Long-term dynamics of new residential supply: A case study of the apartment segment in Sweden

Sviatlana Engerstam, Abukar Warsame, Mats Wilhelmsson

Working Paper 2022:5

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
Long-term dynamics of new residential supply: A case study of the apartment segment in Sweden

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

Abukar Warsame
Division of Real Estate Economics and Finance
Department of Real Estate and Construction Management
Royal Institute of Technology, Stockholm, Sweden
Email: abukar.warsame@abe.kth.se

Mats Wilhelmsson
Division of Real Estate Economics and Finance
Department of Real Estate and Construction Management
Royal Institute of Technology, Stockholm, Sweden
Email: mats.wilhelmsson@abe.kth.se

Abstract:
Since the size of the homeownership ratio differs significantly between countries, it is important to understand the mechanisms that lie behind decrease or growth of certain sectors of the housing market like rentals and housing cooperatives. The aim of this study is to analyze the long-term dynamics of the new residential supply in Sweden’s three largest cities for the period of 1990-2020 and estimate in what way market fundamentals affect it through new construction and housing conversions. We apply panel data methodology and, in distinction to previous research, consider the development of the housing market (urban growth) as physical volume. The results demonstrate that structural changes are driven mainly by fundamental demand factors and that the displacement effect occurs primarily in the market’s rental sector and not in the owner-occupied segment. The apartment price per square meter, together with mortgage interest rates, are the major driving factors in the process of converting dwellings into housing cooperatives. Fundamental variables that affect new construction in both the rental and housing cooperative sectors are population and income growth. In the presence of a rent control environment, the rent or price level does not contribute to adding new units to the total housing stock.

Keywords: Housing supply, Swedish apartment market, Panel data analysis

JEL-codes: C33, R15, R31, R52
1. Introduction

Housing is one of the basic necessities. Some people prefer to own a house; however, many rent due to individual circumstances, generational trends and flexibility when moving.

Housing is important for the economic vitality of communities. Therefore, the growth of the housing sector through new construction, renovations and property conversions from other real estate sectors as well as a balanced development of different housing forms is, in the long run, an essential component of urban growth. Kemeny (1981) argues that housing policy should be “tenure-neutral”, that is, the role of governments in housing should be to maximize effective consumer choice by encouraging the development of a wide range of tenures at comparable cost. However, the housing market structure differs between countries. The share of the private rental market in European countries in 2020 varied between 3.9 percent in Romania to 57.7 percent in Switzerland. On average, about two-thirds of the population in Europe lives in owner-occupied houses or apartments (69.7%) and about one third (30.3%) in rental housing.

Haffner (2003) emphasizes that the government should not assist one tenure more than another; consumers of housing services should be able to make a free choice. However, some misbalances in this process can be observed in some European countries such as, for example, Sweden. The Swedish housing market has been characterized as dysfunctional for a number of years. Despite rapid urban growth over recent decades, an insufficient number of rental accommodations have been built. This has resulted in long queues for rental housing in major Swedish cities, and a housing shortage has been reported by 70 percent of municipalities (The Government of Sweden, 2021).

As Andersson & Turner (2014) point out, public rental housing in Sweden has since the 1930s been a key element in governmental policies intended to establish a housing system that would secure high-quality, affordable accommodation for all. However, since the early 1990s changes in housing policies have been directed towards more local decision-making concerning tenure conversion and turning public rental apartments into market-based (cooperative) ones. As Andersson & Turner (2014) documented, in 1990 32 percent of all residents in Sweden’s capital city, Stockholm, lived in rentals, while this proportion in 2010 stood at 18 percent. They argue thus that these policies have resulted in increasing levels of socio-economic segregation in Stockholm.

The small size of the rental housing market might be detrimental to macroeconomic stability. Rubaszk & Rubio (2020) provide evidence that the response of house prices to macroeconomic fundamentals is attenuated by the size of the private rental market. Therefore, it is important to understand the mechanisms that contribute to long-term changes in the housing market structure, and more specifically, the continuous decrease of the rental sector.

Various government policies, such as the implementation of rent control, can lead to crowding in- and out effects for different sectors of housing markets by reducing the number of available

---

1 Source: Eurostat, 2020. [https://ec.europa.eu/eurostat/cache/digpub/housing/vis/01_01_01/index.html](https://ec.europa.eu/eurostat/cache/digpub/housing/vis/01_01_01/index.html)
housing units. Accordingly, Molloy (2020) states that one of the substantial gaps in the literature is the relationship between regulation and rents. She underlines that a better understanding of the effects of regulation on the relative supply of owner-occupied housing and the ability of households to transit from renting to owning might be helpful. Keeping this in mind, we consider Sweden as a good case country for an investigation of the mechanisms that contribute to the development of housing market structure.

The aim of this paper is therefore to analyze the long-term dynamics of the new residential supply in Sweden’s three largest cities and estimate in what way market fundamentals affect it through new construction and housing conversions. The research questions are as follows:

1) How do fundamental factors of supply and demand contribute to multifamily housing stock dynamics over the long run through a) the new construction of multifamily apartments and b) added multifamily apartment stock through dwelling conversions.

2) Are there any Displacement effects in the form of crowding out or crowding in from one sector to another? (i.e., to what extent do the rental and cooperative apartment sectors contribute to the growth or decrease of the total new construction of multifamily apartments and total property conversions to housing).

An analysis of new housing supply and its dynamics over the long run is important for the development of efficient housing policies that avoid future displacement effects for certain sectors of the housing market. This paper is based on theoretical and practical implications from existing research done on single-family houses, and it contributes to the body of knowledge in this area by adding empirical findings from the analysis of the new supply of homes in the apartment sector of several Swedish cities’ housing markets. It also applies models that are based on the development of the housing market (urban growth) as physical volume. Our results indicate that a displacement effect occurs primarily through property conversions in the market’s rental sector, and not through the owner-occupied segment.

The paper proceeds as follows. Section 2 provides a brief literature review on new housing supply. Section 3 proposes a theoretical model of new supply coming from new construction and dwelling conversions, as well as an assessment of displacement effects from excess demand that flows out from the rental sector towards the housing cooperative sector. Section 4 describes data and presents the “Swedish case”, and Section 5 presents empirical results from the regression analysis, which is then followed by analysis and discussion in Section 6. Section 7 includes a conclusion and policy implications.

---

2 More details of the urban dynamics and new housing supply in Sweden are presented as the “Swedish case” in section 4.1.
2. Literature review

DiPasquale (1999) underlines the complexity of the determinants of new housing construction. He argues that housing supply is determined not only by the production decisions made by builders of new units but also choices that owners (and their agents) make concerning the conversion of existing housing stock. One of the determinants of long-term housing supply widely mentioned in the literature is thus its elasticity to price changes.

Definitions of housing supply elasticity

Glaeser et al., (2008) demonstrated that elasticity of housing supply plays a significant role in house price dynamics. Although house price bubbles might be observed in the markets where housing supply is relatively inelastic, Ball et al., (2010) argues that new construction might press the bubbles down. At the same time, high elasticity of supply might lead to an over-supply of properties on the market (Goodman & Thibodeau, 2008).

Mayer & Somerville (2000) defines elasticity of housing supply as the percentage change in the entire housing stock from a percentage change in house prices. It should be differentiated from elasticity of housing starts, which describes the change of flow in new construction. Housing starts’ elasticity is sensitive to the length of time over which it is calculated; the longer the period, the lower the elasticity (Mayer & Somerville, 2000). Thus, the major difference between housing supply elasticity and that of housing starts is that a one time increase in house prices leads to a temporal rather than permanent increase in new construction, yielding a finite increase in the stock of housing (Mayer & Somerville, 2000). Wheaton (1999) provides evidence that in different sectors of the property market construction lags might be quite different in length.

Another concept that is used to understand the elasticity of housing starts is development elasticity, which Murphy (2018) defines as the percentage change in the development rate associated with a 1 percent change in house prices, where the change in price also affects expectations concerning future profit. The author argues that forward-looking behavior plays a considerable role in lowering development elasticity when prices are high due to timing the market.

In distinction to house price dynamics and its effects on housing supply elasticity, which is well examined in a large number of research studies, the dynamics of new housing supply (or housing stock adjustments) over the long run has not received much attention in the literature. A brief summary of existing research on this issue is presented below. In addition, Table A1 in the Appendix presents an overview of the major factors that affect housing supply in physical volume form.
**Fundamental determinants of housing supply**

DiPasquale & Wheaton (1994) estimates housing stock adjustments in a long-term equilibrium framework. They model new construction as a function of new housing price, short-term real interest rate, price of agricultural land, construction costs, lagged housing stock, the change in aggregate employment and number of months on the market. They found that long-term price elasticities vary from 1.0 to 1.2 for new construction and from 1.2 to 1.4 for housing stock. The authors emphasize that construction reflects the long-term adjustment of the current stock. Housing prices affect new construction only when current stock deviates from its long-run equilibrium level for this price level. Therefore, changes in housing prices stimulate the development of urban land and drive long-run urban spatial growth.

Mayer & Somerville (2000) have developed an empirical model of new single-family housing supply that reflects the role of land development and urban growth. They report a fairly moderate response of supply to house price changes, around 0.8 percent. Moreover, they claim that housing starts’ elasticity decreases over the long run. Similarly, Riddel (2004) examines housing market price and stock dynamics in the US and found that long-term price elasticity of supply lies between 0.025 and 0.49, which is higher than reported by Wigren & Wilhelmsson (2007) for Sweden, with long-term supply price elasticity of approximately 0.10 and construction price elasticity of -0.16. It is also lower than reported in previous studies by DiPasquale & Wheaton (1994) and Owusu-Ansah (2014). The latter estimated price elasticity of supply in Aberdeen, Great Britain, in the range of 2.0 to 3.2 for housing starts and 0.01 to 0.02 for housing stock. In another study, Lerbs (2014) reported the average long-term price elasticity of new single-family housing supply in German counties and cities to be 0.33.

Riddel (2004) found that price appreciation signals developers to build more units about two periods later, which is consistent with a two-year building and permitting horizon. Wigren & Wilhelmsson (2007) moreover found that on average it takes around 4 years for a shock to be fully incorporated into the housing stock. An analysis by Stevenson & Young (2014) reveals that, although developers did respond to disequilibrium in supply, the rate of adjustment is relatively slow. In contrast, disequilibrium in demand did not impact upon supply, suggesting that inelastic supply conditions could explain the prolonged nature of the boom. It confirms that supply adjusts slowly to changes in market conditions from the demand side because housing markets are inefficient, as proposed by Case & Shiller (1989).

Riddel (2004) argues that supply shocks might arise from a variety of sources such as changes in building material costs, wages, or lending rates for development loans. Somerville (1999) found that increases in costs do reduce housing starts in USA, and Lerbs (2014) suggests that the local ratio of existing home prices to housing construction costs and past local permit rates act as important drivers of new local housing investment in Germany. In addition, Owusu-Ansah (2014) found that changes in house prices, time on market, planning regulation, lagged stock and lagged and future housing starts are the main factors that influence new residential construction in Aberdeen, Great Britain.
Role of regulatory policies

Molloy (2020) provides an extensive overview of housing supply regulation effects on housing affordability including such dimensions as housing costs and household income. A study by Landis & Reina (2021) confirmed that more stringent land use regulations are associated with higher housing values and rents. These effects are magnified in faster-growing and more prosperous economies, thus decreasing the affordability of housing over the long run. To make housing more affordable and stimulate new construction, governments might subsidize either housing developers or low-income households.

Murray (1999) found that public housing for low income households has added to the total stock of housing, while conventionally financed subsidized housing for moderate income households most likely adds little or nothing to the total housing stock. Furthermore, Sinai & Waldfogel (2005) discovered that government-subsidized housing units crowded out low income housing units that would otherwise be provided by the private sector.

Government policies might impact the elasticity of housing supply since they play deterministic role of what is being built and when. Hence Ball et al. (2010) suggest that supply elasticities are highly variable and, amongst other factors, related to existing land-use patterns, topology and planning policy. Accordingly, Pryce (1999) concludes that private-sector new construction is sufficiently sensitive to the overall amount of land available for construction.

Another example of government policies is the implementation of rent control. However, it might lead to crowding in- and out effects for different sectors of housing markets. Jud et al. (1996) reveal that rent control hurts renters in the long run by making rental markets less efficient and reducing the number of available rental units. Therefore, analysis of new housing supply and its dynamics over the long run is important for the development of efficient housing policies that avoid displacement effects for certain sectors of the housing market in the future.

Approaches to estimating housing supply dynamics

DiPasquale (1999) points out that much of the literature focuses on the supply of the single-family owner-occupied houses, while knowledge of new supply determinants regarding multifamily rental housing units is very limited. The reason for this is the lack of available statistical data and longer time frames needed to provide an opportunity for empirical estimations and modelling. One of few studies on this topic is an article by Follain et al., (1993) who analyses the effects of tax reform on the supply of multifamily housing in the United States. A similar study by Warsame et al. (2010) for Sweden indicates that an interest subsidy has a positive impact on the total production of housing units and especially multifamily units.

Two major approaches can be found in the empirical literature for the analysis of housing supply: 1) housing supply in the form of residential investments (as financial value) and 2) housing supply in the form of the number of housing units under construction (as physical volume in several dwellings). The study by Wigren & Wilhelmsson (2007), as well as the earlier study by DiPasquale (1999), contains a good overview of the research on the dynamics of housing investment and housing stock. Furthermore, Riddel (2004) argues that housing
markets, like other durable goods markets, might be viewed as having a flow- and stock dimension. The flow dimension is the sum of the construction of new residential units and depreciation of existing units or net investment. Therefore, the long-run supply, or stock of housing, is the accumulation of net investment.

Riddel (2004) emphasizes that in many models of housing investment, new construction is directly related to the price level, implying that an overall increase in the price level leads to permanent increases in new construction (see, for example, studies by Clapp & Giaccotto, 1994; Glennon, 1989; Hanushek & Quigley, 1980). These models hypothesize that those areas with high price levels should have higher construction rates, whereas less investment will be observed in areas with relatively low housing prices. Riddel (2004) also underlines that this restriction is unrealistic since slow growth in housing stocks is often observed in conjunction with a relatively high price level.

In distinction to the first approach, our article is focused on modeling housing supply with the second approach (in physical form). The major findings from previous research are that market fundamentals of supply and demand such as house prices, rent levels, construction costs, land prices, population, income and interest rates are the major driving factors behind new housing construction (See Table A1 in the Appendix). In the next section we develop an econometric model for estimating the effects of these factors on housing supply dynamics. When we consider the physical supply, it is important to mention that there is no standard housing quantity since housing units might vary considerably in quality dimensions, size and with respect to other features.

3. The model and methodology

The specification of the model is based on DiPasquale and Wheaton’s (1992) 4-quadrant model for markets and space that describes the interaction between demand and supply forces over the short- and long run. Their model emphasizes that demand comes from the occupiers of space, whether they are tenants or owners. The household demand for space depends on income and the costs of occupying that space relative to the costs of consuming other commodities. Rent is the cost of occupying space for households. Rent is determined in the property market for space, while price is determined in the asset market for ownership. The demand for space depends on rent, $R$, and other exogenous economic factors such as income and the number of households, $E$. In equilibrium, the demand for space, $D$, is equal to the stock for space, $S$. Taken that the stock as given in the short run rent is determined so that the demand is equal to the stock,

$$D(R, E) = S$$  \hspace{1cm} (1)

Change in population, income, and financing conditions shift the demand and drive house prices. Lower interest rates, for example, imply that for the same annual payment (rent) a household can afford to pay a higher purchase (asset) price. Accordingly, a single decision by the user/owner determines both rent and price in the short run. Simultaneously, the same economic and capital market conditions determine the construction and equilibrium market for
space in the long run. For example, if construction is very elastic with respect to asset prices, then the levels of prices and rents will not be affected much in the long run, while if supply is inelastic, the significant growth in price and rents is expected in the long run. Thus, contribution to differences in the local level in the degree to which house prices and rents might change in the long run will depend on growth of population, $Pop^3$, change in the real earned income, $Inc$, and the real mortgage interest rates, $r$.

Growth of house prices and rents will stimulate new housing production as well as conversions of other real estate properties such as commercial premises or industrial buildings into residential dwellings. Therefore, the total change in the aggregate housing stock should include the number of dwellings constructed, $NC$, and dwelling conversions from other property market sectors to housing in a given period, $DC$, in both the rental and housing cooperative sectors, minus losses from the stock measured by depreciation (removal rate), $d$:

$$\Delta S = NC + DC - dS$$

In this paper we assume that the depreciation rate is equal between different tenure forms. The property removal rate in Sweden is quite low since properties are well maintained. Therefore, in our analysis for simplicity we set physical depreciation rate close to zero, $d=0$.

According to DiPasquale and Wheaton (1992), construction depends on the price of the assets relative to the costs of replacing or constructing them. Previous research by Mayer & Somerville (2000) point out that the new housing construction is a flow, and therefore the model should be constructed on changes in independent variables such as housing prices and costs (first differences) rather than on levels. Thus, the number of dwellings constructed as a response from the supply side is a function of change in prices, $P$, rent level, $R^4$, construction costs, $K$, (including costs of building materials, labor, and financing costs), and cost of land, $L$.

$$NC = f(\Delta P, \Delta R, \Delta K, \Delta L)$$

For housing conversions the number of dwellings added to housing stock is a function of change in prices, $P$, and rent level, $R$, from the supply side and population growth, $Pop$, real earned income, $I$, and mortgage interest rates, $r$, from the demand side of the housing market$^5$:

$$DC = f(\Delta R, \Delta P, \Delta Pop, \Delta Inc, \Delta r)$$

Inserting (3) and (4) into (2) we will give the formula for the total change of the housing stock:

$$\Delta S = NC + DC - dS$$

---

$^3$ In this article we use population growth as one of the independent variables in regression, due to 1) the non-stationary character of the data and 2) the fact that household size in Sweden has not changed greatly during the 1990-2020 period and is around 2.1 persons per household. Thus this population growth will represent the effect of population dynamics in a better way. (Source: SCB Sweden).

$^4$ Prices as well as rents for new construction depend on the aggregated price and rent level for existing stock as well as expectations about its future development. This data is not available for Sweden, therefore we use price and rent levels for existing stock as a proxy for prices and rent levels in new construction.

$^5$ For the dwelling conversions the demand is primarily driven by short run demand factors since these apartments are already a part of existing property stock. Since the data for renovation costs for dwelling conversions, as well as land prices, are unavailable, we exclude them from the model.
\[
\Delta S = f (\Delta R, \Delta P, \Delta Pop, \Delta Inc, \Delta r, \Delta K, \Delta L)
\] (5)

To assess the effects of different factors on the change of housing stock over the long run through new construction and dwelling conversions in rental and housing cooperative sectors of the market, we estimate the set of models presented in the Table 1.

In econometric equations (6)-(14) in Table 1 the subscript \(i\) denotes the location (i.e., given city). Variable \(\Delta r\) is the change in real mortgage interest rate, and this term is common across all locations in the dataset. Variables \(\Delta K_{ren}^i\) and \(\Delta L_{ren}^i\) represent change in construction and land costs for rental apartments, and \(\Delta K_{coop}^i\) and \(\Delta L_{coop}^i\) represent change in construction and land costs for housing cooperative apartments.

In line with the literature review presented in Section 2, we expect a positive sign for population, income and housing prices in existing stock, and negative signs for mortgage interest rates, construction and land costs.

We define displacement effects as a situation where the rising new construction either of rental or housing cooperative apartments leads to a decrease in total new construction (crowding out) or stimulates the total new construction of apartments in multifamily houses (filling in) in addition to impacts from different economic factors. To assess the displacement effects of housing cooperatives, its data is combined with data for rental apartments. The main strategy is to run a cross-section regression of apartment construction and dwelling conversions controlling for other fundamental drivers of housing supply as in line with what was done in previous research literature (see, for example, Mayer & Somerville (2000), Eriksen & Rosenthal (2010), Warsame et al. (2010)).

Coefficients \(\sigma_1\) and \(\sigma_2\) in expressions (11) and (12) represent crowding in and out effects for total new multifamily housing constructions coming from respective new construction in the rental and housing cooperatives sectors.

If coefficient \(\sigma_1\) equals 0, that would indicate that the new construction of rental apartments has no effect on the total number of newly constructed housing dwellings in multifamily houses. If it instead equals -1, that would imply complete crowding out and indicate that the new construction of rental apartments does little to increase the total new construction of multifamily dwellings. On the other hand, if \(\sigma_1\) equals 1, total new construction will grow twice as much as the increase in rental apartments, that is 100% filling in. The same principle is applied for the coefficient \(\sigma_2\) regarding the impact of the new construction of housing cooperative apartments.

Coefficients \(\varphi_1\) and \(\varphi_2\) in expressions (13) and (14), similar to expressions (11) and (12), represent displacement effects for the total number of dwelling conversions coming from netto conversions that occur in the rental and housing cooperatives sectors, respectively.

If coefficient \(\varphi_1\) equals 0, that would indicate that the netto of conversions to rental apartments has no effect on the total number of multifamily housing units added to housing stock through conversions. If it instead equals -1, that would imply a complete crowding out and indicate that the netto of conversions to rental apartments does little to increase the total conversions to multifamily dwellings. On the other hand, if \(\sigma_1\) equals 1, total new conversions will grow twice as much as the increase in netto of conversions to rental apartments, that is 100% filling in. The
same principle is applied for the coefficients $\sigma_2$ regarding the impact of the netto of dwelling conversions in the housing cooperative sector.

Table 1. Econometric models

| Models and econometric equations                                                                 | Equation number |
|--------------------------------------------------------------------------------------------------|-----------------|
| 1. Change in the total multifamily housing stock                                                  | (6)             |
| $\Delta S_i = b_0 + b_1 \Delta R_i + b_2 \Delta P_i + b_3 \Delta Pop_i + b_4 \Delta Inc_i + b_5 \Delta r + b_6 \Delta K_i^{ren} + b_7 \Delta L_i^{ren} + b_8 \Delta K_i^{coop} + b_9 \Delta L_i^{coop} + e_i$ |                 |
| 2a. New construction of rental apartments                                                          | (7)             |
| $NC_i^{ren} = b_0 + b_1 \Delta R_i + b_2 \Delta P_i + b_3 \Delta Pop_i + b_4 \Delta Inc_i + b_5 \Delta r + b_6 \Delta K_i^{ren} + b_7 \Delta L_i^{ren} + e_i$ |                 |
| 2b. New construction of housing cooperative apartments                                              | (8)             |
| $NC_i^{coop} = b_0 + b_1 \Delta R_i + b_2 \Delta P_i + b_3 \Delta Pop_i + b_4 \Delta Inc_i + b_5 \Delta r + b_6 \Delta K_i^{coop} + b_7 \Delta L_i^{coop} + e_i$ |                 |
| 3a. Dwelling conversions to rental apartments                                                      | (9)             |
| $DC_i^{ren} = b_0 + b_1 \Delta R_i + b_2 \Delta P_i + b_3 \Delta Pop_i + b_4 \Delta Inc_i + b_5 \Delta r + e_i$ |                 |
| 3b. Dwelling conversions to the housing cooperatives sector                                         | (10)            |
| $DC_i^{coop} = b_0 + b_1 \Delta R_i + b_2 \Delta P_i + b_3 \Delta Pop_i + b_4 \Delta Inc_i + b_5 \Delta r + e_i$ |                 |
| 4a. Displacement effects for total new apartments construction from the rental sector              | (11)            |
| $NC_{i total}^{ren} = b_0 + b_1 \Delta R_i + b_2 \Delta P_i + b_3 \Delta Pop_i + b_4 \Delta Inc_i + b_5 \Delta r + b_6 \Delta K_i^{ren} + b_7 \Delta L_i^{ren} + \sigma_1 NC_i^{ren} + e_i$ |                 |
| 4b. Displacement effects for total new apartments construction from the housing cooperatives sector | (12)            |
| $NC_{i total}^{coop} = b_0 + b_1 \Delta R_i + b_2 \Delta P_i + b_3 \Delta Pop_i + b_4 \Delta Inc_i + b_5 \Delta r + b_6 \Delta K_i^{coop} + b_7 \Delta L_i^{coop} + \sigma_2 NC_i^{coop} + e_i$ |                 |
| 5a. Displacement effects for total dwelling conversions from the rental sector                      | (13)            |
| $DC_{i total}^{ren} = b_0 + b_1 \Delta R_i + b_2 \Delta P_i + b_3 \Delta Pop_i + b_4 \Delta Inc_i + b_5 \Delta r + \varphi_1 DC_i^{ren} + e_i$ |                 |
| 5b. Displacement effects for total dwelling conversions from the housing cooperatives sector        | (14)            |
| $DC_{i total}^{coop} = b_0 + b_1 \Delta R_i + b_2 \Delta P_i + b_3 \Delta Pop_i + b_4 \Delta Inc_i + b_5 \Delta r + \varphi_2 DC_i^{coop} + e_i$ |                 |
4. Data

4.1 The Swedish case

_Urban growth and new housing supply in Sweden_

New housing supply in Swedish cities is a subject of continuous discussion and analysis at both the national and regional levels. During the last three decades, many more housing cooperative apartments were built than rental apartments despite the high demand for rental apartments and long queues. The total number of apartments in multifamily houses has grown by 27 percent between 1990-2020, while the total number of rental apartments in multifamily houses in Swedish cities has decreased by 13 percent, and the number of housing cooperative apartments has increased by 123 percent over the same period of time (Table 2). This implies that together with the process of urban growth at 27% of the multifamily housing market segment, we observe displacement effects (-13% decrease in rental sector and +123% in housing cooperatives sector) in housing stock dynamics. These effects reflect the way the housing market structure changes over the long run.

| Table 2. The housing stock in Sweden, year 1990-2020. |
|-------------|-------------|-------------|-------------|-------------|-------------|
|             | Stockholm   | Gothenburg  | Malmo       | Sweden      | Sweden      |
|             | Number      | Number      | Number      | Number      | Number      |
| City        | % 1990      | % 2020      | % 1990      | % 2020      | % 1990      | % 2020      |
| Single-family houses | 191445 | 25 | 253516 | 24 | 159418 | 36 | 262972 | 36 | 595327 | 76 | 758370 | 75 | 425495 | 72 | 324813 | 43 | 169832 | 29 | 433557 | 57 |
| Apartments in multi-family houses | 127865 | 36 | 159418 | 36 | 226972 | 64 | 281951 | 64 | 171238 | 75 | 173716 | 62 | 55724 | 25 | 108235 | 38 |
| Rental apartments in multi-family houses | 85532 | 35 | 105979 | 34 | 160196 | 65 | 204178 | 66 | 99381 | 62 | 108175 | 53 | 60815 | 38 | 96003 | 47 |
| Housing cooperative apartments in multifamily houses | 1710282 | 44 | 1914270 | 43 | 2170535 | 56 | 2583310 | 57 | 1554457 | 72 | 1502851 | 58 | 616078 | 28 | 1080459 | 42 |

Growth for Swedish cities, year 1990-2020 28 27 -13 123
Growth for Sweden, year 1990-2020 12 19 -3 75

Source: SCB Sweden; authors calculations.

_Housing market structure in Swedish cities_

While for single-family houses the share of ownership is relatively high (the vast majority of single-family houses are in private ownership), the share between rental and housing cooperative housing varies for the apartment sector. For example, in major Swedish cities, the

---

6 See, for example, publications of the Swedish National Board of Housing, Building and Planning (2021, 2020, 2016a; 2016b; 2016c, 2015)

7 See, for example, Hellekant (2019).
share of the apartment sector varies between 64-75 percent of the total housing stock in 2020, of which the share of rental apartments varied between 43-62 percent. The rest consists of apartments in a form of housing cooperatives (Table 2).

**Institutional factors in the context of the Swedish housing market**

Swedish housing policies in early 1990s experienced a pivotal shift, from a housing system that was mainly based on a large share of public housing, to more market-based system that allowed tenant conversions to cooperative housing. In addition, financial liberalization in the banking sector allowed for better financing solutions for existing homes and new housing development. At the same time, rental regulations in the housing sector limited investments in new housing development to some extent.

As a result of these policies, as shown in Table 2, the apartment market sector structure has changed over three decades. We can observe a decrease in the rental sector (minus 29 percent for Stockholm, minus 14 percent in Gothenburg and minus 9 percent in Malmo) and growth in the housing cooperative sector to the same extent, respectively. For the whole of Sweden, the rental sector decrease between 1990 and 2020 was minus 13 percent. It is worth noting that the share of single-family housing in total housing stock has not changed significantly (it was 44 percent in 1990 and 43 percent in 2020).

This restructuring of the apartment market in major Swedish cities has occurred primarily for two reasons: 1) new apartment construction; 2a) property conversions from both office and industrial sectors into housing, and 2b) conversions of rental dwellings to cooperative housing apartments. In section 5 we present empirical results from estimations of the models 1-5 that represent this long-run restructuring of the housing market.

**4.2 The dataset**

The data includes the period of 1990-2020 regarding the three largest cities in Sweden. Data sources and a detailed description is presented in Table A2 in the Appendix. Data is unbalanced with some missing observations in either the beginning or end of the time period. Summary statistics are presented in Table 3.

---

8 See, for example, the Government of Sweden (2021) report for the historical overview of the legislation on rental regulations in Sweden.
### Table 3. Summary statistics of data

| Variables                                           | Unit            | Obs. | Mean        | Std. dev.   | Min.   | Max.   |
|-----------------------------------------------------|-----------------|------|-------------|-------------|--------|--------|
| New construction of rental apartments               | Dwellings       | 90   | 1628.822    | 1225.466    | 278    | 5514   |
| New construction of housing cooperative apartments  | Dwellings       | 90   | 1761.644    | 1936.032    | 10     | 8819   |
| Netto of conversions to rental apartments           | Dwellings       | 93   | 141.1075    | 226.7104    | -46    | 1032   |
| Netto of conversions to housing cooperative apartments | Dwellings       | 93   | 299.4409    | 308.1546    | -346   | 1496   |
| Rental apartment stock                              | Dwellings       | 93   | 232967.1    | 122883      | 99381  | 439057 |
| Housing cooperative apartment stock                 | Dwellings       | 93   | 146023.7    | 113604.5    | 55724  | 442936 |
| Total apartment stock in multifamily buildings      | Dwellings       | 93   | 379097.9    | 223744.6    | 160196 | 829655 |
| Rent per square meter                               | SEK             | 53   | 1010.81     | 147.7724    | 778.1182 | 1334.373 |
| Apartment price per square meter                    | SEK             | 75   | 26780.47    | 18588.57    | 2934.346 | 75179.64 |
| Population                                          | Inhabitants     | 93   | 1158798     | 598119.6    | 529315 | 2391990 |
| Population growth                                   | Inhabitants     | 90   | 13795.54    | 10078.1     | 3394   | 39083  |
| Total earned income per capita                      | Thousand SEK    | 87   | 211.8199    | 59.93995    | 111.8399 | 351.2326 |
| Mortgage interest rate                              | Percent         | 84   | 3.151127    | 2.156006    | -0.1877261 | 7.729706 |
| Construction costs per square meter for newly built rental apartments | SEK             | 76   | 20081.17    | 6422.699    | 8299.674 | 33684.54 |
| Land costs per square meter for newly built rental apartments | SEK             | 76   | 2715.752    | 1421.144    | 695.5837 | 7047.27 |
| Construction costs per square meter for newly built cooperative apartments | SEK             | 76   | 25377.88    | 9653.017    | 9615.283 | 48413.08 |
| Land costs per square meter for newly built cooperative apartments | SEK             | 76   | 7008.156    | 4649.454    | 1118.098 | 21047.41 |

*Source: SCB Sweden; Central Bank of Sweden; Swedbank Sweden.*

**Panel unit root tests**

Data is tested for stationarity with the help of Im et al.’s (2003) unit root test, which allows for heterogeneous autoregressive roots (the IPS test). The results of IPS stationarity tests are presented in Table A3 in the Appendix). As shown in Table A3, the majority of independent variables in the model(s) are non-stationary at levels, but stationary at first differences.
Dependent variables such as the new construction of apartments and netto of dwelling conversions are stationary at levels and first differences.

5. Empirical results

Models 1-5 were estimated by fixed and random effects regression. Hausman test is performed to determine a better choice between fixed and random effect regressions for each of the models’ estimations. Results are reported in Tables 4-8.

Post-estimation tests include Breusch-Pagan statistics for cross-sectional independence in the residuals of a fixed effect regression model and Wald statistics for groupwise heteroscedasticity in the residuals of a fixed effect regression model. Breusch-Pagan tests have provided evidence of cross-sectional independence in the residuals in all regressions. It implies that estimators are consistent.

Results of the Wald test indicates no deviations from homoscedastic errors in the context of panel data for all models except for model 5. Observed heteroscedasticity in model 5 indicates that the assumption of normality is violated at least in asymptotic terms. Though in terms of small sample properties, simulations of the test statistics have shown that its power is very low in the context of fixed effects and this test should be used with caution.

For all regressions a Wooldridge test for autocorrelation and Breush and Pagan Lagrangian multiplier test for random effects were done. In all models, no autocorrelation was detected nor was any heteroscedasticity in error terms for random effects estimations reported. It implies that estimators are efficient.

In addition, Variance Inflation Factor (VIF) tests that represent a measure of the amount of multicollinearity in a set of multiple regression variables are presented in Tables A4-A8 in the Appendix. Results of VIF tests provide evidence that multicollinearity is not observed. High values for VIF tests for new construction and netto of dwelling conversions are expected since these independent variables are components of the dependent variable in models 4 and 5.

Estimation results for Model 1 “Dynamics of the total housing stock of multifamily dwellings over the long run” are presented in Table 4.

R-squared for regression on total stock of multifamily dwellings is 34%, which implies that fundamental variables can explain about one third of the total change in stock. Moreover, random effects regression estimators are more efficient than fixed effects estimators according to Hausman test.

Rent level, mortgage interest rate and land costs have a negative effect on the development of housing stock. A one percent higher growth in rent level decreases the growth rate of the total housing stock of multifamily buildings by 0.0624 percent. Rent level might have both negative and positive effect depending on whether the effect is generated from demand or supply. For example, higher rents decrease demand for rental housing but increase new construction on the
supply side of the market. In this case the negative effect implies that driving forces from the demand side prevailed during the estimated period. Higher growth rate in land costs per square meter for multifamily apartments decrease the growth of the total stock of multifamily buildings by 0.0098 percent. An increase in mortgage interest rate by one percentage point decreases the growth of the total housing stock of multifamily buildings by 0.0033 percent. Total earned income has positive effect, implying that a one percent increase in income growth leads to a 0.2346 percent increase in the total housing stock of multifamily buildings. This is highest impact among variables.

**Table 4.** Dynamics of the total housing stock of multifamily dwellings over the long run.

| Variables                                         | Fixed effects | Random effects |
|---------------------------------------------------|---------------|----------------|
|                                                   | Coefficient   | t              | Coefficient | z   |
| Const                                             | -0.0424*      | -1.84          | -0.0026     | -0.27|
| Rent per square meter, SEK                        | -0.0828       | -2.54          | -0.0624*    | -1.83|
| Apartment price per square meter, SEK              | 0.0011        | 0.12           | -0.0053     | -0.57 |
| Population growth, inhabitants                     | 0.0053**      | 2.19           | 0.0011      | 1.15 |
| Total earned income per capita, thousands SEK      | 0.2428**      | 2.53           | 0.2346**    | 2.29 |
| Mortgage interest rate, percent                    | -0.0026*      | -1.90          | -0.0033**   | -2.40|
| Construction costs per square meter for rental apartments | 0.0046        | 0.55           | 0.0060      | 0.67 |
| Land costs per square meter for rental apartments  | 0.0037        | 1.04           | 0.0042      | 1.11 |
| Construction costs per square meter for cooperative apartments | -0.0065       | -0.61          | -0.0021     | -0.18|
| Land costs per square meter for cooperative apartments | -0.0079**     | -2.18          | -0.0098**   | -2.59|
| Number obs.                                       | 47            |                | 47          |      |
| Number of groups                                  | 3             |                | 3           |      |
| R-squared: within                                 | 0.4228        |                | 0.3716      |      |
|                                                   | 0.0179        |                | 0.0013      |      |
|                                                   | 0.2118        |                | 0.3351      |      |
| Hausman chi2                                      | 2.43          |                | 0.9826      |      |

*Note:* * denotes statistical significance at the 10 percent level. ** denotes statistical significance at the 5 percent level. *** denotes statistical significance at the 1 percent level.
Estimation results for Model 2a “Dynamics of the new construction of dwellings in the rental sector” and Model 2b “Dynamics of the new construction of dwellings in the housing cooperative sector” are presented in Table 5.

The results of Hausman test justify that random effects regression provides more efficient estimates for the new construction of rental apartments and housing cooperatives. In both cases the increase in population growth and change in total earned income have a positive effect on the new construction of housing dwellings. These effects are a bit higher for the housing cooperative sector (with a 1.2690 percent population growth and 25.7465 percent income growth in comparison with 0.7960 percent and 20.5942 percent for rental sector). This implies that new construction in this sector is more elastic to changes in fundamental variables. Rent per square meter has a negative effect on the new construction for housing cooperatives and no significant effect on the new construction of rental apartments. Increase in the growth rate of the rent level decreases the new construction of housing cooperatives by 11.0016 percent. Estimation results for apartment price per square meter is not significant. Higher growth in land costs per square meter for newly built cooperative apartments has a negative effect on new construction in this sector, implying the importance of municipality land policies on the development of the housing market in larger metropolitan agglomerations. The R-squared value is 64 percent for rental apartments and 84 percent for housing cooperative apartments. It implies that the fundamental variables used in Models 2a and 2b might explain more than half of the variation of new dwellings construction.

\textsuperscript{9} It is worth noting that the variables “Rent per square meter” and “Apartment price per square meter” related to existing housing stock. The similar data for new housing construction is not available at an aggregated level. Therefore, these variables for existing housing stock use a proxy for the same variables for new construction since they reflect market dynamics.
Table 5. Dynamics of the new construction of dwellings.

| Variables                                              | Model 2a. Dependent variable: New construction of rental apartments | Model 2b. Dependent variable: New construction of housing cooperatives |
|--------------------------------------------------------|--------------------------------------------------------------------|-----------------------------------------------------------------------|
|                                                        | Fixed effects                                                      | Random effects                                                       | Fixed effects                                                      | Random effects |
|                                                        | Coefficient t                                                     | Coefficient z                                                        | Coefficient t                                                     | Coefficient z |
| Cost                                                   | 0.1793                                                             | -0.7426                                                              | -0.4611                                                           | -5.1156***    |
| Rent per square meter, SEK                            | -5.3911                                                            | -4.9694                                                              | -9.3021***                                                       | -11.0016***   |
| Apartment price per square meter, SEK                  | -0.1165                                                            | -0.0680                                                              | -1.7926*                                                          | -2.03         |
| Population growth, inhabitants                        | 0.6956***                                                          | 0.7960***                                                            | 0.7772***                                                        | 3.21          |
| Total earned income per capita, thousands SEK          | 22.3792**                                                          | 20.5942*                                                             | 26.9603**                                                        | 2.88          |
| Mortgage interest rate, percent                        | -0.2354                                                            | -0.2125                                                              | -0.2311*                                                         | -0.1334       |
| Construction costs per square meter for rental apartments | 0.0520                                                             | 0.0137                                                              |                                                                   |               |
| Land costs per square meter for rental apartments      | -0.4382                                                             | -0.4329                                                              |                                                                   |               |
| Construction costs per square meter for cooperative apartments |                                                                   |                                                                     | 1.1304                                                           | 0.4551        |
| Land costs per square meter for cooperative apartments  |                                                                   |                                                                     | -0.8575***                                                       | -3.11         |
| Number obs.                                           | 47                                                                 | 47                                                                  | 47                                                               | 47            |
| Number of groups                                      | 3                                                                  | 3                                                                  | 3                                                                | 3             |
| R-squared: within                                      | 0.2966                                                             | 0.2940                                                              | 0.5365                                                           | 0.5079        |
| R-squared: between                                     | 0.9665                                                             | 0.9697                                                              | 0.9963                                                           | 0.9960        |
| R-squared: overall                                     | 0.6335                                                             | 0.6359                                                              | 0.8038                                                           | 0.8389        |
| Hausman chi2                                           | 1.62                                                               |                                                                     |                                                                  | 4.52          |
| Prob>chi2                                              | 0.9779                                                             |                                                                     |                                                                  | 0.7187        |

Note: * denotes statistical significance at the 10 percent level. ** denotes statistical significance at the 5 percent level. *** denotes statistical significance at the 1 percent level.

Estimation results for Model 3a “Dynamics of dwelling conversions in the rental sector” and Model 3b “Dynamics of dwelling conversions in the housing cooperative sector” are presented in Table 6.

The results of the Hausman test indicates that for the rental sector fixed effects regression provides more consistent estimators, while for housing conversions random effect regression is more efficient. For the netto of dwelling conversions, only the growth of rent level per square meter provided a significant and negative estimator, implying that rent plays a major role for housing conversions. A higher rent level decreases the conversions to rental apartments by -15.0121 percent. A negative sign of this effect is unexpected but might still be explained by driving forces from demand side of the market – higher rent growth might decrease the tenants demand for rental apartments if tenants cannot afford higher rent levels. It might also be an indicator of the rent control effect that exists in housing market in Sweden. Companies might prefer not to do these conversions due to higher rent levels for other types of premises and more profitable conversions to housing condominiums. This is confirmed by the positive and
significant impact of apartment price growth on the netto of dwelling conversions to housing cooperatives. A one percent higher growth in apartment prices increases the conversions to housing cooperatives by 4.9820 percent. It is interesting to observe that the impact of population growth is almost twice as high for dwelling conversions to rental apartments than for housing condominiums. Higher population growth might be a result of higher migration flows to major Swedish cities and more rapid urbanization processes in Sweden during last two decades. However, according to banking regulations the purchase of new apartments in Sweden requires a down payment that equals 15 percent of the market price – an amount that not all inhabitants new to the city can afford. Therefore, the effect on conversions to rental apartments coming from population growth is higher than the effect on conversions to housing cooperatives.

R-squared, however, was very small, implying that the interconnection between the netto of dwelling conversions in the rental sector and fundamentals is very weak or almost zero. R-squared for the netto of dwelling conversions to housing condominiums is 42 percent.

Table 6. Dynamics of dwelling conversions.

| Variables                              | Model 3a. Dependent variable: Netto of dwelling conversions to rental apartments | Model 3b. Dependent variable: Netto of dwelling conversions to housing cooperative apartments |
|----------------------------------------|---------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------|
|                                        | Fixed effects Coefficient | t | Random effects Coefficient | z | Fixed effects Coefficient | t | Random effects Coefficient | z |
| Cost                                   | 5.2325 | 0.99 | -15.0121*** | -5.69 | 4.1389 | 0.90 | -2.6907 | -1.40 |
| Rent per square meter, SEK             | -15.3914* | -1.93 | -23.6998** | -2.55 | -7.5585 | -1.09 | -10.4554 | -1.54 |
| Apartment price per square meter, SEK  | -1.1318 | -0.59 | 1.2190 | 0.55 | 4.1819** | 2.51 | 4.9820*** | 3.06 |
| Population growth, inhabitants         | -0.1352 | -0.24 | 2.0037*** | 7.38 | 0.1874 | 0.39 | 0.9087*** | 4.58 |
| Total earned income per capita, thousands SEK | 29.3052 | 1.28 | 23.9163 | 0.88 | -13.8602 | -0.70 | -15.4924 | -0.78 |
| Mortgage interest rate, percent        | -0.3331 | -1.04 | 0.0537 | 0.15 | 0.1496 | 0.54 | 0.2795 | 1.04 |
| Number obs.                            | 47 | 47 | 47 | 47 | 3 | 3 | 3 | 3 |
| R-squared: within                      | 0.1239 | 0.0314 | 0.1987 | 0.1658 |
| between                                | 0.4979 | 0.9780 | 0.9866 | 0.9821 |
| overall                                | 0.0042 | 0.5999 | 0.2465 | 0.4211 |
| Hausman chi2                           | 18.93 | 7.46 |
| Prob>chi2                              | 0.0020 | 0.1889 |

Note: * denotes statistical significance at the 10 percent level. ** denotes statistical significance at the 5 percent level. *** denotes statistical significance at the 1 percent level.

Estimation results for Model 4a “Displacement effects for new construction in the rental sector” and Model 4b “Displacement effects for new construction in the housing cooperative sector” are presented in Table 7.

R-squared in models for the rental and housing cooperative sector equals 95 and 96 percent, respectively. The random effects model provides more efficient estimators for both sectors in comparison with the fixed effect model. The coefficients $\sigma_1$ and $\sigma_2$ for the rental and housing cooperatives sectors are very close to each other and equal 0.7779 and 0.7581. It implies that we do not observe displacement effects from either sector for the total new construction of
housing dwellings in major Swedish cities. An increase in growth rate of rent per square meter decreases the new construction of rental dwellings by 2.8911 percent. This is opposite to what was expected. It indicates that despite the growth of rent level, the new construction of rental apartments is decreasing. It might be evidence of the rent control effect on the behavior of the property developers from the supply side and also a shift down in demand from tenants since the rent level might be already high and unaffordable, thus leading to the shift down in the demand curve. An increase in the population growth rate by one percentage point will increase the new construction of rental apartments by 0.4136 percent. Estimations for fundamental variables for the housing cooperative sector appears to be insignificant. The insignificant estimators of land costs might indicate that land policies do not have an impact on the level of new residential construction in both sectors.

Table 7. Displacement effects for new apartments construction.

| Variables | Model 4a. Dependent variable: Total new construction of rental apartments | Model 4b. Dependent variable: Total new construction of housing cooperatives |
|-----------|--------------------------------------------------------------------------|--------------------------------------------------------------------------|
|           | Fixed effects | Random effects | Fixed effects | Random effects |
|           | Coefficient  | t            | Coefficient  | z            | Coefficient  | t            | Coefficient  | z            |
| Cost      | -0.2832      | -0.29        | -1.6767***   | -3.95        | 1.75*        | 1.73         | 1.7071***    | 3.16         |
| New construction of rental apartments, dwellings | 0.7970*** | 12.39 | 0.7779*** | 11.75 | |
| New construction of housing cooperative apartments, dwellings | | | | |
| Rent per square meter, SEK | -1.9214 | -1.29 | -2.8911* | -1.91 | 0.5772 | 0.36 | 0.8100 | 0.50 |
| Apartment price per square meter, SEK | -0.5809 | -1.65 | -0.3982 | -1.12 | 0.3369 | 0.82 | 0.2683 | 0.71 |
| Population growth, inhabitants | 0.2538** | 2.27 | 0.4136*** | 6.07 | 0.0472 | 0.39 | 0.0679 | 0.70 |
| Total earned income per capita, thousands SEK | 6.6818 | 1.50 | 7.4555 | 1.62 | 3.0994 | 0.68 | 2.7595 | 0.60 |
| Mortgage interest rate, percent | -0.0402 | -0.66 | -0.0192 | -0.31 | -0.0753 | -1.23 | -0.0767 | -1.33 |
| Construction costs per square meter for rental apartments | -0.0761 | -0.24 | -0.1664 | -0.50 | |
| Land costs per square meter for rental apartments | 0.0278 | 0.22 | 0.0281 | 0.21 | |
| Construction costs per square meter for cooperative apartments | | | | -0.0125 | -0.03 | 0.0245 | 0.06 |
| Land costs per square meter for cooperative apartments | | | | -0.1782 | -1.30 | -0.1998 | -1.53 |
| Number obs. | 47 | 47 | 47 | 47 |
| Number of groups | 3 | 3 | 3 | 3 |
| R-squared: within | 0.8859 | 0.8799 | 0.8859 | 0.8853 |
| between | 0.9902 | 0.9938 | 0.9931 | 0.9937 |
| overall | 0.9490 | 0.9543 | 0.9565 | 0.9567 |
| Hausman chi2 | 5.6 | 3.78 |
| Prob>chi2 | 0.0609 | 0.1507 |

Note: * denotes statistical significance at the 10 percent level. ** denotes statistical significance at the 5 percent level. *** denotes statistical significance at the 1 percent level.
Estimation results for Model 5a “Displacement effects for dwelling conversions in the rental sector” and Model 5b “Displacement effects for dwelling conversions in the housing cooperative sector” are presented in Table 8.

**Table 8.** Displacement effects for dwelling conversions.

| Variables                                                                 | Model 5a. Dependent variable: Total netto of dwelling conversions to apartments | Model 5b. Dependent variable: Total netto of dwelling conversions to apartments |
|---------------------------------------------------------------------------|---------------------------------------------------------------------------------|---------------------------------------------------------------------------------|
|                                                                           | Fixed effects          | Random effects         | Fixed effects          | Random effects         |
| Cost                                                                     | Coefficient | t     | Coefficient | z     | Coefficient | t     | Coefficient | z     |
|                                                                           | 1.6366      | 0.51  | 2.6387      | 1.53  | 0.7678      | 0.70  | -2.6867***   | -5.22 |
| Netto of dwelling conversions to rental apartments, dwellings             | 0.5505***   | 5.72  | 0.5233***   | 6.84  | 0.9059***   | 23.96 | 0.9402***   | 23.09 |
| Netto of dwelling conversions to housing cooperative apartments, dwellings |                                                                                 | 0.9059***   | 23.96  | 0.9402***   | 23.09  |
| Rent per square meter, SEK                                               | -0.3054     | -0.06 | -0.2100     | -0.04 | -1.9317     | -1.17 | -2.7808     | -1.53 |
| Apartment price per square meter, SEK                                    | 3.6479***   | 3.13  | 3.5051***   | 3.21  | -0.7636*    | -1.80 | -0.5411     | -1.15 |
| Population growth, inhabitants                                          | 0.2426      | 0.72  | 0.1487      | 0.73  | -0.0016     | -0.01 | 0.3428***   | 5.39  |
| Total earned income per capita, thousands SEK                             | -21.4275    | -1.53 | -20.7208    | -1.55 | 7.2624      | 1.55  | 6.3595      | 1.22  |
| Mortgage interest rate, percent                                          | 0.1916      | 0.98  | 0.1671      | 0.93  | -0.1273*    | -1.94 | -0.0676     | -0.95 |
| Number obs.                                                              | 47          | 47    | 47          | 47    | 47          | 47    | 47          | 47    |
| Number of groups                                                         | 3           | 3     | 3           | 3     | 3           | 3     | 3           | 3     |
| R-squared: within                                                        | 0.5599      | 0.5588| 0.9491      | 0.9377|
|                                                                           | 0.9995      | 0.9990| 0.9974      | 1.0000|
|                                                                           | 0.7813      | 0.7826| 0.9399      | 0.9671|
| Hausman chi2                                                             | 0.24        | 12.66 | 0.9997      | 0.0488|
| Prob>chi2                                                                |             |       |             |       |

 Note: * denotes statistical significance at the 10 percent level. ** denotes statistical significance at the 5 percent level. *** denotes statistical significance at the 1 percent level.

R-squared for dwelling conversions equals 78 percent for the rental sector and 94 percent for the housing cooperative sector. The random effect model is more efficient for the rental sector and fixed effect model provides more consistent estimators for the housing cooperative sector.
Growth in apartment prices have a positive and significant effect on the number of dwelling conversions to rental apartments of 3.5051 percent. At the same time, it has a negative effect of 0.7636 percent for the housing cooperative sector. This implies that the growth rate of apartment prices might be too high and that the demand for added apartments through conversions from other sectors and between sectors flows more towards the rental sector. A higher growth in the mortgage interest rate decreases conversions to housing cooperatives by 0.1273 percent.

The coefficients \( \varphi_1 \) and \( \varphi_2 \) for the rental and housing cooperative sectors are 0.5233 and 0.9059, respectively. This implies that there are no crowding out effects for the total number of housing conversions from either the rental or housing cooperative sector. Since the coefficient \( \varphi_2 \) is almost twice as higher as the coefficient \( \varphi_2 \), it implies that conversions to housing cooperatives demonstrate a filling in effect (dominant effect) over the conversions to rental apartments.

6. Discussion

In order to examine the long-term dynamics of new residential supply in Sweden we estimated the relationship between new construction of apartments and market fundamentals as well as impact of municipal land policies and housing policies on property conversions.

Role of market fundamentals\(^{10}\)

The rapid urbanization process that occurs in many countries includes three major Swedish cities (Stockholm, Gothenburg and Malmo). Higher employment and population growth results in a higher demand for housing, which results in continuous house price growth and longer waiting times for rental housing.

Municipalities have provided extensive subsidies to housing producers and property owners over the past two decades. Supply side subsidies include lower land prices to increase the supply of rental housing units and decisions on mortgage interest rates for income tax purposes for homeowners. Lower land prices intended to increase the new construction of rental apartments. Subsidies on mortgage interest rates increase demand for housing through price mechanisms, which in turn should stimulate new housing construction of housing cooperatives. However, the impact on construction depends on the price elasticity of supply. The results of our study indicate that new housing supply is not price elastic and mainly depends on other market fundamentals such as population and income growth and a decrease in mortgage interest rates. Construction costs do not have an effect on the size of new construction in both sectors. Rent growth has a negative impact on new construction in the housing cooperative sector and no

\(^{10}\) We do not provide comparison of estimations done in previous studies in this section since, as indicated in Table A1 in the Appendix, the major dependent variables are expressed as new constructions of single-family housing, housing starts or construction permits, which is not directly comparable with the dependent variables used in our models.
effect on the new construction of rental apartments. This might be explained by the existence of rent control policies in the Swedish housing market. However, we have not found evidence of the displacement mechanisms in new construction between the rental and housing cooperative sectors (model 4), which implies that new construction in both sectors contributes to long-run housing market dynamics in a similar way.

The role of municipal land policies

The results of estimations in models 1–2 indicate that higher land costs decrease the new construction of housing cooperative apartments and decrease the growth of the total housing stock. At the same time, the effect of land costs for rental apartments was insignificant, which implies that we were unable to provide evidence that municipal land policies lead to an increase in the new construction of rental dwellings in the long run.

The role of policies on property conversions

As seen from models 3 and 5, the major way the structure of the housing market is changing in Sweden is through the dwelling conversion decisions of tenants and public property owners. Their investment decisions adjust housing supply to changing market conditions. These housing policies implemented in Sweden since 1990s have helped many people to become homeowners over the last two decades.

The major assumption in housing economics is that property owners maximize the value of the net benefits from the property. For tenants that are becoming members of the housing cooperatives, the benefits include housing consumption in a form of housing services and the return on housing investment in the form of capital gains when the apartment is sold. It is important to note that these investment decisions occur independent of income (as a fundamental variable in models 3 and 5), implying that this process is mainly based on house price adjustments that are driven by low elasticity of housing supply and not fundamentals from the demand side of the market.

Rent control in the housing sector is another major factor for property conversions. With market rents there will no market forces to convert rental apartments and other type of properties like offices or industrial premises to housing cooperatives. Instead, market rents would stimulate the housing supply of rental dwellings as an alternative to other housing tenure forms like housing cooperatives and condominiums and would press the house prices down over the long run making housing more affordable to different population groups.

Impact on housing market dynamics

As a result of liberalization policies implemented in 1990s in Sweden, we can observe two major effects in housing market dynamics – a decline of the rental housing sector and growth of the housing cooperative sectors. This is accompanied by the growth of house prices supported by a low interest rates environment.
If these trends will sustain in future the result over the long run might be that a majority of the urban population will find themselves living in expensive tenant-owned apartments, while the renting sector will decline and waiting time in queues for rental accommodation will increase.

Rental housing is important for young people entering the housing market, elderly households that do not need large housing due to a decrease of household size with time when children move out, and single parents with children who are looking for apartments after separation and might not have enough savings for the down payment needed to buy a housing cooperative apartment. Rental housing is also important for low/income households that might not be able to pay high rents.

7. Conclusion and policy implications

Econometric results indicate that the growth of the total housing stock, as tested in three major Swedish cities, occurs through new construction and dwelling conversions into owner-occupied apartments. The impact for the majority of fundamental variables lies in line with theory and previous studies and provides evidence of the interplay of the market forces of demand and supply.

The work done in this article allows us to draw the following conclusions:

- The major driving factors of new construction are income and population growth.
- Change in price, as one of the major determinants of housing supply, does not appear to be statistically significant in determining the size of new construction.
- Insignificant results for land costs for new construction in the rental sector indicates that we are unable to provide evidence of the effects of local municipalities’ land policies to stimulate the new construction of rental apartments.
- We have not found a considerable difference in new construction with respect to property tenures. New construction of different types of housing tenures (rental and housing cooperatives) does not crowd out other types of new construction of multifamily dwellings.
- Our results suggest that mortgage interest rates do not stimulate more production of housing cooperative apartments than rental ones but do stimulate more property conversions to housing cooperative apartments. The low interest rate environment that Sweden experienced over the last two decades makes monthly payments for housing loans affordable to tenants in comparison to monthly rental payments they might pay. This makes the rental apartments they live in an attractive investment alternative, especially when considering the persistent growth in house prices that has occurred in Sweden since 1990s.
- The importance of other fundamentals such as rent level is difficult to explain. It either has no or a negative impact on the size of the new construction and conversions to rental apartments and the total change in housing stock.
- Home renters are more likely to improve their housing by building housing cooperatives instead of buying apartment in new constructions. The apartment price per square meter in relation to rent level is the major driving factor in this process. We clearly see a displacement.
effect that occurs through dwelling conversions to housing cooperatives. One property unit converted to a housing cooperative dwelling almost doubles the total netto of dwelling conversions to housing, while at the same time one property unit converted to a rental dwelling adds one unit to the total netto of dwelling conversions to housing.

In addition, it is important to mention that much of the research done on new supply is focused on the new supply of single-family owner-occupied housing and multifamily housing as housing cooperatives. We know much less about the determinants of the new supply of multifamily rental housing. Understanding these housing market dynamics is crucial for formulating future housing policies. We need to know more about the decision-making process of builders, investors and landlords, as they are important actors that determine housing supply in the rental sector as well as the renovation and conversion decisions of the property companies. Therefore, future research directions should lie in bringing new data on decision-making processes by local suppliers and municipal policies that can improve rental housing construction in efficient way.

References

Andersson, R., & Turner, L. M. (2014). Segregation, gentrification, and residualisation: From public housing to market-driven housing allocation in inner city Stockholm. *International Journal of Housing Policy, 14*(1), 3–29. https://doi.org/10.1080/14616718.2013.872949

Ball, M., Meen, G., & Nygaard, C. (2010). Housing supply price elasticities revisited: Evidence from international, national, local and company data. *Journal of Housing Economics, 19*(4), 255–268. https://doi.org/10.1016/j.jhe.2010.09.004

Case, K. E., & Shiller, R. J. (1989). The efficiency of the market for single-family homes. *American Economic Review, 79*(1), 125–137. https://doi.org/10.2307/1804778

Clapp, J. M., & Giaccotto, C. (1994). The influence of economic variables on local house price dynamics. In *Journal of Urban Economics, Vol. 36*(2), pp. 161–183. https://doi.org/10.1006/juec.1994.1031

DiPasquale, D. (1999). Why Don’t We Know More about Housing Supply? *Journal of Real Estate Finance and Economics, 18*(1), 9–23. https://doi.org/10.1023/A:1007729227419

DiPasquale, D., & Wheaton, W. C. (1994). Housing market dynamics and the future of housing prices. In *Journal of Urban Economics, Vol. 35*(1), pp. 1–27. https://doi.org/10.1006/juec.1994.1001

Eriksen, M. D., & Rosenthal, S. S. (2010). Crowd out effects of place-based subsidized rental housing: New evidence from the LIHTC program. *Journal of Public Economics, 94*(11–12), 953–966. https://doi.org/10.1016/j.jpubeco.2010.07.002

Follain, J. R., Leavens, D. R., & Velz, O. T. (1993). Identifying the effects of tax reform on multifamily rental housing. In *Journal of Urban Economics, Vol. 34*(2), pp. 275–298. https://doi.org/10.1006/juec.1993.1037

Glaeser, E. L., Gyourko, J., & Saiz, A. (2008). Housing supply and housing bubbles. *Journal of Urban Economics, 64*(2), 198–217. https://doi.org/10.1016/j.jue.2008.07.007
Glennon, D. (1989). Estimating the income, price, and interest elasticities of housing demand. *Journal of Urban Economics*, 25(2), 219–229. https://doi.org/10.1016/0094-1190(89)90036-3

Goodman, A. C., & Thibodeau, T. G. (2008). Where are the speculative bubbles in US housing markets? *Journal of Housing Economics*, 17(2), 117–137. https://doi.org/10.1016/j.jhe.2007.12.001

Haffner, M. E. A. (2003). Tenure neutrality, a financial-economic interpretation. *Housing, Theory and Society*, 20(2), 72–85. https://doi.org/10.1080/14036090304262

Hanushek, E. a, & Quigley, J. M. (1980). What is the Price Elasticity of Housing Demand? *The Review of Economics and Statistics*, Vol. 62(3), pp. 449-454 Published by : The MIT Press. Stable URL: https://www.jstor.org/stable/1927113

Hellekant J. (2019). Record long queues for rental apartments: "Social housing crisis" (In Swedish: Rekordköer till hyresrätt: "Bostadssocial kris"). Svenska Dagbladet, Stockholm. Publication date: 19/08/2019. https://www.svd.se/a/Opeolb/rekordkoer-till-hyresratt-bostadssocial-kris

Jud Donald G., Benjamin John D., S. S. G. (1996). What Do We Know about Apartments and Their Markets? *Journal of Real Estate Research, 11*(3), 243–257. https://doi.org/10.1080/10835547.1996.12090826

Landis, J., & Reina, V. J. (2021). Do Restrictive Land Use Regulations Make Housing More Expensive Everywhere? *Economic Development Quarterly*, 35(4), 305–324. https://doi.org/10.1117/j089124242411043500

Lerbs, O. W. (2014). House prices, housing development costs, and the supply of new single-family housing in German counties and cities. *Journal of Property Research*, 31(3), 183–210. https://doi.org/10.1080/09599916.2014.893249

Mayer, C. J., & Somerville, C. T. (2000). Residential Construction: Using the Urban Growth Model to Estimate Housing Supply. *Journal of Urban Economics*, 48(1), 85–109. https://doi.org/10.1006/juec.1999.2158

Molloy, R. (2020). The effect of housing supply regulation on housing affordability: A review. *Regional Science and Urban Economics*, 80 (103350). https://doi.org/10.1016/j.regsciurbeco.2018.03.007

Murphy, A. (2018). A dynamic model of housing supply. *American Economic Journal: Economic Policy*, 10(4), 243–267. https://doi.org/10.1257/pol.20150297

Murray, M. P. (1999). Subsidized and Unsubsidized Housing Stocks 1935 to 1987: Crowding out and Cointegration. *Journal of Real Estate Finance and Economics*, 18(1), 107–124. https://doi.org/10.1023/A:1007741630145

Owusu-Ansah, A. (2014). Modelling the supply of new residential construction in aberdeen, uk. *International Journal of Housing Markets and Analysis*, 7(3), 346–362. https://doi.org/10.1108/IJHMA-07-2013-0043

Pryce, G. (1999). Construction elasticities and land availability: A two-stage least-squares model of housing supply using the variable elasticity approach. *Urban Studies*, 36(13), 2283–2304. https://doi.org/10.1080/0042098992421

Riddel, M. (2004). Housing-market disequilibrium: An examination of housing-market price and stock dynamics 1967-1998. *Journal of Housing Economics*, 13(2), 120–135. https://doi.org/10.1016/j.jhe.2004.04.002
Rubaszek, M., & Rubio, M. (2020). Does the rental housing market stabilize the economy? A micro and macro perspective. *Empirical Economics*, 59(1), 233–257. https://doi.org/10.1007/s00181-019-01638-z

Sinai, T., & Waldfogel, J. (2005). Do low-income housing subsidies increase the occupied housing stock? *Journal of Public Economics*, 89(11–12), 2137–2164. https://doi.org/10.1016/j.jpubeco.2004.06.015

Somerville, C. T. (1999). Residential Construction Costs and the Supply of New Housing: Endogeneity and Bias in Construction Cost Indexes. *Journal of Real Estate Finance and Economics*, 18(1), 43–62. https://doi.org/10.1023/A:1007785312398

Stevenson, S., & Young, J. (2014). A Multiple Error-Correction Model of Housing Supply. In *Housing Studies*, Vol. 29(3), pp. 362–379. Taylor & Francis. https://doi.org/10.1080/02673037.2013.803040

Swedish National Board of Housing, Building and Planning (2021). The necessity of housing construction - regional and national until 2030 (In Swedish: Behov av bostadsbyggande – regionalt och nationellt till 2030), Report 2021:31, Boverket, Karlskrona. https://www.boverket.se/sv/om-boverket/publicerat-av-boverket/publikationer/2021/bohev-av-bostadsbyggande--regionalt-och-nationellt-till-2030/

Swedish National Board of Housing, Building and Planning (2020). The need of housing construction 2020-2029 (In Swedish: Bostadsbyggnadsbehov 2020–2029), Report 2020:32, Boverket, Karlskrona. https://www.boverket.se/globalassets/publikationer/dokument/2020/bostadsbyggnadsbehov-20202029

Swedish National Board of Housing, Building and Planning (2016a). Who benefits from more housing, Report 2016:12, Boverket, Karlskrona. https://www.boverket.se/globalassets/publikationer/dokument/2016/who-benefits-from-more-housing.pdf

Swedish National Board of Housing, Building and Planning (2016b). Housing internal migration and economic growth in Sweden, Report 2016:13, Boverket, Karlskrona. https://www.boverket.se/globalassets/publikationer/dokument/2016/housing-internal-migration-and-economic-growth-in-sweden.pdf

Swedish National Board of Housing, Building and Planning (2016c). The method for estimation the need for housing construction (In Swedish: En metod för bedömning av bostadsbyggnadsbehovet), Report 2016:32, Boverket, Karlskrona. https://www.boverket.se/globalassets/publikationer/dokument/2016/en-metod-for-bedomning-av-bostadsbyggnadsbehovet.pdf

Swedish National Board of Housing, Building and Planning (2015). The need for housing construction - Theory and method together with analysis of the need for housing until 2025 (In Swedish: Behov av bostadsbyggande – Teori och metod samt en analys av behovet av bostäder till 2025, Report 2015:18, Boverket, Karls-krona. https://www.boverket.se/globalassets/publikationer/dokument/2015/bohev-av-bostadsbyggnande.pdf

The Government of Sweden (2021) Free market rents in new construction. (In Swedish: *Fri hyressätting vid ny produktion*), Report, SOU 2021:50, The Government of Sweden. https://www.regeringen.se/rattsliga-dokument/statens-offentliga-utredningar/2021/06/sou-202150/

Warsame, A., Wilhelmsson, M., & Borg, L. (2010). The effect of subsidy on housing
construction in various regions of Sweden. *Journal of European Real Estate Research, 3*(3), 228–244. https://doi.org/10.1108/17539261011094731

Wheaton, W. C. (1999). Real Estate Cycles: Some fundamentals. *Real Estate Economics, Vol.27*(2), pp. 2009–2030.

Wigren, R., & Wilhelmsson, M. (2007). Housing stock and price adjustments in 12 west European countries between 1976 and 1999. *Housing, Theory and Society, 24*(2), 133–154. https://doi.org/10.1080/14036090601119589

**Appendix**

**Table A1.** Overview of the research literature on new housing supply.

| Authors and year of publication | Country/ City | Type of housing in analysis | Years of analysis | Method of analysis | Dependent variable | Independent variable | Sign of effect |
|---------------------------------|---------------|-----------------------------|------------------|-------------------|--------------------|----------------------|---------------|
| DiPasquale & Wheaton (1994)     | United States | Single-family housing starts | 1963-1990        | OLS regression    | New construction of single-family houses | Current house prices | +(not significant) |
|                                 |               |                             |                  |                   |                    | Real costs of short-term construction financing | -             |
|                                 |               |                             |                  |                   |                    | Cost index for construction | +(not significant) |
|                                 |               |                             |                  |                   |                    | Cost index for land | -(not significant) |
|                                 |               |                             |                  |                   |                    | Stock of housing | +             |
|                                 |               |                             |                  |                   |                    | Current change of employment | -             |
|                                 |               |                             |                  |                   |                    | The number of months on the market for new homes recently sold |               |
|                                 |               |                             |                  |                   |                    | Price series for new homes | +             |
| Pryce (1999)                    | Great Britain | Private house starts        | 1988, 1992       | Two-stage least-squares regression | Private house starts | House price | +             |
|                                 |               |                             |                  |                   |                    | Unemployment rate | -             |
|                                 |               |                             |                  |                   |                    | Land supply | +             |
|                                 |               |                             |                  |                   |                    | Percentage of residential development on land in former urban areas | -             |
| Somerville (1999)               | United States | Single-family houses        | 1979-1991        | Hedonic regression with use of instrumental regression. | Housing starts in a form of housing permits | Change in housing prices | +             |
|                                 |               |                             |                  |                   |                    | Change in construction costs | -             |
Table A1. Overview of the research literature on new housing supply. Continuation (1).

| Authors and year of publication | Country/City | Type of housing in analysis | Years of analysis | Method of analysis | Dependent variable | Independent variable | Sign of effect |
|---------------------------------|--------------|-----------------------------|-------------------|-------------------|-------------------|---------------------|---------------|
| Mayer & Somerville (2000)       | United States | Single-family houses        | 1975-1994         | OLS regression    | Housing starts in a form of supply of developed lots | Change in price | +             |
|                                 |              |                             |                   |                   |                   | Change in price (t-1) | +             |
|                                 |              |                             |                   |                   |                   | Change in price (t-2) | +             |
|                                 |              |                             |                   |                   |                   | Change in price (t-3) | +             |
|                                 |              |                             |                   |                   |                   | Change in real prime rate | -             |
|                                 |              |                             |                   |                   |                   | Change in real prime rate (t-1) | -             |
|                                 |              |                             |                   |                   |                   | Stock (t-1) | +             |
|                                 |              |                             |                   |                   |                   | Median month on market until sold-New homes (t-1) | -             |
|                                 |              |                             |                   |                   |                   | Change in real building material costs index | -             |
| Riddel (2004)                   | United States | Owner occupied single-family units | 1964-1999         | Augmented least squared regression | Supply model: Stock of residential units | Price index | +             |
|                                 |              |                             |                   |                   |                   | Rate on 3-month treasury bills | - (not significant) |
|                                 |              |                             |                   |                   |                   | GDP | +             |
|                                 |              |                             |                   |                   |                   | Apartment vacancy | - (not significant) |
|                                 |              |                             |                   |                   |                   | Construction cost index | - (not significant) |
| Riddel (2004)                   | United States | Owner occupied single-family units | 1967-1998         | SUR | Change in stock | Disequilibrium from the demand side | -(not significant) |
|                                 |              |                             |                   |                   |                   | Disequilibrium from the supply side | -             |
|                                 |              |                             |                   |                   |                   | Change in price | -(not significant) |
|                                 |              |                             |                   |                   |                   | Change in rent | -             |
|                                 |              |                             |                   |                   |                   | Change in vacancy rate | -(not significant) |
|                                 |              |                             |                   |                   |                   | Change in vacancy rate (t-1) | +             |
|                                 |              |                             |                   |                   |                   | Change in price (t-2) | +             |
|                                 |              |                             |                   |                   |                   | Change in treasury bill (t-1) | -(not significant) |
|                                 |              |                             |                   |                   |                   | Change in treasury bill (t-2) | -             |
| Study                          | Region                      | Units                          | Periods                                 | Method                          | Types of Production/Supply                     | Variables                                                                 |
|-------------------------------|-----------------------------|-------------------------------|---------------------------------------|---------------------------------|-----------------------------------------------|---------------------------------------------------------------------------|
| Wigren & Wilhelmsson (2007)   | 12 West-European countries | Number of residential dwellings | 1976-1999                            | Panel data analysis             | Supply in a number of dwellings               | Construction price + Property price - Interest rate - Consumer Price Index + Price level + GDP + |
| Ball et al. (2010)            | Great Britain, United States and Australia | Private housing starts | 1969-2007, 1970-2007, 1983-2008 | SUR 2 step, OLS regression      | Log of housing stock                          | Housing starts + Log of housing stock + Lagged changes in log of real house price + Changes in short-term interest rate - Changes in log of construction costs - |
| Warsame et al. (2010)         | All regions in Sweden      | Single- and multifamily houses | 1976-2006                            | Instrumental variable (IV) and seemingly unrelated regressions (SUR) | Total production of single- and multifamily houses | Real production costs -/+ Real income per capita + Stock per capita -/+ Interest subsidy -/+ Construction taxes -/+ Interest rate -/+ Population -/+ |
**Table A1. Overview of the research literature on new housing supply. Continuation (3)**

| Authors and year of publication | Country/City | Type of housing in analysis | Years of analysis | Method of analysis | Dependent variable | Independent variable | Sign of effect |
|--------------------------------|--------------|-----------------------------|------------------|-------------------|--------------------|----------------------|---------------|
| Lerbs (2014) Germany, 413 counties and cities | Single-family houses | 2004-2010 | Dynamic panel data analysis | Construction permits | Permit rate (t-1) | House price-construction costs ratio | + |
| | | | | | | Spatial lag of house-price construction costs ratio | + |
| | | | | | Land price | - |
| | | | | | Time effects | - |
| Owusu-Ansah (2014) United Kingdom, Aberdeen | Single-family houses | 1986-2010 | OLS regression | Private single-family housing starts | Lagged housing stock | + |
| | | | | | Property price index rate of change | + |
| | | | | | Material costs index rate of change | -/+ (not significant) |
| | | | | | Interest rate | -(not significant) |
| | | | | | Time on the market | - |
| | | | | | Building warrant granted to approved ratio | + |
| Stevenson & Young (2014) Ireland | Private housing completions | 1978-2008 | Multiple error-correction model | Housing completions | Real new house prices | + |
| | | | | | Real building costs | - |
| | | | | | Real after tax interest rate | - (not significant) |
| | | | | | Time effects | - |
| Variable                                          | Definition                                           | Unit           | Data sources                                      |
|---------------------------------------------------|------------------------------------------------------|----------------|--------------------------------------------------|
| New construction of rental apartments             | New construction of rental apartments                | Dwellings      | National Statistical Bureau SCB Sweden           |
| New construction of housing cooperative apartments| New construction of housing cooperative apartments   | Dwellings      | National Statistical Bureau SCB Sweden           |
| Netto of conversions to rental apartments         | Netto of conversions to rental apartments            | Dwellings      | National Statistical Bureau SCB Sweden           |
| Netto of conversions to housing cooperative apartments| Netto of conversions to housing cooperative apartments| Dwellings      | National Statistical Bureau SCB Sweden           |
| Rental apartment stock                            | Rental apartments stock (existing and new construction) | Dwellings      | National Statistical Bureau SCB Sweden           |
| Housing cooperative apartment stock               | Housing cooperative apartments stock (existing and new construction). | Dwellings      | National Statistical Bureau SCB Sweden           |
| Total apartment stock in multifamily buildings    | Total apartments stock (existing and new construction) | Dwellings      | National Statistical Bureau SCB Sweden           |
| Rent per square meter                             | Rent per square meter in existing stock.             | SEK            | National Statistical Bureau SCB Sweden           |
| Apartment price per square meter                  | Apartment price per square meter in existing stock.  | SEK            | Mäklarstatistik Sweden                           |
| Population                                        | Total number of inhabitants.                         | Inhabitants    | National Statistical Bureau SCB Sweden           |
| Population growth                                 | Growth of the total number of inhabitants.           | Inhabitants    | National Statistical Bureau SCB Sweden           |
| Total earned income per capita                    | Total earned income of private persons.              | Thousands SEK  | National Statistical Bureau SCB Sweden           |
| Mortgage interest rate                            | Interest rate for mortgage borrowing.                | Percent        | Central Bank of Sweden and Swedbank Sweden      |
| Variable                                                      | Definition                                                                 | Unit | Data sources                                      |
|---------------------------------------------------------------|---------------------------------------------------------------------------|------|--------------------------------------------------|
| Construction costs per square meter for newly built rental apartments | Construction costs per square meter for new construction of rental apartments | SEK  | National Statistical Bureau SCB Sweden           |
| Land costs per square meter for newly built rental apartments  | Land costs per square meter for new construction of rental apartments       | SEK  | National Statistical Bureau SCB Sweden           |
| Construction costs per square meter for newly built cooperative apartments | Construction costs per square meter for new construction of cooperative apartments | SEK  | National Statistical Bureau SCB Sweden           |
| Land costs per square meter for newly built cooperative apartments | Land costs per square meter for new construction of cooperative apartments   | SEK  | National Statistical Bureau SCB Sweden           |

**Data sources**

Central bank of Sweden Riksbanken (2021). Interest rates. Riksbanken, Sweden. Retrieved from [https://www.riksbank.se/en-gb/statistics/search-interest--exchange-rates/](https://www.riksbank.se/en-gb/statistics/search-interest--exchange-rates/)

Mäklarstatistik Sweden (2021). Apartment prices. Mäklarstatistik Sweden. Retrieved from [https://www.maklarstatistik.se/omrade/riket/](https://www.maklarstatistik.se/omrade/riket/)

National Statistical Bureau SCB Sweden (2021). New construction, property conversions, housing stock, land and construction costs, rent levels. SCB Sweden. Retrieved from [https://www.scb.se/en/finding-statistics/statistics-by-subject-area/housing-construction-and-building/](https://www.scb.se/en/finding-statistics/statistics-by-subject-area/housing-construction-and-building/)

National Statistical Bureau SCB Sweden (2021). Income. SCB Sweden. Retrieved from [https://www.scb.se/en/finding-statistics/statistics-by-subject-area/household-finances/income-and-income-distribution/income-and-tax-statistics/](https://www.scb.se/en/finding-statistics/statistics-by-subject-area/household-finances/income-and-income-distribution/income-and-tax-statistics/)

National Statistical Bureau SCB Sweden (2021). Inflation. SCB Sweden. Retrieved from [https://www.scb.se/en/finding-statistics/statistics-by-subject-area/prices-and-consumption/consumer-price-index/consumer-price-index-cpi/](https://www.scb.se/en/finding-statistics/statistics-by-subject-area/prices-and-consumption/consumer-price-index/consumer-price-index-cpi/)

National Statistical Bureau SCB Sweden (2021). Population. SCB Sweden. Retrieved from [https://www.scb.se/en/finding-statistics/statistics-by-subject-area/population/](https://www.scb.se/en/finding-statistics/statistics-by-subject-area/population/)

Swedbank Sweden (2021). Mortgage interest rates. Swedbank, Sweden. Retrieved from [https://hypotek.swedbank.se/rantor.html](https://hypotek.swedbank.se/rantor.html)
Table A3. Stationarity test for variables.

| Variables                                                      | Level t | Level P  | First difference t | First difference P |
|----------------------------------------------------------------|---------|----------|--------------------|--------------------|
| New construction of rental apartments, dwellings                | -4.8686*** | 0.0000   | -10.4048***        | 0.0000             |
| New construction of housing cooperative apartments, dwellings    | -4.3045*** | 0.0000   | -8.6867***         | 0.0000             |
| Netto of conversions to rental apartments, dwellings             | -5.7540*** | 0.0000   | -8.4685***         | 0.0000             |
| Netto of conversions to housing cooperative apartments, dwellings | -3.5332 *** | 0.0005   | -6.5882***         | 0.0000             |
| Rental apartment stock, dwellings                                | -0.2504  | 0.9954   | -3.0614***         | 0.0046             |
| Housing cooperatives apartment stock, dwellings                  | -1.0147  | 0.8316   | -2.4092**          | 0.0446             |
| Total apartment stock in multifamily buildings, dwellings        | -0.2514  | 0.9956   | -3.4299***         | 0.0007             |
| Rent per square meter, SEK                                       | -1.6756  | 0.5043   | -4.0411***         | 0.0004             |
| Apartment price per square meter, SEK                           | -1.9289  | 0.2290   | -3.7516***         | 0.0003             |
| Population, number of inhabitants                                | -0.2063  | 0.9968   | -2.1576            | 0.1050             |
| Population growth, number of inhabitants                         | -2.5685** | 0.0293   | -4.6846***         | 0.0000             |
| Total earned income per capita, thousands SEK                    | -1.6432  | 0.3667   | -3.7455***         | 0.0002             |
| Mortgage interest rate, percent                                  | -1.4394  | 0.5112   | -6.3066***         | 0.0007             |

Note: The IPS test is based on the individual ADF regressions with an intercept, trend, and first lag of the dependent variable. The test statistic has an asymptotic standardised normal distribution. ** 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 A4. Results of the VIF tests on variables in Model 1.

| Variables                                                      | Model 2a. For rental apartments | Model 2b. For housing cooperatives |
|---------------------------------------------------------------|----------------------------------|-----------------------------------|
| Total stock of multifamily dwellings, number of dwellings     | 1.50                             | 0.6649                            |
| Rent per square meter, SEK                                    | 1.92                             | 0.5198                            |
| Apartment price per square meter, SEK                        | 1.48                             | 0.6775                            |
| Population growth, number of inhabitants                      | 1.10                             | 0.9102                            |
| Total earned income per capita, thousands SEK                 | 5.05                             | 0.1980                            |
| Mortgage interest rate, percent                               | 4.10                             | 0.2441                            |
| Construction costs per square meter for newly built rental apartments, SEK | 2.10                             | 0.4163                            |
| Land costs per square meter for newly built rental apartments, SEK | 2.91                             | 0.3442                            |
| Construction costs per square meter for newly built cooperative apartments, SEK | 2.31                             | 0.4337                            |
| Land costs per square meter for newly built cooperative apartments, SEK | 2.58                             | 0.3882                            |

### Table A5. Results of the VIF tests on variables in Models 2a and 2b.

| Variables                                                      | Model 2a. For rental apartments | Model 2b. For housing cooperatives |
|---------------------------------------------------------------|----------------------------------|-----------------------------------|
| New construction of dwellings, number of dwellings            | 2.75                             | 0.3641                            |
| Rent per square meter, SEK                                    | 1.83                             | 0.5479                            |
| Apartment price per square meter, SEK                        | 1.13                             | 0.8830                            |
| Population growth, number of inhabitants                      | 2.64                             | 0.3795                            |
| Total earned income per capita, thousands SEK                 | 4.73                             | 0.2115                            |
| Mortgage interest rate, percent                               | 3.65                             | 0.2737                            |
| Construction costs per square meter for newly built rental apartments, SEK | 1.74                             | 0.5763                            |
| Land costs per square meter for newly built rental apartments, SEK | 1.82                             | 0.5502                            |
| Construction costs per square meter for newly built cooperative apartments, SEK | 1.47                             | 0.6783                            |
| Land costs per square meter for newly built cooperative apartments, SEK | 1.47                             | 0.6813                            |
**Table A6.** Results of the VIF tests on variables in Models 3a and 3b.

| Variables                                                        | Model 3a. For rental apartments |       | Model 3b. For housing cooperatives |       |
|-----------------------------------------------------------------|----------------------------------|-------|------------------------------------|-------|
|                                                                | VIF  | Tolerance | VIF  | Tolerance |
| Netto of dwelling conversions, number of dwellings               | 2.50 | 0.4001     | 1.73 | 0.5789     |
| Rent per square meter, SEK                                       | 2.01 | 0.4971     | 1.84 | 0.5445     |
| Apartment price per square meter, SEK                           | 1.12 | 0.8936     | 1.37 | 0.7326     |
| Population growth, number of inhabitants                        | 2.45 | 0.4079     | 1.59 | 0.6283     |
| Total earned income per capita, thousands SEK                    | 4.20 | 0.2379     | 4.19 | 0.2389     |
| Mortgage interest rate, percent                                  | 3.29 | 0.3039     | 3.38 | 0.2962     |

**Table A7.** Results of the VIF tests on variables in Models 4a and 4b.

| Variables                                                        | Model 4a. For rental apartments |       | Model 4b. For housing cooperatives |       |
|-----------------------------------------------------------------|----------------------------------|-------|------------------------------------|-------|
|                                                                | VIF  | Tolerance | VIF  | Tolerance |
| Total new construction of dwellings in multifamily housing, number of dwellings | 21.88 | 0.0457     | 23.09 | 0.0433     |
| New construction of rental apartments, number of dwellings       | 12.72 | 0.0786     |       |           |
| New construction of housing cooperative apartments, number of dwellings |       |           | 25.70 | 0.0389     |
| Rent per square meter, SEK                                       | 2.00 | 0.4998     | 2.26  | 0.4432     |
| Apartment price per square meter, SEK                           | 1.17 | 0.8549     | 1.35  | 0.7423     |
| Population growth, number of inhabitants                        | 5.19 | 0.1927     | 5.77  | 0.1733     |
| Total earned income per capita, thousands SEK                    | 5.05 | 0.1979     | 4.95  | 0.2021     |
| Mortgage interest rate, percent                                  | 3.66 | 0.2730     | 3.57  | 0.2804     |
| Construction costs per square meter for newly built rental apartments, SEK | 1.75 | 0.5725     |       |           |
| Land costs per square meter for newly built rental apartments, SEK | 1.82 | 0.5495     |       |           |
| Construction costs per square meter for newly built cooperative apartments, SEK |       |           | 1.47  | 0.6782     |
| Land costs per square meter for newly built cooperative apartments, SEK |       |           | 1.56  | 0.6419     |
Table A8. Results of the VIF tests on variables in Models 5a and 5b.

| Variables | Model 5a. For rental apartments | Model 5b. For housing cooperatives |
|-----------|---------------------------------|----------------------------------|
|           | VIF    | Tolerance | VIF    | Tolerance |
| Total netto of dwelling conversions, number of dwellings | 4.60   | 0.2174    | 30.36  | 0.0329    |
| Netto of dwelling conversions to rental apartments, number of dwellings | 5.43   | 0.1843    |        |           |
| Netto of dwelling conversions to housing cooperative apartments, number of dwellings |        |           | 24.75  | 0.0404    |
| Rent per square meter, SEK | 2.01   | 0.4971    | 1.94   | 0.5145    |
| Apartment price per square meter, SEK | 1.41   | 0.7110    | 1.41   | 0.7091    |
| Population growth, number of inhabitants | 2.48   | 0.4025    | 2.75   | 0.3640    |
| Total earned income per capita, thousands SEK | 4.45   | 0.2245    | 4.34   | 0.2303    |
| Mortgage interest rate, percent | 3.36   | 0.2975    | 3.45   | 0.2896    |