0.00897	0.0558**	0.0248	0.0104***
	(0.00876)	(0.0355)	(0.0202)	(0.0149)	(0.00283)
Intercept	-0.203***	-0.0268	-0.306*	-0.122	-0.0110
	(0.0521)	(0.217)	(0.126)	(0.0964)	(0.0187)
N	48	48	47	48	47
R^2	0.295	0.197	0.337	0.385	0.410
adj. R^2	0.263	0.162	0.307	0.358	0.383
RMSE	0.00888	0.00841	0.00716	0.00864	0.00515

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Looking at metropolitan areas alone (Table 5) shows that risk alone explains 10.4% of housing return. The price effect is substantially reduced to 0.009 compared to 0.030 at the aggregate level. This supports the interpretation that a risk-return relationship is more apparent in metropolitan areas.

Table 5. Cross-sectional regression of housing returns on volatility and price in metropolitan areas.

	(C) Estimate	(D) Estimate
Volatility	0.181*	0.152*
	(0.0698)	(0.0716)
lnPrice		0.00891**
		(0.00326)
Intercept	0.0603***	0.00201
	(0.00668)	(0.0203)
N	44	44
R^2	0.104	0.305
adj. R^2	0.082	0.271
RMSE	0.00620	0.00552

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

We now estimate our model (6) by including Local Labor Markets (LLM) as a proxy for clustering effects, creating 74 dummy variables. In Table 6, the original model is compared to the one using LM fixed effects. The model remains robust to LM fixed effects but with lower volatility and price effects. In addition, LLM effects only explain 21.8% of total return variation in the municipalities.

Table 6. Cross-sectional regression with LM fixed-effects.

	(E) Original model	(F) LLM clustering-effects
Volatility	0.180***	0.107***
	(0.0295)	(0.0307)
lnPrice	0.0303***	0.0254***
	(0.00160)	(0.00188)
Intercept	-0.148***	-0.112***
	(0.0113)	(0.0147)
N	238	238
R^2	0.692	0.910
adj. R^2	0.689	0.876
RMSE	0.00845	0.00534

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

6.2 PANEL REGRESSIONS ON HOUSING RETURN[15]

Following section present the results from the panel regression models, using data for the five- and 10-year investment periods. By using municipality fixed effects, we find that investors get decreasing returns for an increase in risk and, on the 10-year horizon, slightly increasing returns for a higher initial price level on the day of investment. Looking at the 5-year horizon instead, we find further support for a negative risk-return relationship, but no significant results of price level effects.

6.2.1 PANEL REGRESSIONS - 10 YEAR HORIZON

Table 7 shows the results from the 10-year panel models. By using this model for fixed effects we obtain significant coefficients on both regressions. Interesting to note is that the coefficients for volatility are negative, which strongly suggests that an investor do not get any reward from taking a larger risk. Moreover, the statistically significant coefficient of -0.188 for volatility implies that there is a negative relationship between risk and return when investing over a 10 year period. Since the municipality dummies captures the municipality specific characteristics we can expect the volatility and price level coefficients to be the pure net effects on return. This implies that a 10% increase in volatility, and thus risk, over a 10 year period would give a house investor a 1.88% decrease in average annualized return when investing. Although, the explanatory power of the model (within R^2) is low at 3.7% a result that we can easily follow in the widespread scatter in graph 1 below.

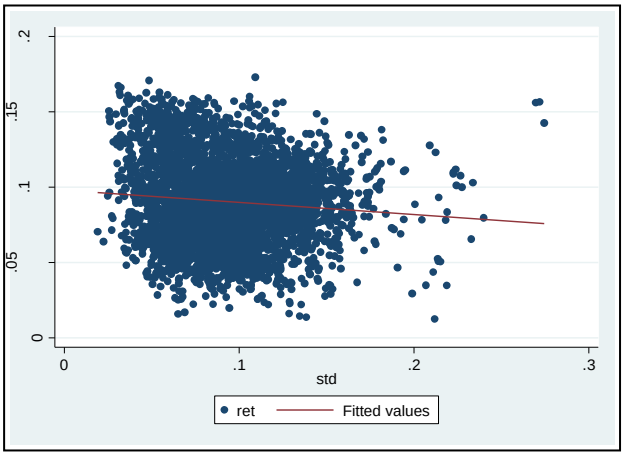
[15] See appendices for descriptive statistics.

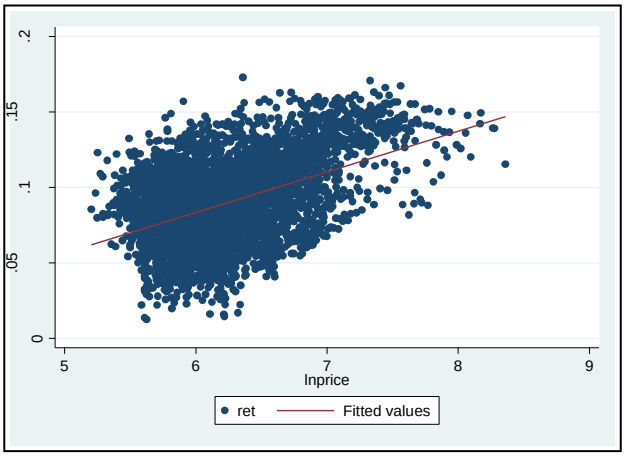
Looking at the price level coefficient we find it significantly negative at a value of 0.00568. This implies that you would get an additional 0.394% less in return when buying a 2,000,000 SEK house compared to a 1,000,000 SEK house when holding the investment for a 10 year period (calculated as 0,00568*[ln(2000)-ln(1000)]). These results suggests that a real price level effect operates in the single family house market and that the price level when investing makes a modest deduction of the yearly investment return for a 10 year holding period.

Table 7. Fixed effects panel regressions of housing returns on volatility and price level. 10-year horizon.

	Municipality fixed effects	**Municipality fixed effects**
	Estimate	Estimate
Volatility	-0.155***	-0.188***
	(0.0127)	(0.0185)
lnPrice		-0.00568**
		(0.00200)
Intercept	0.105***	0.144***
	(0.00131)	(0.0138)
N	4284	4284
R^2	0.035	0.037
adj. R^2	0.035	0.037
RMSE	0.0210	0.0210

Figure 2 (to the left). Scatter plot with volatility on x-axis and return on y-axis for the 10 year horizon data.
Figure 3 (to the right). Scatter plot with lnPrice on x-axis and return on y-axis for the 10 year horizon data.





6.2.2 PANEL REGRESSIONS - 5 YEAR HORIZON

Table 8 shows the estimates from the five-year panel data model. By using this model for fixed effects on panel data and looking at a 5 year investment period, we obtain significant results for all estimates except the price level. Again, the municipality dummies are set up to capture the municipality specific volatilities and price levels.

Again we find that the coefficients for volatility are negative, which support the notion that an investor does not get any reward from taking a larger risk. Coefficient on volatility implies that a 10% increase in volatility, and thus risk, over the 5 year period would give a house investor a 1.33% decrease in average annualized return when investing. Although, the explanatory power of the model (within R^2) is even lower than for the 10-year model at only 1.2%.

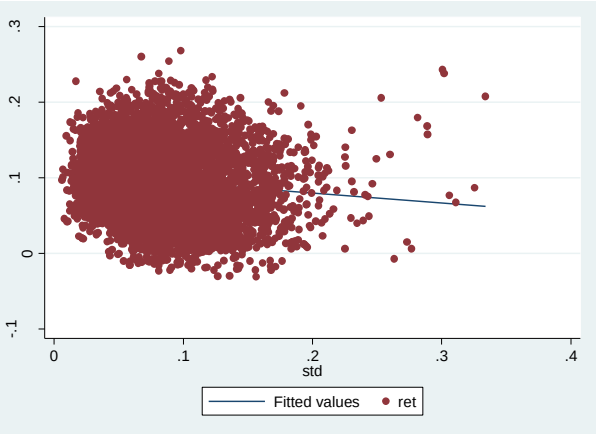
Getting insignificant results on the lnPrice coefficient we cannot determine any price level effect on a 5 year investment horizon.

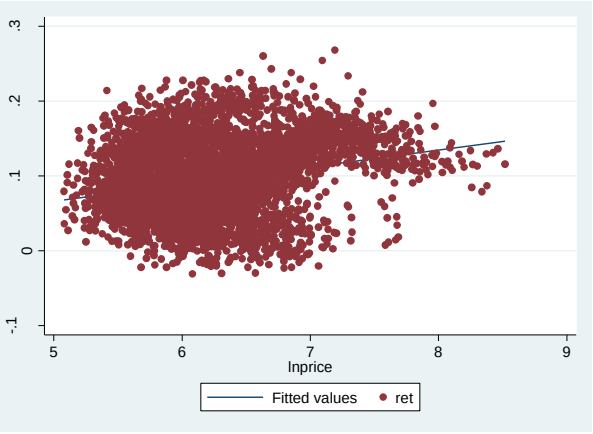
Table 8. Panel regressions of housing returns and price levels including municipality fixed effects. 5-year horizon.[16]

	Municipality fixed	**Municipality fixed**
	Estimate	Estimate
Volatility	-0.137***	-0.133***
	(0.0170)	(0.0175)
lnPrice		0.00235
		(0.00170)
Intercept	0.106***	0.0913***
	(0.00146)	(0.0112)
N	5474	5474
R^2	0.012	0.012
adj. R^2	0.012	0.012
RMSE	0.0445	0.0445

[16] See **Table 19** in appendices for more detailed version.

Figure 4 (to the left). Scatter plot with volatility on x-axis and return on y-axis for the 5 year horizon data.
Figure 5 (to the right). Scatter plot with lnPrice on x-axis and return on y-axis for the 5 year horizon data.





7 CONCLUSION

We apply an asset-pricing analysis using both cross-sectional and panel data of the Swedish single-family housing market over the period 1981-2008. Using aggregate data in our cross-sectional model, we find weak evidence of a positive risk and return relationship, where a 10 % increase in risk leads to a 1.80 % increase in return. However, the price level effect is substantial showing a 2.10 % higher return for an investment made in a house with a market price of 2,000,000 SEK compared to a house with a market price of 1,000,000 SEK. By ranking municipalities by market price we find more distinct evidence for a positive return-volatility-price level relationship, where the explanatory power increases with the price level. However, the price effect seems to be diminishing. The model is robust to local labor market clustering effects.

Using the panel models, controlling for fixed effects, we found varying price level results depending on the time horizon. But when looking at the risk and return relationship we found that investors obtain significantly lower returns for an increase in risk in both horizons.

For a 10 year investment, an increase in volatility of 10 % resulted in a 1.88 % decrease in average annualized return. For the 5 year investment the same regression results showed instead a 1.33% decrease.

The impact of price level on return was insignificant for the 5 year time horizon but showed a modest positive price level effect on return at the 10 year investment horizon.

From these results we find evidence of a negative risk-return relationship in the aggregate Swedish market. However, the diverse results in price level effects indicate a small price level effect only in the short 5 year investment horizon.

8 DISCUSSION

The very nature of real estate is a possible reason for our weak results for the volatility effect in the cross-section. Housing is heterogeneous, and we can expect very large differences between metropolitan and non-metropolitan areas of Sweden. Another possible explanation is that there might be a varying risk-return relationship within Swedish submarkets. Furthermore, treating housing as a financial asset analogous to equities is problematic because buyers generally do not have extensive economic knowledge and are not concerned about price risk in the same way as for equities, as long as they do not lose significant amounts when divesting in the future. Such a scenario has not occurred in Sweden due to continuous appreciation of house prices over the last 30 years, with exception for 1991-1992.

In line with this, we believe that location, size and affordability are more important factors. Considering affordability, it might be the case that people are more worried about the interest rate risk rather than housing price risk when deciding on buying a house, because this corresponds to whether they can afford their future living. Accordingly, in areas where incomes are higher, people have a higher margin when it comes to affordability which might drive prices and also affect the risk and return relationship.

Local submarkets attractiveness regarding, for example status, might also drive the prices. In addition, inflation has a significant effect when prices appreciate. Things that are discussed above might work to erode a risk-return relationship, at least on an aggregate level. Based on our results in the cross-section, we suspect that metropolitan areas experience more homogeneity, and that a separating analysis would give a better understanding of how risk and return works in the Swedish single family housing market

Using the panel regressions, we have controlled for many of the problems discussed above. But we still believe that further studies are required to confirm the results.

9 FURTHER STUDIES

- In our models, we use volatility as a risk measure. This might not be the best measure of risk because it recognizes positive return as risk. By using other measures of risk, such as Value at Risk, one might get a better estimate of the relationship between risk and return.
- In our investor model, we have not taken into account the fact that most families borrow when buying a house. Developing an extended model which takes into account debt and interest rate payments would make an interesting contribution.
- House prices are affected by inflation. Also, when having large debt on a property the inflation becomes even more important in the investment. Building a model that considers these factors would also make an important contribution.
- A major problem with the data we use is that it is not quality-adjusted or includes median prices. Furthermore, our figures are aggregated on municipality level and single transactions are not possible to follow. Developing a data set that overcomes these problems would give estimates of the price development in Sweden that is superior. Being able to sample house prices in submarkets within municipalities would also be a better way to reduce heterogeneity.
- In our analysis we do not include co-operative apartments, which represent the majority of housing in urban areas of Sweden. Analyzing the risk-return relationship in this market would be interesting.

10 LIMITATIONS

Ideally, we would use median house price data because this would reflect house price development better and overcome some of the problems regarding size and standard of houses that are sold. Our data is not adjusted for quality, location and other factors that might have large effects on price, and we expect to have multiple observations that contain large structural variations. In other words we have extensive heterogeneity in our data. This is partly countered by using an adjusted K/T- ratio in the return calculations, but the measure is far from perfect. Moreover, we do not have data on single transactions or submarkets within municipalities, reducing the precision of our analysis.

In addition, some house sales are made privately or in connection with some other transaction (e.g. a tenancy agreement) which would benefit the seller. This would adjust the selling price downwards and increase the K/T ratio. However, we have assumed that such transactions are quite rare and have thereby not taken the issue into account.

Furthermore, by examining one- and two dwelling buildings, we expect oversampling in proportion to population in rural municipalities and undersampling in urban ones, e.g. the cities Stockholm, Gothenburg and Malmo.

Another concern is that, even though we have a long time series, intra-year house prices are not available by municipality, making it impossible to seize the intra-year return and volatility which would be better.

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12 APPENDICES

12.1 ASSUMPTIONS MADE

Below we explain in detail the different assumptions made when calculating the returns and volatilities used in our two panel data sets.

12.1.1 RENT

The average cost of renting an apartment in Sweden is assumed to be an opportunity gain for the property investor. We assume that the investor has only two choices of living, either he lives in an apartment or in his house investment. This implies that the investor makes a trade-off when investing in the house, in one hand a large initial payment must be made, but on the other hand the investor saves the rent cost.

The opportunity gain was calculated using average rent cost per year for Swedish apartments based on the time period 1992 to 2007. Each year’s average cost was divided by the average property value for the same year. The median value for the time period was finally used as a proxy for the opportunity gain of making a house investment.

Table 9. Median rent/property value calculation

	1992	1993	1994	1995	1996	1997	1998	1999
Average rent per month	3 130	3 398	3 538	3 640	3 785	3 890	3 914	3 938
Average rent per year	37560	40776	42456	43680	45420	46680	46968	47256
Average Property value	572840.34	518970.59	544743.70	547613.45	559558.82	602693.28	646336.13	694252.10
Rent/Property value	6.56%	7.86%	7.79%	7.98%	8.12%	7.75%	7.27%	6.81%
	2000	2001	2002	2003	2004	2005	2006	2007
Average rent per month	3 981	4 027	4 161	4 279	4 405	4 520	4 558	4 646
Average rent per year	47772	48324	49932	51348	52860	54240	54696	55752
Average Property value	760142.86	812239.50	861441.18	929340.34	1015386.55	1106903.36	1247117.65	1368369.75
Rent/Property value	6.28%	5.95%	5.80%	5.53%	5.21%	4.90%	4.39%	4.07%

12.1.2 PROPERTY FINANCING

We assume that the investor finance the property without taking any loan. This is a somewhat unrealistic assumption since most homeowners in Sweden have financed their properties with extensive lending. However, from an asset pricing perspective it can be argued that it is a more interesting way of looking at housing as an asset for investment which gives payment in form of rent and house price returns.

12.1.3 TIME OF INVESTMENT

We assume that each investor invests in the beginning of a year and sell his investment in the end of a year. This coins all calculations.

12.1.4 PROPERTY TAX

At the beginning of our sample period, until 1990, Sweden had a tax rate of 2 % of the assessed value of a property. Although, the 50 % marginal tax rate during the same period made the effective rate on land 1 %. After 1990 the tax rate was changed to a fixed 1 % of the assessed value. Therefore we assume a fixed property tax during our sample period of 1 % of the assessed value.

Property aged less than five years are excluded from property tax. In addition, property aged between 5 and 10 years pay only 50 % of the property tax. We did not take this into account since the Swedish houses older than 10 years make up approximately 97 % of the single family house stock. [17]

[17] Swedish Law, SFS(1990:1650), (1984:1052)

12.1.5 DEPRECIATION

We assume that a single family house has a life span of 100 years, which makes it depreciate at a rate of 1 % per year. Since you get both land and structure when making the property investment, but there is no depreciation on land, the property depreciation will be 0.5 % per year, assuming that land and structure have an equal value distribution.

12.1.6 MAINTENANCE COSTS

Maintenance and repair costs are assumed to affect the returns for an investor negatively. Based on the years 1992 to 2007, we calculated annual costs using the average useful floor space per dwelling, multiplied with the average repair costs per square meter. We further divided the annual costs by the current year's average property value and used the median value as our proxy. A weak, but assumed negligible link in this measure is the data on average useful floor space per dwelling, which was only available for the year of 2003.

Table 10. Maintenance and repair cost/property value calculation

	1992	1993	1994	1995
Average useful floor space per dwelling	122	122	122	122
Maintenance and repair cost per square meter (Private, Average)	90	89	105	105
Maintenance and repair cost per dwelling	10980	10858	12810	12810
Maintenance and repair cost/property value	1.92%	2.09%	2.35%	2.34%
	1996	1997	1998	1999
Average useful floor space per dwelling	122	122	122	122
Maintenance and repair cost per square meter (Private, Average)	106	116	116	119
Maintenance and repair cost per dwelling	12932	14152	14152	14518
Maintenance and repair cost/property value	2.31%	2.35%	2.19%	2.09%
	2000	2001	2002	2003
Average useful floor space per dwelling	122	122	122	122
Maintenance and repair cost per square meter (Private, Average)	122	117	128	125
Maintenance and repair cost per dwelling	14884	14274	15616	15250
Maintenance and repair cost/property value	1.96%	1.76%	1.81%	1.64%
	2004	2005	2006	2007
Average useful floor space per dwelling	122	122	122	122
Maintenance and repair cost per square meter (Private, Average)	147	141	165	149
Maintenance and repair cost per dwelling	17934	17202	20130	18178
Maintenance and repair cost/property value	1.77%	1.55%	1.61%	1.33%
Median maintenance and repair cost/property value	**1,937%**			

12.1.7 TRANSACTION COSTS

We assume that the investor pays a stamp duty of 1.5 % when investing and a 3 % real estate agent fee when selling the property. The Swedish government had the duty stamp removed by the end of 2007 but since this restructuring only affect one year in our data, and by a small to nonexistent amount, we still use 1.5 % as a proxy fee for the whole period 1981 to 2008.

12.1.8 CAPITAL GAINS TAX

The reason for not taking capital gains tax into account is because of the large differences in conditions between a young and old property investor. Under Swedish law, and individual is excluded from capital gains tax if the gains are fully reinvested into another property. However, if an individual reinvests into a smaller, less expensive property, the difference in value is treated as capital gains and thus chargeable. This makes younger investors better off than elder since they are more likely to demand a house upgrading than a downgrading as they start a family. In order to get a correct asset pricing picture regardless of investor type we therefore exclude capital gains tax from our model.

12.1.9 BACKGROUND CHECK-, INSPECTION- AND INSURANCE COSTS

We do not take background check costs or inspection costs when selling and buying into account in our calculations since these costs are not considered general for all investors. We assume that there are no insurance costs neither because the property insurance depend on each corporations specific classification of different variables, such as moisture class, which are hard to estimate.

12.1.10 INFLATION

Inflation is not taken into account directly in the price calculations and we use nominal values of the underlying prices.

12.2 DESCRIPTIVE STATISTICS CROSS-SECTIONAL REGRESSION

Table 11. Cross-sectional descriptive statistics.

Variable	Obs.	Mean	Median	Std.	Min	Max	Kurt.	Skew
Price(SEK,000s)	238	663.584	535.661	365.859	251.929	2787.143	10.780	2.288
lnPrice	238	6.285	6.211	0.407	5.503	7.742	3.435	0.723
Popsqkm(2008)	238	124.844	31.800	365.213	0.900	4307.800	77.127	7.539
Return	238	5.894	5.742	1.515	2.411	9.075	2.203	0.085
Volatility	238	9.369	9.270	1.879	4.707	19.869	6.985	1.001

12.3 CROSS-SECTIONAL REGRESSION ON MEAN HOUSE PRICES

These tables represent the regression using figures of average real estate prices from Statistics Sweden. However, we do not believe that the results are as reliable as those computed using the adjusted K/T-ratio.

Table 12. Cross-sectional regression of housing returns on volatility and price level.

	(1)	(2)
VARIABLES	Return	Return
Volatility	0.186***	0.179***
	(0.0464)	(0.0298)
lnPrice		0.0296***
		(0.00154)
Intercept	0.0417***	-0.144***
	(0.00413)	(0.0107)
Observations	238	238
R-squared	0.056	0.705

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 13. Cross-sectional regression of housing returns on volatility by market segment.

	QPrice=1	QPrice=2	QPrice=3	QPrice=4	QPrice=5
	ret	ret	ret	ret	ret
Volatility	0.246**	0.259**	0.165**	0.277***	0.266***
	(0.0860)	(0.0853)	(0.0498)	(0.0550)	(0.0577)
Intercept	0.0182*	0.0295***	0.0406***	0.0429***	0.0515***
	(0.00877)	(0.00719)	(0.00473)	(0.00499)	(0.00555)
N	48	48	47	48	47
R^2	0.151	0.167	0.196	0.355	0.321
adj. R^2	0.132	0.149	0.178	0.341	0.306
rmse	0.00964	0.00819	0.00752	0.00859	0.00550

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 14. Cross-sectional regression of housing returns on volatility and price level by market segment.

	QPrice=1	QPrice=2	QPrice=3	QPrice=4	QPrice=5
	ret	ret	ret	ret	ret
Volatility	0.283***	0.258*	0.162***	0.278***	0.178**
	(0.0726)	(0.0982)	(0.0427)	(0.0362)	(0.0605)
lnPrice	0.0389***	-0.000924	0.0560**	0.0241	0.0103**
	(0.00850)	(0.0366)	(0.0196)	(0.0145)	(0.00294)
Intercept	-0.211***	0.0351	-0.307*	-0.113	-0.0113
	(0.0508)	(0.223)	(0.122)	(0.0939)	(0.0188)
N	48	48	47	48	47
R^2	0.353	0.167	0.330	0.404	0.441
adj. R^2	0.324	0.130	0.300	0.378	0.415
rmse	0.00851	0.00828	0.00694	0.00835	0.00505

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 15. Cross-sectional regression of housing returns on volatility and price in metropolitan areas.

	(1)	(2)
	ret	ret
Volatility	0.187*	0.129
	(0.0731)	(0.0755)
lnPrice		0.00918**
		(0.00334)
Intercept	0.0595***	0.00202
	(0.00690)	(0.0194)
N	44	44
R^2	0.116	0.325
adj. R^2	0.095	0.292
rmse	0.00611	0.00541

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

12.4 DESCRIPTIVE STATISTICS PANEL REGRESSIONS

Table 16. Descriptive statistics of the 10 year panel data set.

Variable	Obs.	Mean	Std. Dev.	Min	Max
Return	4284	0.0902798	0.0271991	0.0123845	0.1730565
Volatility	4284	0.0952009	0.0325326	0.0190438	0.2745072
lnPrice	4284	6.256641	0.4617822	5.20248	8.358702

Table 17. Descriptive statistics of the 5 year panel data set.

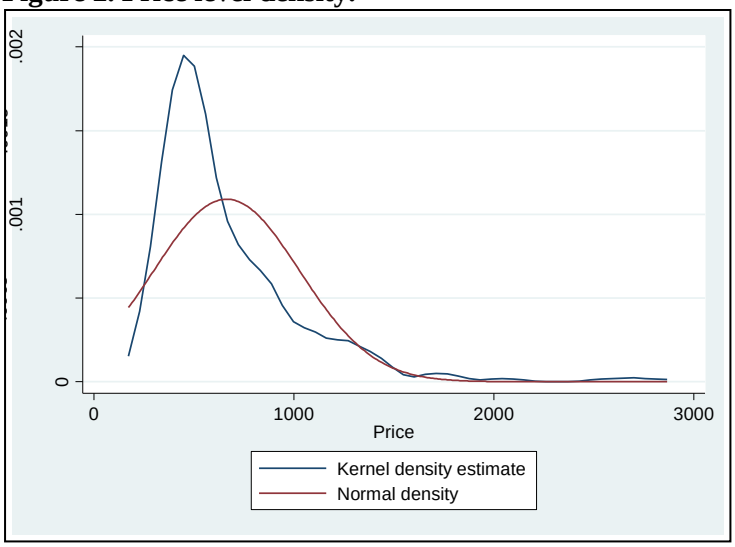
Variable	Obs.	Mean	Std. Dev.	Min	Max
Return	5474	0.094649	0.04807	-0.03104	0.268022
Volatility	5474	0.084773	0.040939	0.00597	0.33394
lnPrice	5474	6.249252	0.527242	5.078436	8.517109

12.5 TEST OVERVIEW

12.5.1 PRICE LEVEL

Skewness of variable market price (2.287).

Figure 2. Price level density.



12.5.2 CROSS-SECTIONAL REGRESSION ON HOUSING RETURNS.

Figure 3. Scatter plot of Returns on Volatility.

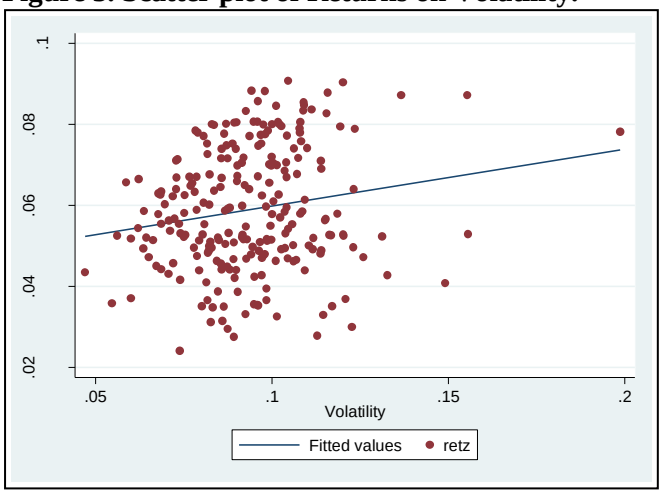
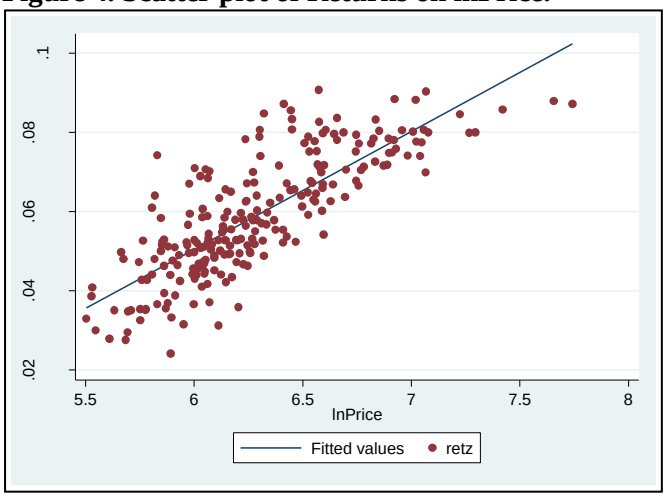


Figure 4. Scatter plot of Returns on lnPrice.



12.5.2.1 HETEROSKADICITY

We use the Breusch-Pagan test to examine heteroskedasticity in our model. The null hypothesis is that the residuals are homoskedastic. Heteroscedasticity -robust standard errors are applied if needed.

Table 18. Test for heteroskedasticity. Cross-sectional regressions.

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
Ho: Constant variance
Variables: fitted values of return(z)
$r_i = \alpha_0 + \alpha_1 Vol_i + \varepsilon_i$
chi2(1) = 7.17
Prob > chi2 = 0.0074
$r_i = \alpha_0 + \alpha_1 Vol_i + \alpha_2 lnPrice_i + \varepsilon_i$
chi2(1) = 0.97
Prob > chi2 = 0.3239

Table 19. Test for heteroskedasticity. Quintile portfolios.

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
Ho: Constant variance
Variables: fitted values of return(z)
$r_i = \alpha_0 + \alpha_1 Vol_i + \varepsilon_i$
QPrice=1
chi2(1) = 0.43
Prob > chi2 = 0.5113
QPrice=2
chi2(1) = 0.95
Prob > chi2 = 0.3301
QPrice=3
chi2(1) = 0.00
Prob > chi2 = 0.9638
QPrice=4
chi2(1) = 2.27
Prob > chi2 = 0.1316
QPrice=5
chi2(1) = 0.01
Prob > chi2 = 0.9059

12.5.2.2 NORMALITY OF RESIDUALS

Table 20. Shaprio-Wilk W test for normal data. Volatility on return.

	Shapiro-Wilk W test for normal data				
Variable	Obs	W	V	z	Prob>z
e	238	0.97892	3.661	3.012	0.0013

Table 21. Shaprio-Wilk W test for normal data. Return on volatility and price level.

	Shapiro-Wilk W test for normal data				
Variable	Obs	W	V	z	Prob>z
e	238	0.99047	1.655 1.169		0.12127

12.5.2.3 MODEL SPECIFICATION

Table 22. Model specification test.

Ramsey RESET test using powers of the fitted values of return(z)
Ho: model has no omitted variables
$r_i = \alpha_0 + \alpha_1 Vol_i + \varepsilon_i$
F(3, 233) = 0.93
Prob > F = 0.4279
$r_i = \alpha_0 + \alpha_1 Vol_i + \alpha_2 lnPrice_i + \varepsilon_i$
F(3, 232) = 11.52
Prob > F = 0.0000

12.5.3 PANEL REGRESSIONS TEST OVERVIEW

Overall results from the tests made on our models:

Table 23. Panel regressions test overview.

Statistical tests and their results	Outcome 10 year horizon model:	Outcome 5 year horizon model:
Testing for fixed effects	Needed	Needed
Hausman test	Fixed effect preferred	Fixed effect preferred
Testing for Time-fixed effects	Needed	Needed
Testing for heteroskedasticity	Present	Present
Testing for cross-sectional dependence	Present	Present
Testing for serial correlation	Present	Present

Figure 7. Observing the heterogeneity in returns across our municipalities. The red dots illustrate the mean values of the returns while the dots are the returns in different years:

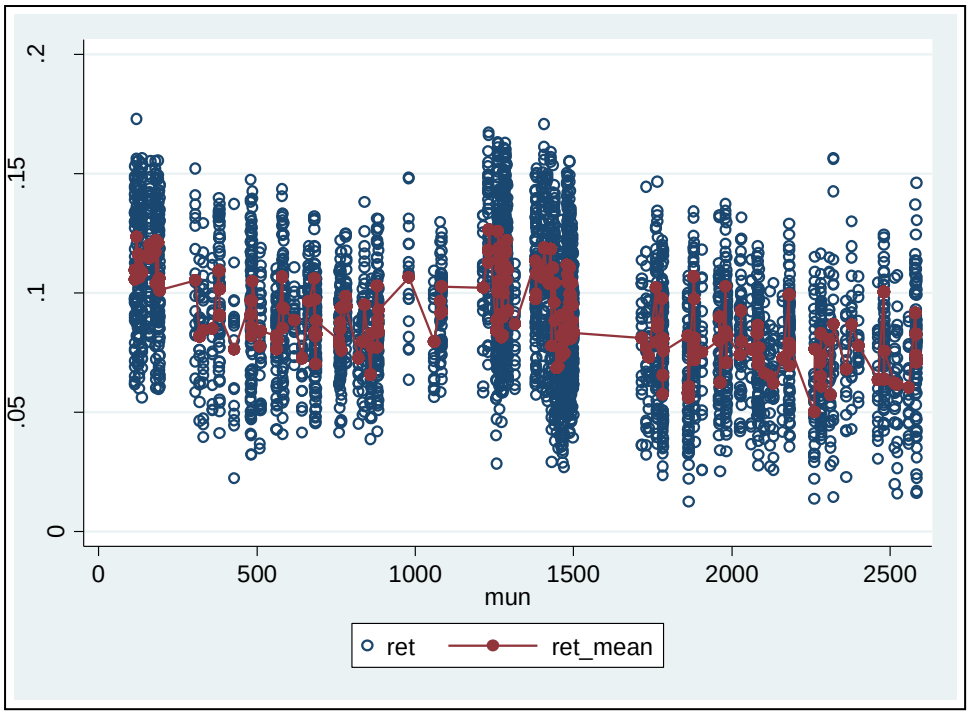


Figure 8. Observing the heterogeneity across time periods 1981-1999. The red dots illustrate the mean returns over the time period.

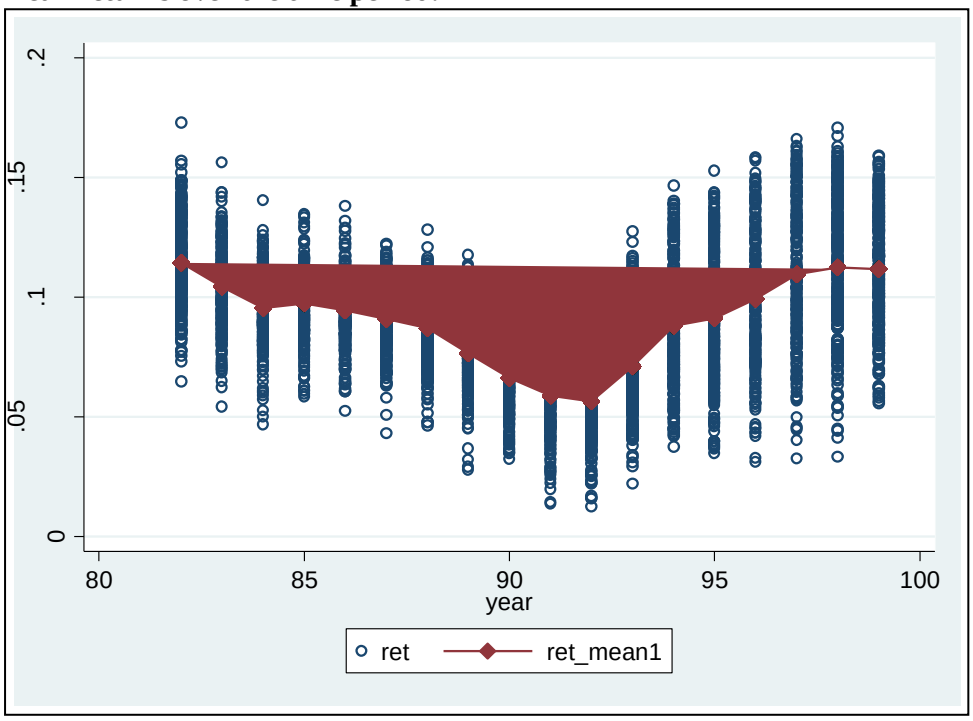


Table 24. Running the Hausman test we see that the fixed effect model is preferred over the random effects:

```
. hausman fixed random

                 ---- Coefficients ----
                 (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
                 fixed        random         Difference          S.E.
------------------------------------------------------------------------------
         std    -.1877828    -.1448576       -.0429252        .0102991
------------------------------------------------------------------------------
                           b = consistent under Ho and Ha; obtained from xtreg
            B = inconsistent under Ha, efficient under Ho; obtained from xtreg

    Test:  Ho:  difference in coefficients not systematic

                  chi2(1) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =          17.37
                Prob>chi2 =         0.0000
```

Table 25. Running the fixed effects test we see that we need municipality fixed effects:

```
 (227)  _Imun_2480 = 0
 (228)  _Imun_2481 = 0
 (229)  _Imun_2482 = 0
 (230)  _Imun_2514 = 0
 (231)  _Imun_2523 = 0
 (232)  _Imun_2560 = 0
 (233)  _Imun_2580 = 0
 (234)  _Imun_2581 = 0
 (235)  _Imun_2582 = 0
 (236)  _Imun_2583 = 0
 (237)  _Imun_2584 = 0

 F( 17,   237) =  226.42
      Prob > F =    0.0000
```

Table 26. Running the heteroskedasticity test we find it present:

```
. xttest3

Modified Wald test for groupwise heteroskedasticity
in fixed effect regression model

H0: sigma(i)^2 = sigma^2 for all i

chi2 (238)  =   1736.13
Prob>chi2 =      0.0000
```

Table 27. Running the test of cross sectional dependence we find it present:

```
. xtcsd, pesaran abs


Pesaran's test of cross sectional independence =   489.556, Pr = 0.0000

Average absolute value of the off-diagonal elements =     0.690
```

Table 28. Running the test for autocorrelation we find it present:

```
. xtserial ret std lnprice

Wooldridge test for autocorrelation in panel data
H0: no first-order autocorrelation
    F(  1,     237) =    690.008
           Prob > F =      0.0000
```

12.5.3.3 PANEL DATA 5 YEAR HORIZON

Figure 9. Observing the heterogeneity in returns across our municipalities. The red dots illustrate the mean values of the returns while the dots are the returns in different years.

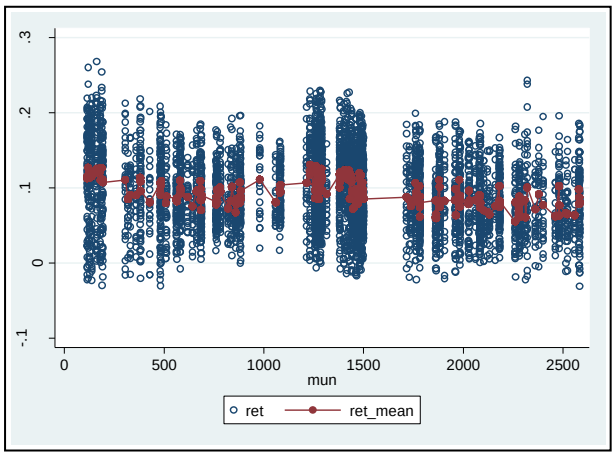
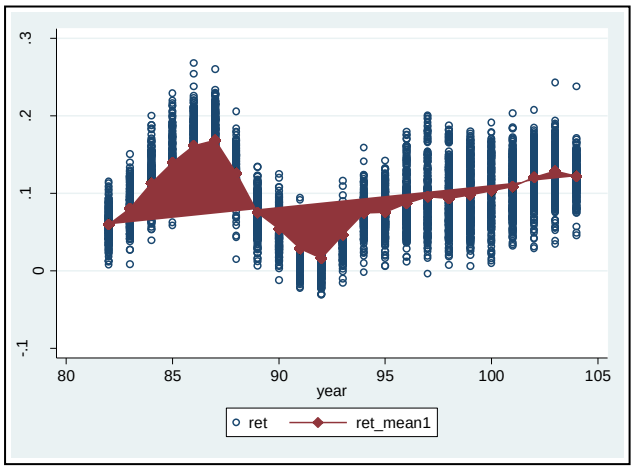


Figure 10. Observing the heterogeneity across time periods 1981-1999. The red dots illustrate the mean returns over the time period:



12.5.3.4 PANEL REGRESSIONS TEST RESULTS – 5 YEAR HORIZON

Table 29. Running the Hausman test we see that the fixed effect model is preferred over the random effects:

```
. hausman fixed random

                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |    fixed         random       Difference          S.E.
-------------+----------------------------------------------------------------
         std |   -.133298     -.0829094      -.0503886        .0075575
      lnprice |    .0023474     .0209275      -.0185801        .0013113
------------------------------------------------------------------------------
                           b = consistent under Ho and Ha; obtained from xtreg
            B = inconsistent under Ha, efficient under Ho; obtained from xtreg

    Test:  Ho:  difference in coefficients not systematic

                  chi2(2) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =      219.77
                Prob>chi2 =      0.0000
```

Table 30. Testing for fixed effects:

```
(230)  _Imun_2514 = 0
(231)  _Imun_2523 = 0
(232)  _Imun_2560 = 0
(233)  _Imun_2580 = 0
(234)  _Imun_2581 = 0
(235)  _Imun_2582 = 0
(236)  _Imun_2583 = 0
(237)  _Imun_2584 = 0

      F(237,  5234) =    2.00
           Prob > F =    0.0000
```

Table 31. Testing for heteroskedasticity:

```
. xttest3

Modified Wald test for groupwise heteroskedasticity
in fixed effect regression model

H0: sigma(i)^2 = sigma^2 for all i

chi2 (238)  =   2394.81
Prob>chi2 =      0.0000
```

Table 32. Testing for cross-sectional dependence:

```
. xtcsd, pesaran abs


Pesaran's test of cross sectional independence =   592.848, Pr = 0.0000

Average absolute value of the off-diagonal elements =     0.736
```

Table 33. Testing for serial-correlation:

```
. xtserial ret std lnprice

Wooldridge test for autocorrelation in panel data
H0: no first-order autocorrelation
    F(  1,     237) =   1201.805
           Prob > F =      0.0000
```