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Abstract:

We can observe a trend of smaller housing units in new residential construction in many countries with rapid urban growth. It is of interest to recognize the driving forces that are behind this trend because if it sustains in the long run, as both positive and negative consequences for sustainable development of the housing market can be expected. Therefore, the purpose of this paper is to examine the main underlying factors affecting the average size of apartments in new construction in metropolitan areas in Sweden. Panel data methodology applied in the analysis. The model uses the average size of an apartment in new housing construction as a function of the changes in the population, apartment prices, mortgage interest rates, rents, land prices, building permits per capita. We estimate the interrelationship between apartment size and these variables through simultaneous equation models. The data covers both the rental and the cooperative housing sectors over 24-28 years depending on availability of variables. The analysis demonstrates that the land values and building policies, along with market fundamentals, are the underlying factors that affect the average size of an apartment in new residential construction. Opposite to previous studies that focus on explaining the number of new housing, we analyze the average size of new housing units and factors that affect it on an aggregated level.

Keywords Apartment size, Housing market, New construction, Land and Building policies

JEL-code: R14, R31, R52

1. Introduction

Sweden is, among many, one of the countries that are experiencing a shortage of housing due to, among other things, rapid urban growth and low level of residential construction. About 83% of the counties in Sweden reported a shortage of housing in 2019. Around 94% of the Swedish population reside in those counties (Boverket, 2019). The situation is more difficult in larger urban regions like Stockholm, Gothenburg, and Malmö, where it takes up between 8-12 years to get a rental apartment in the inner city than in small and medium-sized cities (Bostadsförmedlingen, 2018).

Apartments, including both rental housing and housing cooperatives, are an important part of the urban housing stock. Along with rapid urban development in recent years, which results in fast growth of urban residential construction, one can observe some new trends in apartment construction itself – for example, the emergence of new forms of apartments, like studio apartments and micro-apartments, along with decreasing average size of apartments and housing affordability problems due to housing price appreciations. Market analysts report that *“The average size of new apartments in the U.S. in 2018 is 941 square feet, 5 percent smaller than ten years ago, with studio apartments shrinking the most, by more than 10 percent; meanwhile, overall rents have increased by 28% over the same period of time.”* (Rent Café report, 2018).

Infranca (2013) points out efforts of city planners, business leaders, and local officials towards a more affordable new supply as a respond to changing demographics in New York City. This affordability trend in residential development together with increased urbanization has led to the emergence of micro-apartments in the USA (Burinsky, 2017; Ross, 2013).

Clinton (2019) has surveyed people who have bought micro-apartments in Sydney, Australia. Most respondents explained that they did not actively seek out this kind of dwelling form, but rather that they stumbled across it when looking for conventional studios. This might imply that smaller apartments are not a question of household preferences, but rather the lack of choice that is coming from the supply side. According to Clinton (2019), Australian occupants of micro-apartments perceived affordability as more than a numerical threshold, but rather as a relative and qualitative concept which considers both the price and quality of comparable dwellings. The final users (renters and buyers) of the apartments might not perceive this downsizing since smaller apartment size might be considered as a result of improvement of

construction technologies, architectural efforts towards more effective use of the apartment area and government policies to increase the affordability of the housing market for different population groups like younger people and households with low income.

One more explanation behind this trend might be simply the “new ways of living” coming from the demand side. Indeed, a more flexible working market makes people live in more accessible locations but sacrifice in size in exchange for more affordable rents or monthly mortgage payments (Clinton, 2019).

Furthermore, these trends from demand-side are also exacerbated by the continuous growth of land prices and more restrictive local housing policies. Hulse and Yates (2017) argue that high land prices in inner urban areas of major capitals in Australia lead to redevelopment of previously underutilized land, and construction of smaller dwelling units. It is not surprising that population density increase when land prices increase. Hence, the land policy by the municipality may be one important factor that explains the construction of smaller apartments. Construction in a more central location within the urban area can also explain the trend of smaller apartments. Therefore, the building permit policy by the municipality may be another important factor that explains the construction of smaller apartments.

Randolph (2006) notes that the desire to accommodate smaller households with higher density centers may lead to a degree of urban spatial segregation based on lifestyle or life stages. Singles, couples, and empty nesters will become concentrated in flats in high-density centers while large household families will be consigned to houses in lower-density areas. Higher-density developments should be included in a mix of flats with various sizes in order to achieve socially inclusive cities with more balanced communities (Randolph, 2006; Talen 2002).

On the other hand, the construction of smaller apartments can also be associated with lower energy consumption per capita since the amount of energy used is related to the number of residents, which is determined by the total size of the apartment’s area (Danielski, 2011). Building smaller apartments can be a good long-term strategy for increasing density and reducing human footprints on the environment, thus meeting the Sustainable Development Goals stated by the United Nations.

According to data from Statistics Sweden, construction activity is in tandem with demographic trends, with some tendency to slow down in recent years. In other words, supply seems to be in

line with population growth, and the number of people per dwelling unit does not vary a lot in the last two decades. (SCB, authors calculations). However, the share of "smaller apartments" in the new construction has increased in recent years. 6 out of 10 new apartments are two-room apartments or smaller, while the share of similar size apartments in existing stock is about half of the total apartments stock. There is a certain difference in the housing tenure forms because the bigger quantity of rental apartments are build as "small apartments" in comparison with housing cooperatives sector. Only 5 percent of all new constructed apartments have five rooms or more, which is smaller in comparison with the share of apartments of similar size in the existing stock. The typical apartment that is build in both in rental and housing cooperatives sector is two room apartment with a kitchen. (Region Stockholm, 2019).

Decreasing housing size might lead to different kinds of adverse socio-economic effects in the longer run (Boverkett, 2016) and an impediment to the sustainable development of the housing market in Sweden. Thus, it is interesting to analyze factors that affect the downsizing of apartments in new housing construction in larger urban regions with particular focus on how land values and land policies contribute to potential unbalances in the housing market. The aim of this paper is, therefore, to explore the following issues:

- What are the significant factors that contribute to the downsizing of apartments in new housing construction in rental and housing cooperative sectors in the major urban regions in Sweden?
- What is the effect of land and building permits regulations on the downsizing in new housing construction in the major urban regions in Sweden?

Contrary to previous studies that focus on the number of new housing, we analyze the average size of new housing units and factors that affect it on an aggregated level. We estimate the interrelationship between apartment size and relevant variables through simultaneous equation models. The data covers both the rental and the cooperative housing sectors for period over 24 years. Our analysis demonstrates that the land values and building policies, along with market fundamentals, are the underlying factors that affect the average size of an apartment in new residential construction.

The rest of this paper organized as follows: Section 2 provides a brief literature review on factors affecting new construction. Section 3 provides an overview of the econometric

methodology and explains the theoretical model used in this paper, as well as a description of the data. Section 4 contains the empirical results of the regressions and discussions of the results. Finally, section 5 contains conclusions and further research suggestions.

2. Literature review and the theoretical framework

A brief literature review

Numerous studies on new housing constructions focus on price and construction costs as the main determinants of the new housing supply. Skitmore et al. (2006) examine two main theories that are used to explain the construction contract pricing: classical microeconomic theory and full-cost pricing theory. They underlined that in the construction industry, it is clear that firms are market-aware and concerned with both production costs and market prices. Construction prices are market-driven, i.e., the level of demand and supply determined them. The construction contractors are "price-takers". If prices are too high, the lower the demand for construction will be. If prices are too low to cover the underlying construction costs, the construction will decrease. There are also other factors considered to be relevant to the price elasticity of the new housing supply. Meikle (2001) analyzed the trends in house construction and land prices in Great Britain and argues that the price of land is the most significant non-construction element of house prices. The price of land has risen faster than house prices and much higher than construction costs.

Akintoye and Skitmore (1994) have grouped the general factors of construction demand for the UK into the following: economic conditions, construction price, real interest rate, unemployment level, and profitability. They analyzed construction demand in the UK for the period 1974-1988 and found that construction demand is negatively correlated with construction price level and positively correlated with GNP and real interest rate.

Tang et al. (1990) have, in an early article, estimated the demand for residential construction in Thailand with data between 1976-1985. Their results indicate that rising per capita income, the ratio of consumer price index to construction costs index and population are significant determinants of demand for residential construction. Similarly, Hua (1996) has presented an extended list of economic and social indicators that are relevant for the analysis of demand for residential construction. He analyzed the demand for residential construction in Singapore for the period of 1975-1993. He used several indicators in his model: GDP per capita, overall demand for construction, real GDP, building material price index, money supply, household

personal savings, homeownership rate, inflation rate, prime lending rate, property price index, labor force, unemployment rate. All indicators were significant, though the signs for some of them, like for example, for lending rate and unemployment, were not in line with theory.

Meikle (2001) claims that demand for housing is related to changes in the number of households seeking housing due to the natural increases in population and increased household formation (the average size of households is falling) as well as regional population shifts and losses to stock through demolition or redevelopment. Riddel (2004) examined housing market price and stock dynamics in USA in 1967-1998. Her results suggest that income and price are important factors in determining long-run housing demand. Rents and changes in interest rates effect are moderate. She argues that supply fails to respond adequately to price changes causing the disequilibrium in housing market. Choy et al. (2011) have analyzed the residential construction demand by using a panel dataset from 31 Chinese regions for the period between 2001 and 2006. They have found that that change in population, income, and business confidence are the primary determinants that cause residential investment to vary among different regions. Real interest rates and planning regulations have modest impacts on residential investment. Moreover, Fan et al. (2011) have tested different models for predicting construction demand for Hong Kong. They concluded that local GDP and interest rates primarily drive overall construction demand.

DiPasquale and Wheaton's (1994) demonstrated that financing costs together with construction costs and land values determines the construction supply in USA. Prices for new homes effect new construction to a higher extend than existing house prices. Blackley (1999) estimated the long run elasticity of housing supply in USA. He argues that housing price is determined by cost factors and housing quantity is determined by demand factors such as income and demographic characteristics. Mayer and Somerville (2000) reported that changes in housing prices and interest rates have impact on housing construction in USA. Neto (2005) provides evidence that production side variables, such as land, raw material and labour costs play an important role in the determination of new housing production in Spain. Wigren and Wilhelmsson (2007) analyzed the European housing market for the period 1976-1999, and their finding indicates that the price and cost elasticity of housing supply is low. According to Owusu-Ansah (2014), the main factors that affect new housing construction may be grouped into five major groups: house prices, costs of construction, and interest rate as well as planning regulation and market conditions.

Ball (2003) examined markets and the structure of the housebuilding industry in several countries in Europe and concluded that institutional and industrial efficiency are factors that explain changes in supply. Ball et al. (2010) have analyzed price elasticities of supply in the UK, US, and Australia, and found that planning regulation does affect the supply elasticities both at local and national levels.

In more recent literature, Oikarinen et al. (2015) analyze the link between housing construction and local factors in Finland, which mainly have a low population density and dispersed population. They conclude that, above all, local and specific phenomena are what can explain the supply of housing. Their results mainly follow the results they have found in studies that analyze housing markets in the USA. Geographical constraints and local restrictions, such as zoning, can account for 80 percent of the variation in supply elasticity. Jackson (2016) analyzes whether land-use restrictions have an impact on the number of completed housing projects. Moreover, the results indicate that land-use restrictions have an impact on the number of building projects granted. Of the regulations, it is zoning and general control that has the most significant impact.

Gyourko and Molloy (2015) review the literature on regulation and housing supply. They focus on both the causes and the effects of regulations. They conclude that regulations have a significant effect on housing prices, housing construction, resilience, and how the city is shaped. Recently, Glaeser and Gyourko (2018) discuss in their article the economic effects of housing supply restrictions. They conclude that cities with a high degree of regulation will have higher prices and a population growth that is lower than it would otherwise be. The economic consequences of this are that it will have an impact on the distribution of wealth in the economy, and it will affect productivity. The former is that those who own their accommodation will have higher real wealth relative to those who rent their accommodation. The latter is an effect that the regions with restrictions on construction will make it more challenging to move to, which in the long run will affect the labor market and productivity. We do not explicitly use different types of land use restrictions in our analysis, but instead, we use the building permits per capita directly as a measure of the number of local restrictions.

In addition, preferences of individual households can play a role in the demand for small apartment sizes. An analysis conducted by Bollo (2015) shows that market conditions, federal regulations, building and health codes, and local housing preferences are the four driving forces of the housing size changes. Bolo (2015) refers to Wright (1981), who stated how housing

authorities used the construction of small dwellings in new projects in order to discourage tenants from large families. This approach of using apartment size as a means of family planning was not effective and resulted in over-crowding (Bolo, 2015). Proximity to public transport, affordability, and flexibility to move out later are factors considered by households for living in small units (Lau & Wei, 2018).

To conclude, previous research lacks studies that investigate different factors that affect the size of the housing unit in the new supply. It is important to put attention on it because even if the quantity of the new housing supply expressed in the number of housing dwellings might follow the demographic and economic trends, the relative quantity of the new supply might be different due to changes in the average size of the new housing unit constructed. Bolo (2015) concluded that *“the subject of dwelling size and dwelling size changes is interdisciplinary, simultaneously architectural, sociological and political, and a compelling topic for further study.”*

The theoretical model

We follow DiPasquale and Wheaton's (1994) theoretical framework for housing market equilibrium. Recently the theoretical model been used in, for example, Antoniucci and Marella (2016) and Murphy (2018).

DiPasquale and Wheaton's (1994) underline that though the general approach in theoretical studies with no capital constraints is that the demand for owner/occupied housing should depend only upon the relative annual costs of owning as opposed to renting. However, in most empirical studies, demand depends separately upon price levels, interest rates, and average rents (DiPasquale and Wheaton, 1994). The long-term housing demand (Q_t^D) might be expressed as a function of price (P) and a set of demand variables (X):

$$Q_t^D = \alpha_0 + \alpha_1 P_t + \alpha_2 X_t \quad (1)$$

The long-term equilibrium stock (Q_t^S) is expressed as a function of price (P) and exogenous variables (Y):

$$Q_t^S = \beta_0 + \beta_1 P_t + \beta_2 Y_t \quad (2)$$

Where the variables included in vector Y are factor costs and various interest rates, DiPasquale and Wheaton (1994) note that if Q_t^S is measured in units, then the demand function in equation (1) reflects household formation decisions as well as tenure choice. Alternatively, if Q_t^S is

measured in money units, then the demand function combines decisions about not only household formation and tenure choice but also the consumption of housing services.

Differing from DiPasquale and Wheaton (1994), we apply the model that measures the Q_t^S as the average size of housing units in the new construction of apartments. In other words, we descale the total quantity of the square meters in new construction on an aggregated level to the number of square meters of the average housing unit in new construction, which reflects the number of square meters supplied in newly constructed per one household/one housing unit. A long-run equilibrium on the housing market is described as:

$$Q_t^D = Q_t^S \quad (3)$$

where Q_t^S is equal to supplied quantity, and Q_t^D is equal to the demanded quantity. Subscript t is the period. We transform equation (3) in such a way that in our model Q_t^S is equal to the average size of the supplied housing unit (apartment), and Q_t^D is equal to the average size of the demanded housing unit (apartment). Thus, following the approach used by Warsame *et al.* (2010), we have:

$$Q_t^D = \alpha_0 - \alpha_1 P_t + \alpha_2 X_{1t} - \alpha_3 X_{2t} \quad (4a)$$

$$Q_t^S = \beta_0 + \beta_1 P_t - \beta_2 Y_{1t} + \beta_3 Y_{2t} \quad (4b)$$

where P is equal to price, X_1 is equal to other positive demand determinants such as the growth of population and disposable income, and X_2 is equal to negative determinants such as the growth of land prices and mortgage interest rate. Y_1 is equal to negative supply determinants such as the growth of land prices and construction costs, and Y_2 represents positive supply determinants such as the growth of rents and prices on the secondary housing market. In equilibrium, the quantity demanded is equal to quantity supplied. Solving for equilibrium between supply and demand (Q^*) we get equation (5):

$$Q^* = \delta_0 + \delta_1 X_{1t} - \delta_2 X_{2t} - \delta_3 Y_{1t} + \delta_4 Y_{2t} \quad (5)$$

where:

$$\delta_0 = \frac{1}{\alpha_1 + \beta_1} \left(\frac{\alpha_0}{\alpha_1} + \frac{\beta_0}{\beta_1} \right); \delta_1 = \frac{\alpha_2}{\alpha_1(\alpha_1 + \beta_1)}; \delta_2 = \frac{\alpha_3}{\alpha_1(\alpha_1 + \beta_1)}; \delta_3 = \frac{\beta_2}{\beta_1(\alpha_1 + \beta_1)}; \text{ and } \delta_4 = \frac{\beta_3}{\beta_1(\alpha_1 + \beta_1)}.$$

All estimations in this paper will be based on equation (5).

3. Empirical model and data description

Empirical model

Our model analyzes long-run demand and supply for new apartments in the three major urban regions in Sweden. The model divides the housing sectors into renter and cooperative housing since these two are the major forms of housing tenure for the apartment segment of the housing market in Sweden. These two subsectors are interconnected and affect each other in two ways. The price of renting an apartment in comparison to buying affects the number of households who rent or buy new apartments. The total demand for urban land depends on the total demand for new apartments in each subsector. The system of equations representing these subsectors represents these markets in our model of the urban housing sector.

The aggregate tenant demand in the rental sector depends on the price of rental housing services relative to the price of other goods, average disposable *income*, the number of *households* (renters). The aggregate supply of rental apartments, in the long run, depends on the *rent* for rental services, *interest rate*, and *construction costs*.

The aggregate tenant demand in the housing cooperatives sector depends on the price per square meter relative to the price of other goods, average disposable *income*, the number of *households* (potential buyers looking for a new apartment). The aggregate supply of housing cooperatives apartments, in the long run, depends on the *price* per square meter, *interest rate*, and *construction costs*.

Though there might be some differences in factors mentioned above, like for example, differences in the average income or preferences in the type of housing for population, this formulation of fundamental factors affecting demand and supply in rental and housing cooperatives sectors is in line with previous studies in the literature review.

Land is an essential component in the provision of the housing services, and its supply is not elastic. In the market, investors (or property owners), demand rental and housing cooperatives properties, and property developers build them. The long-run supply of rental and housing cooperatives properties depend on the investment values of real estate *land prices* and other components such as the price for building materials and wages for construction workers. The price of land in urban areas depends on the quantity of the new housing produced on the market in both rental and housing cooperatives sectors.

One more component to be added to the model is the number of *building permits* per capita. It works as a proxy for more/less permissive type of building policies in the municipality. An indirect measure used as an approximation of regulation is to include the gap between house prices and construction cost, as in Glaeser *et al.* (2005). Even if both housing prices and construction costs are included in our model, we utilize the number of building permits per capita as a direct measure of regulation. Likewise, we include land prices as a direct measure of land price policy. An alternative could be to include the gap between house prices or rent and land prices as an indirect measure of land price regulation.

Modeling approach

We follow the standard econometric methodology and focus on the estimation of a set of equations with panel data. Our dataset contains data for three major urban areas in Sweden and covers more than 24 years on an annual basis. It covers both rental and housing cooperatives market of new construction. Thus, we intend to estimate the equations jointly: first, to allow cross-equation restrictions to be imposed or tested, and second, to gain efficiency, since we might expect the error terms across equations to be contemporaneously correlated. Such equations are often called seemingly unrelated regressions (SUR), which was proposed by Zellner (1962).

According to Wooldridge (2009), the SUR estimator is used if N in the dataset is small, say $N < 10$. Examples of SUR equations might be a set of demand equations across different sectors, industries, or regions. Zellner's (1962) approach is simplified since it captures the efficiency due to the correlation of the disturbances across equations. It matches well to our dataset since there might be factors that affect the dependent variable (average size of apartment) jointly both in the rental and the housing cooperatives sector, and we might expect the error terms across equations are correlated. Thus, the joint set of equations for SUR estimations in equation (6) will be:

$$\begin{aligned} Q_r^* &= \delta_0 + \delta_1 X_{1t} - \delta_2 X_{2t} - \delta_3 Y_{1t} + \delta_4 Y_{2t} \\ Q_b^* &= \delta_0 + \delta_1 X_{1t} - \delta_2 X_{2t} - \delta_3 Y_{1t} + \delta_4 Y_{2t} \end{aligned} \tag{6}$$

where Q_r^* is the equilibrium size of an apartment in new construction in the rental sector, and Q_b^* is the same for the housing cooperatives sector.

Data description

The dataset comprises annual data on several variables for 28 years, covering the period from 1991 to 2018. The data for the average apartment area in new build apartments include the period from 1994 to 2017, that is, 24 years. The majority of data come from Statistic Sweden, except for variables such as prices per square meter for apartments and single-family homes that come from the company Mäklarstatistik¹. Mortgage interest rates come from the Swedbank.

The number of building permits per capita is calculated as the number of building permits issued by the city council in each city over the population within its area. All economic variables are transformed into real terms. Table 1 presents the definition and the summary statistics of the variables.

Table 1: Summary statistics of data

Variables	Unit	Number of observations	Average	Standard deviation	Minimum	Maximum
Average apartment area for newly build rental apartments	m ²	70	71.27616	6.969403	59.95862	98.77792
Average apartment area for newly build cooperative apartments	Swedish crowns (SEK)	70	79.75369	8.286576	63.4912	100.9552
Population	Number of people	87	1142741	585846.9	529315	2344124
Annual population change	Number of people	84	13743.87	10169.43	3394	39083
Mortgage interest rate	%	78	3.358928	2.089622	0.0953882	7.729706
Disposable income per year	Thousands of SEK	69	154.9579	41.63621	90.22888	237.7326
Rent per square meter in rental apartments	SEK	47	981.5061	128.4854	778.1182	1230.962
Price per square meter for cooperative apartments	SEK	69	24751.22	17221.65	2934.346	71402.31
Land costs per square meter for newly build rental apartments	SEK	70	2563.476	1315.282	695.5837	6419.174
Land costs per square meter for newly build cooperative apartments	SEK	70	6607.923	4493.704	1118.098	21047.41
Building permits for multifamily houses	Number	69	3666.435	3552.095	240	14797
Building permits for multifamily houses per capita	Number	69	.0028331	.0019265	.0003344	.0079983

¹ Mäklarstatistik is a company that collects data about transactions on housing market in Sweden. Web-site: <https://www.maklarstatistik.se/>

As is seen from Table 1, the average apartment area is about 71 square meters and 80 square meters for newly build rental apartments and cooperative apartments, respectively. The annual population change in major Swedish cities is 13,744, which is 1.2 percent growth to the average population within its areas. The average mortgage interest rate is about 3.36 percent, with a minimum of 0.1 percent and a maximum of 7.7 percent. The average disposable income is 155.0 thousand SEK per year, with a standard deviation of 41.6 thousand SEK.

The average price per square meter for housing cooperatives is 24,751 SEK per square meter. The average annual rent is 982 SEK per square meter. Average land costs per square meter for newly build rental apartments are 2,563 SEK, which is 2.6 times less than for cooperative apartments, which is 6,608 SEK per square meter. The average number of building permits for multifamily houses is 3,666 per year, which contributes to 0.0028 building permits per capita on average or 2.8 building permits per 1,000 inhabitants of major cities in Sweden.

4. Results and discussion

Pre-test of data

Macroeconomic data are often non-stationary with means, variances, and covariances that change over time. We follow the standard econometric procedure by first checking the data for stationarity. We apply Im–Pesaran–Shin (IPS) test for testing unit root in data. Im–Pesaran–Shin (2003) developed a set of tests that relax the assumption of a common autoregressive parameter such as cultural, institutional, and other factors. Moreover, the IPS test does not need balanced datasets. Since property market dynamics depends very much on location, this test is the most appropriate for the type of data we have.

Tables 2 presents the results obtained from the stationarity test. In order to obtain consistent, reliable results, the non-stationary data transformed into stationary data by taking first differences on variable levels. The results show that all first-difference variables are integrated of order 0, that is, all variables are stationary. Therefore, in *models 1* and *2* below the dependent variable average apartment area in newly build apartment is taken in levels, while all independent variables except building permits per capita for multifamily houses are taken on first differences.

Table 2: Stationarity test for variables transformed to natural logarithms

Variables	Level		First-difference	
	t-bar	P-value	t-stat	P-value
Average apartment area for newly build rental apartments	-4.2396	0.0001***	-6.5740	0.0000***
Average apartment area for newly build cooperative apartments	-4.2396	0.0001***	-6.5740	0.0000***
Population	0.1775	0.998	-2.2293	0.0838*
Annual population change	-2.6921	0.0188**	-4.7233	0.0000***
Mortgage interest rate	1.1698	0.9995	-3.3777	0.0386**
Disposable income per year	-2.1121	0.1284	-5.1196	0.0000***
Rent per sqm in rental apartments	-1.6210	0.5230	-3.5808	0.0023***
Price per square meter for cooperative apartments	-1.6713	0.3654	-3.7103	0.0006***
Land costs per square meter for newly build rental apartments	-3.1000	0.0055***	-6.9198	0.0000***
Land costs per square meter for newly build cooperative apartments	-3.1000	0.0055***	-6.9198	0.0000***
Building permits for multifamily houses	-3.9891	0.0003***	-8.8965	0.0000***
Building permits for multifamily houses per capita	-3.8461	0.0006***	-8.9057	0.0000***

Note:

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

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

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

Regression results

We adjust for small-sample and estimate the Breusch–Pagan test for independent equations. The default is the two-step SUR estimation (*Model 1*). Because SUR estimation reduces to OLS if the same set of regressors appears in each equation, we omit some variables from the first equation for the rental sector and another variable from the second equation for the housing cooperatives sector (*Model 2*). We estimate the correlation matrix for the fitted residuals that are used to form a test of the independence of the errors in the two equations. The results from the SUR estimations are presented next.

Table 3: SUR Regression results on model for first differences

Variable	Coefficient	
	Model 1	Model 2
Ln of Area in rental apartments		
Obs:	55	55
R-sq	0.5256	0.5131
F-stat	8.86	15.50
P	0.0000	0.0000
Population change	-0.1083663***	-0.1069383***
Disposable income	2.024364***	2.182995***

Variable	Coefficient	
	Model 1	Model 2
Mortgage interest rate	0.0111049	-
Rent per square meter in rental apartments	0.6556687**	0.9343258***
Price per square meter in cooperative apartments	0.0469981	-
Land costs per square meter in rental apartments	-0.0354319*	-0.0365979*
Building permits per capita for multifamily houses	-0.0434411***	-0.0444545***
Ln of Area in cooperative apartments		
Obs:	55	55
R-sq	0.5840	0.5731
F-stat	11.58	14.22
P	0.0000	0.0000
Population change	-0.0298085	-0.0313548
Disposable income	1.967134***	2.196959***
Mortgage interest rate	0.0423004***	0.0292725***
Rent per square meter in rental apartments	-0.3792538	-
Price per square meter in cooperative apartments	0.1813644	-0.1368541**
Land costs per square meter in cooperative apartments	-0.0591849**	-0.0592054**
Building permits per capita for multifamily houses	-0.0774874***	-0.0775536***
Correlation matrix of residuals	0.8413	0.8290
Breush-Pagan test of independence:		
chi2(1)	38.924	37.802
P	0.0000	0.0000

Note:

* denotes statistical significance 10 percent level.

** denotes statistical significance 5 percent level.

*** denotes statistical significance 1 percent level.

We have obtained the following results for *Model 1*: A test of the joint significance of all regressors in the equation for the rental sector has a value of 52.56% with a p-value of 0.000 and 58.40% for housing cooperatives sector with a p-value of 0.000. Almost all of regressors are jointly significant at 1% level. The interest rate and price per square meter are not significant in the rental equation. Population change, rent per square meter, and price per square meter are not significant in the housing cooperatives equation. The errors in the two equations are positively correlated, with a correlation coefficient of 84.13%. The correlation is strong, so the efficiency gains to SUR estimation is substantial. The Breush-Pagan Lagrange multiplier test for error independence indicates a statistically significant correlation between the errors in two equations, as should be expected because two categories of the average size of the apartment may have similar underlying determinants.

The most influential factor that affects the size of apartment size in new construction in both rental and housing cooperatives sector is disposable income. Population change seems to be important for apartment size in the rental sector, but not in housing cooperatives. Land costs per square meter and building permits per capita have both negative impacts and are significant.

Model 1 demonstrates that interest rate and price per square meter for housing cooperatives do not affect the apartment size in construction in the rental sector. At the same time, rent per square meter is not significant for apartment size in housing cooperatives sectors. *Model 2* is estimated without insignificant factors from *Model 1*.

The overall results for *Model 2* indicate that we explain around 51 percent of the variation in the apartment size in newly constructed residentials in the rental sector. On the other hand, we explain around 57 percent of the variation in the average apartment size in the cooperative housing sector. Hence, it seems that the fundamental variables explain the variation in apartment size better in the less regulated market than in the more regulated market, such as the rental sector where the rents are subject to rent control. The F-statistics indicates that we can reject the null-hypothesis that all coefficients jointly are equal to zero. The Breush-Pagan Lagrange multiplier test for error independence indicates a statistically significant correlation between the errors in two equations.

Model 2 explains the variation in apartment size across the regions and over time. The result seems to suggest that all fundamental variables are statistically significantly different from zero in the model concerning the rental sector. The estimated parameter concerning the change in population is significant and negative. The adverse effects of average apartment size can be observed concerning land prices. Higher land prices will cause the developers to build smaller rental apartments. However, higher income leads to larger apartments. Rents are related to apartment size, that is, higher rent level growth leads to larger apartments and vice versa. Interesting to note that building permits per capita have an adverse impact on apartment size in the rental sector.

If we are analyzing the results from the cooperative housing market in *Model 2*, we can observe that income will have a positive impact on the rental market. Population growth has a negative impact on the size, but it turned to be insignificant. The interest rate has a positive impact on constructed apartment size. Though interest rates have decreased during recent decades, the housing prices went up a lot, which resulted in the building of smaller cooperative apartments. Land prices also have significant and negative affect on average apartment size. Building permits per capita is statistically significant from zero, indicating that building permit regulation is important, though the effect is negative.

Discussion

As can be noticed from the results, land and building permits policies do contribute to a gradual decrease in average apartment size in the long run. We can observe these effects for both rental and housing cooperatives subsectors of the housing market.

Keeping in mind the fact that new construction contributes only about 1-2 percent of the total housing stock, and therefore might not be considered as a significant change in the structure of the housing market, the impact of these changes should not be neglected. Moreover, the state of the new construction and the economic indicators like prices or rent levels affect existing housing stock through spillover effects and play an essential role in providing the information needed for evaluating this development and analyzing the current state of the housing market.

As it is presented in the results of this paper, the most influential factor that affects the size of apartments in new construction both in rental and housing cooperatives sector is disposable income. Its effect is strongly positive, i.e., the higher the disposable income, the higher the average apartment area that will be demanded by final consumers of the housing goods. The lower the disposable income, the process will go in the opposite direction.

However, in the environment with low inflation and the rate of economic growth lower than expected, it is difficult to expect a significant increase in real earnings rates. This makes us have a look at other factors like land and building policies that might explain the downsizing process in the final housing good that is produced.

What will be the implications of this process if it will sustain in the future? Average dwelling size and quality change over time. The housing market is operating in a low-interest-rate environment during recent decades. However, it does not lead to an increase in housing supply, but rather decrease in the size of the final product of construction (i.e., apartment dwelling), which in turn creates an environment where the house prices are not falling over the long term (due to so-called “sticky prices”), and since mortgage loans finance housing, we can instead observe growth in household debt.

Another important implication is that decrease in apartment sizes will lead to an increase in the density of population in large urban regions. It might have negative socio-economic consequences, like overcrowding and higher risk for socio-psychological problems and infectious disease spread.

5. Conclusion and policy implications

In line with the main objectives of this paper, we can draw several conclusions. The primary factor that affects the size of the new apartments in new residential construction is disposable income. The effect is positive and strong in comparison with other fundamentals. However, we can conclude that the main factors that bring adverse effects and contribute to downsizing of the final housing product are land prices and building policies. More expensive the land allocated to residential construction, the smaller the apartment sizes that will be built in the longer run. We expected that more restrictive building policies contribute positively to downsizing of the apartment area since developers that operate in the environment with building constraints compensate these high land prices by sacrificing on size of the final housing goods produced. Our result does not support this hypothesis.

Several lessons can be learned from this study: In a market with building policies restrictions and high land prices, the housing market will react in downsizing the final product to the consumer instead of decreasing the price. This implies deviations from sustainable development in housing markets in the long run, which happens through short term adjustments in construction. Moreover, the unregulated market, like the cooperative housing sector in Sweden, reacts more significantly to these changes in comparison to a regulated market like the rental apartment sector in the Swedish housing market. Therefore, building policies should be formulated and applied in a way to avoid these deviations from sustainable development in the long run.

CRedit author statement

Sviatlana Engerstam: Conceptualization, Methodology, Data collecting and analysis, Software, Original draft, Reviewing; **Abukar Warsame:** Initial idea, Supervision, Reviewing; **Mats Wilhelmsson:** Supervision, Methodology, Reviewing.

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