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Swedish House Prices and Fundamentals:

A Study of the Price Development of Small Houses from 1986 - 2005

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Abstract

This thesis uses almost 20 years of quarterly data to examine the relationship between prices of residential real estate and fundamental variables in Sweden. Real estate prices have increased substantially in the investigated period, also in relation to disposable income and rents. However, the results show that the development of residential real estate prices can be well explained by fundamental variables. The population aged 35-54 has a positive relationship to real estate prices, while population aged 60-64 has a negative relation. Increases in employment, construction costs, GDP, and household debt are all associated with increasing real estate prices. The interest rate of the three month T-bill rate on the other hand has a negative relation to real estate prices. Furthermore, a cointegration and error correction test reveals the existence of a long run relationship between real estate prices and fundamental variables. These results, however, do not indicate that prices of residential real estate cannot fall. Instead it is likely that demographic change towards an older population could put downward pressure on house prices. A higher interest rate environment could have a similar effect.

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1. Introduction

The run up in house prices in many industrialized countries since the middle of the nineties has spurred a global debate regarding the sustainability of house prices. Sweden is no exception. In Sweden the average price of a one or two dwelling building has almost quintupled since 1981. Investing in a house is one of the major investments an individual makes in his/her lifetime, which makes the development of house prices an issue of general interest.

House prices have received a lot of media attention, both nationally and internationally. For example, the Economist (2005) writes:

> "the total value of residential property in developed economies rose by more than $30 trillion over the past five years, to over $70 trillion, an increase equivalent to 100% of those countries' combined GDPs. Not only does this dwarf any previous house-price boom, it is larger than the global stockmarket bubble in the late 1990s (an increase over five years of 80% of GDP) or America's stockmarket bubble in the late 1920s (55% of GDP). In other words, it looks like the biggest bubble in history"

During 2007 and the beginning of 2008, the subprime loans market in the U.S. created a lot of turbulence, both in the U.S. housing market, and in the global financial markets. Currently, the house prices in the U.S. are falling. However, just because house prices are falling, does not necessarily mean that a bubble has burst. For Sweden, on the other hand, house prices are still increasing.[1]

An important aspect of this debate is whether the increase in house prices can be explained by changes in fundamentals, or if it is indicative of speculative behavior. If house prices are driven by speculative behavior, i.e. a bubble, there is the possibility that a sudden change in investor sentiments could lead to a quick decline in the housing market. Such a development could have detrimental effects on the economy. On the other hand, if house prices are explained by fundamentals, then the possibility of a sudden crash are smaller. It does not mean, however, that prices cannot go down.

This thesis seeks to investigate the nature of the contemporary house price increase in Sweden. Specifically, the purpose of this thesis can be posed as the following question:

[1] www.maklarstatistik.se (home page with real estate prices from a majority of Swedish real estate agents)

To what extent can the development of Swedish residential real estate prices be explained by movements in fundamentals?

The methodology employed in order to answer this question is a standard OLS regression alongside a graphical analysis. The regression model will include both demand and supply variables that in theory and from previous research are believed to be related to house prices. The graphical analysis follows from conventional measures used in the house pricing literature.

This thesis is limited to studying the price of one or two dwelling buildings, as defined by Statistics Sweden. Henceforth, when referring to house prices or real estate prices for Sweden, this is the type of building referred to.

The outline of the thesis is as follows. Section 2 gives a brief overview of the house price literature and discusses potential variables that are relevant for explaining house prices. Section 3 contains a description of the data utilized for our study. Section 4 describes the methodology used. Section 5 presents the results, and section 6 analyzes the results. Section 7 concludes.

2. Theory and Previous Studies

The literature attempting to explain residential real estate prices generally fall into two broad categories, an econometric approach and a finance based approach. The econometric approach tries to explain house prices by using fundamental macroeconomic variables. The finance based approach sees housing as an investment and attempts to value it by discounting future streams of income stemming from the house investment, similar to the way other financial assets are valued. This is used both to calculate a net present value, and to compare the cost of home ownership to renting. A third approach is the behavioral approach, which is briefly described later in this section. The last part of this section discusses the relevant variables that emerge from the house pricing literature and the theoretical ground for how these variables affect house prices.

2.1 Econometric

The econometric approach is usually conducted by estimating a reduced form price equation attempting to explain the development of house prices with fundamental variables. Usually this entails the estimation of some sort of regression model. Explanatory variables can include both supply and demand side variables. If the fundamental variables can explain a significant part of the development of house prices, this is taken as evidence that prices are in line with fundamentals. A similar method is investigating for long run relationships by looking for cointegration and using error correction models. There are numerous studies utilizing these methods with varying data sets, time periods, countries, variables, and results. We will now discuss the results of some of these studies.

Hort (1998) studies the Swedish housing market from 1968 till 1994 and finds that personal income, user cost, and construction cost have a significant impact on real house prices. She concludes that the price follows fundamental variables closely. Bourassa et al. (2001) study major cities in the U.S., Sweden, and New Zealand, and identify real income (employment and the real wage rate), real construction costs, and the real after-tax interest rate as being important explanatory variables for house prices. Sutton (2002) examines if fluctuations in house prices in six OECD countries can be explained by changes in national incomes, interest

rates, and stock prices. His conclusion is that fundamentals explain a large part of the run up in prices, although prices seem to have increased more than what is reasonable considering the impact of fundamentals.

Foley (2004) uses a regression model to investigate real estate prices in Ireland. The fundamental factors include inflation, income, population, interest rate, and housing stock. The author concludes that Irish house prices can be modeled successfully using fundamentals. The two most significant variables were population and housing stock.

McCarthy and Peach (2004) find that changes in house prices in the U.S. reflect movements in personal income and nominal mortgage rates. Shiller (2005), on the contrary, finds that fundamental variables cannot explain U.S. house prices. The fundamental variables used by Shiller include personal income, building costs, population, user cost of housing, and interest rates.

Ng and Chow (2004) study the effect of credit availability in Singapore. A unique regulatory environment in Singapore allows for a comparison of two similar housing markets, with the same mortgage rate dynamics, but different levels of credit availability. They find that credit availability is a significant factor determining house prices, besides interest rates, and that credit availability appears to cause changes in house prices rather than the other way around.

Tsatsaronis and Zhu (2004) find that inflation, the yield curve, and bank credit are important for explaining house prices. Furthermore, the authors find that house prices are more sensitive to short term rates in countries where variable rate mortgage rates are more predominantly used, such as Sweden.

The Swedish Riksbank (2005) use a regression model and finds that the low interest rates, higher disposable incomes, and low construction activity can explain much of the rise in house prices in Sweden. However, the Riksbank also discusses the fact that even if house prices are explained well by fundamentals, it does not rule out the risk of falling house prices. OECD (2005) reviews the role of fundamentals in explaining house prices, and concludes that overvaluation presumably only applies to a relatively small number of countries. Notably Sweden is not one of them. However, the size and duration of price increases are unprecedented, also for Sweden. Furthermore, the notion that house prices are fairly valued relies heavily on a low interest rate environment.

Jacobsen and Naug (2005) use an OLS regression model to investigate the relationship between house prices and fundamental variables for Norway. They find that interest rates, housing construction, unemployment, and household income are the most important variables for explaining house prices. They find no evidence for overvaluation in the housing market, compared with the value predicted from fundamentals.

Ahearne et al. (2005) finds that house prices are pro-cyclical, moving together with real GDP, consumption, investment, CPI, budget balance, current account, and output gaps. They also discuss that the rise and synchronization of house prices across countries are unparalleled. According to the authors, it is likely that a fall in house prices will be associated with slowdowns in consumption and investment. This could expose households, construction companies, and possibly also mortgage institutions to higher risks. Terrones (2004) investigates if there is a global house price cycle and if house prices are related to global or country specific factors. The results indicate that house prices are highly synchronized across countries and reflect changes in global interest rates and economic activity. Sweden, together with the U.S, the U.K, and France are the countries that show the strongest correlations of house prices with other industrial countries. Furthermore, the authors conclude that any downturn in house prices are likely to also be highly synchronized across countries with corresponding implications for economic activity.

Gallin (2006) investigates long run relationships between house prices, per capita income, and population using a cointegration and error correction model. Mikhed and Zemcik (2007a) use a similar method relating house prices to rents, consumer price index, construction cost, income, population, and mortgage rates. Both these studies find that the fundamental variables are not cointegrated with house prices. While Mikhed and Zemcik (2007a) interpret this as evidence that house prices do not reflect fundamentals, Gallin is more cautious in interpreting the results. He argues that the possibility that prices are affected by fundamentals cannot be ruled out; instead this could be evidence of a lack of a long-run stable relationship as shown by a cointegrating relationship. In addition, Gallin asserts that the absence of cointegration suggests that the methodology used might be inappropriate for modeling house prices.

2.2 Finance

The finance based approach has a different method for determining if house prices are misaligned with fundamentals. This method recognizes that housing is a financial asset and should be valued as such. If the assets anticipated cash flow is not reflected in the market prices, prices may be misaligned. In its simplest form, the rent-price ratio is studied, much like a price-earnings ratio. However, more advanced models incorporate other factors affecting the cash flow from investing in real estate including rental savings (what the rent would have been if the property had instead been rented), transaction costs, the down payment, insurance, maintenance costs, property taxes, mortgage payments, tax savings, and income earned if the house is sold.

The net present value can then be calculated using the investors required rate of return. By setting the net present value equal to zero, a reservation price can be calculated. This is the price at which the investor is indifferent between buying the property or renting it. Importantly, this can be interpreted as the fundamental value of the house. By comparing this price to the actual price, overvaluation or undervaluation can be determined. Smith and Smith (2006) apply this methodology to investigate the real estate market in California. Even though house prices have been rising rapidly, they find no evidence of a bubble. The price levels are justified by fundamentals. Weeken (2004) applies the asset-pricing theory to the housing market in England. Although the ratio of house prices to rentals has increased, this can to a large extent be explained by lower real interest rates, and house prices are judged to be close to sustainable levels.

Himmelberg et al. (2005) use a financial model to calculate the user cost of housing, or "imputed rent". To calculate the annual user cost of housing, the authors take the following factors into consideration; the cost of forgone interest, property taxes, tax benefits, maintenance costs, capital gain, and a risk premium of owning. By comparing the user cost of housing to incomes and rents, measures of home values can be constructed. This is done for several major U.S. cities and the authors find no evidence that houses are systematically mispriced.

In a lecture in 2005, Andrew Farlow asserts that to determine the degree of overvaluation in the property market by using a price rent ratio one must know when the market actually was in equilibrium. Also, Gallin (2004) argues that "the rent to price ratio must have predictive power for house prices for it to be a useful measure of valuation in the housing market".

Consequently, Gallin (2004) uses an error-correction model and a long-run regression model to examine how well the rent to price ratio predicts future changes in real rents and prices for the U.S. The results indicate that rents and prices tend to correlate over three year horizons. However, with user cost included the result was inconclusive. According to the author, the results show that the rent to price ratio does predict changes in real rents and house prices. The most interesting results are that when the rent to price ratio is low, this tends to be corrected by a change in prices, not a change in rents. This could indicate that a low rent to price ratio is an indication of a bubble. However, Gallin points out that the result must be interpreted with caution, since the data is imperfect, the model might be too simple and even though the rent to price ratio could be a valuation measure, it is not saying anything about when the house prices could change direction.

Mikhed and Zemcik (2007b) use a cointegration and error correction model with house prices and rents on U.S. data. The authors include rents as a measure of a cash-flow variable, using net present value as the theoretical framework. They find that house prices and rents are not cointegrated, which they take as evidence that there is a house price "bubble". The conclusion stems from the fact that prices and rents are not cointegrated of the same order. Specifically they construct a "bubble" indicator that suggests housing bubbles in the late 1980s and the early 2000 to 2005.

2.3 Behavioral

A third approach utilized by Shiller (2007) draws on recent advances in behavioral economics and attempts to explain rapidly rising house prices as a purely psychological phenomenon. Using three case studies of housing booms, the 1950 home construction boom in the U.S., the 1970s U.S. farmland boom, and the UK boom in 2005, Shiller is unable to identify a shift in "the traditional list of fundamentals" (p. 35) significant enough to explain the price movements. Instead, theories from behavioral economics are presented as a more plausible explanation of house prices. These theories include "psychological framing, representativeness heuristic, social learning, collective consciousness, attention anomalies, gambling anomalies such as myopic loss aversion, emotional contagion, and sensation seeking" (p. 9). As his explanations are based on speculative behavior and mirrors the

conditions seen today, he concludes that the real estate market in the U.S. is experiencing a bubble.

2.4 Identification of Variables

Our survey of the literature concerning the determination of house prices suggests the following fundamental variables: nominal or real interest rates, inflation, housing stock, construction costs, national income, population and demographic structure, credit availability, taxes and subsidies, disposable income, employment, and rents. In this section we will discuss the theoretical and empirical grounds for the relationship between the variables and house prices.

Nominal or real interest rates affect house prices by affecting financing costs. Lower interest rates allow households to borrow more which tends to push up house prices, and vice versa (Riksbank 2005). Although lower nominal interest rates make housing cheaper, this ignores the effects of inflation. As long as nominal interest rates are low because inflation is low, the real burden of debt will be eroded more slowly over time with mortgage payments high in relation to income for much longer (the Economist 2003). Farlow (2004) also asserts that it is important to include inflation or to look at real interest rates when assessing house prices.

Housing stock is a supply side variable that influences house prices. A greater housing stock pushes down prices and vice versa. It is worth noting that changes in the housing stock are gradual, because construction takes time.

Increases in construction costs leads to a reduction in new house developments which pushes up the price of housing. Hort (1998) finds a significant relationship between construction costs and real house prices in Sweden.

Rises in national income is expected to affect house prices in the long run. The main reason is that national income growth generates more demand for living and recreation space which also drives up the price of construction land (ECB 2003).

The population size and demographic development influences the demand for housing. In particular, previous studies have found that the cohort 25-44 year olds tend to have particularly high demand for single family houses (Hort 1998). Similarly it can be argued that

older age cohorts are more prone to selling single family houses. Yang and Turner (2004) discuss the demographic structure of Swedish housing and find that in 2002, approximately one-third of single person households rented apartments while more than 60 percent of married couples lived in owner occupied houses. Furthermore, over 80 percent of single-aged pensioners, defined as people over the age of 63, lived in rental and cooperative accommodation, while less than 50 percent of married pensioners lived in owner-occupied houses. All this indicates that the demographic structure could be an important factor for explaining the demand for housing.

Credit constraints could influence house prices, since less constraints implies that borrowers can take on more debt. Farlow (2004) argues that lower nominal interest rates for the same real interest rate and the same life-time income enables borrowers to get closer to their desired level of debt, given that they were constrained when rates were higher. Supposedly consumers can sustainably take on much higher levels of real debt, even at the same real interest rate, which could put upward pressure on house prices. Similarly, an expansion of bank credit is likely to cause house prices to rise. This effect has been documented by BIS (2001), Ng and Chow (2004), and Tsatsaronis and Zhu (2004).

Tax treatments and subsidies affect the cost of owning housing. Government policy in Sweden and many other countries has encouraged people to own their house by favorable tax treatments and subsidies. A common method is to make interest payments tax deductable. This affects the real interest rate payments which are likely to have an impact on housing demand. Also, since 1975, Sweden has had substantial interest rate subsidies for new housing which has affected the level of housing supply (Hort 1998). Englund et al. (1995) find that the tax reform in 1991 that reduced interest rate deductions and interest rate subsidies decreased demand for house ownership. This had a significant effect on house prices, which fell by 10-15 percent.

Higher disposable income is believed to increases the demand for housing, given that housing is a normal good. Several authors assume a somewhat strong relationship between disposable income and house prices (Abraham and Hendershott 1996, Meen 2002). Often this is shown as the “affordability ratio”, which is the ratio of house prices to personal income or disposable income.

Employment affects house prices through two channels. First it is assumed to affect household income. Second, households are presumably more reluctant to borrow when

employment prospects worsen. Also, credit institutions may be more restrictive with lending towards unemployed (Riksbank 2005).

Rents are deemed important in the development of real estate prices. The reason is that renting housing is an alternative to buying. Therefore, if rents are high it makes buying a more attractive option, which could lead to higher demand for buying housing, creating upward pressure on house prices.

3. Data Description

The data series used in this study are all from Statistics Sweden, except the interest rates which are from the Swedish Riksbank. The series contain quarterly observations from 1986:1 till 2005:4. The choice of time period was limited by the fact that the real estate price index only reports quarterly observations beginning in 1986. Another limiting factor was that the building price index is only available till the end of 2005. All series are measured in nominal terms. Below follows a description of the different variables included in the econometric analysis. The name of the variables is indicated in the brackets.

Real Estate Price Index [Price]

Our measure of price is based on Statistics Sweden's real estate price index, an index which measures the development of the price of real estate with 1981 being the base year. The index specifically measures the price of one- and two-dwelling buildings for permanent living. The index is weighted by the Tax Authorities assessed value, in order to control for quality changes.[2] According to Statistics Sweden, the real estate index is more reliable than using, for example, average prices because average prices are affected by the differences in quality of houses sold. The importance of a reliable measurement of house prices has also been noted by a number of articles (cf. Smith and Smith 2006, Case and Shiller 2003).

Population [Pop20-24; Pop25-34; Pop45-44; Pop45-54; Pop55-59; Pop60-64]

The population variable measures the number of people living in Sweden. We have further divided the population into different age cohorts to investigate if different segments of the population have differential effects on the price of housing. The age division was devised as follows; 20-24, 25-34, 35-44, 45-54, 55-59, and 60-64. In order to get quarterly data the population data has been taken from Statistics Sweden AKU (labor force survey). This unfortunately limits the data to working age population, otherwise it would have been interesting to also investigate the effects of pensioners.[3]

[2] In Sweden the assessed value includes both adjustments for market prices and adjustments for a range of quality factors. Such factors include a wide range of things such as area, number of bathrooms, quality of materials used, facilities such as garage, sauna etc. For a full range of factors see www.skatteverket.se.

[3] An alternative specification of the model was tested using interpolated annual population data. This allowed for the inclusion of pensioners. However, the results were different from the quarterly data, the same age cohorts' yielded insignificant and/or wrong sign of coefficients, indicating that interpolating population data is unsuitable.

Employment [Employment]

The employment variable measures the number of people employed in Sweden. The employment data also comes from AKU.

Building Price Index (output price index) [BPI]

The building price index measures the development of prices for newly constructed dwellings of equal value. The index is quality adjusted.

Construction Cost Index (input price index) [FPI]

Construction cost index measures the price of different inputs used in the construction sector. These include machines, transportation, energy, wages, etc.

Interest Rate [SSVX3M; SSVX6M; SEGVB5Y]

We use three different variables to proxy for interest rates, SSVX3M, SSVX6M, and SEGVB5Y. SSVX3M and SSVX6M are the interest rates of three month and six month Swedish treasury bills respectively. SEGVB5Y is the interest rate of a Swedish treasury five year bond. The reason for using interest rates of different maturities is to test if long term and short term rates differ in their impact on house prices. We also believe that it is appropriate to use both shorter and longer term interest rates to capture effects related to mortgage rates that can be tied both to short and long term interest rates.

Consumer Price Index [CPI]

The Swedish consumer price index is used as a measure of inflation. We have chosen to include nominal variables and control for inflation, instead of using real variables. This is partly due to the difficulty of deflating a weighted price index.

Gross Domestic Product [GDP]

The Swedish GDP is a measure of the market value of all goods and services produced within the country in one year. This is both a measure of national income and an indicator of economic activity.

Rents [Rents]

The data collected for rents is the average cost of renting a four room apartment in Sweden, on a yearly basis. There are two principal reasons why we chose to use a four room apartment. First of all, graphical examination of rents for three, four, and five room apartments show a similar trend, making the choice of which type of apartment to use less crucial. Second, we believe that a four room apartment is a reasonable alternative to a small house. Since the data is only available on a yearly basis, the data has been linearly interpolated to quarterly data. This follows the practice of Riksbanken (2005), Foley (2004), and Jacobsen and Naug (2005). Although these authors do not interpolate rent data specifically, they use interpolation to construct a more frequent time series for other similarly structured variables.

Consumption [Consumption]

The consumption variable represents household consumption and is taken from the national accounts. This variable is used as a proxy for disposable income, which is not available quarterly before 1993. Our testing showed that after 1993, with quarterly data, consumption and disposable income had a correlation coefficient of 0.98. This justifies using household consumption as a proxy for disposable income.

Household Debt [HouseholdDebt]

The Household debt variable is a measure of total household debt in Sweden. This variable is used to assess the effect of credit availability on house prices. We believe that this variable could also capture the effect of changes in bank lending policies and regulatory changes, which is not captured by interest rates. Household debt is only available quarterly from 1997, therefore earlier data has been interpolated from annual data. Examination of the quarterly data from 1997 suggests that linear interpolation is appropriate.

Unavailable Variables

Some variables that were identified as interesting by theory and previous studies have been excluded from the analysis due to data limitations. These variables include housing stock, taxes and subsidies, and disposable income. The data on housing stock is only available on annual basis from 1990, and only for every five years in the eighties. Taxes and subsidies have undergone several changes in the investigated period, which makes it very complicated

to include. Disposable income is only available annually until 1993, and thereafter quarterly. An examination of the quarterly date show considerable seasonal variations, therefore it was deemed inappropriate to interpolate this variable. Since disposable income is available annually, it is used for the graphical analysis. However, it is not included in the econometric analysis where personal consumption is used as a proxy.

Imputed Rent

Following the practice of Himmelberg et al. (2005), we have collected data for calculating the imputed rent, or actual cost of owning. These variables include the interest rate of a Swedish one year T-bill rate, the property tax rate, the assessed value of property, tax deductibility of interest rate and the mortgage interest rate. The T-bill rate comes from the Swedish Riksbank, the property tax, assessed value and the tax deductibility of interest rates comes from the Swedish tax authority and from Englund et al. (1995), and the mortgage interest rate comes from Swedbank, one of the large mortgage institutions. For more details see Appendix B.

4. Methodology

4.1 Graphical Analysis

To investigate the development of house prices in Sweden, several indicators are examined graphically. These include the price development, the development of the affordability ratio and the price to rent ratio. The affordability ratio is the ratio of house prices to per capita disposable income. Large changes in the affordability ratio are seen as evidence for prices being out of line with fundamentals (Gallin 2006). According to Gallin (2004) a high price to rent ratio could be an indication of a house price bubble.

Additionally, the imputed rent ratio (actual cost of owning to rents) will be analyzed, following the practice of Himmelberger et al. (2005). To calculate the imputed rent, we calculate the cost of forgone interest, property taxes, after tax interest rate, depreciation, capital gain, and a risk premium of owning. For details see Appendix B.

To investigate the relationship between house prices and fundamental variables more thoroughly a formal econometric model is used.

4.2 The Econometric Model

We estimate an OLS regression with price as the dependent variable. All variables will be used in logarithmic form. In order to avoid spurious results the time series must be tested for stationarity. Stationarity is important if the results are to be valid and is the basis for all statistical work with time series (Gujarati 2003).

To test for stationarity the Dickey-Fuller (DF) test with three specifications: 1) with no constant, 2) with constant, and 3) with constant and trend, are employed. This is done in order to test if the variables are difference-stationary or trend-stationary. For variables that follow a difference-stationary process, first differences will be used, and variables that follow a trend-stationary process will be de-trended, otherwise the variable will be used in levels. It is important to keep in mind that when testing for stationarity, the tests are not conclusive, but indicative, regarding stationarity. Ideally, a hypothesis regarding the true specification should

be formed prior to testing. However, since it is impossible to know beforehand which specification is correct in practice, it is necessary to estimate all three specifications (Gujarati 2003). The final decision is then based both upon the results from the testing procedure as well as *a priori* theory. The test procedure and the results are found in Appendix A.

From the Dickey-Fuller tests for stationarity we conclude that all variables are non-stationary except Pop60-64 that is stationary. We also interpret the results for GDP and Consumption as trend-stationary. This decision is also validated by a graphical examination of GDP and Consumption, which exhibits a clear trend-stationary pattern. Hence de-trended versions of these variables will be used. The Pop55-59 variable rejects the same DF specifications as Consumption, but a graphical examination of Pop55-59 does not indicate a trend-stationary process for this variable. Therefore the variable is used in first differences. These graphs are displayed in Appendix A.

Interest rates will be used in levels although the DF tests indicate non-stationarity. This is because it is the level of interest rates that is believed to influence house prices, not the change in interest rates. Therefore levels have a more meaningful economic interpretation. We have estimated alternative specifications of interest rates in the model, but this yielded spurious results where interest rates have been insignificant and/or exhibited an incorrect sign of the estimated coefficient, which is inconsistent with previous studies.

All other variables will be used in first-differences. The transformations of the variables are summarized in table 1 below.

Table 1. *Variable transformations*

Variable name	Transformation	Variable name	Transformation
Price	Logarithm, first difference	FPI	Logarithm, first difference
Pop20-24	Logarithm, first difference	SSVX3M	Logarithm
Pop25-34	Logarithm, first difference	SSVX6M	Logarithm
Pop35-44	Logarithm, first difference	SEGVB5Y	Logarithm
Pop45-54	Logarithm, first difference	CPI	Logarithm, first difference
Pop55-59	Logarithm, first difference	GDP	Logarithm, de-trend
Pop60-64	Logarithm	Rents	Logarithm, first difference
Employment	Logarithm, first difference	Consumption	Logarithm, de-trend
BPI	Logarithm, first difference	HouseholdDebt	Logarithm, first difference

Model (1) includes all the variables and takes the following form:[4]

Model (1)

$$Price_t = \beta_1 + \beta_2 Pop20\text{-}24_t + \beta_3 Pop25\text{-}34_t + \beta_4 Pop35\text{-}44_t + \beta_5 Pop45\text{-}54_t + \beta_6 Pop55\text{-}59_t + \beta_7 Pop60\text{-}64_t + \beta_8 Employment_t + \beta_9 BPI_t + \beta_{10} FPI_t + \beta_{11} SSVX3M_t + \beta_{12} SSVX6M_t + \beta_{13} SEGVB5Y_t + \beta_{14} CPI_t + \beta_{15} GDP_t + \beta_{16} Rents_t + \beta_{17} Consumption_t + \beta_{18} HouseholdDebt_t + \varepsilon_t$$

Initially the full model (1) is estimated. Thereafter the least significant variable is dropped and the model is re-estimated. This process is repeated until all the remaining variables are statistically significant at the ten percent level. This results in Model (2), which includes the following variables:

Model (2)

$$Price_t = \beta_1 + \beta_2 Pop35\text{-}44_t + \beta_3 Pop45\text{-}54_t + \beta_4 Pop60\text{-}64_t + \beta_5 Employment_t + \beta_6 FPI_t + \beta_7 SSVX3M_t + \beta_8 GDP_t + \beta_9 HouseholdDebt_t + \varepsilon_t$$

[4] For convenience all models are available in Appendix D.

4.3 Structural Stability

To investigate if the model is stable over time or if there is a structural break two tests will be employed. The first is a dummy variable regression, which means estimating model (3):

Model (3)

$$Price_t = \beta_1 + \beta_2 Pop35\text{-}44_t + \beta_3 Pop45\text{-}54_t + \beta_4 Pop60\text{-}64_t + \beta_5 Employment_t + \beta_6 FPI_t + \beta_7 SSVX3M_t + \beta_8 GDP_t + \beta_9 HouseholdDebt_t + \beta_{10} D_t + \beta_{11} Pop35\text{-}44_t D_t + \beta_{12} Pop45\text{-}54_t D_t + \beta_{13} Pop60\text{-}64_t D_t + \beta_{14} Employment_t D_t + \beta_{15} FPI_t D_t + \beta_{16} SSVX3M_t D_t + \beta_{17} GDP_t D_t + \beta_{18} HouseholdDebt_t D_t + \varepsilon_t$$

Where D_t is a dummy variable that takes the value zero in the time period 1986 till 1995 and takes the value one in the time period 1996 till 2005. Looking at figure one, it appears that the real estate index increases at a faster rate from 1996, which motivates the chosen time periods. Model (3) makes it possible to detect any differences in the estimated coefficients in the two periods. If the model is stable then all the coefficients of the dummy terms should jointly be zero.

The second test involves estimating a rolling regression of model (2) to examine how the estimated coefficients change over time. This specifically entails estimating all coefficients over time using a rolling regression. The rolling regression enables a more detailed analysis of the models stability over time than the dummy variable regression allows because the rolling regression is estimated continuously. We have chosen to use a time frame of 30 observations because this seemed like a good compromise between accuracy and detail. On the one hand, using a longer time frame could allow for a more accurate estimation, while on the other hand, employing a shorter time frame gives a more detailed analysis. Alternative time frames have been tried, but utilizing 30 observations seemed to be the most appropriate. Using 30 observations means that the rolling regression estimates one coefficient for each variable for every 30 observations. Every estimated coefficient is therefore based on the 30 previous observations. Since we have 79 observations in total, 49 rolling regression coefficients is estimated and plotted against time.

4.4 Cointegration and Error Correction

Cointegration means that there is a long run or equilibrium relationship between non-stationary variables integrated of the same order (Gujarati 2003). Model (2) will be used as a basis for a cointegration analysis, to investigate if there is a long run relationship between house prices and the explanatory variables. However, the cointegration model (4), will include only non-stationary variables that follow a difference-stationary process. If the variables show a cointegrating relationship, this can be interpreted as evidence that house prices follow a long run relationship with fundamental variables. That is a result that could indicate the absence of a house price bubble (Mikhed and Zemcik 2007b).

In order to test for cointegration we will start from model (2), but use the variables in logarithmic form and exclude variables that are not difference-stationary and integrated of order one. That means that Pop60-64 and GDP must be excluded. Hence the cointegration test involves estimation of the following model (4):

Model (4)

$$Price_t = \beta_1 + \beta_2 Pop35\text{-}44_t + \beta_3 Pop45\text{-}54_t + \beta_4 Employment_t + \beta_5 FPI_t + \beta_6 SSVX3M_t + \beta_7 HouseholdDebt_t + \varepsilon_t$$

The residuals from the model are then saved for further analysis. The next step is performing a Durbin-Watson and a Dickey Fuller test on the obtained residuals. These tests are performed to examine if the residuals are stationary, which means that the variables are cointegrated, i.e. there is a long run relationship between the variables. The test statistic for the Durbin Watson test is:

$$d = \frac{\sum_2^n (u_t - u_{t-1})^2}{\sum_1^n u_t^2}$$

Where u_t is the estimated residuals from model (4).

The Dickey Fuller test without intercept and trend is used following Gujarati (2003):

$$\Delta u_t = \delta u_{t-1} + \varepsilon_t$$

Where Δu_t is the change in the residuals, and u_{t-1} is the lagged residuals.

In the short run cointegrated variables can be in disequilibrium. Variables that are used in first differences in a regression show the short run relationship, while the presence of cointegration shows the long run relationship. The obtained residuals from the cointegration regression, are the short run equilibrium error, and are used to tie the short run values of the variables to the long run values (Gujarati 2003). In order to control for any error correction mechanism, model (2) is re-estimated including the lagged residuals u_{t-1}. Formally, the error correction model entails the estimation of model (5):

Model (5)

$$Price_t = \beta_1 + \beta_2 Pop35\text{-}44_t + \beta_3 Pop45\text{-}54_t + \beta_4 Pop60\text{-}64_t + \beta_5 Employment_t + \beta_6 FPI_t + \beta_7 SSVX3M_t + \beta_8 GDP_t + \beta_9 HouseholdDebt_t + u_{t-1} + \varepsilon_t$$

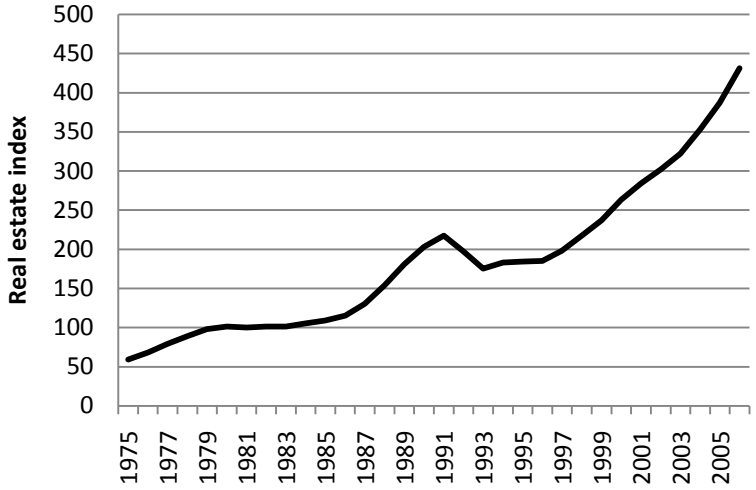
If the equilibrium error term u_{t-1} is non-zero it suggests that house prices reacts to changes in the explanatory variables and the error correction term. In order to observe if there are any changes in the equilibrium error term over time, a rolling regression of model (5) is estimated, and the error correction term is plotted against time.

5. Results

In this section the results from the graphical analysis and the econometric model will be presented.

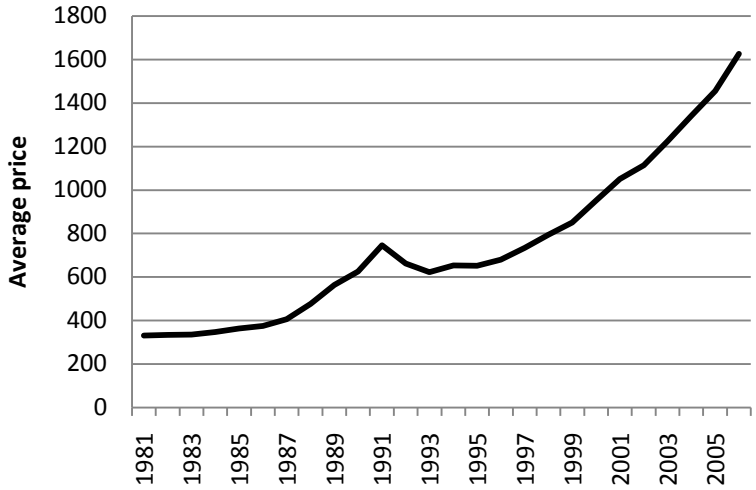
5.1 Graphical Analysis

Figure 1. *Real Estate Price Index for Sweden*



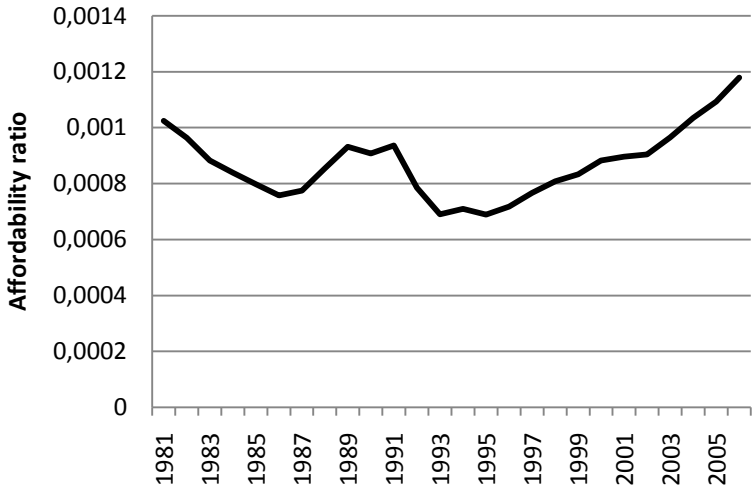
The development of the real estate index is shown in the graph above. It is clear that there has been a substantial increase in real estate prices since 1975. The prices were increasing from 1975 to 1979, to stay rather flat until 1986. Then a period of sharp price increases followed up until 1991. The only period of declining prices can be seen in the period 1991 to 1993. From 1996 and onwards, the price index has climbed dramatically and prices today are at record levels.

Figure 2. *Average Real Estate Prices for Sweden*



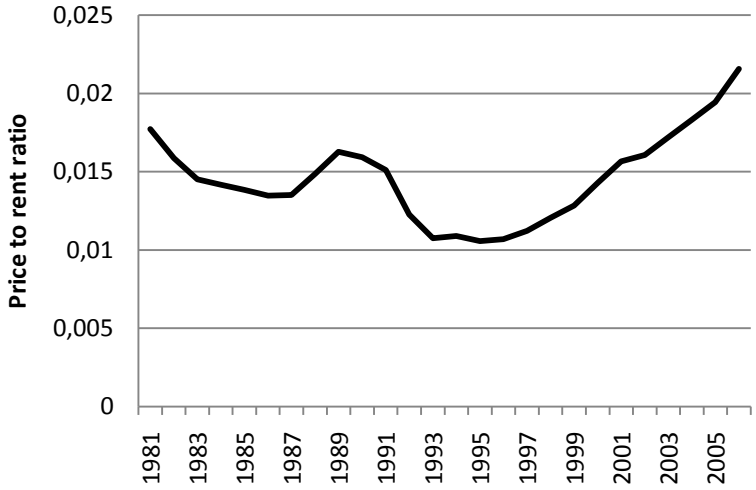
The development of average real estate prices, pictured above, shows a development similar to the real estate price index. This justifies using the average real estate prices in calculating the affordability ratio and the price to rent ratio. The reason for using the average real estate prices instead of the index is that it gives a more telling result because then the numerator and the denominator of the ratio will be in the same units. From both graphs above, it is clear that prices have increased markedly. However, the development of prices must be seen in relation to the development of other factors, such as disposable income and rent, in order to gain a fairer view of the progression of house prices.

Figure 3. *Affordability Ratio for Sweden*



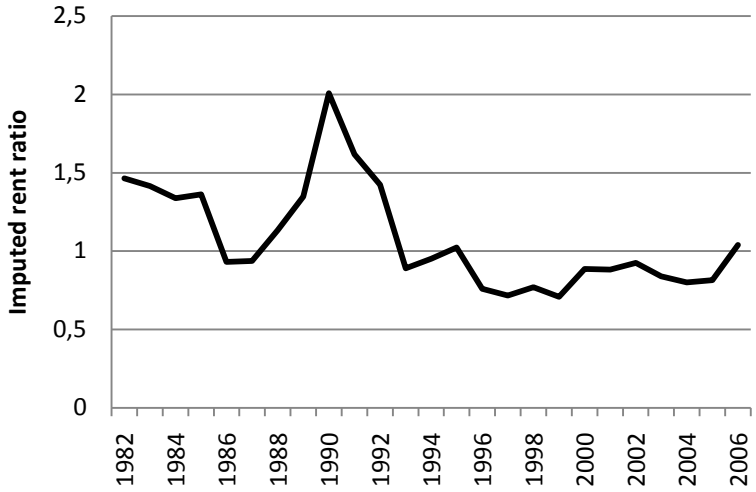
The affordability ratio pictured above is a measure of house prices in relation to disposable income. When interpreting these ratios it is important to keep in mind that it is the long term trend that is of interest, not any specific levels. An increase in the affordability ratio means that housing has become relatively more expensive in terms of disposable income. In other words, people can afford to buy less housing with their income. The graph shows that prices in relation to income were falling from 1981 till 1986, during a period when house prices were rather flat. Then prices increased faster than income until 1989, to stay fairly flat to 1991, when prices subsequently fell in relation to income. From 1996 and forward there has been an upward trend, and the affordability ratio has today surpassed previous highs. Evidently, house prices are increasing at a faster rate than disposable income in the last half of the period.

Figure 4. *Price to Rent Ratio for Sweden*



Above is a graph of the ratio of house prices to rents. During the first half of the eighties the ratio of price to rents decreased. From 1987 to 1989 the ratio increased, while the ratio fell from 1989 to 1993. Prices have been rising faster than rents since 1996 and are at the end of the series at a historically high level. This ratio should be interpreted with some caution though, since the rents in Sweden are regulated, which could be one explanation why prices would rise faster than rents. Also, the affordability ratio and price to rent ratio does not take interest rates, subsidies, depreciation, etc. into account. Therefore the more sophisticated imputed rent ratio is shown and discussed below.

Figure 5.*Imputed Rent Ratio for Sweden*



The imputed rent ratio above gives a different picture than the other measures. This measure compares the actual cost of owning to the cost of renting. This ratio fell until 1986 during the period of flat house prices. Then there was a rapid increase to around 1990, followed by a rapid decrease till 1993. Unlike the affordability ratio and price to rent ratio, the development of the imputed rent ratio appears to be rather stable since 1993.

The evidence from the graphical analysis appears to be mixed. House prices have increased substantially, also in relation to national income and in relation to rents, making house prices less affordable and more expensive in relation to renting, especially since 1996. However, the increases in house prices do not appear to have caused any long run increase in the cost of owning compared to renting. It is also worth noting that the magnitude of the changes is greatest for house prices that have increased by almost a factor of three since 1996. The affordability ratio and price to rent ratio has more or less doubled since 1996, while the imputed rent ratio has increased by about 35 percent since 1996.

5.2 Estimation of Econometric Model

The results from the OLS regression of model (2) are shown below:

***Table 2**. Results from estimation of model (2)*

Variable	**β**	**p-value**
Constant	1.158	0.004***
Pop35-44	2.956	0.095*
Pop45-54	3.656	0.002***
Pop60-64	-0.086	0.004***
Employment	0.577	0.000***
FPI	0.725	0.000***
SSVX3M	-0.035	0.000***
GDP	0.055	0.088*
HouseholdDebt	0.823	0.000***
R-square	0.741	
Adj. R-square	0.712	

* *Significant at a 10% level*

** *Significant at a 5% level*

*** *Significant at a 1% level*

All the coefficients are significant at the one percent level, except Pop35-44 and GDP that are significant at the ten percent level. Furthermore all the coefficients have the correct sign as expected *a priori* from economic theory. The R-square (0.74) and the adjusted R-square (0.71) are high suggesting that the model has good explanatory power.

The population variables show that different age groups have a different effect on house prices. An increase in 35 to 54 year olds has a positive effect on house prices, whereas an increase in 60 to 64 year olds has a negative effect on house prices.

Increases in employment are associated with increases in house prices. This is also true for construction costs (FPI), gross domestic product (GDP), and household debt. Conversely, an increase in interest rates (SSVX3M) has a negative effect on house prices. The next step is to test for structural stability of the model over time.

5.3 Structural Stability

The results from the dummy variable regression, model (3), are shown in the table below.

***Table 3**. Results from model (3)*

Variable	**β**	**p-value**
Constant	-0.150	0.774
Pop35-44	0.803	0.764
Pop45-54	3.180	0.044**
Pop60-64	0.022	0.597
Employment	0.422	0.028**
FPI	0.756	0.000***
SSVX3M	-0.072	0.000***
GDP	0.104	0.033**
HouseholdDebt	0.934	0.000***
ConstantD	-0.058	0.122
Pop35-44D	1.990	0.581
Pop45-54D	-2.598	0.330
Pop60-64D	-0.005	0.115
EmploymentD	0.335	0.214
FPID	-0.057	0.913
SSVX3MD	0.047	0.016**
GDPD	0.019	0.793
HouseholdDebtD	-2.529	0.006***
R-square	0.804	
Adj. R-square	0.753	

* *Significant at a 10% level*

** *Significant at a 5% level*

*** *Significant at a 1% level*

Structural stability implies that all added dummy variables should jointly be equal to zero. To test if all added coefficients are equal to zero, i.e. no structural break, an F-test is used. The test statistic is:

$$F = \frac{(RSS_R - RSS_{UR})/m}{RSS_{UR}/(n-k)} = \frac{(0.011725 - 0.008901)/8}{0.008901/(78-17)} = 2.419225 > F_{crit} = 2.09$$

As can be seen above, the test value is above the five percent critical value. Hence we conclude that there is a structural break in the model. Indeed, this appears to be a reasonable result since some of the individual coefficients have changed, and warrant further investigation.

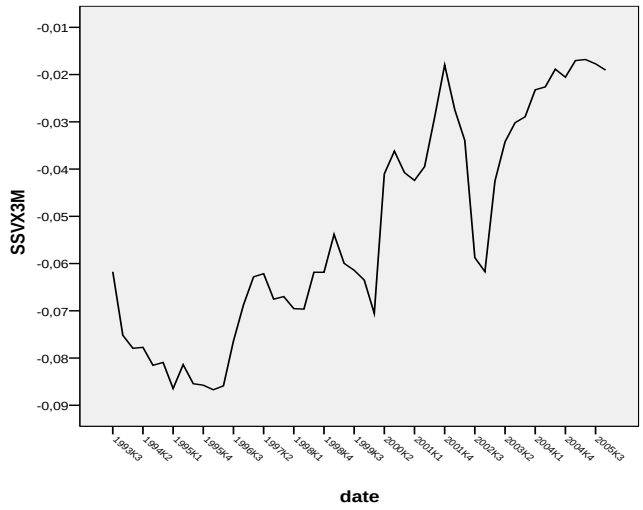
There are specifically three results that emerge from the dummy variable regression that stand out. Firstly, the Pop35-44 and Pop60-64 variables are rendered insignificant for both periods separately. Secondly, the SSVX3MD is significant and the coefficient is smaller in the second period. Thirdly, the HouseholdDebtD variable is significant and the sign of the coefficient changes in the second period.[5]

The fact that Pop35-44 and Pop60-64 are insignificant in the dummy model contradicts the result from model (2), and indicates that these population variables are unstable over time. This could perhaps be explained by changes in demographic structure, i.e. that people are progressing to another age cohort, during the 20 years investigated. Because these variables are insignificant, we will focus on the results for SSVX3M and HouseholdDebt below.

To get further insight into the development of the model over time a rolling regression is used. That involves estimating all coefficients over time using a rolling regression technique with 30 observations. Note that the estimated coefficient for a certain date is based on the 30 observations prior to that date. The results from the rolling regression for SSVX3M and HouseholdDebt are displayed below. The findings from the rolling regressions confirm the result from the dummy variable regression regarding SSVX3M and HouseholdDebt. The estimated coefficients from the rolling regression for the remaining variables are presented in Appendix C.

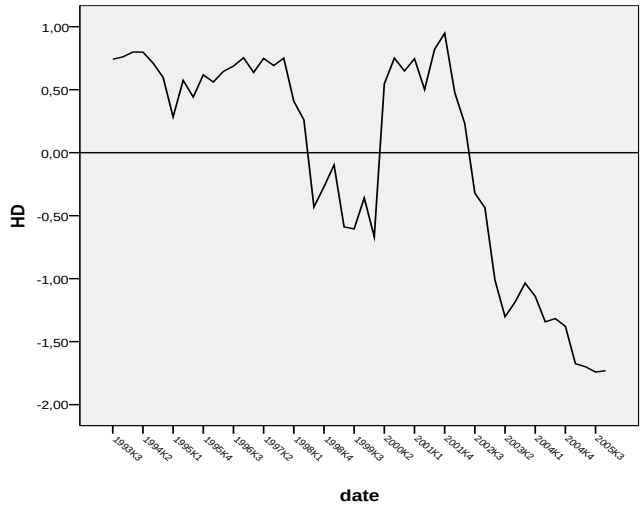
[5] The coefficient for the second period is equal to the sum of the coefficient for the variable and the corresponding dummy variable. Consequently the coefficient for HouseholdDebt is -1.594 (0.935 -2.529) for the second period, and the coefficient for the SSVX3M is -0.025 (-0.072+0.047) for the second period.

Figure 6. *Rolling regression for SSVX3M*



The rolling regression of the SSVX3M shows that the coefficient for the interest rates becomes smaller over time, but it remains negative for the whole period. Thus the relation appears to be stable, although the importance of the interest rate is diminishing towards the end of the period.

Figure 7. *Rolling regression for HouseholdDebt*



The coefficient for household debt changes sign three times during the estimated time period. Especially it appears to have become negative since the third quarter of 2002. Clearly something changes in this relationship.

5.4 Cointegration and Error Correction

Cointegration means that there is a long run relationship between non-stationary variables. The test procedure for cointegration involves testing the residuals from model (4) for stationarity. To test for stationarity the Durbin-Watson and Dickey-Fuller tests are employed. The result are presented in the tables below.

Table 4a*. Results from Durbin-Watson test for cointegration*

Durbin-Watson	**d**	**Critical value**
Durbin- Watson d	0.835	0.386

Table 4b*. Results from Dickey-Fuller test for cointegration*

Variable	**β**	**t-value**
Lag Residual	-0.433	-4.599
τ critical value at 5%	-1.95	

The Durbin-Watson test statistic is clearly above the critical value. Therefore we conclude that the Durbin-Watson tests indicate that there is cointegration. The result from the Dickey-Fuller test confirms this result. It appears that the variables are cointegrated, i.e. there is a long run relationship. The next step is to test for any error correction mechanism.

***Table 5**. Results from model (5)*

Variable	β	p-value
Constant	0.944	0.010***
Pop35-44	3.497	0.040**
Pop45-54	3.526	0.002***
Pop60-64	-0.070	0.012**
Employment	0.809	0.000***
FPI	0.740	0.000***
SSVX3M	-0.032	0.000***
GDP	0.071	0.022**
HouseholdDebt	0.749	0.000***
Error Correction	-0.255	0.001***
R-square	0.780	
Adj. R-square	0.750	

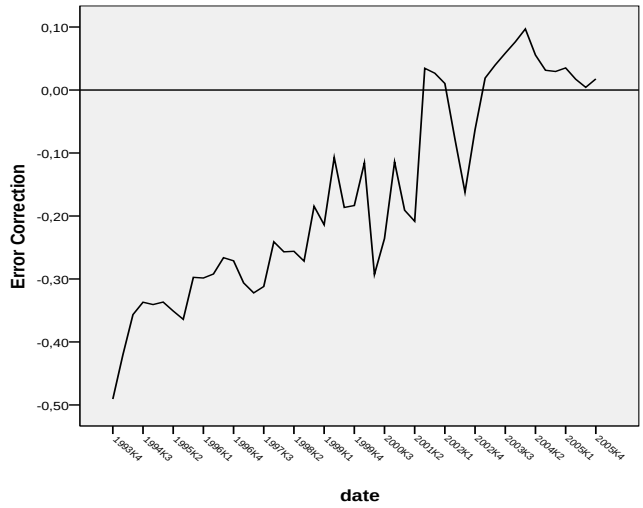
* *Significant at a 10% level*

** *Significant at a 5% level*

*** *Significant at a 1% level*

The table above shows the result from the error correction model. The error correction term is negative and highly significant. This confirms that there is a long run equilibrium relationship. Also the R-square and the adjusted R-square are higher than for model (2), suggesting that the inclusion of the error correction term improves the model. The development of the error correction coefficient is investigated over time by estimating a rolling regression of model (5) and the result is plotted below.

Figure 8. *Rolling regression for Error Correction*



The previous tests for structural stability showed that the model was not stable over time. This means that the short run relationship between the variables changes during the period. Hence, it could be expected that the error correction term would have to change over time to maintain the long run cointegrating relationship. The graph above confirms this expectation, and shows that the error correction term indeed changes over the estimated period.

6. Analysis

In Sweden there has been a significant increase in the house prices over the last decades. This trend is obvious both when looking at average prices, but also when studying the development of the quality adjusted real estate price index. Two common measures in the house price literature are the affordability ratio and the price to rent ratio. Investigating these ratios for Sweden, both measures indicate that house prices have outpaced both disposable income and rents. This development is particularly evident in the period since 1993 to the present period. Although it is reasonable to assume that house prices were depreciated in 1993 following the Swedish economic crisis, the rise in prices up to date means that the previous historical high has been surpassed. Can this development be explained by fundamental variables, or does this constitute evidence of speculative behavior in the housing market?

One way to answer this question is to look at the imputed rent to actual rent ratio, relating the actual cost of owning to renting, common in the literature (e.g. Himmelberg et al. 2005). This ratio gives a different impression of the run up in house prices than the ratios discussed above. It appears that the current house prices are justifiable. The run up in house prices caused the cost of owning housing to increase in the early nineties, which led to a large increase in the imputed rent ratio. However, the imputed rent ratio subsequently declined. No similar trend can be seen since; in fact the ratio appears to be quite stable over time.

For greater exposition on the issue of sustainable house prices, an econometric model is estimated. The aim of the model is to analyze the extent to which fundamental variables can explain house prices. The relevant variables to include in the model have been selected based on previous literature. After econometric estimation a number of variables are shown to have a significant explanatory power. These variables include population in different age cohorts, employment, construction cost, three months interest rate, GDP, and household debt. The model also has a high explanatory power with an R-square of 74 percent and an adjusted R-square of 71 percent. This means that 74 percent of the changes in the real estate index are explained by the model. In other words, the fundamental variables explain a significant part of the changes in house prices.

The population variables show that different age cohorts have different effects on house prices. There is a positive relationship between house prices and 35-44, and 45-54 year olds,

while there is an inverse relationship between house prices and 60-64 year olds. Previous studies indicate that owner occupied housing is most common among married couples and families with children (Yang and Turner 2004). Also, Yang and Turner show that a majority of pensioners rent their housing. This provides a plausible explanation for the observed results. An implication of our result is that the current demographic tendency in Sweden towards an older population could put a downward pressure on house prices. However, some caution is advised, since the structural stability test shows that the relation between prices and 35-44 and 60-64 years olds respectively is unstable over time. This indicates that the short run relationship changes over time. On the other hand, 35-44 year olds appear to be cointegrated with house prices, which indicate that there is a long run relationship. Furthermore, 60-64 year olds have significant explanatory power when included in the error correction model. Possibly, this could mean that the short run relationship changes during the period, while the long run relationship between the variables is still maintained.

Employment has a positive relationship with house prices. This is expected since employment prospects affect both credit availability and households income expectations. Constructions cost were also shown to have a positive effect on house prices. Construction cost affects the cost of erecting new real estate, and could probably be thought of as an opportunity cost for buying existing real estate. A possible channel for how construction cost affects house prices is that building a new house is an alternative to buying an existing house.

An increase in the short term interest rates (three month government bill rate) has a negative effect on house prices. This effect is intuitive since it increases the cost of borrowing. Increased cost of borrowing leads to households becoming more credit constrained, which limits the possibility to buy real estate. The interest rate is included in the model in levels, as we believe that it is the level of interest rate that is important, not the changes in interest rate. The model was estimated with interest rate in differences, which gave nonsense results. Because previous studies have found interest rates significant, we believe that the effects of interest rates are important to include in the model. Interest rates of longer maturity were also included in the model, but rendered insignificant. Perhaps the explanation is that many people in Sweden have variable mortgage rates, which could mean that it is the short term interest rate that is of greater importance (Tsatsaronis and Zhu 2004). Furthermore, in the structural stability test of the model, it was shown that the effect of the interest rate decreased over time, at least for the period 1993 and forward. In this period the interest rate went from eight percent down to one and a half percent in 2005 (the last year of our study). We believe this

indicates that the effects of interest rates on house prices are stronger when the interest rate is at a higher level.

GDP has a positive relation with house prices. Again this is what could be expected from theory, since a rise in national income creates more demand for housing, assuming that housing is a normal good. GDP could also be seen as a measure of economic activity. In that case the results can be interpreted as meaning that the price of housing increases together with increases in economic activity.

Household debt has a positive co movement with house prices. One explanation for this is that an increase in debt is associated with increases in house prices. It is also possible that this could be explained by viewing household debt as a measure of credit constraint. If households were credit constrained at higher interest rates, a fall in interest rates could enable households to take on more debt and thus get closer to their desired debt level, which could lead to increases in house prices. Also this could show the effect of changes in bank lending policies and regulatory changes. The test for structural stability shows that the estimated coefficient for household debt changes during the period of investigation. Specifically it appears to become negative from the third quarter of 2002 and forward. This is a somewhat perplexing result, as it would mean that increasing household debt is associated with lower house prices.

Two testing procedures are employed to investigate the models stability over time. The results show that the model is not stable over time. This means that the short run relationship between the variables changes during the period.

Based on the variables included in the final model, a cointegration and error correction model is estimated. The variables that are not difference stationary had to be excluded, which meant that the 60-64 age cohort and GDP are excluded. The cointegration model shows that there is cointegration between house prices and the fundamental variables, indicating a long run relationship. Also, the error correction test is significant indicating that the long run relationship displays short run disequilibrium. The presence of cointegration and error correction is a rather strong indicator that house prices are in line with fundamentals, thus the development of house prices is not driven by speculative behavior.

7. Conclusion

The purpose of this thesis is to investigate to what extent the development of Swedish residential real estate prices can be explained by movements in fundamentals. The methodological approach is to use a graphical analysis, combined with an econometric model.

The graphical analysis of affordability ratio and price to rent ratio indicated that house prices are misaligned with fundamental variables. On the contrary, the more advanced measure, imputed rent, which relates the ratio of actual cost of owning to renting housing, shows a more stable development of house prices.

The econometric model includes population in different age cohorts, employment, building price index, construction costs, short and long term interest rates, inflation, GDP, rents, consumption, and household debt. The variables are examined for stationarity, and where necessary, transformed to the appropriate functional form. The fundamental variables with statistically significant explanatory power for house prices are (sign of coefficient in parentheses): population aged 35-44 (+), population aged 45-54 (+), population aged 60-64 (−), employment (+), construction costs (+), the three month government bond rate (−), GDP (+), and household debt (+). In the final model the fundamental variables explain 74 percent of the changes in house prices.

Finally, a cointegration and error correction model is used to investigate for a long run relationship between house prices and fundamental variables. Both cointegration and error correction is found to be present, which indicates the presence of a long run relationship between house prices and fundamental variables. This result is an indication that house prices are in line with fundamentals.

In conclusion, the development of house prices in Sweden can be well explained by fundamental variables.

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Appendix A - Stationarity Tests

The Dickey Fuller test is conducted for three different specifications of times series Y_t:

(1) Y_t is a random walk: $\Delta Y_t = \delta Y_{t-1} + u_t$

(2) Y_t is a random walk with drift: $\Delta Y_t = \beta_1 + \delta Y_{t-1} + u_t$

(3) Y_t is a random walk with drift around a stochastic trend: $\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + u_t$

Where ΔY_t denotes the change in Y_t, t is the time variable, and u_t is a white noise error term. In all three specifications the null hypothesis is that $\delta = 0$, i.e. the time series is non-stationary, and the alternative hypothesis is that $\delta < 0$, i.e. the time series is stationary. Under the null hypothesis, the estimated *t*-values follow the τ statistic and the null is rejected if the absolute value of the test statistic is greater than the critical value (Gujarati 2003).

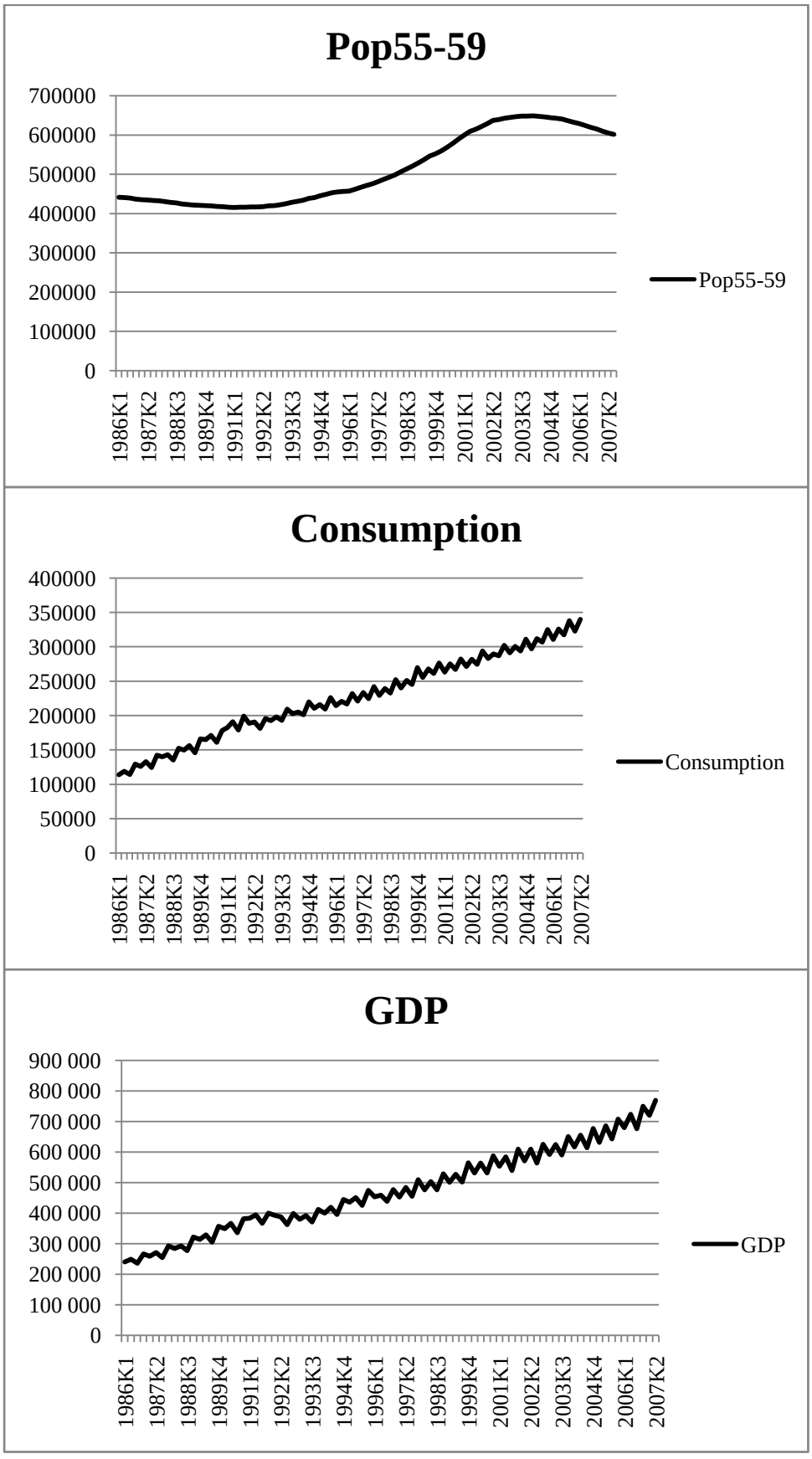
Since it is impossible to know beforehand which specification is correct, it is necessary to estimate all three specifications.

***Table A**. Results of Dickey-Fuller test*

Specification	Critical value at 5% significance level
No constant (1)	-1.95
Constant (2)	-2.89
Trend, constant (3)	-3.45

	Test statistic for specification:			
Variable	**No constant (1)**	**Constant (2)**	**Trend, constant (3)**	**Decision: Reject**
Price	5.92	-0.59	-1.01	(1)
Pop20-24	-2.88	0.13	-2.16	(1)
Pop25-34	0.50	-1.04	1.09	
Pop35-44	-0.12	-0.51	1.03	
Pop45-54	4.96	-7.30	0.14	(1), (2)
Pop55-59	5.66	2.09	-3.63	(1), (3)
Pop60-64	2.75	6.01	4.88	(1), (2), (3)
Employment	0.30	-1.38	-1.32	
BPI	6.00	-1.98	-1.55	(1)
FPI	6.05	-3.10	-1.77	(1), (2)
SSVX3M	-1.91	0.50	-1.63	
SSVX6M	-1.94	0.44	-1.70	
SEGVB5Y	-1.68	-0.31	-2.41	
CPI	6.52	-5.12	-1.30	(1), (2)
GDP	1.62	-1.49	-7.00	(3)
Rents	8.23	-7.01	-1.40	(1), (2)
Consumption	2.10	-1.62	-5.07	(1), (3)
HouseholdDebt	10.64	-0.60	-0.90	(1)

Figure A. *Graphs of variables Pop55-59, Consumption, and GDP*



Appendix B - Imputed Rent[6]

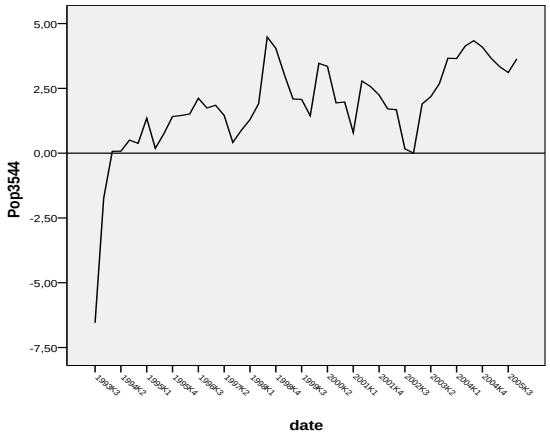
The imputed rent is calculated as the sum of six components. The first component is the cost of foregone interest. This is calculated as the price of housing times the risk-free interest rate. The second component is the cost of property taxes. The third component is the benefit of the tax deductibility of interest rates. The fourth component reflects depreciation as a fraction of home value. Finally, the fifth component is the expected capital gain (or loss) during the year, and the sixth component, represents an additional risk premium to compensate homeowners for the higher risk of owning versus renting. The sum of these six components gives the total annual cost of homeownership.

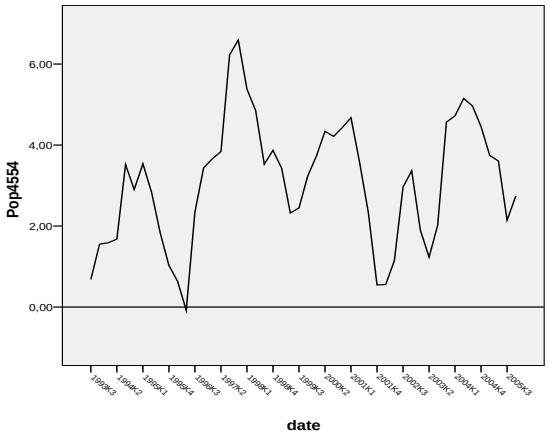
Following the practice of Himmelberg et al. (2005), we use a depreciation rate of 2.5 percent, a capital gain of 4 percent and a risk premium of 2 percent. For the cost of property taxes we use a tax deductibility of 30 percent after the tax reform 1990-1991. For the previous years the tax deductibility depends on the individuals' marginal tax rate. According to Englund et al. (1995), the marginal tax rate for the median home owner in 1980 was 51 percent in Sweden, which is the figure we use before the tax reform. Property tax rates and assessed values are from the Swedish Tax Authority.

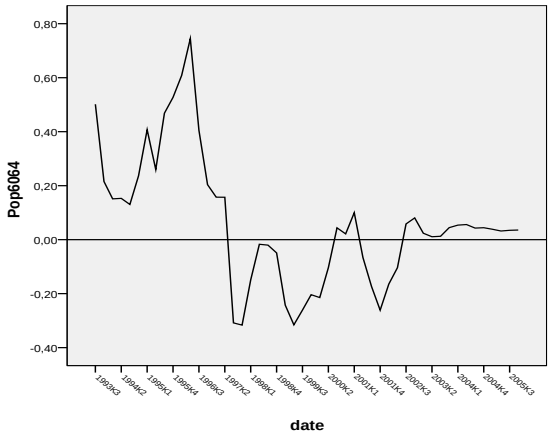
[6] This section is largely based on Himmelberg et al (2005).

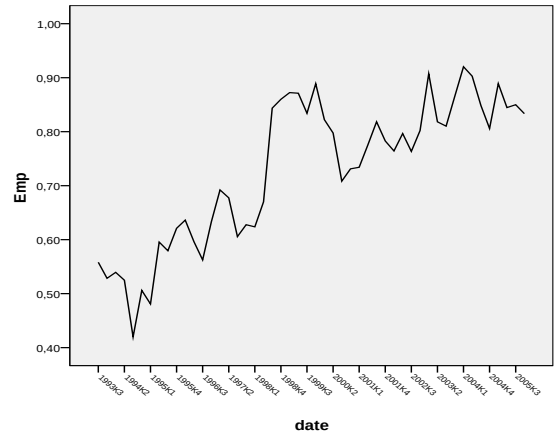
Appendix C - Rolling Regression

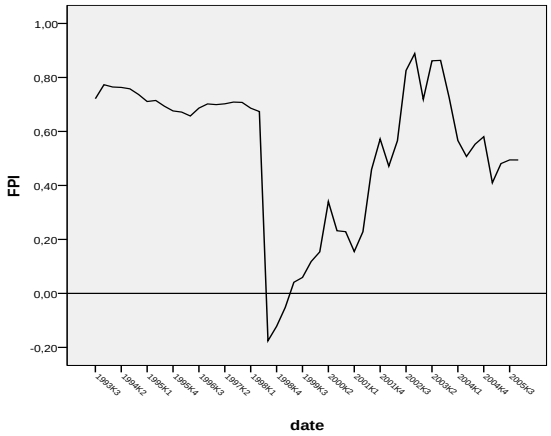
The results from the rolling regressions for all coefficients in model (2) are displayed below.

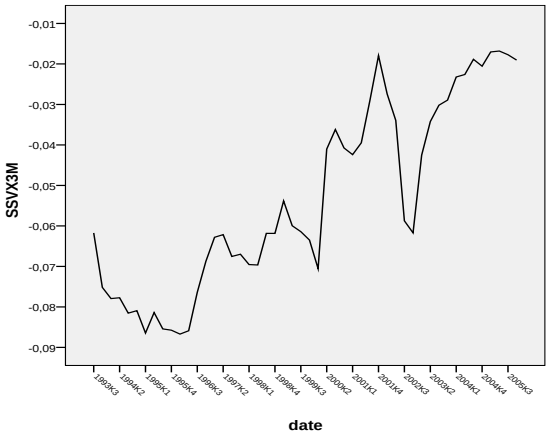


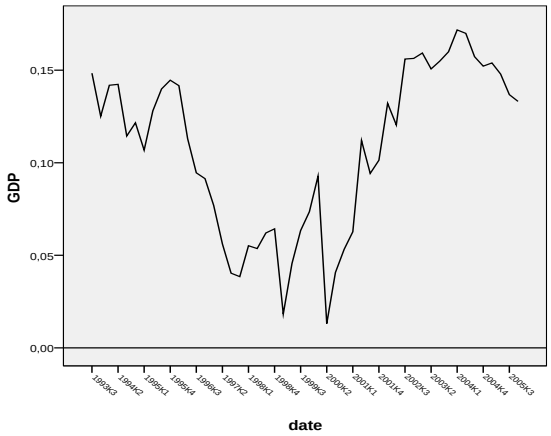


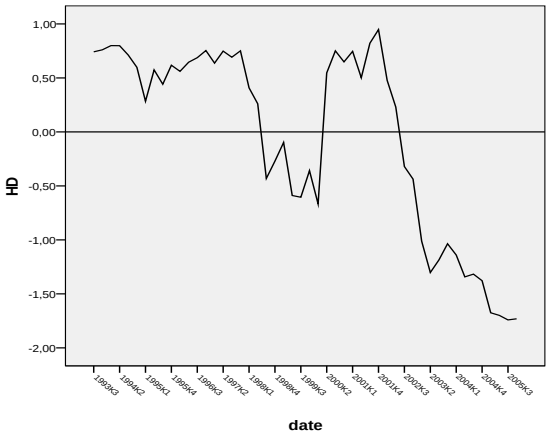





FPI
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0,60
0,40
0,20
0,00
-0,20
1993K3
1994K2
1995K1
1995K4
1996K3
1997K2
1998K1
1998K4
1999K3
2000K2
2001K1
2001K4
2002K3
2003K2
2004K1
2004K4
2005K3
date


SSVX3M
-0,01
-0,02
-0,03
-0,04
-0,05
-0,06
-0,07
-0,08
-0,09
1993K3
1994K2
1995K1
1995K4
1996K3
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GDP
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1997K2
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1998K4
1999K3
2000K2
2001K1
2001K4
2002K3
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Appendix D – Model Specifications

Model (1)

$$Price_t = \beta_1 + \beta_2 Pop20\text{-}24_t + \beta_3 Pop25\text{-}34_t + \beta_4 Pop35\text{-}44_t + \beta_5 Pop45\text{-}54_t + \beta_6 Pop55\text{-}59_t + \beta_7 Pop60\text{-}64_t + \beta_8 Employment_t + \beta_9 BPI_t + \beta_{10} FPI_t + \beta_{11} SSVX3M_t + \beta_{12} SSVX6M_t + \beta_{13} SEGVB5Y_t + \beta_{14} CPI_t + \beta_{15} GDP_t + \beta_{16} Rents_t + \beta_{17} Consumption_t + \beta_{18} HouseholdDebt_t + \varepsilon_t$$

Model (2)

$$Price_t = \beta_1 + \beta_2 Pop35\text{-}44_t + \beta_3 Pop45\text{-}54_t + \beta_4 Pop60\text{-}64_t + \beta_5 Employment_t + \beta_6 FPI_t + \beta_7 SSVX3M_t + \beta_8 GDP_t + \beta_9 HouseholdDebt_t + \varepsilon_t$$

Model (3)

$$Price_t = \beta_1 + \beta_2 Pop35\text{-}44_t + \beta_3 Pop45\text{-}54_t + \beta_4 Pop60\text{-}64_t + \beta_5 Employment_t + \beta_6 FPI_t + \beta_7 SSVX3M_t + \beta_8 GDP_t + \beta_9 HouseholdDebt_t + \beta_{10} D_t + \beta_{11} Pop35\text{-}44_t D_t + \beta_{12} Pop45\text{-}54_t D_t + \beta_{13} Pop60\text{-}64_t D_t + \beta_{14} Employment_t D_t + \beta_{15} FPI_t D_t + \beta_{16} SSVX3M_t D_t + \beta_{17} GDP_t D_t + \beta_{18} HouseholdDebt_t D_t + \varepsilon_t$$

Model (4)

$$Price_t = \beta_1 + \beta_2 Pop35\text{-}44_t + \beta_3 Pop45\text{-}54_t + \beta_4 Employment_t + \beta_5 FPI_t + \beta_6 SSVX3M_t + \beta_7 HouseholdDebt_t + \varepsilon_t$$

Model (5)

$$Price_t = \beta_1 + \beta_2 Pop35\text{-}44_t + \beta_3 Pop45\text{-}54_t + \beta_4 Employment_t + \beta_5 FPI_t + \beta_6 SSVX3M_t + \beta_7 HouseholdDebt_t + u_{t-1} + \varepsilon_t$$