Macroeconomic determinants of apartment prices in Swedish and German cities

Sviatlana Engerstam

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Division of Real Estate Economics and Finance
Division of Real Estate Business and Financial Systems
Department of Real Estate and Construction Management
School of Architecture and the Built Environment
KTH Royal Institute of Technology

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Sviatlana Engerstam

Royal Institute of Technology
Department of Real Estate and Construction Management
Division of Real Estate Economics and Finance
Stockholm, Sweden
Email: Sviatlana.engerstam@abe.kth.se

Abstract

We study the long-term effects of macroeconomic fundamentals on apartment prices in major urban areas in Sweden and Germany. The panel cointegration analysis was chosen as the primary approach due to the limited availability of data for a more extended period and frequency. The dataset consists of 2 countries – Germany and Sweden. The Swedish dataset includes three major cities and a period of 23 years, while the German dataset includes 7 "Big cities" for 29 years. Pooling the observations allows overcoming data restrictions in econometric analysis of long-term time series such as spatial heterogeneity, cross-sectional dependence and non-stationary, but cointegrated data. The results lie in line with previous studies and also allow comparison of single city estimations in an integrated equilibrium framework. The empirical results indicate that apartment prices react much stronger on changes in fundamentals in major Swedish cities than in German ones despite quite similar underlying fundamentals. Comparative analysis of regulations on the rental market, bank lending policies, and approaches to valuation for mortgage purposes in these two countries provide evidence that this overreaction arises due to institutional differences in form bank lending policies, mortgage valuation practices, and regulations on the rental market. Application of the more sustainable value concept such as mortgage lending value in mortgage valuations could make lending for housing less procyclical and stabilize house prices over the long run. Moreover, it will help to keep house prices away from overreaction on changes in macroeconomic fundamentals.

Keywords: Housing market, Macroeconomy, Price determinants, Panel cointegration, Dynamic OLS

JEL Classification C33, C51, R15, R30

1. Introduction

House prices have been rising in many countries since the 1990s (Figure 1). In some European countries such as, for example, Sweden and Norway, the price growth was so extreme, that it raised debates about emerging speculative bubbles. At the same time, these dynamics were not the same for all European countries. For example, in Germany and Portugal, real house prices have been stagnating over the last few decades (see Figure 1). The real house price growth in Sweden during 1995-2018 was plus 216 percent or 9,4 percent per year, while in Germany, it was only 18,6 percent for the same period or one percent per year (Source: Eurostat, Authors calculations).

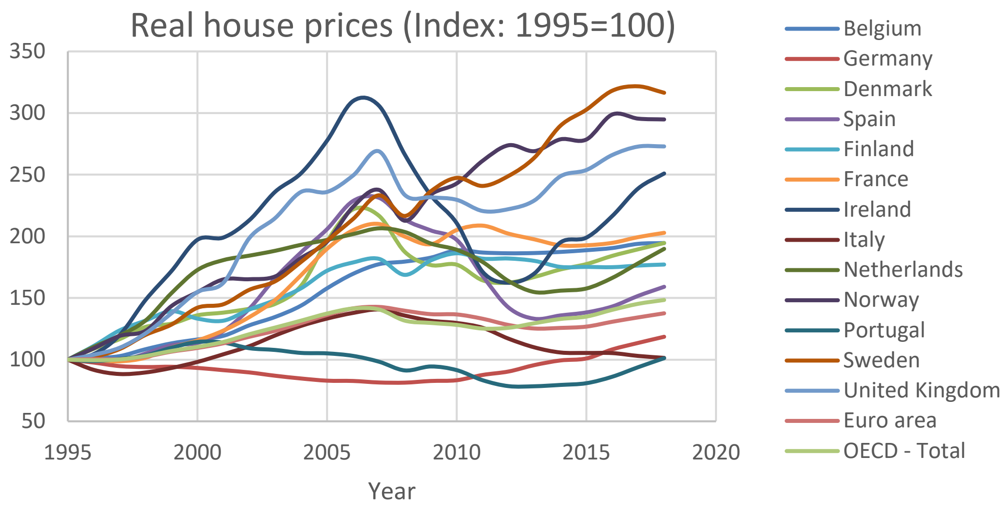

Figure 1. Real house prices (Index: 1st quarter 1995=100). Source: Eurostat

On the one hand, such high and persistent growth in house prices makes it an attractive investment that outperforms the traditional investments in stocks and bonds even if taking into lower liquidity of this type of asset. On the other hand, high house price growth in comparison with slow income growth occurring in the low-interest-rate environment makes housing less affordable with time. One more consequence of this process is that high house price growth might be an indicator of a potential bubble formation, and thus, it might induce risks for the stability of the financial system. For example, one might suspect a potential price bubble formation in cooperative apartments segment in Sweden, because it looks more volatile over the long run in comparison with single-family house price dynamics (See Figure 2).

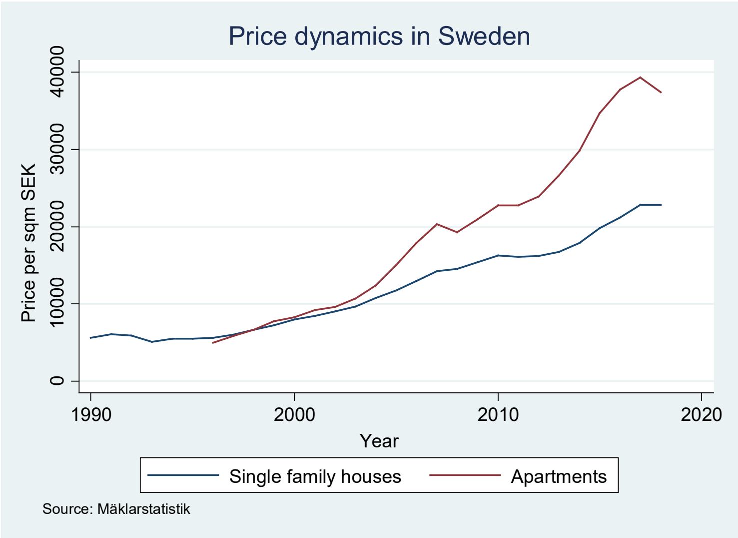

Figure 2. Housing price dynamics in Sweden

The 2008 sub-prime mortgage crisis in the USA raised many debates, which led to intensive research about housing bubbles and factors that contribute to their emergence and growth. The major bulk of this research might be divided into three major groups:

1) Discussions whether house price growth on housing markets can be defined as a speculative bubble or whether it is a normal dynamic that might be explained by fundamentals;
2) Econometric analysis of the determinants of the house prices with a wide variety of the model specifications[1];
3) Analysis of other factors that might affect house prices and discussions regarding their distinction from fundamentals.

Although the main factors that contribute to house price growth in different countries are well examined, one question remains: What are the factors that prevent house prices from persistent rising over the long run? If one of the goals of the central bank policy is to maintain stainability in the financial system, which in turn is closely connected to the housing market, then the focus should be on the relatively stable housing markets and factors that contribute to this stability. This study is trying to analyze house price dynamics from this new perspective and to correct this probably conceptual misunderstanding. It might be done by making a comparative analysis of two opposite countries – one with the stable price dynamics like, for example, in Germany and another one with the persistent house price growth as it is observed in Sweden during recent decades. This kind of analysis was never done before and the results from it might help to understand long-run property market dynamics in a better way. As the major housing stock is generally concentrated in larger urban areas, it is worth to make such comparative analysis on the regional level like metropolitan areas.

[1] For example, Girouard et al (2006) point out that macroeconomic variables used in the analysis of house prices depend on the underlying the econometric model specifications, affordability indicators and asset pricing approaches. Another study of Gallin (2006) mention that the level of house prices in USA does not appear to have a stable long run equilibrium relationship with the level of fundamentals such as income. Thus, the levels regressions found in the literature are likely spurious, and the associated error-correction models may be inappropriate.

The main *research questions* of this study are:

1. Is it possible to explain the difference in long-run house price dynamics in Germany and Sweden by fundamental factors?

2. If not, are there any other factors that might explain these differences?

The rest of the paper is organized as follows: Section 2 contains a brief literature review of different studies focused on house price determinants in different countries and econometric approaches used in the analysis. Section 3 describes the data. Section 4 presents the methodological approach and panel cointegration technique for non-stationary panel data used to estimate the long-term equilibrium relationship between apartment prices and macroeconomic fundamentals. Section 5 provides the empirical results of the model implementation. Section 6 discusses the results and provide insights into other factors that might contribute to differences in house price dynamics over the long run. Finally, Section 7 contains conclusions and further research suggestions.

2. Brief literature review on macroeconomic determinants of house prices

Empirical literature provides extensive evidence regarding various factors that affect the house price developments. The primary body of research is quite vast and consists of more than 350 thousands of different studies that analyze factors affecting house prices[2]. Most of the studies on house price dynamics focused on the USA, UK, and some other countries, primarily OECD members. (For extended research overview in housing and macroeconomics see, for example, studies done by Leung (2004), Panagiotidis and Printzis (2016), Piazzesi and Schneider (2016)).

Only a number of selected studies are presented below to highlight the essence of this extensive research in the area. The selection of studies was made to match the following major criteria: 1) Studies are done within the housing economics area, 2) Studies are published in research journals with high impact factors, and 3) Studies that cover developed countries in Europe and the USA. Some of these studies done on an aggregated country level, others on a regional level, and in some cases, they cover both levels. These studies provide a base for the development of a methodological approach and model in this paper.

Ozanne and Thibodeau (1983) were one of the first who tried to find out the determinants of house prices in the USA, but their regression results were not significant. Other studies on more extended data have found interconnections between different fundamental factors and house price dynamics. Particularly, Reichert (1990) has found that population, employment, mortgage rate, permanent income and construction costs affect the house prices at a national and regional level, and the impact of these variables differ between different regions. Poterba (1991) concluded that changes in real income and real construction costs are important explanatory

[2] The search on house price determinants studies done using Royal Institute of Technology (Sweden) library catalogue, which include over 100 databases and subscriptions to over 11,000 e-journals as well as a large number of open access resources.

factors of the cross-city pattern of house price appreciation. Abraham and Hendershott (1996) have found that the growth in real income and real construction costs and changes in the real after-tax interest rate, employment growth, income growth and real interest rate have an impact on house price changes. Baffoe-Bonnie (1998) demonstrated that housing prices are influenced by economic fundamentals such as mortgage rates, consumer price index, changes in employment and money supply. Jones and Hyclak (1999) also confirmed that unemployment and labor force affect house prices. Jud and Winkler (2002) have found that real housing price appreciation is strongly influenced by the growth of population and real changes in income, construction costs and interest rates, as well as growth in housing wealth. A recent study done by Oikarinen et al. (2018) explores spatial heterogeneity in house price dynamics and discuss the role of price elasticity of housing supply as well as income elasticity of prices.

Giussani and Hadjimatheou (1992) were one of the first who developed an econometric model for house prices in the UK. They suggested that the number of households, personal disposable income per capita, house building costs and the total housing stock are the driving forces behind increases in house prices in the long run. Their results also suggest that fiscal and monetary policy have a direct impact on house prices, both in the short and the long-run, through changes in personal disposable income, interest rates, and tax allowance on mortgage interest payments. Muellbauer and Murphy (1994) have found that the main determinants of the regional deviation in house prices from the UK average are income, rate of return, index of financial liberalization, the mortgage interest rate, mortgage stock/income ratio, the rate of acceleration of unemployment and regional population. Xu and Tang (2014) concluded that construction cost, credit, GDP, interest rate, and unemployment rate have a positive impact on house prices, while disposable income and money supply are negatively correlated with house prices. White (2015) confirmed the existence of a cointegrating relationship between Greater London real house price movements and income, gross mortgage lending and interest rates. A recent study was done by Sivitanides (2018) provide evidence of a strong long-term relationship between London house prices and key macroeconomic variables, such as UK GDP, London population and housing completions.

Studies done on an international level demonstrate a similar effect from fundamentals in comparison with studies done in the USA and UK. For example, Englund and Ioannides (1997) confirmed that GDP growth and real interest rate are also strongly significant, but demographics do not appear to be matter at all. Terrones and Otrok (2004) postulate that the growth rate of real house prices is explained by the past growth rates of real house prices, housing affordability ratio, real income growth, interest rates, the growth rate of real credit, population growth and a bank crisis dummy. The empirical results of Adams and Füss's (2010) study indicate that house prices are affected by construction costs and long-term interest rates. Caldera Sánchez and Johansson (2011) concluded that the housing stock tends to have a positive and significant effect on prices in the long-run, while the effect of declining interest rates is modest or small.

It is interesting to note that while some of the authors argue that fundamental factors play a certain role (see McCarthy and Peach (2004), Himmelberg et al. (2005), Hwang and Quigley (2006), Cameron, Muellbauer and Murphy (2006)), others point out that the impact of these factors can be different depending on the data period (Case and Shiller (1990, 2003), Mikhed and Zemčik (2009), Kundan Kishor and Marfatia (2017)). In addition, some of the factors might have stronger effects, while other low or no effect at all (see Quigley (1999), Capozza et al. (2004), Gallin (2006), Miles and Pillonca (2008), Taltavull and White (2011)).

Studies done after the Global financial crisis add other factors to the analysis. For example, Wheaton and Nechayev (2008) point out that second home and speculative buying, as well as the emergence of the risk-priced sub-prime mortgage market, are new and unique factors on the housing market in comparison with what is pointed out in the previous research in this area. Duca, Muellbauer and Murphy (2011) found that credit standards for first-time homebuyers are important determinants of house prices, along with income, real user costs and the housing stock.

In summary, major part of the literature in housing economics considers factors that might affect house prices both from the demand and the supply side. On the demand side, the typical factors are household income, mortgage rates on housing loans, different demographics, and labor market factors like population and employment growth. Construction costs and housing stock developments often represent the supply side. This variety of factors that affect house prices are often called "fundamentals." Another group of factors that are different from fundamentals includes such factors as the behavior of the market participants, financing conditions, mortgage valuation policies.

3. Data

3.1. Selection of the study objects

Similar cities in Germany and Sweden selected for comparative analysis in this study. The three biggest cities in Sweden are Stockholm, Göteborg, and Malmö. The population size and description of these cities presented in Table 1 in Appendix A.

Due to various historical, geographical, climate, and other reasons, the housing market in Germany is heterogeneous and diverse in terms of price and types of housing. The biggest German metropolitan area often called the "Big Seven." They are Berlin, Hamburg, München, Cologne, Frankfurt, Stuttgart, Düsseldorf, and Bremen. Because houses in the eastern states of Germany do not meet modern standards of construction, they were not considered comparable for this study, and therefore they excluded from the analysis below (i.e., Berlin). The population size and description of these cities presented in Table 2 in Appendix B.

The "Big Seven" German cities have several similarities with three major Swedish cities in terms of historical and socio-economic development, and therefore they are comparable in the following way:

- Stockholm is comparable to München, Frankfurt, and Düsseldorf;
- Göteborg is comparable to Hamburg and Stuttgart;
- Malmö is comparable to Cologne and Bremen.

The share of the apartment segment in the total housing stock varies between 24-41 percent in Swedish cities and between 26-45 percent in Germany (see figures 4 and 5 in Appendix C). Since the apartment, the segment represents quite significant and, in some cases, even a major part of the total housing stock in larger urban areas, the analysis in this paper done with a focus on this part of the housing market.

3.2. Data description

The dataset consists of 2 cross-section panels: 3 major cities in Sweden of 23 periods each (year 1996-2018) and 7 major cities in Germany of 29 periods each (years 1990-2018). The dataset is unbalanced with some missing values for certain variables either at the beginning or at the end of the dataset. All economic variables expressed in real terms. In contrast to other variables like population and income that are different on the city level, the mortgage interest rate is common for all cities in each country.

The apartment price per square meter is the main dependent variable in the model. The city population, disposable income per capita, apartment stock, mortgage interest rate, and unemployment used as the main independent variables in the model. Data sources and detailed descriptions presented in Appendix D. Tables 3 and 4 provide descriptive statistics for Swedish and German cities data.

Table 3. Descriptive statistics for Swedish cities.

Variable name	Number of observations	Mean	Standard deviation
Price for apartments per sq.m, SEK	69	24751.2	17221.7
Population, number of inhabitants	87	1142741.0	585846.9
Apartment stock in multifamily buildings, dwellings	87	141254.7	108063.9
Total apartment stock per capita	87	0.5	0.0
Disposable income per capita, thousands SEK	69	155.0	41.6
Mortgage interest rate, percent	78	3.4	2.1
Unemployment, percent	42	8.6	2.3

Table 4. Descriptive statistics for German cities.

Variable name	Number of observations	Mean	Standard deviation
Price for apartments per sq.m, Euro	203	2252.8	889.9
Population, number of inhabitants	203	919487.4	423730.5
Apartment stock in multifamily buildings, dwellings	161	154793.3	73324.5
Total apartment stock per capita	196	0.5	0.0
Disposable income per capita, Euro	154	20415.4	2963.5
Mortgage interest rate, percent	175	3.0	1.9
Unemployment, percent	147	8.6	2.4

Considering the fact that exchange rate between Swedish krona and Euro varied between 8,5 and 10 SEK per Euro during the last two decades (Source: ECB), the simple calculation of economic variables in both countries into the same currency allows to conclude that underlying fundamentals are very similar in both countries. Later, all variables used in econometric estimations transformed into the natural logarithm form mainly for the comparative analysis purpose.

4. The methodology and the model

4.1. The methodological approach

This study applies DiPasquale and Wheaton's (1996) theoretical framework for the long-run model of supply and demand in the housing market. It also applies Adams and Füss's (2010) approach and Pedroni's (2004) econometric methodology with some smaller modifications explained below. One principal difference is that analysis done at a cross-city panel level in distinction to Adams and Füss's (2010) study, where the analysis was done on cross-country panel level. City-level is more homogeneous in distinction to country-level because countries might differ in socio-economic and legal environments, while cities of the same country are not[3]. Therefore, the comparative analysis of two countries based on two cross-city panels seems to be more appropriate in this setting.

Traditionally the analysis of the long-run equilibrium models of house prices and macroeconomic fundamentals requires long time-series data to be able to apply cointegration techniques such as Engle-Granger (1987) or Johansen's (1991) approach. This, however, might be different when the analysis was done on data for the apartment segment of the housing market.

For Sweden, the majority of studies was done on house price data for single-family houses which is available for an extended period (see studies done by Asal (2018, 2019), Berg (2004), Claussen (2013), Hort (1998), Turner (1997), Wilhelmsson (2008), Yang et al. (2010)). Apartment prices data in Sweden covers a bit more than about two decades, which is a rather short period if observations are taken annually. To overcome this restriction, it is worth to follow the methodology applied in Adams and Füss (2010) and to apply a panel cointegration approach proposed by Pedroni (1999, 2004). This approach allows us to use the T observations of time series of a single city as well as to pool the observable data over all cities N so that the effect of $N \cdot T$ real observations is available for analysis. The advantage of this method is that: (1) it provides robust estimations due to larger sample asymptotics; (2) it estimates the country result at aggregated level by weighting the individual cities estimations; and (3) it presents differences among cities' elasticities, which allows us to analyze the level of cross-city integration. In addition, Adams and Füss (2010) point out that the panel data variables on house prices and their fundamentals are often cointegrated even when there is no cointegration between them in individual time series (Adams and Füss, 2010, p.38).

Previous research done on German data includes, for example, studies done by Dust and Maening (2007), Koetter, and Poghosyan (2010) that analyze single-family house prices at a regional level and include shorter time series like one year or a decade. The study done by Kajuth et al. (2013) differentiates between single-family houses and apartments and point to significant effects of the housing stock per capita, income per capita, unemployment, population density, and growth expectations on house prices. They conclude that apartments in German cities show significant overvaluation between 5 and 7 percent in the years 2011 and 2012, while single-family houses do not. Belke and Keil (2018) demonstrated that supply-side factors such as construction activity and housing stock as well as the demand side factors in form of apartment rents, market size, age structure, local

[3] At the same time cities of the same countries might be heterogeneous due to local socio-economic differences.

infrastructure and rental prices are robustly linked to fundamental real estate prices and thus can be used to detect misalignments of market prices.

In distinction to the major part of previous research done on Swedish and German data, this study focuses on the apartment segment of the market and examines apartment price elasticities from a long-term perspective. Also, the results from this study presented below highlight the differences between the two countries at the city level in an integrated long-run equilibrium framework.

4.2. Macroeconomic fundamentals of apartment prices over the long run

In line with DiPasquale and Wheaton (1996) model and literature review presented in section 2, the following variables were chosen for analysis as macroeconomic fundamentals of apartment prices over the long run:

1. *Disposable income:* According to DiPasquale and Wheaton (1996), an increase in economic activity leads to an increase in demand for space, D. This shifts the demand curve to the right and leads to an increase in rents, R, which increases house prices, P. According to Adams and Füss (2010), the widely used indicator of economic activity is disposable income, I. Therefore, the long-run price elasticity of income might be determined as follows:

$$\underbrace{\frac{\partial hp}{\partial income}}_{+} = \underbrace{\frac{\partial hp}{\partial D}}_{+} \cdot \underbrace{\frac{\partial D}{\partial income}}_{+}.$$

2. *Mortgage interest rate*: An increase in the mortgage interest rate affects the demand for houses negatively. A higher mortgage interest rate, i, lead to lower house prices, which in turn decrease construction and thus translates to lower housing stock. Lower housing stock increases rents, R, and house prices, P. Therefore, the long-run price elasticity to mortgage interest rate might be determined as follows:

$$\underbrace{\frac{\partial hp}{\partial rate}}_{-} = \underbrace{\frac{\partial hp}{\partial S}}_{+} \cdot \underbrace{\frac{\partial S}{\partial C}}_{-} \cdot \underbrace{\frac{\partial C}{\partial hp}}_{-} \cdot \underbrace{\frac{\partial hp}{\partial D}}_{-} \cdot \underbrace{\frac{\partial D}{\partial rate}}_{-}.$$

3. *Housing stock and construction*: An increase in construction leads to the higher housing stock in the long run and vice versa. Higher housing stock lead to lower house prices keeping all other variables unchanged. Thus, the long-run elasticity of prices to construction in the might be determined as:

$$\underbrace{\frac{\partial hp}{\partial C}}_{-} = \underbrace{\frac{\partial hp}{\partial S}}_{-} \cdot \underbrace{\frac{\partial S}{\partial C}}_{+}$$

The minus sign of the effect of the construction and housing supply on house prices depends on the size of the construction in relation to the shift in demand. If overbuilding occurs, the effect of construction and thus increase in the supply of housing will be negative, while if the opposite situation takes place. i.e., when the size of the construction corresponds to the shift in demand or is less than that, the effect on prices will be either zero or positive[4].

4. *Population:* An increase in population lead to higher demand for space, D, thus leading to an increase in house prices, P. Many studies found insignificant or even adverse effects of population growth on house prices (see, for example, Mankiw and Weil (1989), Hort (1998), Poterba (1991)). Nevertheless, this study considers it because population growth is one of the driving factors behind rapid urbanization and an increase in housing demand in the cities. An increase in population might happen through natural demographic growth like baby boom periods, as well as high immigration from outside of the country and natural urbanization processes when people were moving to the cities from suburban areas. Adding this variable to the equation of house prices might also help to avoid omitted variable bias. The price elasticity of population growth might be determined as follows:

$$\underbrace{\frac{\partial hp}{\partial pop}}_{+} = \underbrace{\frac{\partial hp}{\partial D}}_{+} \cdot \underbrace{\frac{\partial D}{\partial pop}}_{+}.$$

5. *Unemployment rate*. Higher unemployment usually observed over periods with low economic activity and, therefore, considered as a factor that leads to a decrease in demand for housing. Moreover, considering the unemployment rate as a part of the equation for house prices might help to capture the effect of the changes in the employment rate of the working force that is part of the population. Thus, the price elasticity of the unemployment rate might be determined as follows:

$$\underbrace{\frac{\partial hp}{\partial u}}_{-} = \underbrace{\frac{\partial hp}{\partial D}}_{-} \cdot \underbrace{\frac{\partial D}{\partial u}}_{-}$$

4.3. The long-run model of supply and demand

In line with DiPasquale and Wheaton (1996) model the demand function is given as

$$D_t = \alpha + \beta' x_t^D + \delta' z_t^D + e_t, \quad (1)$$

where x_t^D is a vector of macroeconomic variables affecting demand. Vector z_t^D captures city-specific factors were affecting the housing demand at the micro-level, such as location, social environment, mortgage market characteristics, and taxation regulations. For estimation of the macroeconomic impact on the house prices, the vector z_t^D should be incorporated into the error term and Eq.(1) will be written as

$$D_t = \alpha - \beta_1 hp_t + \beta_2 pop_t + \beta_3 income_t - \beta_4 rate_t - \beta_5 unemp_t + \tilde{e}_t. \quad (2)$$

In Eq. (2) higher house prices hp_t have a negative impact on demand (unless it is not a speculative demand), while higher income or population growth has a positive effect on

[4] For the effects of supply elasticity on house prices see for example studies done by Glaeser et al (2008) and Oikarinen et al (2018). They provide evidence that lower supply elasticity cause larger and longer price bubbles in the 2000s. However, the study done by Davidoff (2013) concludes that there is no evidence that differences in supply elasticity caused different reactions in house prices on US during the 2000s housing cycle.

demand. Higher mortgage rate and unemployment rate are expected to have negative effect on demand for housing.

In a similar way housing supply is given by

$$S_t = \eta + \gamma' x_t^S + \lambda' z_t^S + \nu_t. \quad (3)$$

According to Colwell (2002), the long-run supply of houses is directly connected to the construction of new houses and the depreciation levels of housing stock. Housing construction depends on house price level and construction costs. Construction costs include a wide range of cost items, including building materials and transportation, as well as labor costs. It is reasonable to assume that the construction costs level is not very diverse among different housing developers due to competitiveness in the construction industry. Thus, change in construction costs affect long-run housing supply through construction level in the short run.

One more component that affects the long-run supply of houses is the depreciation rate. Since the maintenance level and overall housing standard is quite high in Sweden and Germany, we can assume that the depreciation rate is close to zero and ignore the effect depreciation has on housing supply. Therefore, in line with DiPasquale and Wheaton (1996) and Colwell (2002), the long-run housing supply equals initial housing stock plus aggregated housing construction over the long run minus depreciation of housing stock. With an assumption of zero depreciation rate, the long-run housing supply will be equal total aggregated construction or total housing stock constructed over the long run.

Thus, the supply equation expressed in more details as

$$S_t = \eta + \gamma_1 hp_t + \gamma_2 stock_t + \tilde{\nu}_t, \quad (4)$$

which incorporates micro factors such as the availability of land, governmental building provisions, construction costs level and depreciation of housing into the error term, $\tilde{\nu}_t$. In Eq. (4) higher house prices as an incentive for housing developers to increase the supply of houses. Given that supply equals demand in equilibrium relationship, then solving for house prices and considering panel structure, the final equation for house price will be

$$hp_{it} = \alpha_i^* - \gamma_{2i}^* stock_{it} + \beta_{2i}^* pop_{it} + \beta_{3i}^* income_{it} - \beta_{4i}^* interest_{it} - \beta_{5i}^* unemp_{it} + e_{it}^*, \quad (5)$$

with

$$\alpha_i^* = \frac{\alpha_i - \eta_i}{\gamma_{1i} + \beta_{1i}},\ \gamma_{2i}^* = \frac{\gamma_{2i}}{\gamma_{1i} + \beta_{1i}} = \frac{\partial hp_i}{\partial stock_i},\ \beta_{2i}^* = \frac{\beta_{2i}}{\gamma_{1i} + \beta_{1i}} = \frac{\partial hp_i}{\partial pop_i},\ \beta_{3i}^* = \frac{\beta_{3i}}{\gamma_{1i} + \beta_{1i}} = \frac{\partial hp_i}{\partial income_i},$$

$$\beta_{4i}^* = \frac{\beta_{4i}}{\gamma_{1i} + \beta_{1i}} = \frac{\partial hp_i}{\partial interest_i},\ \beta_{5i}^* = \frac{\beta_{5i}}{\gamma_{1i} + \beta_{1i}} = \frac{\partial hp_i}{\partial unemp_i}, \text{ and } e_{it}^* = \tilde{e}_{it} - \tilde{\nu}_{it}$$

According to the theoretical model outlined above the expected sign for γ_{2i}^*, β_{4i}^*, β_{5i}^* is negative, and for β_{2i}^* and β_{3i}^* is positive.

The econometric approach in this study is to apply the cointegration analysis for non-stationary panel data. The panel data combine information on the variation of the city data with information over time. The analysis is done on two levels: (1) The variables are tested for stationarity using panel unit root tests; (2) The long-run equilibrium relationships are estimated though panel cointegration tests.

4.4. Panel unit root tests

Im, Pesaran, and Shin (1997) proposed the unit root test that allows for heterogeneous autoregressive roots. The IPS test have a null hypothesis of non-stationarity assuming the parameters of the lagged endogenous variable p_i to be homogeneous for all individuals,

$$\Delta y_{it} = \alpha_1 + \delta_i t + p_i \Delta y_{it-1} + e_{it}$$

for $t = 1, \dots, T$ and $i = 1, \dots, N$,

$$H0: p_1 = p_2 = \cdots = p_N = p = 0 \quad (6)$$

against alternative hypothesis

$$H1: p_1 < 0 \text{ for } i = 1, 2 \dots, N_1 \text{ and} \quad (7)$$

$$p_i = 0 \text{ for } N_1 + 1, N_2 + 2, \dots, N,$$

so that slope parameters p_i are allowed to differ across group members, and not all N members need to be cointegrated.

Results of stationarity tests for Swedish and German dataset presented in Tables 5 and 6. As it comes from the p-values from the IPS, test the null hypothesis could not be rejected for all variables. Taking first differences reveals stationarity in the panel setting so that all variables considered as $I(1)$ and are thus suitable for the cointegration test procedure.

Table 5. Stationarity test for Swedish variables.

Variables	Level		First-difference	
	t-bar	P-value	t-stat	P-value
Price for apartments per sq.m, SEK	-1.6713	0.3654	-3.7103***	0.0006
Population, number of inhabitants	0.1775	0.9998	-2.2293*	0.0838
Apartment stock in multifamily buildings, dwellings	-0.6026	0.9683	-2.5075**	0.0333
Total apartment stock per capita	-1.2611	0.6614	-3.3042***	0.0013
Disposable income per capita, thousands SEK	-2.1121	0.1284	-5.1196***	0.0000
Mortgage interest rate, percent	-1.0175	0.6997	-3.3777**	0.0386
Unemployment, percent	-2.5059*	0.0600	-4.8580***	0.0004

Note: The IPS test is based on the individual ADF regressions with an intercept, trend, and the first lag of the dependent variable. The test statistic has an asymptotic standardized normal distribution.
** denotes rejection of the null hypothesis of unit root based on their P-value at the 0.10 significance level.*
*** denotes rejection of the null hypothesis of unit root based on their P-value at the 0.05 significance level.*
**** denotes rejection of the null hypothesis of unit root based on their P-value at the 0.01 significance level.*

Table 6. Stationarity test for German variables.

Variables	Level		First-difference	
	t-bar	P-value	t-stat	P-value
Price for apartments per sq.m, Euro	-0.8855	0.9739	-4.3016	0.0000***
Population, number of inhabitants	-0.4320	0.9996	-4.3768	0.0000***
Apartment stock in multifamily buildings, dwellings	-1.6250	0.4004	-2.7139	0.0009***
Total apartment stock per capita	-1.9735	0.1255	-4.6324	0.0000***
Disposable income per capita, Euro	-2.0931	0.0420**	-4.6199	0.0000***
Mortgage interest rate, percent	-0.9750	0.7166	-4.4288	0.0118**
Unemployment, percent	-1.9508	0.1023	-3.9213	0.0000***

Note: The IPS test is based on the individual ADF regressions with an intercept, trend, and the first lag of the dependent variable. The test statistic has an asymptotic standardized normal distribution.

** denotes rejection of the null hypothesis of unit root based on their P-value at the 0.10 significance level.*

*** denotes rejection of the null hypothesis of unit root based on their P-value at the 0.05 significance level.*

**** denotes rejection of the null hypothesis of unit root based on their P-value at the 0.01 significance level.*

4.5. Panel cointegration test

The Pedroni (2000) test for cointegration applied to heterogeneous panel with multiple regressors. The null hypothesis is that there is no cointegration, and this test also allows for unbalanced panels to be tested. The regression residuals in this test come from the regression

$$y_{it} = a_i + \delta_i t + y_{1t}x_{1it} + y_{2t}x_{2it} \dots + y_{Mi}x_{Mit} + \hat{e}_{it} \qquad (8)$$

for $= 1, \dots, T \,;\, i = 1, \dots, N;\, m = 1, \dots, M$

with individual effects a_i and individual time trends $\delta_i t$. Time demeaning (or time dummies) might be excluded in any situations where there is reason to believe that averaging over the N dimension may destroy the cointegrating relationship, or where there are comparability concerns between panel units in the data.

In this equation, m regressors x_{mit} are allowed and the slope coefficients p_{mi} and thus, cointegration vectors are heterogeneous for all i. The residuals $\hat{e}_{it}$ from Eq.(8) are then tested for unit root,

$$\hat{e}_{it} = p_i \hat{e}_{it-1} + \varepsilon_i \qquad (9)$$

Including fixed effects and time trends changes the asymptotic distribution and increases the critical values of the unit root statistics. This is because in the presence of a unit root, the sample average of a variable with a stochastic trend $\bar{y}_i = \frac{1}{T}\sum_{t=1}^{T} y_{it}$ does not converge to the population mean by increasing T.

Pedroni (1999) proposed seven test statistics to test if data are cointegrated. They are Panel v-Statistic, Panel rho-Statistic, Panel t-Statistic, Panel ADF-Statistic, Group rho-Statistic, Group t-Statistic, and Group ADF-Statistic. The first four statistics are known as panel cointegration statistics and are based on the within approach; the last three statistics are group panel cointegration statistics and are based on the between approach. In the presence of a cointegrating relationship, the residuals are expected to be stationary. In later studies, Pedroni (2000, 2004) demonstrate that under general requirements the test statistic follows a normal distribution as T and N grow large and that the group and panel ADF statistics have the best power properties when T < 100, with the panel v and group p-statistics performing comparatively worse.

Table 7 presents Pedroni (1999) test statistics for the Swedish dataset. A group ADF test statistic of -1.672 for the Pedroni (1999) test rejects the null hypothesis of no cointegration at a 5 percent significance level. Thus, house prices in Sweden are cointegrated with apartment stock, population, disposable income, mortgage interest rate, and unemployment. Table 8 presents Pedroni (1999) test statistics for the German dataset. A test statistic of -2.086 for the Pedroni (1999) test rejects the null hypothesis of no cointegration at a 5 percent significance level. Thus, house prices in Germany are cointegrated with apartment stock, population, disposable income, mortgage interest rate, and unemployment.

Table 7. Pedroni (1999) test statistics for the Swedish dataset.

Test statistics	Panel	Group
V	-1.599	
Rho	1.643	2.388
T	-5.48***	-6.638***
Adf	0.1872	-1.672**
Number of panel units:	3	
Number of regressors:	5	
Number of observations:	39	

Null Hypothesis: No cointegration. Time trend is included. Data has not been time-demeaned. Automatic lag length selection based on AIC[5]

*Note: All statistics are from Pedroni's procedure (1999), where the adjusted values can be compared to the N(0,1) distribution. The Pedroni (2004) statistics are one-sided tests with a critical value of -1.64 (k < -1.64 implies rejection of the null), except the v-statistic that has a critical value of 1.64 (k > 1.64 suggests rejection of the null). ***, ** indicates rejection of the null hypothesis of no-co-integration at 1% and 5%, levels of significance.*

Table 8. Pedroni (1999) Test statistics for the German dataset.

Test statistics	Panel	Group
V	-0.6884	
Rho	1.793	2.878
T	-0.2572	0.005955
Adf	1.212	-2.086**
Number of panel units:	7	
Number of regressors:	5	
Number of observations:	133	

Note: similar testing approach and assumptions as Swedish dataset (see below table 7).

[5] Akaike's information criterion (AIC) is used to estimate the autoregressive lag length. It is superior than the other criteria under study in the case of small sample in the manners that it minimizes the chance of under estimation while maximizing the chance of recovering the true lag length. (See Khim-Sen (2004))

4.6. Cointegration-vector estimates

The single equation cointegration vector estimator proposed by Engle and Grander (1987) provides consistent estimations when the sample size T is large, but the statistical properties might be different for a smaller sample size. Inder (1993) and Stock and Watson (1993) demonstrate that for with macroeconomic time series data when the number of observations is not large, it might result in quite poor estimations.

The Panel Dynamic Ordinary Least Squares (DOLS) estimator introduced by Saikkonen (1991), Phillips and Moon (1999), and Pedroni (2000) augments the conventional OLS estimator by taking serial correlation and endogeneity of the regressors to the account. In a series of Monte-Carlo simulations Kao and Chiang (2000) and Mark and Sul (2003) test the small sample performance of the panel DOLS estimator and provide evidence that it, in general, outperforms single-equation estimation techniques.

Keeping in mind restrictions that are valid for the dataset used in this study and in line with Eq.(8), the main goal is to obtain the coefficient vector estimate γ' of

$$y_{it} = a_i + \gamma' x_{it} + u_{it}^*, \qquad (10)$$

with the regressors x_{it} being integrated of order 1: $x_{it} = x_{it-1} + v_{it}$. In Eq.(10) y_{it} is the apartment price of a city i and time t and x_{it} is a $5x1$ vector of housing stock, population, disposable income, mortgage interest rate, and unemployment of city i and time t respectfully. Inserting this expression into (10) yields the endogeneity and serial-correlation adjusted regression:

$$y_{it} = a_i + \gamma' x_{it} + \delta_i' z_{it} + u_{it} \qquad (11)$$

from which the coefficient vector $\beta_{DOLS} = (\gamma',\ \delta_i', \dots,\ \delta_N')'$ can be obtained.

The interpretation of the DOLS estimator is similar to a conventional panel OLS estimator except for one important aspect: A fixed-effect estimator would show the response of house prices at a time t or general at a time $t - p$. The DOLS estimator shows the long-run effects, which capture the accumulation of effects over time, as well as the stickiness of house prices. Thus, if all variables are in logs, the elements of the coefficient vector $\gamma' = (\gamma_{1t}', \gamma_{2t}', \gamma_{3t}')$ show the average long-term percentage in the regressor.

5. Empirical results

Table 9 demonstrates the estimation results for each city in Sweden as well as for the whole panel at the country level. In the latter case, the coefficients obtained by averaging over the individual city coefficients. Therefore, we can interpret the panel group coefficients as a group country's results.

Population and disposable income have a positive impact. Thus, a 1 percent increase in population leads to an 8.8 percent increase in apartment prices, and a one percent increase in disposable income leads to a 2,6 percent increase in apartment prices. Despite the expected negative impact on apartment prices from the supply side, apartment stock estimate has a positive sign - a 1 percent increase in apartment stock leads to, on average 3.7 percent increase in apartment prices in Swedish cities. Meen (2002) argues that if the housing supply is perfectly inelastic, the increase in demand will be choked off by higher prices. At the other extreme, if supply is fully elastic, the output will increase to the point at which prices are unchanged and therefore, higher supply elasticities induce lower long-run income elasticities of house prices. Moreover, the ratio of house prices to income in the long run not only is determined by the *direct* estimate of the coefficient on income in the house price equation but is a *systems* property depending also on the effect of the housing stock on prices and the price elasticity of new housing supply (Meen (2002), p.12). Housing supply in Sweden is not considered as perfectly elastic due to regulations that exist in the rental sector, and this leads to the process that demand for housing cooperatives sector continuously growing despite persistent growth in prices, which in turn perfectly corresponds to the supply side respond over the long run.

Table 9. DOLS estimates for Swedish cities

City	Apartment stock		Population		Disposable income		Mortgage interest rate		Unemployment	
	Coef.	t-stat	Coef.	t-stat	Coef.	t-stat	Coef.	t-stat	Coef.	t-stat
Stockholm	2.158***	49.94	7.332***	11.88	1.921***	17.55	-35.82***	-11.66	-0.2066	-1.433
Göteborg	3.681***	19.94	13.61***	5.092	2.65***	8.011	-52.62***	-21.11	-0.9159***	-7.274
Malmö	5.249***	34.12	5.534***	5.557	3.219***	8.244	-48.42***	-17.19	0.6888***	6.436
Number of obs.	21		21		18		21		9	
t-stat critical value at	df=19	2.539	df=19	2.539	df=16	2.583	df=19	2.539	df=7	2.998
1%, 5%, 10%		1.729		1.729		1.746		1.729		1.895
significance level		1.328		1.328		1.337		1.328		1.415
Panel Group DOLS (Group mean average)										
Coefficient	3.696***	60.04	8.826***	13.01	2.597***	19.51	-45.62***	-28.84	-0.1446	-1.311
Number of obs.	63		63		54		63		27	
t-stat critical value at	df=61	2.390	df=61	2.390	df=52	2.423	df=61	2.390	df=25	2.485
1%, 5%, 10%		1.671		1.671		1.684		1.671		1.708
significance level		1.296		1.296		1.303		1.296		1.316

Table 10. DOLS estimates for German cities

City	Apartment stock		Population		Disposable income		Mortgage interest rate		Unemployment	
	Coef.	t-stat	Coef.	t-stat	Coef.	t-stat	Coef.	t-stat	Coef.	t-stat
Bremen	2.337***	11.48	2.152***	4.011	-3.879**	-2.347	-4.5*	-1.586	0.94954	0.3019
Cologne	-0.9371***	-7.411	-5.92***	-8.693	2.564***	3.67	-7.251***	-3.139	0.8699	1.03
Dusseldorf	-2.377***	-7.168	9.697***	8.64	1.494	1.082	-6.122**	-2.535	-1.602***	-5.144
Frankfurt (Main)	-1.929**	-1.824	-5.83***	-6.12	2.739***	3.285	-8.415***	-5.793	1.119***	3.4
Hamburg	-3.817	-1.145	-3.657***	-6.118	1.521	1.231	-12.21***	-3.663	-1.464**	-2.222
Munich	-7.32	-0.4021	3.339***	6.867	0.03985	0.03817	-17.81***	-5.428	-3.463***	-4.728
Stuttgart	-2.565**	-2.484	0.1874	0.1354	2.269	1.327	-10.39***	-4.176	1.502***	3.268
Number of obs.	18		24		17		20		16	
t-stat critical value	df=16	2.583	df=22	2.508	df=15	2.602	df=18	2.552	df=14	2.624
at 1%, 5%, 10%		1.746		1.717		1.753		1.734		1.761
significance level		1.337		1.321		1.341		1.330		1.345
Panel Group DOLS (Group mean average)										
Coefficient	-2.373***	-3.385	-0.004291	-0.4826	0.9638***	3.132	-9.527***	-9.948	-0.4268*	-1.547
Number of obs.	126		168		119		140		112	
t-stat critical value	df=124	2.358	df=166	2.358	df=117	2.364	df=138	2.358	df=110	2.368
at 1%, 5%, 10%		1.658		1.658		1.660		1.658		1.662
significance level		1.289		1.289		1.290		1.289		1.291

The mortgage interest rate has a negative impact on apartment prices. One percent increase in mortgage interest rate leads to a 45.6 percent decrease in apartment prices in Swedish cities but only 9.5 percent decrease in Germany cities.

The results strongly confirm the theoretical implications of the DiPasquale and Wheaton (1996) model. However, individual effects vary widely among cities. For example, the effect of population growth on apartment prices in Göteborg is about twice as large as in Stockholm and Malmö. Unemployment has a negative effect in Göteborg, while positive in Malmö and is insignificant in Stockholm. The impact of unemployment is insignificant at the country level.

It is interesting to note that the impact of disposable income on apartment prices is almost double in Swedish cities in distinction to previous research which found elasticities of income below unity (see Terrones and Otrok (2004)) and to results for the German dataset, which indicate that one percent increase in disposable income leads to almost one percent increase in apartment prices in Germany. As Terrones and Otrok (2004) mention, real income growth per capita increases households' purchasing power and borrowing capacity, which, together with lower interest rates, increases households' capacity to borrow and drives house prices up.

The results for the German dataset in Table 10 indicate that apartment stock, mortgage interest rate, and unemployment harm apartment prices. Thus, a one percent increase in apartment stock leads to 2.4 decreases in apartment prices, while a one percent decrease in mortgage interest rate leads to a 9.5 percent increase in apartment prices in German cities. The unemployment rate has a negative effect, though it is not that strong – only 0.43 percent.

The effect of the population variable found insignificant for Germany. However, individual cities' effect varies a lot from a highly positive impact of 9.7 percent in Dusseldorf and to minus 5.9 percent in Cologne and minus 5.8 percent in Frankfurt, which lies in line with previous research (see Mankiw and Weil (1989)).

As it is seen from the comparison of results in Tables 9 and 10, the impact of Swedish fundamentals, in general, is much stronger than the impact of German fundamentals. However, if to compare the descriptive statistics of Swedish and German fundamentals (see Tables 3 and 4), they look quite similar. Moreover, if to compare the development of fundamentals in both countries over the long run, they are not able to explain the difference in house price dynamics to the full extent (See table 11). The population and disposable income that are drivers of apartment prices from the demand side were growing much faster in Swedish cities than in Germany, but the apartment stock that affects prices from the supply side also demonstrated much stronger growth. The mortgage interest rate was falling faster in German cities, and that drives apartment prices up, but the effect is quite moderate in comparison to Swedish cities. In total house price growth resulted in 759 percent difference over the period of two decades, which is impressive in comparison with the difference in total growth in fundamentals.

Table 11. Long term development of fundamentals in Swedish and German cities

Variables	Time period	Swedish cities		German cities		Difference	
		Total growth, %	Per annum, %	Total growth, %	Per annum, %	Total growth, %	Per annum, %
Price for apartments per sq.m, SEK	1996-2016	831.84	11.57	72.82	2.68	759.02	8.89
Population, number of inhabitants	1996-2016	25.75	1.15	9.78	0.46	15.97	0.69
Apartment stock in multifamily buildings, dwellings	1996-2016	73.88	2.72	26.50	1.18	47.38	1.54
Disposable income per capita, (thousands SEK /Euro)	1996-2016	120.06	4.02	39.20	1.67	80.86	2.35
Mortgage interest rate, percent	1996-2016	-85.67	-4.30	-100.03	-5.03	14.36	0.73
Unemployment, percent	2005-2016	-10.42	-0.95	-39.66	-3.61	29.24	2.66

6. Discussion

Though analysis in the previous section provide some insights to the answer on the first research question of this study, the second question remains still unanswered:

Why fundamentals affect apartment prices differently, and are there any other factors that might explain these differences?

One of the hypotheses might be that these two countries differ in institutional arrangements on the housing markets, and these arrangements might contribute to the size of house price elasticities from changes in fundamentals. These arrangements might include various banking sector policies, including mortgage financing and valuation approaches, as well as different government regulations on the housing market, like rent control policies.

Tsatsaronis and Zhu's (2004) study on house prices in 17 industrialized economies for over three decades time period demonstrated that household income has a minimal explanatory power over housing price movements. They suggest that "purchasing decisions are more sensitive to the nominal amount of monthly payments than to the size of the loan in relation to household income." (Tsatsaronis and Zhu, 2004, p.74) and the costs of mortgage credit and the conditions under which it becomes available to play a significant role in house price dynamics. Another important result presented in Tsatsaronis and Zhu's (2004) study is that "The feedback from house prices to credit growth is stronger in the case of countries with more market-sensitive valuation methods for mortgage accounting." (Tsatsaronis and Zhu, 2004, p.66) It raises further interest to look into the bank lending policies and mortgage valuation practices in Germany and Sweden in order to find out if any differences between them might affect apartment price dynamics over the long run.

The main characteristics of the bank lending policies and mortgage valuation practices in these two countries are summarized in Table 12. Germany and Sweden represent two opposite cases that are different in almost all characteristics of mortgage financing, valuation approaches, and rent regulations.

In Sweden, the majority of loans are taken on a 3 months flexible interest rate basis in contrast to Germany that has a long tradition of long term fixed-rate mortgages. Interest rate payments are not tax-deductible in Germany but are in Sweden. In Germany, banks require amortization and significantly higher down-payments when taking a loan for housing financing. Sweden allowed non-amortizing loans until 2017. The down payment requirement has been introduced in Sweden in 2010 and was set to a minimum of 15 percent of the house prices. Equity withdrawal is possible in Sweden, but not in Germany. Because of the expanding bank lending policies, household mortgage debt has increased significantly in Sweden during the recent decades in contrast to Germany, where loans are falling as a proportion of disposable income. Germany and Sweden use two different approaches to the valuation of mortgage properties. In addition, Germany has a well-functioning rental market with market-level rents, while rents are regulated in Sweden, and queues to rental housing are very long.

Table 12. Housing market and mortgage characteristics in Sweden and Germany

	Sweden	Germany
1. Mortgage market characteristics		
Interest rate on mortgage	Mostly variable	Mostly fixed
Interest rate fixation period	3 month	5 years and more
Interest rate tax deduction	Yes	No
Differential compensation in case of early loan repayment	Yes	Yes (Not after 10 years)
Amortization requirement	Not obligatory until 2017, obligatory for some loans since 2017)	Yes
Loan-to-value (LTV) ratio requirement (maximum)	0,95 (prior to October, 2010) 0,85 (since October, 2010)	0,6 (In some cases up to 0,95)
Equity withdrawn	Yes	No
Outstanding mortgage lending in the long-run	Growing	Not growing
2. Approaches to valuation for mortgage purposes		
Value approach used for mortgage valuation	Market value (MV) with application of LTV limit	Mortgage lending value (MLV)
3. Regulations of the rental market		
Rent determination	Rent control	Market rents

Source: European Mortgage Federation

Fixed vs. variable interest rate

Analysis of interest rate policies of the central bank demonstrates that the situation with continuously lower flexible interest rates in the Swedish market is a result of the monetary policy of the central bank that intended to stimulate the economy by lowering interest rate. If the situation were opposite during the same period of analysis, it would be preferable to loan takers to have a fixed interest rate than a variable interest rate.

In Germany, the majority of housing loans taken at fixed interest rates. It is less risky for the banks because they have stable income flow and more preferable for households because they are defended against high fluctuations in interest rates.

Interest rate tax deduction

Interest rate tax deduction is a measure introduced in order to allow a wider range of households from different income groups to buy their homes. This measure had a good purpose, but in the long run, it led to large household debt and higher house prices (See, for example, Turk (2015)).

Interest rate difference compensation

Interest rate difference compensation is a measure that requires loan takers to pay some amount of money in case if they switch to another loan or bank. It keeps loan takers with a fixed interest rate in Sweden away from switching the loan and more focused on defending the banks than the loan takers against foregone income. It might explain why loans with flexible interest rates have such a high share in the Swedish housing financing market.

In contrast to Sweden, housing loan takers with a fixed interest rate in Germany do not have to pay interest rate difference compensation if they decide to switch loan providers. On the one hand, it gives freedom for loan takers in choosing financing alternatives and on another hand, leads to higher competition between banks.

Amortization requirement for housing loans

Swedish banks require amortizing the loan if the loan amount is lower than 75 percent of the house price. Assuming the case when there is a continuous increase in prices and the initial loan amount is staying constant (no amortization), households can use increased equity for borrowing more and buying even larger and more expensive properties. Low relocation costs often compensated by the price increase difference. Moreover, a capital gains tax (if someone buys a new property at a lower price than the previous property was sold) lock in on the one hand buyers from buying cheaper properties, and on the other hand, sellers from relocation to a smaller property. It creates speculative turnover on the housing market and lead to even higher price increase that is called in the literature the "financial accelerator" effect.

The loan to value ratio and approaches to valuation for mortgage purposes

Before 2010 loan-to-value ratio requirement in Sweden was up to 95% of the house price. From the 1st of October, 2010, the loan-to-value ratio requirement for all new mortgages in Sweden was established at a maximum of 85 percent of the house price.

If banks use loan-to-value ratio requirement to estimate the loan amount and apply it to continue growing the property market values, it lead to sustainable increases the borrowing amount and create a form of spiral movement (or "financial accelerator effect"), which in its turn lead to over-optimism, even higher willingness to pay and further growth in house prices (see Bernanke et al (1996)).

If the banks instead apply loan-to-value ratio to a more sustainable value concept like mortgage lending value, it dampens the ability to borrow more during boom periods in the market, leading to more stable house price dynamics over the long run.

Quentin (2009, p.313-314), talking mainly about the commercial property market, also underlines that "In rising markets, the very pronounced correlation between market value and loan amount leads virtually automatically to increases in loan volumes. On the other hand, in rapidly falling markets, covenants based on the market value are breached very quickly. The interdependence of the volume of loans outstanding with the market value results in a pro-cyclical behavior among all financial institutions, which accelerates market trends and puts property owners under firm pressure in a recessive phase."

Quentin (2009) underlines that "During a property crisis with volatile markets, credit terms based on the market value become burdensome. When a covenant concerning the obligation to maintain a permanent gap between the market value and the loan amount is breached (an event of default) - which at the start of a recession can occur in less than half a year from the payout of the loan - an investor must, for example, provide additional equity. As a one-off event, this is certainly not critical. A fall in prices throughout the entire property sector - the norm in a property crisis - then has various pro-cyclical consequences: a property holding company could find itself obliged to come up with more equity in respect of several of its holdings or on several occasions in respect of one or several properties. This greatly increases the risk to the lending bank that its debtors can no longer fulfill their contractual obligations. It is clear that a market value determined as of a specific date is insufficient for longer-term loan monitoring, and that a different valuation model is necessary to enable a sustainable prognosis to be made." (Quentin, 2009, p.314)

These arguments are also valid for the housing market. Quentin (2009) underlines that the market value of the property is not a secure base for determining mortgage lending, and a different approach to the valuation of collateral is to be considered in this case.

The rules for determining the mortgage lending value in Germany regulated by the mortgage legal act called "Pfandbrief" and the Regulation on the determination of the mortgage lending value (BelWertV). MLV traditionally considered a very secure value of the property. One of the central pillars of the safety of the Mortgage Pfandbrief in Germany is that property financing that may be included to cover only up to the mortgage lending limit of 60 percent of the MLV. The MLV reflects only long-term sustainable aspects of a property, meaning that speculative aspects disregarded. To determine the mortgage lending value, the future marketability of the property is to be taken as a basis within the scope of a prudent valuation, by taking into account long-term sustainable aspects of the property, the normal and local market conditions, the current use and appropriate alternative uses of the property. (See "Regulation on the determination of the mortgage lending values of the properties in accordance with § 16 pars. 1 and 2 of the Pfandbrief Act", p.45)

The differences in the upper mortgage limit based on mortgage lending value and market value are seen in figure 3.

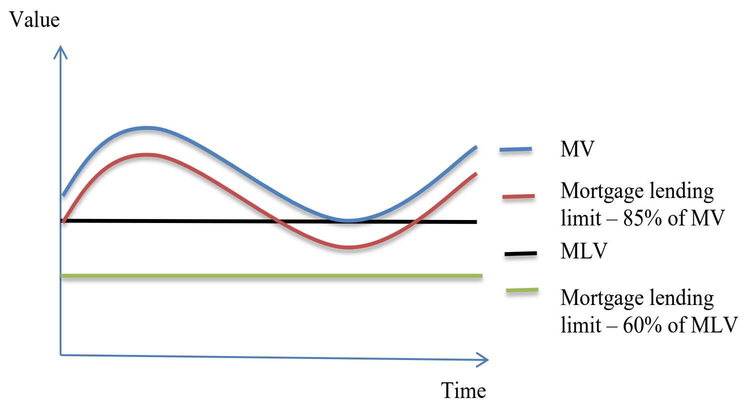

Figure 3. Differences in mortgage lending limit

In such a way, if the loan-to-value requirement is connected to mortgage lending value, borrowers are not be able to borrow more than this amount, which is stable in the long run because it is based on the long-term development of fundamentals, and this in its turn leads to a lower willingness to pay and less increase in house prices.

Regulations on the rental market

The rental housing market in Sweden is subject to rent control in contrast to Germany, where rents are determined by the market. The renter user costs are simply the rent for the housing she rents. For the owner of the house, user costs are interest payments that she is paying to the bank on a mortgage loan, loss in case of a house price decrease, and operating and maintenance costs. In a well-functioning market, these user costs for both types of tenure go together and the user of the house is indifferent to buy or to rent a house.

The Swedish system with rent control on the housing market leads to the situation that rental houses property companies of rental houses are not interested in constructing (or investing in) more rental housing since they cannot get the market level rents. Those people who want to get a rental apartment have to wait for years to get one. On the other hand, not all who need an apartment can afford to buy it because of the high amount of downpayment required to get a loan.

Rent control has different goals, such as, for example, decreasing segregation and equality in access to desirable housing. But rent control lowers accessibility of rental apartments in major cities in Sweden. The option to rent is therefore not available in the same way as in Germany. This means that in most cases, a person is "forced" to buy an apartment because of the more difficult situation in the rental market and long waiting lists. Waiting time is also becoming longer. Average waiting time for those who got rental apartment 2011 is between 4 and 7 years, while for those who got a rental apartment three years earlier, it was between 2 and 4 years.[6] At the same time, the continuously decreasing interest rates make the user costs for the owners go down in comparison with rents that are subject to inflation indexation and therefore are continuously growing. This also has a certain influence on the housing price increase in Sweden.

Though the rents in Germany are determined by the market, private renting is considered as a secure option for many households. The rent for the new contracts is based on the local reference rent ("Mietspiegel"), which is a locally determined average of the rents for the new contracts and the rental growth in existing contracts for dwellings of comparable quality. The tax system treats rental housing as an investment and provides for depreciation allowances, mortgage interest tax relief, deduction of maintenance costs, and possibility to deduct losses from the income tax base. (de Boer R. and Bitetti, 2014, p.15). For existing contracts, there is a limit for rent increase to a maximum of 20% over three years, even if the local reference rent would permit a higher rent increase. (de Boer R. and Bitetti, 2014, p.29). In such a way, the German rental system combines the market elements of rent formation with the protection of the tenants against high rent increases. This does not create barriers for investors for investing in rental properties, and by taking ownership and rental options equal for the user of the housing takes away pressure on house prices. Thus, institutional arrangements in the rental market such as rent control measures, might affect the dynamics of house prices. A recent study done by Rubaszek and Rubio (2019) for the panel of the 28 EU countries provide evidence that the response of house process to macroeconomic fundamentals is attenuated by the size of the private rental market.

[6] According to Stockholm Stads bostadsförmedling. Source: https://bostad.stockholm.se/

7. Conclusions and policy implications

The estimations presented in this paper lead to one important conclusion that is different from the studies done before. Apartment price dynamics in Swedish cities, to a great extent, differs from the one in German cities despite quite similar underlying fundamentals.

The results have shown that fundamental factors like population, disposable income, mortgage interest rate, and housing stock determine the long-run development of apartment prices in Sweden, but the reactions of the same factors are smaller in Germany. Comparative analysis of bank lending policies and approaches to valuation for mortgage purposes in these two countries provides evidence that the difference arises due to institutional differences in the form of different bank lending policies and mortgage valuation practices.

It is worth to underline that factors related to banking policies such as loan-to-value ratio, type of mortgage interest rates, amortization requirements to the loans and other, are not the determinants of house price growth above the fundamental level, but the channels that make these price growth possible as a result of the applying different approach to mortgage valuations. As a result, extreme growth in prices creates necessary conditions for optimistic expectations to arise and makes speculation in the housing market possible. In such a way, application of the different approaches for mortgage purposes could make lending for housing less procyclical by eliminating the effect of the “financial accelerator” and stabilizing house prices over the long run. Moreover, it will help to keep house prices away from overreaction on changes in macroeconomic fundamentals.

One more factor that contributes to house price stability in Germany is the well-functioning rental market. Sweden has a rent control system and long queues for rental housing that puts additional pressure on prices as it reduces access to a substitute segment of the housing market.

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Appendix A

Table 1. Biggest cities in Sweden

No	Name	County	Population in 2019	Description
1	Stockholm	Stockholm	2,3 mln	Stockholm is Sweden's economic, financial and cultural center. The vast majority of jobs in Stockholm belong to the service industry and high technology companies (for example, IBM, Ericsson, Electrolux). The almost total absence of heavy industry makes Stockholm one of the world's cleanest metropolises.
2	Göteborg	Västra Götaland	1,0 mln	Göteborg has the largest port in Scandinavia. Trade and shipping have always played a major role in the city's economic history. Major manufacturing companies operating in the area include SKF, and Volvo.
3	Malmö	Skåne	0,7 mln	Malmö is the third largest city in Sweden. Its economy is traditionally based on shipbuilding and construction related industries, such as concrete factories. The region's leading university, along with its associated hi-tech and pharmaceutical industries, is located in Lund - a town that is located close to Malmö.

Sources: SCB Sweden

Appendix B

Table 2. Biggest cities in Western Germany

No	Name	Federal state	Population in 2019	Description
1	Hamburg	Hamburg	1,8 mln.	Hamburg has the second largest city in Germany and one of the biggest ports in the world. City type is similar to Göteborg with trade, industries and large harbor. Some of Germany's largest publishing companies are also located in the city.
2	München	Bavaria	1,5 mln.	München is similar to Stockholm in the population size and industry characteristics. For example, headquarters of Siemens, the largest electronic and engineering company, is situated in München, in comparison with the telecommunication company "Ericsson" and one of the largest engineering companies "ABB" that are situated in Stockholm. München expensive and rich city and it can be called as "exclusive" in that sense.

No	Name	Federal state	Population in 2019	Description
3	Cologne	North Rhine-Westphalia	1,1 mln.	Cologne can be compared to Malmö. It is not that expensive. The economy of Cologne is primarily based on insurance and media industries, while the city is also an important cultural and research center and home to a number of corporate headquarters.
4	Frankfurt	Hessen	0,7 mln.	Frankfurt is a major financial center. It hosts more than 400 banks, both headquarters and representatives, and has one of the largest international airports. Frankfurt is also a big industrial (automobile company “Opel”, pharmaceutical company “Bayer”, chemical companies, etc. is situated there) and trade center in Germany. It is similar to Stockholm by these characteristics.
5	Stuttgart	Baden-Württemberg	0,6 mln.	Stuttgart is the most innovative city and the center of the automobile industry. Such companies as Daimler AG, Porsche, Bosch, Hewlett-Packard/Compaq Deutschland и IBM Deutschland have their headquarters in Stuttgart. It has several educational institutions. It is comparable to Göteborg.
6	Düsseldorf	North Rhine-Westphalia	0,6 mln	Düsseldorf is one of the most exclusive cities (before the financial crisis it was the center for the German banks such as IKB, West LB etc.). It belongs to the Ruhr region that is known as one of the largest industrial centers. Electrical and gas companies like RWE and E.ON, trade concerns such as ALDI, Karstadt Quelle and Tengelmann can also be found there. Düsseldorf is probably can be compared to Stockholm from a socio-economic perspective.
7	Bremen	Bremen	0,6 mln.	Bremen is not that large city and it has the same city structure as Malmö with harbor and dockyards. It forms part of the production network of Airbus Deutschland GmbH, There is also a Mercedes-Benz factory and a large number of food producing or trading companies are located in Bremen (for example, Kellogg's, Kraft Foods, etc.).

Source: BulweinGesa AG

Appendix C

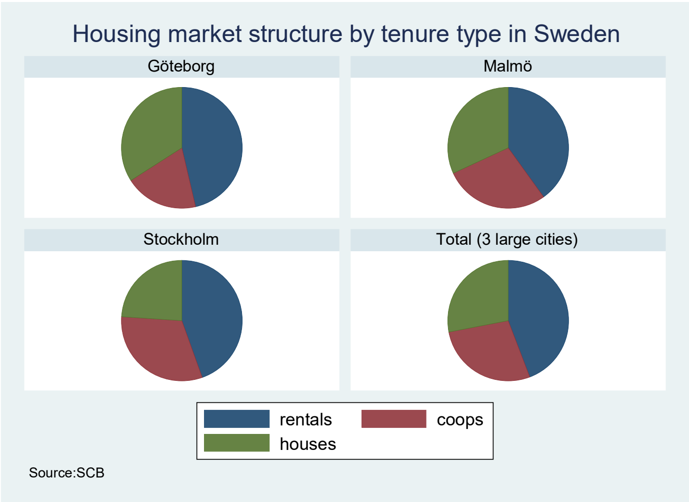

Figure 4. Housing market structure by tenure type in Sweden

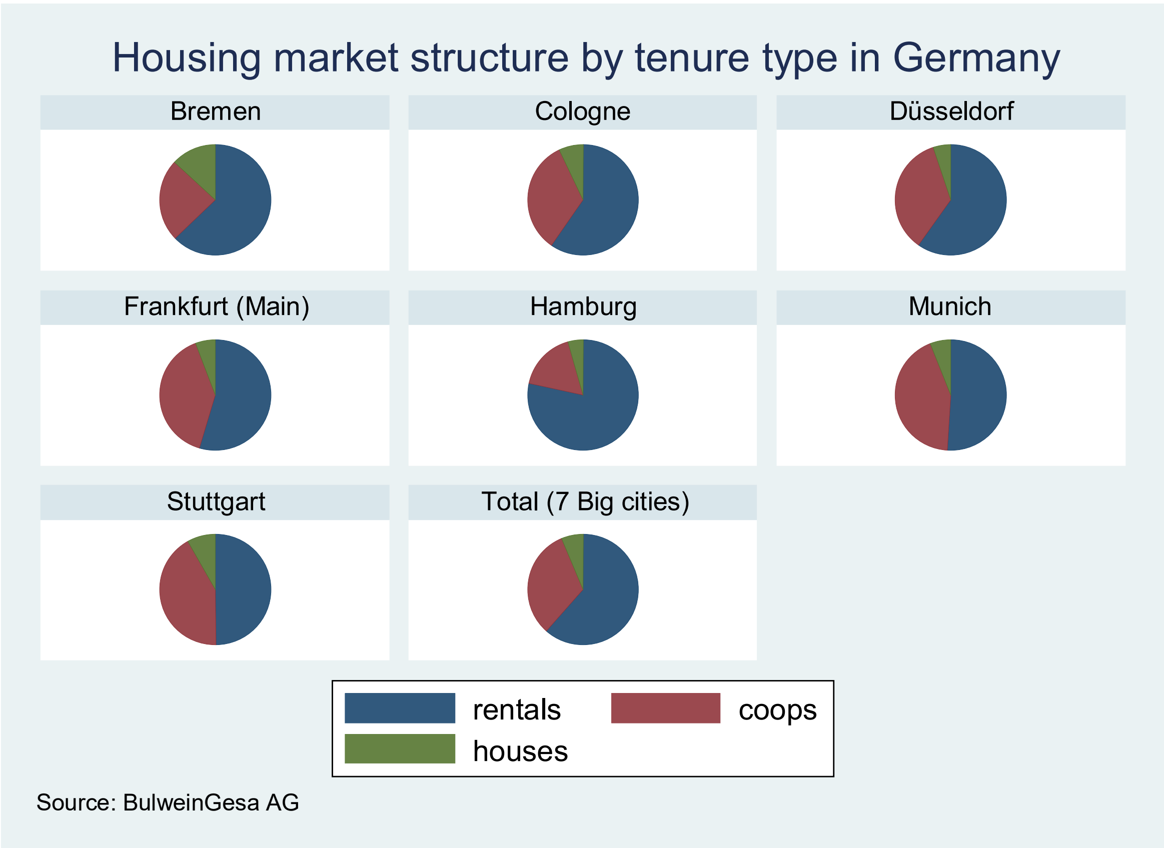

Figure 5. Housing market structure by tenure type in Germany

Appendix D

Variable description and Data sources

House prices:
Definition: Nominal house prices (average) from national sources.
Units: EUR per square meter
Source: BulweinGesa AG (Germany), National Statistical Bureau and Mäklarstatistik (Sweden)

Interest rates
Definition: Interest rate for mortgage borrowing
Unit: percent
Source: Deutsche Bundesbank (Germany), Riksbanken and Swedbank (Sweden)

Existing dwelling stock
Definition: Total stock (existing and new construction) in a number of dwelling units
Unit: number
Source: BulweinGesa AG (Germany), National Statistical Bureau (Sweden)

Population
Definition: Total resident population
Units: person
Source: BulweinGesa AG (Germany), National Statistical Bureau (Sweden)

Disposable income per capita
Definition: Disposable income of private households.
Units: EUR
Source: BulweinGesa AG (Germany), National Statistical Bureau (Sweden)