LUND UNIVERSITY

School of Economics and Management

Tobin's q – what to do?

A study of the relationship between

the Swedish housing supply and Tobin's q

Authors: Sofia Duvander and Elvira Forsberg

Supervisor: Claes Bäckman

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Abstract

This thesis concerns the Swedish housing market, which is under constant debate. Prices keep increasing and many believe that this trend will consist due to low interest rates, high demand and lack of attractive building land. This tendency, resulting in a housing shortage, is particularly evident in the metropolitan areas.

Earlier research states that the well-known Tobin's q theory has a short-run, as well as a long-run, impact on housing supply and housing investment. Therefore, this thesis seeks to analyse whether Tobin's q can contribute with an increased understanding of the underlying reasons behind the ongoing housing shortage in Sweden. Except for the usage of up-to-date data, our study additionally presents new perspectives in terms of regional division and dwelling types.

The relationship between regional dwelling starts and Tobin's q is tested through an Error Correction Model as well as standard OLS, depending on the cointegrating relationship. The results of the estimations show that short-run relationships are found for all metropolitan areas concerning one- or two-dwellings, yet only for one metropolitan area upon investigating multi-dwellings. Furthermore, there is a long-run relationship and error correcting mechanism between building starts and Tobin's q for a minority of the examined regions and dwelling types. In the cases of statistically insignificant estimation results, this is interpreted as an indication of the housing markets in these regions not functioning properly and there are hence other factors affecting the housing supply. It is further concluded that an intervention on these markets is necessary to potentially improve the market conditions, ideally resulting in the number of dwelling starts being directly related to indications of Tobin's q.

Key words: housing supply, Tobin's q, housing shortage, ECM, OLS

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1. Introduction

There are many opinions and concerns regarding the Swedish housing market today. The prices of housing in primarily the urban areas keep reaching successively higher levels at the same time as its demand is increasing nonetheless. Compared to other European countries, the financial crisis in 2008 did not lead to as large a price decrease on the housing market in Sweden, which many see as an indicator that there was, and still is, a substantial housing shortage. Despite the steady upward trend in housing prices, the housing supply does not seem to catch up. According to the latest national housing market survey, 255 out of 290 municipalities evaluate that they have an ongoing housing shortage, which is an increase of 72 municipalities in 2 years (Boverket, 2017). There are many theories, but yet no consensus on the driving forces behind this development, and a reason as to why we do not see more houses being built remains unclear.

One of the most common economic theories to be viewed as an indicator of when it is profitable to engage in new investments is the Tobin's q theory. The theory states, when applied to the housing market, that when the costs of building a new house is less than the potential revenue, it is worth building. Potentially, the Tobin's q theory can contribute with an increased understanding of the underlying reasons behind the housing shortage. Moreover, the existing research conducted on Tobin's q and the Swedish housing market has so far only focused on owner-occupied housing and merely on a national level.

For the above-mentioned reasons, the aim of this thesis is to investigate the development of the Swedish housing supply from 2000 to 2015, with Tobin's q as the main explanatory variable of interest. In order to pursue this research question, we will examine the relationship between Tobin's q and building starts on a regional level using an Error Correction Model as well as standard OLS, depending on the cointegrating relationship. The purpose is to explore to what extent investment- and building incentives can explain the continuing housing shortage. By involving both one- or two-dwellings as well as multi-dwellings, in conjunction with adhering to regional differences, we attempt to fill a gap in the existing literature. Hence, the contribution of this thesis may hopefully be of interest to policy makers connected to the Swedish housing market.

The thesis is structured in the following way. The subsequent chapter accounts for the existing research on the topic. Chapter 3 will provide a theoretical background on the q theory as well as on the housing supply and its price elasticity. In chapter 4, the data and the adjustments of the same will be described. Chapter 5 presents the methodology behind the empirical analysis, focusing on our variable selection and econometric model. Thereafter, chapter 6 consists of the results found using the previously stated method. These results are then discussed in chapter 7, along with a connection to the ongoing housing shortage as well as to earlier research. Some suggestions for future researchers are also found in this section. Lastly, chapter 8 consists of concluding remarks.

2. Previous research

The Tobin's q theory as a whole was first introduced in James Tobin's article "A General Equilibrium Approach to Monetary Theory" (1969). Generally, the theory is most commonly applied to company-specific data. However, it can also be applied to the housing market, which has become of further interest to researchers during the last decades.

The two Finnish authors Takala and Tuomala (1990) are often regarded as the first researchers who properly examined the theory in terms of housing investment. Their article investigates the housing investment in Finland during 1972-1987. Using OLS estimation and two different time intervals due to structural changes, the authors found that the q theory could explain the housing investment better during the last half of the estimation period. A similar investigation has also been performed on the U.S. housing market by Jud and Winkler (2003), examining the impact on building permits, building starts and housing investment expenditures as measures of investment. Once again, the q theory is found to have significant explanatory power over the development in housing investment.

Furthermore, the first implementation of Tobin's q on the Swedish housing market was performed by Jaffee (1994). In his book "The Swedish property crisis" the author examines the determinants of housing prices and discovers a positive correlation between Tobin’s q and housing investment in Sweden. This is further indicated by Barot and Yang (2002). They study housing prices and housing investment in Sweden and the United Kingdom by estimating an Error Correction Model. According to their calculations, the speed of adjustment coefficient for Sweden in terms of Tobin's q indicates that 6 percent of the shock is corrected within one year in the case of disequilibrium. In other words, the authors have found that when housing investment diverge from the long-run relationship, Tobin's q will error correct 6 percent of the diversion within a year. They further state that Tobin's q is significant for the Swedish housing supply only in the long run.

To our knowledge, the most recent paper in this field regarding the Swedish housing market comes from Lennart Berg and Tommy Berger (2005) who tested the Tobin's q theory on the Swedish housing market with data from 1981-2003 for owner-occupied housing. They choose to include a structural break in the beginning of the 1990's with the intention to see if the policy changes in the end of the 1980's and beginning of 1990's had an impact on housing market investments. The policy changes involved increased pre-tax interest rates, a tax reform that increased after tax rates, strict fiscal policy measures to control inflation and also reductions in interest-subsidized loans from the government. To test the effects of these policy changes, they investigated the relationship between Tobin's q and housing investments using an Error Correction Model. For the first period sample, between 1981-1992, they could not find a significant relationship between Tobin's q and investments. However, for the later period between 1992-2003, they found a stable long run relationship and a significant correlation between Tobin's q and housing investments. In terms of the long run elasticity, they found that if the q ratio change with 1 per cent building starts will change with approximately 6 percent. They also estimated that the speed of supply response (speed of adjustment) was around –0,46, indicating that almost half of the excising housing gap in the market for buildings of family houses is closed in a quarter of a year. Altogether, the authors mean that their results indicate that housing investments have become more market driven during the second half of the investigated time period.

Another related subject of interest, when looking at the housing market, is the price elasticity of housing supply. Among the latest research in this area is a study by Caldera and Johansson (2013), where the authors analyze the price responsiveness of housing supply for several OECD countries, Sweden included. The results, based on an Error Correction Model with data from the early 1980's to mid-2000's, indicate that Sweden has a fairly high degree of responsiveness of housing supply, and adjusts the housing supply rather fast to changes in housing prices. The average price elasticity of housing supply for Sweden was estimated 1,38, which means that a 1 percent increase in housing prices is offset by a higher than 1 percent increase in the housing supply. This value was the second highest out of 21 countries. The authors also studied the speed-of-adjustment coefficient for Sweden, which was estimated to –0,13. This coefficient says that if there is a disequilibria in the housing market, and hence less houses available than what is demanded, 13 percent of the housing shortage will be adjusted for, in terms of increased housing supply, within one year.

Based on their findings, Caldera and Johansson state several factors that influence the housing supply's responsiveness to prices. Firstly, there are possible geographical and demographical conditions that may limit the housing supply. Some areas are simply not suitable for housing construction. Secondly, housing supply elasticity is lower in areas with a higher population density, which means that urban areas have a more rigid housing supply, compared to rural areas. Another important factor is government policies. For instance, there are land-use restrictions with the intention to reduce externalities that may occur from increased settlement in specific areas. There could also be restrictions due to security reasons from air, rail and car-traffic or even military safety reasons. A more controversial possible restriction is that municipalities may keep certain areas restricted in order to discourage new housing constructions. The reason is that many municipalities do not want to increase their housing supply, if it leads to lower housing prices and less wealth for their current residents. Another factor connected to government policies is building permits. Areas where the process for a building permit is more comprehensive do most likely have a more rigid housing supply (ceteris paribus). One last potential factor that could have a negative effect on new construction and maintenance is the price of rentals. If there are strict rent regulations that cap the price of rentals, the potential return from investments in both new rentals and new owner-occupied housing decrease, which in the long run can limit the housing supply of all properties.

When summarizing all the earlier research, we find many possible ways to improve and update the current work done on the subject. Primarily, there has been no research regarding the Swedish housing market done later than 2003, which means that the last years' economic development has not been investigated with the help of the Tobin's q theory. Secondly, there has been no up-to-date regional analysis with Swedish data, which is a highly relevant perspective to include in an analysis of Tobin's q. The Swedish Riksbank (2015) provided a report including data showing that q values vary to a large extent depending on the specific region.

Moreover, we find that earlier studies has focused merely on owner-occupied houses and not multi-dwellings. We would like to extend this earlier research by also looking at multi-dwellings, since apartment buildings naturally stand for a big part of the total housing supply that we wish to investigate. Yet, we are aware of the fact that multi-dwellings are subject to more regulations than one- or two-dwellings, which can explain why previous research focuses on owner-occupied housing only. On the other hand, we still believe that by extending the research and include multi-dwellings, a more realistic view of Sweden's current housing market is obtained and hence, an existing gap in the present literature is filled. Furthermore, there is a lack of research combining the theory of the housing supply elasticity and Tobin's q. We wish to investigate their interdependencies and the relationship between the two in order to enable an analysis of the current housing shortage in Sweden.

3. Theoretical framework

In this chapter, the theoretical framework behind the research will be discussed. The first subsection will review the Tobin's q theory and how it is theoretically implemented to suit the housing market. The second subsection will present the theory behind the housing supply and its elements that are affected by new construction of dwellings.

3.1 Tobin's q theory

James Tobin (1969) is the creator behind the neoclassical investment model, which suggests that investment is a function of q. The q itself equals a ratio between the market value of capital and the replacement cost of capital. The market value is affected by expected returns and interest rates, which should be investigated in relation to the acquisition cost. This ratio is then proposed to be correlated with the rate of investment.

$$Tobin's\ Q = \frac{Market\ Value\ of\ Capital}{Replacement\ Cost\ of\ Capital} \quad (3.1)$$

In this thesis, the q theory will be used as a housing investment theory. The expression above is hence altered to suit the housing market by studying the ratio between the price of existing dwellings and the production cost.

$$Tobin's\ Q = \frac{Value\ of\ Existing\ House}{Total\ Production\ Cost} \quad (3.2)$$

From the expression above and under the assumption of a homogenous market, a long-run equilibrium implies a q value equal to 1, as asset prices converge towards construction costs (Barot & Yang, 2002). When q is less than 1, it is not profitable to build new housing since the production costs exceed the property value. When q is larger than 1, the opposite is true, since the constructors receive a larger payment upon selling the property than what is spent on the construction of the property. The increase in demand hence puts an upward pressure on prices, creating a positive profit margin for the constructors, under the condition of perfect competition (Fregert & Jonung, 2013).

The motivation behind using the average housing price as the proxy for market value is that if the number of housing sales is large, then it is reasonable to assume that the average purchase price coincides with the average market value. However, the single purchasing price is the result of a negotiation between a seller and a buyer, and therefore, cannot be expected to equal the market value for each individual sale (Berger, 2000).

Generally, the marginal q rather than the average q is of the highest importance to an investor. However, only the average q is empirically observable, where the ratio consists of the market value of existing capital and its replacement cost. Although, these two are equal under the assumption that the producers are price-takers with constant returns to scale in production and installation. Thus, the average q is used as a proxy for marginal q (Hayashi, 1982). This simplification also holds true for this thesis. Additionally, the q theory also assumes informational efficiency on the housing market (Berg & Berger, 2006). This implies that current prices incorporate all the information necessary for investment decisions and this information is available to all agents on the market.

Furthermore, the total production cost per dwelling and region in our applied housing investment model consists of land cost per dwelling plus building cost per dwelling. These costs are then evaluated in relation to the average housing price per region in the numerator.

$$Total\ Production\ Cost = \ Building\ Cost + Land\ Cost \quad (3.3)$$

$$Tobin's\ Q = \frac{Value\ of\ Existing\ House}{Building\ Cost + Land\ Cost} \quad (3.4)$$

3.2 Housing supply

The housing market is characterized by several exceptional features, compared to other markets. Especially the housing supply is of a complex nature since it is hard to adjust the housing supply due to changes in the demand for housing. The reason for this is simply because the construction of new housing (adjusting supply upwards) is very time-consuming. Adjusting supply downwards is even more difficult, since housing is so durable and cannot just be removed. Another aspect that adds to the problematic of the housing market is the magnitude of it. Almost all citizens are involved in the housing market and disturbances in it can therefore lead to severe consequences for the whole economy (Green, Malpezzi & Mayo, 2005).

According to the neoclassical macroeconomic theory, the housing supply is fixed in the short run, since the current housing stock is determined by the accumulated level of housing investments from earlier periods. This means that in the short run, the only adjustment mechanism when housing demand changes is the price. In the longer run (H_{t+1}), the housing supply is firstly determined by the present housing stock (H_t), minus its depreciation rate (δ). Secondly, the supply in the long run depends on present investments in housing (I^H), which in turn depends on the supply curve for the construction sector.

$$H_{t+1} = H_t(1-\delta) + I^H \quad (3.5)$$

Under the assumption that the construction sector wants to optimize profits under perfect competition, they will push construction activity to the point where the marginal construction cost equals the market price of a newly constructed house, which basically is the same procedure as when construction firms keep investing as long as Tobin's q is greater than 1. The higher the q, the more incentive to increase building investments. This means that housing investments depend positively on Tobin's q.

Moreover, housing investments more generally do depend positively on income (*Y*), and negatively on interest rate (*r*) and the current housing stock (*H*). This means that, ceteris paribus, a higher current housing stock will lead to a lower current housing price (Sorensen & Whitta-Jacobsen, 2005).

$$I^H = h(Y, H, r) \quad (3.6)$$

3.2.1 Price Elasticity of Housing Supply

As mentioned in the previous chapter, there are several factors that determine the price elasticity of the housing supply and to which extent the housing supply reacts to changes in demand. Such factors are for example geographical and legal restrictions of land or cumbersome building permission processes. Depending on the elasticity, the response on the market either results in changes in constructions, or changes in the housing prices. Existing evidence show that markets with low supply elasticity to a higher degree experience increased prices rather than increased housing construction as a consequence of a positive demand shock (and vice versa for markets with high supply elasticity). There are also evidence suggesting that housing bubbles are more common and last longer in markets with inelastic housing supply (Caldera & Johansson, 2013).

In this study, we will not directly investigate the price elasticity of housing supply, since we have Tobin's q and not price as the explanatory variable. Our estimates will instead explain the "Tobin's q elasticity of housing supply", thus, how the housing supply reacts to changes in Tobin's q. However, since the price is indirectly featured as the numerator in Tobin's q, we assess that our elasticity measure is comparable to the standard price elasticity of supply, and can be interpreted in a similar way. Moreover, there can possibly be some advantages with using this "Tobin's q elasticity measure" instead, since the housing supply primarily depends on housing investments, and not housing prices. As the Tobin's q theory is supposed to describe the incentives for new housing investments, Tobin's q seems to be the optimal explanatory variable. If one instead has housing prices as the explanatory variable, one loses an important variable in terms of investment incentives, namely production costs. We therefore believe that the Tobin's q elasticity could be motivated as a more useful tool when investigating the mechanisms of housing supply.

4. Data

All data used in this thesis has been collected from Statistics Sweden's database. See Appendix 1 for table including a full data description. Our empirical analysis is driven by the public availability of data and due to limitations in the database, the final test period examined is year 2000 to year 2015. Furthermore, quarterly data is not available for all of the required time series and therefore, yearly data has been used, although we are aware that there are some seasonal trends in the data that could have been captured better if we had been able to use quarterly data. Hence, manual transformation of quarterly to yearly data was necessary for the time series only available in quarterly form. On the other hand, the yearly fluctuations are of greater interest to us in our study and therefore, this is not considered a data limitation.

Moreover, several additional adjustments of the data were required in order to complete the final data sets that were compliable with our theoretical and econometric method. These adjustments will be presented and motivated in this chapter.

4.1 Adjustments for regional division

Due to database limitations in terms of the regional division of the data performed by Statistics Sweden, some manual alterations were suitable. Different divisions were used by Statistics Sweden for different time series, resulting in a broader division than the county division we would have preferred. Instead, Sweden has been divided into three metropolitan areas corresponding to Greater Stockholm, Greater Gothenburg and Greater Malmö, in addition to three regional areas making up the rest of the country in the rough shape of the North County Region, the Mid-County Region and the South County Region. Although this division is not as thorough as the one we would have wished for, we still find it satisfactory since

Stockholm has proven to be the leading force behind almost all variation in building starts in Sweden. Hence, as long as we can separate Greater Stockholm from the rest of Sweden, we can account for the change in variables that is due to this area alone. It is of further importance to mention that Statistics Sweden added additional municipalities to each of the metropolitan areas in 2005. Therefore, adjustments have been made for this upon making the manual division for each year, which in turn can explain a possible shift in the variables. For example, the population density in Greater Stockholm decreased significantly in 2005 as four large municipalities were added with more area in relation to population. See Appendix 2 for full description of regional division.

Additionally, for some of the data series, only the metropolitan area subdivision is available in conjunction with data on county level. Hence, manual division of the counties into the three county regions was required. Upon performing this manual sectioning, we collected the same data on municipality level and calculated Greater Stockholm's municipalities', Greater Gothenburg's municipalities' and Greater Malmö's municipalities' share of the total housing stock in Stockholm county, Västra Götaland and Halland county, respective Skåne county. However, data on the housing stock is only available until 2012 and therefore, we have used the growth rate over the entire test period to forecast the residential for 2013, 2014 and 2015. As of 2005, Stockholm county comprises of the same municipalities as Greater Stockholm and therefore, the share of the total housing stock in Stockholm county consisting of Greater Stockholm is 100 percent as of 2005. By obtaining these shares of the total housing stock in the counties, we are able to calculate a weighted average that in turn is required for calculating the average purchasing price for the three county regions, where data originally is only available on county and metropolitan level. For this step, we also needed to calculate weights for every county in terms of its weight in the county region in order to enable a weighted average calculation. Thus, we will obtain realistic average purchasing prices for each of the three county regions (excluding Greater Stockholm, Greater Gothenburg and Greater Malmö), which is dependent on each county's weight in the county region's total housing stock.

Income and population density are two additional time series that have been collected for the empirical analysis. However, the data for these variables are only available on national, county and municipality level. Hence, the data required manual sectioning of the data into the three metropolitan areas and the three county regions, from where the metropolitan areas are excluded. To simplify our calculations, we therefore instead chose to collect data on the area in square kilometers and the population of each county and municipality needed, and then manually divided the data into our chosen county regions and metropolitan areas. This is then finally followed by a calculation of regional population density by dividing the number of inhabitants with the area in square kilometers.

Income proved to be more difficult to divide manually, which motivates using data on national level instead and thereby, control for cyclical fluctuations rather than differences in income between regions. We additionally believe that cyclical patterns in the nation's economy should have a greater effect on building starts than regional differences in income level. Since the type of dwelling does not affect the two control variables, the same values are used for both one- or two-dwellings as well as multi-dwellings.

4.2 Adjustments for calculation of Tobin's q

In order to calculate Tobin's q for the Swedish housing market some further adjustments were necessary. Both the numerator (market value) and the denominator (production costs) have been adjusted to fit the theory behind the model. Without these adjustments, the q values would be significantly lower, which we will explain in more detail below. Even though these calibrations are connected with a certain amount of uncertainty, we still believe that the adjusted values are more trustworthy.

To estimate the numerator, the market value, data on average purchasing price is used. For one- or two-dwellings, the average purchasing price for this dwelling type is used and for multi-dwellings, the average purchasing price for an apartment is used. According to the Tobin's q theory, the numerator must represent the market value of a newly constructed house. Since the price that we observe is the average of both old and new properties, we need to adjust the price upwards to approximate the value of new properties only. To do this, we replicate the method of Berger (2000). Berger has performed studies showing that net depreciation of a dwelling's market value is 1 percent per year and then uses this rate to increase the market value of second-hand housing. In the calculations resulting in the net depreciation rate, Berger has considered demolition and renovation of housing. The author describes his method in the manner that a 10 year old house's sales value is increased by 10 percent, a 20 year old house's sales value is increased 20 percent et cetera.

In the purpose of ensuring that Berger's method is suitable for our data as well, we used the equivalent approach using older data during the same time period that Berger investigated, as well as current housing stock data. Hence, we obtain an estimate of the equivalent appreciation rate. Our results are similar to Berger's, which motivates our usage of his appreciation rate to increase the market value of older dwellings, although extended until 2015. Our course of action and results will be further motivated in the next chapter.

In terms of the denominator, the production cost of housing is adjusted by weighting it against the Quality Price Index (QPI), using 2015 as the base year. QPI adjusts for differences in building quality for newly-built dwellings and should hence be accounted for when implementing production costs, since higher building quality should imply cheaper long-run production costs and vice versa. This statement holds under the condition of a constant purchasing price.

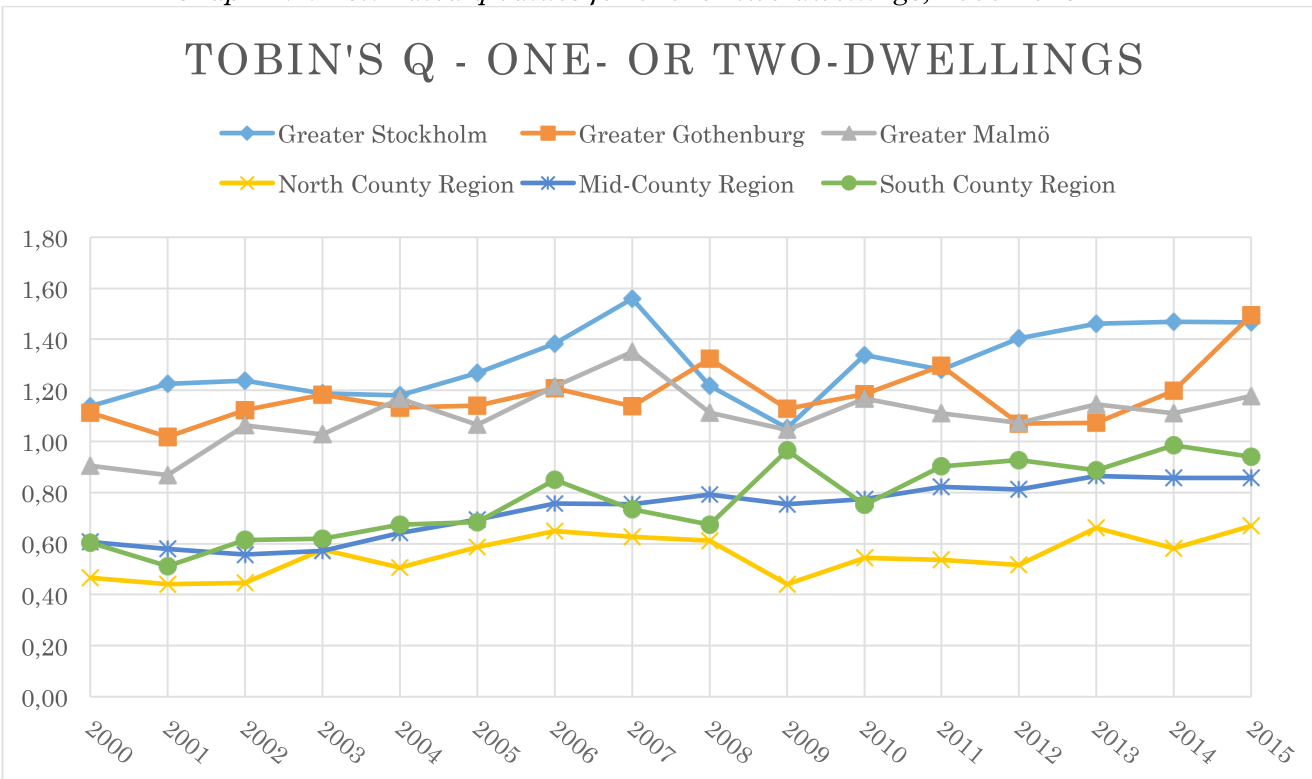
To view an example of how the data adjustments have been made, see Appendix 3 with calculations of Tobin's q for one- or two-dwellings in Greater Stockholm.

4.3 Descriptive statistics

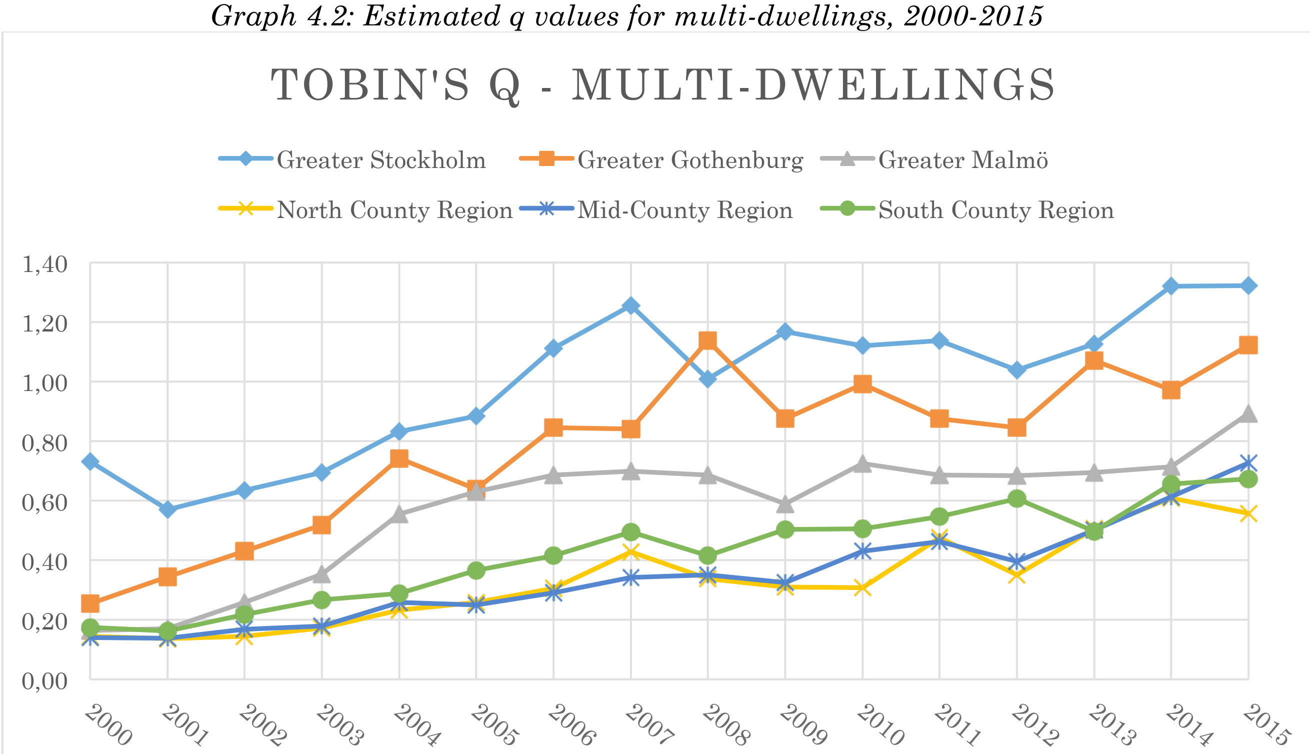
Graph 4.1 and 4.2 below depict our estimated Tobin's q values for the metropolitan areas and county regions. The first graph represents one- or two-dwellings and the second graph represents multi-dwellings. Firstly, it seems that the two types of dwellings generate similar regional patterns. The series are quite non-volatile and show signs of an upward trend throughout the testing period. Although, the q values are constantly higher for one- or two-dwellings. In this setting, all three metropolitan areas lie above the equilibrium value of 1 for almost the entire test period, indicating that it is profitable to build new houses in these areas. It is also observable that it is profitable to build new multi-dwellings in Greater Stockholm and Greater Gothenburg in 2015, but not in the other areas, according to the q theory. In general, there are large regional differences in q, giving further motivation of our studies being on regional level and not national.

Nonetheless, as we have mentioned earlier, these regional subdivisions are far more general than what we would have initially preferred. This implies that the three county regions embody larger land areas than what is optimal in order to draw more precise conclusions. None of the county regions have q values larger or equal to 1 for either dwelling type, although these values do not account for regional differences across counties. It is highly possible that q is larger than 1 for some counties within the county region, although the average q lies below 1.

Graph 4.1: Estimated q values for one- or two-dwellings, 2000-2015



Graph 4.2: Estimated q values for multi-dwellings, 2000-2015



4.4 Data limitations

One limitation in our data sample is that our variables for market value and production costs are estimated per dwelling and not per square meter, since Statistics Sweden does not have data series for these variables per square meter. This means that we have not been able to account for differences in dwelling sizes, both between different areas and over time. Possibly, houses in in urban densely populated areas are smaller than in rural areas, and potentially newly constructed houses on average are bigger today than houses built 15 years ago. We are aware of this shortcoming, but still consider our data valid for a general estimation of Tobin's q in different areas and over time.

Another limitation of the estimated q values is that we have not been able to include subsidies and interest deductions in the construction cost variable. This implies that the estimated production costs probably are overvalued, resulting in lower q values than what is actually accurate.

All data sets are presented in current prices. The optimal case would naturally be to include all data in fixed prices, due to more realistic comparisons of the different variables over time. Yet, when measuring Tobin's q, the choice between current or fixed prices is fairly indifferent, since the q value is measured as a fraction. Income would on the other hand optimally be in fixed prices. Nevertheless, we had no choice but to use current prices upon finding that income adjusted with Consumer Price Index proved to be non-stationary in first differences, which is a critical condition when including the variable in our econometric model that needs the same order of integration for the included variables.

5. Methodology

To find an answer to our main question, namely how Tobin's q affects the housing supply, we have applied an econometric model to investigate the relationship between Tobin's q and building starts. Here follows a description of the motives behind the variables chosen and thereafter a description and motivation of the econometric model.

5.1 Selection of variables

The main intention of the method has been to follow the theoretical framework as carefully as possible. Due to lack of data that perfectly corresponds to the theory of Tobin's q, we had to make some own adjustments, which we described in the Data chapter. In this section, we motivate these assumptions with additional arguments.

5.1.1 Tobin's q

When estimating the Tobin's q variable, we, as mentioned above, applied the method of Berger (2000). His research claims that the value of a house decreases by 1 percent each year and results in an appreciation rate that is multiplied with the market value in order to increase the lower market values of second-hand housing. This is an important adjustment since the vast majority of the dwellings on the housing market are not newly built. The appreciation rate presented by Berger grows larger and larger for each year as we approach present day, indicating that older housing constitutes more and more of the current housing stock. In other words, new houses are built in a far slower rate than old houses' values depreciate and are demolished. We applied Berger's method in the sense that we used the growth rate in his appreciation rate, available for 1981-2000, and extended it until 2015. Thereby, we assume a constant and linear development in the rate.

According to Berger's calculations, the average dwelling in the housing stock of 2000 was built in 1968. The average market value of a house in that year would thereby need to be increased by 32 percentages in order to get the average price of a hypothetical, newly constructed housing stock. When we extended Berger's appreciation rate, the average dwelling in the housing stock of 2015 was built in 1971, resulting in the need for a 44 percentage upward adjustment of the market value of 2015.

In order to confirm that Berger's method is applicable to our data with a testing period 15 years ahead of Berger's, we collected data from a publication by Statistics Sweden (2016), where a graph depicting the age of the total housing stock as of 2012 was included, see Appendix 4. This graph separates the multi-dwellings from one- or two-dwellings, so that we could estimate how old the average apartment respective family house is during 2012. We further extended the observations until 2015 by applying the average growth rate. We then found that the average family house and the average apartment on the Swedish housing market in 2015 were both built during the period 1960-1970. According to the extension of Berger's rate, the corresponding value in 2015 indicates that the average house is built in 1971, as described above. Hence, our results are very similar. Since we obtained the same results for multi-dwellings as well as one- or two-dwellings, we see no disadvantages in applying Berger's extended rate to both types of dwellings.

Furthermore, due to our own calculations, the rate of new construction of dwellings is less than 1 percent each year during 2000-2015, which is less than the assumed depreciation rate corresponding to 1 percent. As long as the rate of new construction is less than the rate of depreciation, the average dwelling will successively grow older. If the rates were equal, then the average dwelling would always be equally old, as the average dwelling's building year would then move forward by one year for every yearly advancement in the housing stock. Our results showing that the rate of new construction is constantly lower than the depreciation rate also imply that there are no signs of a large boom or other important change concerning the new construction of housing during the investigated period. This further motivates why using the extension of Berger's rate is reasonable as we can expect a rather linear growth rate in the 15 years following his calculations.

5.1.2 Control variables

The two chosen control variables, income and population density, are included in the empirical analysis due to their alleged impact upon building starts. Furthermore, these variables should improve the specification of the econometric model and help avert omitted-variable bias. As mentioned in the previous chapter, we use income on a national level in order to control for cyclical turns. Moreover, income should have a direct effect on building starts as increased income results in a higher willingness to buy larger and better housing. This, according to Swedish National Board of Housing, Building and Planning, creates a housing shortage, ceteris paribus, and is the main reason behind Sweden's high growth rate of housing prices (Boverket, 2013). Therefore, a time series of income on a national level is not able to account for regional differences but for other general patterns in the population's economy, whose increasing level is believed to have a positive effect on building starts.

The inclusion of population density is driven by the studies by Caldera & Johansson (2013), whose work is presented more in detail in Previous research. They state that population density is an important factor whilst investigating building starts by the close connection to housing supply elasticity. Housing supply elasticity is lower in areas with a higher population density, implying that the metropolitan areas Greater Stockholm, Greater Gothenburg and Greater Malmö should be less responsive to changes in housing prices. Intuitively, an increase in housing prices should increase the building of new dwellings. Although, if an area is already densely populated, then the new construction will be obstructed by the lack of available land. Hence, population density potentially has explanatory power over the level of building starts across different regions in Sweden.

5.2 Dwelling types

Earlier research has mainly focused on one- or two-family houses, with the motive that the construction incentives for such houses are connected with more comprehensive building permits and other factors that are hard to include in a theoretical analysis. We make the assumption that the extended costs connected with multi-dwelling buildings are included in the total cost variable we use to derive the q value. Nevertheless, we are still aware of the fact that there may be other factors that differ between owner-occupied and multi-dwelling housing, and our intention is to empirically test this and analyze it further. Regarding the definition of the markets, we assume that the market for one- or two-dwellings is separated from the market for multi-dwellings. Although, they can be considered substitutes and be subject to spillover effects.

5.3 Econometric model

To investigate the relationship between our dependent variable building starts and the explanatory variable Tobin's q, we have used a combined econometric approach, using both an Error Correction Model as well as a standard OLS estimation, depending on the cointegration relationship. Below, we will motivate this choice of estimation strategy.

5.3.1 Motivation of econometric model

Since our main intention was to use an Error Correction Model (ECM) approach, the first step was to check if the two variables of interest, building starts and Tobin's q, are stationary and if they are integrated. If they are not, it is not possible to apply an ECM. We wish to use this type of model since we are interested in investigating the long-run relationship as well as the short-run effects.

By running Augmented Dickey-Fuller tests, we found that both variables were non-stationary in levels, but stationary in first differences. The same results were found for the control variables, population density and income. This indicates that our data sample is integrated by order one.

The second critical condition to being able to implement an ECM is that the variables are cointegrated. Two variables are cointegrated if they both have unit roots but there exists a combination between them that is stationarity. In order to perform a Johansen cointegration test, we first estimated an unstructured VAR model for all regions with each dwelling type and used the AIC value to guide us to the appropriate number of lags. The individual number of lags is then used in the Johansen cointegration test, as well as later on in the Granger causality test. Only one cointegrating relationship is required for the application of an ECM. This is due to the residuals of an OLS regression of Tobin's q upon dwelling starts otherwise being non-stationary, which in turn makes the results in terms of the speed-of-adjustment parameter spurious.

Disappointingly, but in accordance with previous studies, cointegration was not found for all of the regions. However, an ECM has been performed for the regions and dwelling type that proved a cointegrating relationship. For the ones without, we have run a standard OLS in first differences in order to still investigate the short-run relationship between dwelling starts and q. First differences are used since, as mentioned above, the variables are stationary in first differences. Hence, the long-run relationship can only be investigated for some regions and dwelling types.

The standard approach when working with this type of data that is structured by regions and years, would be to use panel data. Nonetheless, we have chosen a time series approach instead. Upon discovering that several regions did not have cointegration between the two variables of interest, we tried to check for cointegration when structuring our variables as panel data. Unfortunately, the Pedroni panel cointegration test could not prove cointegration whilst testing the entire series, which makes it impossible to run an ECM with panel data.

Furthermore, Granger causality tests were also performed for all regions and dwelling types in order to check for endogeneity problems as well as examining the forecasting abilities between the dwelling starts and Tobin's q.

5.3.2 Presentation of Econometric Model

To estimate the long-run relationship between dwelling starts and Tobin's q, the following system of equations is estimated separately for every region and dwelling type. This is a two-step approach for estimating an approximate conditional ECM using OLS.

$$\ln DwellingStarts_{it} = \beta \ln Q_{it} + e_{it} \quad (5.1)$$

$$\hat{e}_{it} = \ln DwellingStarts_{it} - \hat{\beta} \ln Q_{it} \quad (5.2)$$

In equation 5.1, dwelling starts is the dependent variable, estimated per year (t) in each region (i). Tobin's Q (Q_{it}) is the explanatory variable and e_{it} is the error term. The estimated OLS residuals, described by equation 5.2, are extracted after regressing equation 1 and thereafter plugged into equation 5.3, lagged by one year.

$$\Delta \ln DwellingStarts_{it} =$$
$$\alpha \hat{e}_{it-1} + \gamma_0 \Delta \ln Q_{it} + \gamma_1 \Delta \ln PopulationDensity_{it} + \gamma_2 \Delta \ln Income_{it} + v_{it} \quad (5.3)$$

In equation 5.3, the control variables population density and income are added as well. All variables are expressed in natural logarithms. v_{it} is an error term.

Equation 5.4 describes the entire error correction process, where all variables are in first differences, earlier motivated by the fact that they are stationary in this form. All regions that contain a cointegrating relationship between dwelling starts and Tobin's q are estimated by this model:

$$\Delta \ln DwellingStarts_{it} = \alpha(\ln DwellingStarts_{it-1} - \hat{\beta} \ln Q_{it-1}) + \gamma_0 \Delta \ln Q_{it} + \gamma_1 \Delta \ln PopulationDensity_{it} + \gamma_2 \Delta \ln Income_{it} + v_{it} \quad (5.4)$$

The α parameter is one of the main coefficients of interest in this equation, since it describes the speed-of-adjustment mechanism. This α parameter should be negative according to econometric theory as long as building starts and Tobin's q are not in perfect equilibrium. α indicates the rate of adjustment that will occur in the next period, in order to return to the long-run equilibrium in case of disequilibrium.

The γ parameter could be described as the short-run coefficient that indicates the marginal effect of each explanatory variable. In equation 5.4, γ_0 is the marginal effect on dwelling starts as Tobin's q changes. This implies that γ_0 could be interpreted as a type of elasticity, as it indicates to which extent dwelling starts are affected by changes in Tobin's q. Since Tobin's q includes both house prices and building costs, γ_0 is a proxy for the price elasticity of housing supply. γ_0 could also be called "Tobin's q elasticity of housing supply".

γ_1 and γ_2, representing the marginal effects on dwelling starts from changes in population density and income are not of any specific importance, since population density and income are included as control variables.

For those regions where cointegration could not be found, the following estimation process is used:

$$\Delta \ln DwellingStarts_{it} = \beta_0 + \beta_1 \Delta \ln Q_{it} + \beta_2 \Delta \ln PopulationDensity_{it} + \beta_3 \Delta \ln Income_{it} + \varepsilon_{it} \quad (5.5)$$

By comparing this expression to the ones presented above, it is clear that the only difference is that the α parameter from equation 5.4, representing the long-run relationship, is replaced by an ordinary intercept (a constant). Additionally, the corresponding γ_0 coefficient is replaced by β_1. The interpretation is the same, though. Hence, it is a standard OLS-estimation approach that provides us with the short-run indicators as well as values corresponding to housing supply elasticity in the means of Tobin's q.

Moreover, we have also tested for serial correlation for each regression using the Breusch-Godfrey Serial Correlation Lagrange Multiplier (LM) test. Thereby, we can make sure that all observations are independent of one another across time. Additionally, White heteroskedasticity tests have been performed in order to ascertain that the error term exhibits equal variance at all levels of the independent variables.

6. Results

This chapter accounts for our findings upon applying our econometric models of choice, as well as the different tests required to optimize the estimations.

6.1 Augmented Dickey-Fuller test

To test for stationarity, Augmented Dickey-Fuller tests were performed. The tests indicate that all variables are non-stationary in levels, but stationary in first differences. See Appendix 5 for detailed results.

6.2 Johansen's Cointegration test

As mentioned earlier, at least one cointegrating equation is required to be able to perform an ECM. To test for this, Johansen's Cointegration tests are performed. The optimal number of lags is determined by the Akaike Information Criterion (AIC) value upon running an unrestricted VAR with a maximum lag length of two. See Appendix 6 for table containing optimal lag structure for each region and dwelling type.

We find cointegration for Greater Malmö, the Mid-County Region and the South County Region when investigating one- or two-dwellings, and for Greater Gothenburg, Greater Malmö and the South County Region when investigating multi-dwellings. Hence, an ECM is only performable for these regions and dwelling types. See Appendix 7 for a summary table of the results from Johansen's Cointegration test.

6.3 Error Correction Model and OLS regression

Complete regression results can be found in Appendix 8. Serial correlation was only found for one- or two-dwellings in the Mid-County Region. Heteroskedasticity was rejected for all regressions.

6.3.1 Greater Stockholm

The metropolitan Stockholm region initiated our estimation process. Here, the standard OLS approach was applied (equation 5.5) when estimating the results for both one- or two- and multi-dwellings. This means that no long-run relationship between building starts and Tobin's q could be measured. Instead, the parameter of interest is the β_1 parameter, our proxy for housing supply elasticity that affects Δ Ln Q. For one- or two-dwellings, β_1 is estimated to the value 1,55 and significant at the five-percent level. Elasticity numbers bigger than one are regarded as elastic, meaning that the housing supply for one- or two-dwellings in Stockholm is elastic. Since our variables are in natural logarithms, our coefficients are in percent. This indicates that a 1 percent increase of the Tobin's q ratio leads to a 1,55 percent increase in building starts. For multi-dwellings, no significant results were found.

Table 6.1 Greater Stockholm

One- or two-dwellings			Multi-dwellings		
Variable	**Coefficient**	**p-value**	**Variable**	**Coefficient**	**p-value**
C	0,1785	0,4539	**C**	0,5059	0,337
Δ Ln Q	1,5524**	0,0207	**Δ Ln Q**	-0,2979	0,7701
Δ Ln Population Density	0,1279	0,7911	**Δ Ln Population Density**	0,1999	0,8253
Δ Ln Income	-6,7717	0,3842	**Δ Ln Income**	-13,555	0,4128

6.3.2 Greater Gothenburg

When the Greater Gothenburg region was analyzed, only the results for multi-dwellings could be estimated with the ECM (equation 5.4). For one- or two-dwellings, the proxy for housing supply elasticity, the β_1 parameter, was measured to 1,35 and hence, indicating an elastic supply. For multi-dwellings, no significant result was found for the same parameter. However, the speed-of adjustment parameter (α) for multi-dwellings was estimated to –0,56 and proved significant at the ten percent level. This value indicates that more than half of the gap for an existing disequilibrium is corrected in one year. In other words, if 100 too few multi-dwellings are built in Gothenburg in one year, compared to what would be optimal in equilibrium, 56 extra houses will be built in the following year, to reach equilibrium in the long run.

Table 6.2 Greater Gothenburg

One- or two-dwellings			Multi-dwellings		
Variable	**Coefficient**	**p-value**	**Variable**	**Coefficient**	**p-value**
C	0,2257	0,3336	**Residuals(-1)**	-0,561*	0,0824
Δ Ln Q	1,3494**	0,0351	**Δ Ln Q**	0,5452	0,3379
Δ Ln Population Density	0,0089	0,9932	**Δ Ln Population Density**	-1,957	0,2698
Δ Ln Income	-8,6637	0,2604	**Δ Ln Income**	0,6244	0,8673

6.3.3 Greater Malmö

The Greater Malmö region was investigated by applying the ECM and equation 5.4 to both one- or two-dwellings and multi-dwellings. The γ_0 parameter turned out to be significant for both dwelling types. For one- or two-dwellings, our proxy for housing supply elasticity is estimated to 1,45 and for multi-dwellings it corresponds to a value of 1,63. These can be viewed as rather high numbers, and they indicate that the housing supply in Malmö adjusts rather quickly to changes in demand for housing. The speed-of-adjustment parameter (α) is only significant for multi-dwellings, with the value -0,66.

Furthermore, it is also worth mentioning that population density has a significant negative effect on building starts for one- or two-dwellings in the examined region. This implies that if Greater Malmö becomes more densely populated, then the incentives for building new housing decrease.

Table 6.3 Greater Malmö

One- or two-dwellings			Multi-dwellings		
Variable	**Coefficient**	**p-value**	**Variable**	**Coefficient**	**p-value**
Residuals(-1)	-0,2932	0,1256	**Residuals(-1)**	-0,6593**	0,0308
Δ Ln Q	1,4494**	0,0414	**Δ Ln Q**	1,6276**	0,0394
Δ Ln Population Density	-2,4032*	0,056	**Δ Ln Population Density**	-1,2561	0,559
Δ Ln Income	-1,216	0,5675	**Δ Ln Income**	-5,6257	0,2522

6.3.4 North County Region

For the northern part of Sweden, the standard OLS approach (equation 5.5) was used for both dwelling types. The results indicate that there is no statistically significant correlation between building starts and Tobin's q in the entire region. Apparently, there are other factors that affect the housing supply in this area, which our econometric model could not detect.

Table 6.4 North County Region

One- or two-dwellings			Multi-dwellings		
Variable	**Coefficient**	**p-value**	**Variable**	**Coefficient**	**p-value**
C	0,0059	0,9762	**C**	0,5738	0,3959
Δ Ln Q	0,3463	0,3216	**Δ Ln Q**	-0,5368	0,5088
Δ Ln Population Density	18,0817	0,1808	**Δ Ln Population Density**	0,5774	0,9891
Δ Ln Income	1,2607	0,8443	**Δ Ln Income**	-14,4359	0,5041

6.3.5 Mid-County Region

The middle part of Sweden was estimated with the ECM approach (equation 5.4) for one- or two-dwellings but not for multi-dwellings. Yet, for the one- or two-dwellings, serial correlation was detected, and one extra lagged variable had to be added for each variable in the regression. This is the standard approach according to the literature, rather than applying robust standard errors. In short, the idea is to add lagged variables, both dependent and explanatory, until the serial correlation disappears. In our case, only one set of lagged variables was required until the Breusch-Godfrey LM test's null hypothesis of no serial correlation was not rejected anymore. Thus, we are left with a set of coefficients that only are estimated for Region II. The only one of these that turned out to be significant was the coefficient for Δ Ln DwellingStarts(-1), which was estimated to 0,77. This indicates that last year's dwelling starts affect the number of this year's dwelling starts and if dwelling starts increased with 1 percent last year, building starts will increase with 0,77 percent this year, ceteris paribus.

The second significant result for the Mid-County Region is the speed-of-adjustment parameter (α) for one- or two-dwellings, which was estimated to –0,44. No significant results were found for multi-dwellings.

Table 6.5 Mid-County Region

One- or two-dwellings			Multi-dwellings		
Variable	**Coefficient**	**p-value**	**Variable**	**Coefficient**	**p-value**
Residuals(-1)	-0,4416**	0,0404	**C**	0,2232	0,5346
Δ Ln Dwelling Starts(-1)	0,7701**	0,0204	**Δ Ln Q**	0,8347	0,2458
Δ Ln Q	1,2017	0,269	**Δ Ln Population Density**	-7,6748	0,4439
Δ Ln Q(-1)	-0,5821	0,566	**Δ Ln Income**	-6,073	0,5824
Δ Ln Population Density	-1,5919	0,7565			
Δ Ln Population Density(-1)	-3,882	0,4379			
Δ Ln Income	-5,8489	0,2903			
Δ Ln Income(-1)	6,1868	0,2088			

6.3.6 South County Region

Lastly, the South part of Sweden was investigated by using the ECM approach (equation 5.4) for both dwelling types. Similar to the North County Region, no significant results were found and thereby, Tobin's has no effect on building starts in the South County Region, neither in the short run, nor in the long run.

Table 6.6 South County Region

One- or two-dwellings			Multi-dwellings		
Variable	**Coefficient**	**p-value**	**Variable**	**Coefficient**	**p-value**
Residuals(-1)	-0,2784	0,1627	**Residuals(-1)**	-0,5013	0,1244
Δ Ln Q	-0,0925	0,8242	**Δ Ln Q**	-0,362	0,6644
Δ Ln Population Density	-6,3245	0,3352	**Δ Ln Population Density**	-3,5435	0,7599
Δ Ln Income	0,0057	0,6443	**Δ Ln Income**	2,4407	0,5845

6.4 Granger Causality test

In order to further examine the relationship between dwelling starts and Tobin's q, we also performed Granger Causality tests, which tell us whether one variable is useful in forecasting the other. Once again, the optimal number of lags for each region and dwelling type are the same as in the Johansen's Cointegration test. That is, the optimal lag length is retrieved by observing the lowest AIC value for unrestricted VAR estimation outputs, comparing one lag with two lags.

No causality was found in either direction for any region when investigating one- or two-dwellings. For multi-dwellings however, we found that dwelling starts have forecasting power over the next period's q value in four regions out of six. There were no signs of the reverse condition being true. See Appendix 9 for full results.

7. Analysis

The principal purpose of our empirical analysis is to investigate how Tobin's q affects the Swedish housing supply. Therefore, our chosen econometric approach considers the long-run relationship between dwelling starts and Tobin's q, where applicable, as well as examines the short-run relationships in the terms of elasticities. In our analysis, we will discuss our findings in conjunction with a comparison to earlier research and a presentation of suggested courses of action to handle the ongoing housing shortage in Sweden. Lastly, some potential topics for future researchers are introduced.

7.1 Elasticities

The estimates for the housing supply elasticities can also be interpreted as representations of the short-run relationship between dwelling starts and Tobin's q. In economic theory, the standard definition of price elasticity of supply is to which extent supply reacts on changes in prices. In our case, we look at housing supply elasticity in terms of how supply is affected by changes in Tobin's q. Our results, indicating the "housing supply Tobin's q elasticity", can hence not be compared to other housing supply price elasticity measures, but can still be interpreted in a similar way.

One of the most interesting results from our regressions, in terms of supply elasticity, are those for one- or two-dwellings in the three metropolitan regions. As opposed to the other regions, we found significant results for all the three city regions, which makes it is possible to compare them. Our results indicate that Stockholm has the highest supply elasticity with a value of 1,55, thereafter Malmö with 1,45 and third Gothenburg with 1,35. These results could be seen as rather surprising, since Stockholm is the city with the most prominent housing shortage with escalating housing prices, and one could possibly assume that this situation has occurred due to a rigid housing supply. However, our results show that the Stockholm housing market for one- or two-dwellings, as compared to Malmö and Gothenburg, has a more flexible supply that can offset changes in demand, instead of adjusting prices. On the other hand, earlier research has indicated that Sweden has a rather adaptive housing supply for one- or two-dwellings, so the results are not really surprising in this sense. The study by Caldera & Johansson (2013) estimated the average Swedish housing supply price elasticity to be 1,38. In our study, we estimated the Tobin's q elasticities in the city regions to be between 1,35 and 1,55, thus slightly higher. This is in line with our expectations, namely that the Tobin's q elasticity should be higher than the price elasticity, since the housing supply theoretically is more sensitive to changes in Tobin's q than to changes in housing prices.

Regarding multi-dwellings, the only significant elasticity measure we found was for Greater Malmö, with the result 1,63. The equivalent result for one- or two-dwellings in Malmö was 1,45, which indicates that the supply of multi dwellings is more elastic. Unfortunately, these elasticities for Malmö are the only two results for one- or two-dwellings and multi-dwellings that are significant and comparable. Nevertheless, these results still indicate that there could exist a general relationship, where the supply of multi-dwellings overall is more elastic than of one- or two-dwellings.

One possible interpretation of this relationship could be that when Tobin's q increases and it is profitable to engage in new construction projects in general, incentives for multi-dwelling constructions may be larger than for one- or two-dwellings. Since the marginal cost of an apartment in a multi-dwelling is lower than the marginal cost of another one- or two-dwelling, it would be more profitable for construction companies working in large scale, to focus on multi-dwellings. On the other hand is Tobin's q on average higher for one- or two-dwellings than for multi-dwellings, so the potential revenues for one- or two-dwellings are theoretically larger. Nonetheless, our results have shown that the supply of one- or two-dwellings is more dependent on Tobin's q than the supply of multi-dwellings, since Tobin's q only has a significant effect on the multi-dwelling supply in one region, Malmö.

7.2 Long-run relationship

As mentioned in the previous chapter, the long-run relationship, also referred to as the speed-of-adjustment parameter or error correction mechanism (α), was only applicable in the cases exhibiting at least one cointegrating equation. Moreover, realistic conclusions about the values of the parameter are only possible to draw when this parameter is statistically significant. Therefore, such a discussion is only possible for the Mid-County Region for one- or two-dwellings, as well as for Greater Gothenburg and Greater Malmö for multi-dwellings.

For one- or two-dwellings, only the Mid-County Region has a statistically significant parameter with a value of –0,44. For multi-dwellings, Greater Gothenburg exhibits a value of -0,56 and Greater Malmö has a corresponding value of -0,66. Thus, they are all negative, indicating a convergence towards equilibrium by 44 to 66 percent respectively each year. Allegedly, despite being in accordance with previous studies, these percentages seem unrealistically high. The whole process of housing construction takes more than one year from start to finish. It therefore seems improbable that roughly half the gap of a housing disequilibrium would be filled within one year. However, when the adjustment to disequilibrium in the model is viewed as a percentage of building starts, rather than a percentage of finished housing, the values are more reasonable.

Unfortunately, we cannot compare the values of one- or two-dwellings with multi-dwellings for the same region, although, the two significant values for multi-dwellings are notably larger than the values for one- or two-dwellings. This could be an indicator that the supply of apartments in multi-dwellings adjusts more rapidly in response to disequilibrium, relative to the supply of one- or two-dwellings. Intuitively, this seems logical since the construction of one multi-family residential consisting of several apartments can result in housing for more individuals and families, than the construction of one- or two-dwellings, which has room for one or two families.

It is also worth mentioning that the Mid-County Region and Greater Gothenburg show proof of a long-run relationship but no short-run relationship as the coefficient for Δ Ln Q is insignificant. Hence, this could be viewed as a confirmation of the theory of the housing supply, which states that the housing stock is fixed in the short-run as housing construction is a lengthy process.

7.3 Housing shortage

In the city regions, our results indicate that Tobin's q has a short run positive correlation with building starts for one- or two-dwellings. In Greater Malmö even the construction of multi-dwellings is positively dependent on Tobin's q in the short and the long run. In these cases, the Tobin's q theory seems to be valid and increased construction incentives lead to more building starts. However, when it comes to multi-dwellings in Stockholm and Gothenburg, increased q values do not seem to be enough to engage in new housing investments. Both Greater Stockholm and Greater Gothenburg have q values bigger than 1 for multi dwellings, and theoretically should housing investments result in positive returns. Despite of that, not as many dwellings as theoretically profitable to build are undertaken. This indicates that there potentially are other things that hinder construction companies from building more multi-dwellings in Stockholm and Gothenburg. Such obstacles could for example be the factors that also can affect housing supply elasticity, such as regulations and land restrictions.

Our results indicate that most of the housing shortage in Stockholm and Gothenburg is caused by a dysfunctional multi-dwelling housing market. As compared to Malmö, where Tobin's q has a significant impact on the total housing supply, the housing shortage is not as tangible as in the two biggest cities. In times of high demand for housing, as we experience today, with high population growth and increased urbanization, new constructions of multi-dwellings are often seen as a natural way to meet the high demand. If the market mechanisms for multi-dwellings in this situation do not work properly and we experience market failures, we will end up with disequilibrium and a housing shortage. This is unfortunately the situation we see today.

According to our results, there is need for interventions and policy changes on the multi-dwelling market in Greater Stockholm and Greater Gothenburg. One way to meet the market failure is to remove the obstacles, in terms of regulations and restrictions that are present on the market. Yet, many of the regulations that we have today are also of importance for the market to function in other ways. This complicates the process and policy changes need to be fully investigated before they are undertaken. Another way to meet the market failure would be to increase subsidies. Since the amount of new built multi-dwellings not is socially optimal, increased interest deductions or cheaper building permits could be a solution.

As mentioned earlier, no short-run relationship between building starts and Tobin's q could be established for the three county regions. A long-run correlation for one- or two-dwellings was only detected in the Mid-County Region. Similarly to the market for multi-dwellings in Greater Stockholm and Greater Gothenburg, one could interpret the lack of significant relationship as a sign of the market mechanisms in these areas being disturbed. An alternative possible explanation could be that our theoretical framework, Tobin’s q, does not function properly for q values less than 1, which they generally are in the county regions. Since the q theory states that housing investments are not profitable when q is less than 1, a change in Tobin's q from 0,7 to 0,8 is theoretically unimportant, since the investment is still non-profitable. Potentially, the impact of Tobin's q can be better explained in cases where the q value is greater than 1. This would explain why the regions with higher q values resulted in more statistically significant results. The exceptions are multi-dwellings in Malmö and one- or two-dwellings in the Mid-County Region, where the q values are less than 1 but the correlation between q and building starts is still statistically significant.

In regard to the discussion above, the impact on building starts of a marginal change in Tobin's q is potentially of higher importance for q values greater than 1, and especially the marginal effect as Tobin's q increases from less than 1 to greater than 1. If our econometric model could have captured these different marginal effects of Tobin's q, and for example had incorporated a dummy to distinguish between q values less and bigger than 1, our results could be different and could potentially have been interpreted in another way.

Due to the uncertainties regarding the results of the county regions, it is more difficult to come up with any concrete solutions in terms of policy recommendations for these areas. The fact that the county regions consist of many different municipalities and cities with different conditions, as well as highly varying q values, is another aggravating factor. Despite the lack of statistically significant results for the county regions, we still consider our results satisfactory in general, as some vital conclusions are drawn and in particular, our research fills a void in the existing literature by incorporating multi-dwellings and regional differences.

7.4 Comparison to earlier research

When comparing our results to those obtained by other researchers, it is of high importance to acknowledge that multi-dwellings never have been included in previous studies. However, we do believe that our significant results for multi-dwellings, in terms of both short-run and long run relationships, indicate that this type of housing should not be neglected and indeed constitutes a large part of the Swedish housing supply.

Our main source of inspiration and comparison is, as earlier mentioned, the working paper by Berg and Berger (2005). Since their publication is the latest concerning Tobin's q and the Swedish housing market, and due to our replication of the method of adjustment for the average purchasing price as well as the usage of the same econometrical approach, a comparative discussion could provide additional substance and conclusions. The comparison is nonetheless limited by the fact that Berg and Berger only examine one- or two-dwellings, they use a structural break in the middle of their test period and lastly, they only perform their studies on a national level. Overall we suggest that our results can be regarded as an improvement and development of Berg and Berger's original studies, in the sense that we extend the research to include multi-dwellings and adhere to regional differences, which have proven to be extensive. Due to the different obtained results for different regions and dwelling-types, we cannot draw equally clear conclusions as in the working paper by Berg and Berger. As presented in chapter 2, Berg and Berger find a significant speed-of-adjustment parameter as well as a significant short run effect between building starts and Tobin's q for the last period of the sample, which stretches until the beginning of our testing period. Therefore, this period is of the highest significance to us for comparison purposes. In terms of one- or two-dwellings, which is the type of dwelling that Berg and Berger investigate, we find a significant speed-of-adjustment parameter for one region only, the Mid-County Region, which cannot be considered as a representation of the entire nation. Hence, our results differ in this aspect. Furthermore, significant short-run relationships for the same dwelling type are found for all three metropolitan areas. We do believe that these areas, Greater Stockholm in particular, are the driving mechanisms behind the increasing housing prices and Tobin's q on a national level.

Therefore, one could claim that our results are in accordance with Berg and Berger in this regard.

Overall, one could state that our results demonstrate higher rates of speed-of-adjustment than previous studies. Berg and Berger (2005) as well as Barot and Yang (2002) obtained a value of 6 percent, while Caldera and Johansson (2013) obtained a value of 13 percent in their research of OECD countries, compared to our significant values of 44 to 66 percent for different regions. Although, all three studies are performed on a national level using quarterly data, investigating one- or two-dwellings only. Hence, their speed-of-adjustment parameters represent the extent to which the disequilibrium is adjusted within one quarter of a year, rather than during a full year. Yet, it is clear that the two older studies' obtained values are far lower in relation to the study from 2013 and our results. This could be an indication of that the housing supply has become more rapidly responsive during recent years, although this claim is only valid for the regions and dwelling types where our speed-of-adjustment parameters are found statistically significant.

Considering the outcome of the Granger Causality test, our results are in accordance with the studies of Takala and Tuomala, who studied the Finish housing market (1990). They performed the test to rule out any endogeneity problems, which is also possible for our results as there are no cases of two-way causality. On the contrary, we find no causality in any direction for one- or two-dwellings, also in accordance with Takala and Tuomala's corresponding results for the housing market in Finland. Yet, for multi-dwellings, our results entail that dwelling starts have forecasting power over the next period's q value in four regions out of six. This is not very surprising since dwelling starts increase the housing stock, which in turn affects the average purchasing price, the nominator in Tobin's q. Although, we had expected to see signs of causality in the other direction as we believe that Tobin's q affects the next period's dwelling starts. On the other hand, this would have caused two-way causality and a violation of exogeneity. Instead, the confirmation of this relationship is provided by the cases when Tobin's q's explanatory power over dwelling starts is statistically significant, above accounted for as elasticities or short-run relationships. The other case of previous research including a Granger causality test is the one performed by Barot and Yang (2002). Although, they find that Tobin's q Granger causes housing investment, while housing starts have not been examined.

7.5 Suggestions for further research

A possible topic of interest for future research could be the Swedish Riksbank's repo rate's effect on the relationship between building starts and Tobin's q, as the repo rate affects all other interest rates, which in turn affects the housing market. Additionally, relying on the availability of data, a similar study to ours but for example on municipality level would be highly interesting. This is further motivated by the fact that we could not detect any significant results, except for a long run relationship in Region II, for our three county regions, indicating that a more narrow regional division could provide more substance and a more correct image of Sweden's housing market. Lastly, an inclusion of a structural break around the financial crisis in 2008 or at the introduction of a mortgage ceiling in 2010 could be of potential interest. Unfortunately, data limitations made it impossible for us to include a structural break if this had been necessary, since it would require more extensive data series. Although, our data set did not show any particular signs of a being affected by these events. It is yet possible that the requirement of a structural break could be proven depending on the data used and the number of observations, since a decrease in housing investment should intuitively have an impact on the number of houses being built as well as the values of Tobin's q. We further believe that additional research similar to the one seen in this thesis is of future interest since the underlying circumstances are subject to constant change. In a few years, it is possible that different conclusions can be drawn.

8. Conclusion

This thesis sought to investigate the relationship between building starts and Tobin's q in three metropolitan areas and three county regions in Sweden. The regional approach is chosen to enable a more realistic view of the driving forces behind increasing housing prices and increasing q values, as our findings state that these two measures vary to a large extent in different parts of Sweden. Except for the regional subdivision, this thesis also contributes with new research in the means of the dwelling types, which constitute the housing market.

The empirical analysis was accomplished through an Error Correction Model in the cases proving cointegration, and through a standard OLS regression for the remaining. The period covered is 2000 to 2015. From the results, we draw the conclusions that there is a long-run relationship and error correcting mechanism between building starts and Tobin's q for a minority of the examined regions and dwelling types. A short-run dependency between the variables is found in all metropolitan areas concerning one- or two-dwellings, yet only for Greater Malmö upon investigating multi-dwellings. When comparing the two values for Greater Malmö, corresponding to each of the dwelling types, we draw the conclusion that the supply of multi-dwellings could be more sensitive to changes in Tobin's q than the supply of one- or two-dwellings. Nonetheless, our results have also shown that the supply of one- or two-dwellings is in general more dependent on Tobin's q than the supply of multi-dwellings, since Tobin's q only has a significant effect on the multi-dwelling supply in one region.

Moreover, it is reasonable to consider the lack of significant results for multi-dwellings, particularly in Greater Stockholm and Greater Gothenburg, as an indication of the housing markets in these regions not functioning properly. The non-existing relationship between Tobin’s q and building starts in the concerned areas imply that the market forces are disturbed and we consider this to be one explanation to why these regions experience a severe housing shortage. Hence, our results potentially reveal a market failure, as they indicate that the market is not responsive to changes in Tobin's q, which in turn creates disequilibrium and a housing shortage. Unfortunately, this is what has happened on the market for multi-dwellings in Greater Stockholm and Greater Gothenburg today. Due to increased population growth and urbanization, the demand for housing in our two biggest cities today is remarkably high. One potential key to easing the housing shortage in these cities is, according to our results, to intervene on the market for multi-dwellings, for example through construction subsidies, interest deductions and reducing regulations. This could potentially improve the condition of the market, resulting in construction companies being able to undertake new multi-dwelling projects when Tobin's q indicates profitability.

Due to our findings of varying results for different regions as well as different dwelling types, we conclude that these two extensions of the previous literature are well motivated. We also consider our analysis significant for the same reason and due to the patterns of the housing market having an impact on the majority of the Swedish population. This statement holds true especially at present day, as both prices and demand for housing keep increasing.

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Appendices

Appendix 1

Table A1: Data Appendix

Variable	Statistics of Sweden label	Observations	Years available
Building starts	Dwellings in newly constructed buildings by region and type of building	Dwelling starts in newly constructed buildings	1975K1-2016K4
Average purchasing price, multi-dwellings	Sold tenant-owned flats by region	Average purchase price in 1000SEK	2000-2015
Average purchase price, one- or two-dwellings	Sold one- and two-dwelling buildings for permanent living by region	Average purchase price in 1000SEK	2000-2016
Production cost, multi-dwellings	Cost per dwelling for newly constructed conventional multi-dwelling buildings by region and gross-/net cost.	Total gross production cost/dwelling	1998-2015
Production cost, one- or two-dwellings	Cost per dwelling for newly constructed conventional collectively built one- or two-dwelling buildings by region and gross-/net cost.	Total gross production cost/dwelling	1998-2015
Income	Total earned income, average income for residents in Sweden throughout the year, thousands of SEK by region, gender, age, income class and age	Average income, thousands of SEK	1999-2015
QPI	Building price index for dwellings (BPI), including VAT by type of building and type of index	Quality price index for multi-dwelling buildings and collectively built one- and two-dwelling buildings	1968-2015
Land area per square km	Population density per sq. km, population and land area by region and sex	Land area per sq. km	1991-2016
Population	Population by region, marital status, age and sex	Population, all marital statuses, all age groups and all genders	1968-2016
Dwelling stock	The dwelling stock, projections by region and type of building	Dwelling stock for multi-dwelling buildings and one- or two-dwelling buildings	1990- 2012

Appendix 2

Table A2: Regional division

Regions	Counties
Greater Stockholm	Stockholm (municipalities: Stockholm, Huddinge, Nacka, Södertälje (as of 2005), Botkyrka, Haninge, Solna, Järfälla, Sollentuna, Täby, Norrtälje (as of 2005), Lidingö, Tyresö, Sigtuna, Upplands Väsby, Österåker, Sundbyberg, Värmdö, Danderyd, Vallentuna, Nynäshamn (as of 2005), Ekerö, Upplands-Bro, Salem, Vaxholm and Nykvarn (as of 2005).
Greater Gothenburg	Part of Västra Götaland and Halland (municipalities: Kungälv, Stenungsund, Tjörn, Öckerö, Göteborg, Mölndal, Partille, Härryda, Lerum, Ale, Alingsås (as of 2005), Lilla Edet (as of 2005) and Kungsbacka)
Greater Malmö	Part of Skåne (municipalities: Malmö, Lund, Trelleborg, Vellinge, Eslöv (as of 2005), Kävlinge, Staffanstorp, Lomma, Svedala, Burlöv, Höör (as of 2005) and Skurup (as of 2005))
North County Region	Jämtland, Västernorrland, Västerbotten, Norrbotten
Mid-County Region	Stockholm county (excl. municipalities in Greater Stockholm), Uppsala, Södermanlands, Östergötlands, Hallands län (excl. municipalities in Greater Gothenburg), Västra Götalands län (excl. municipalities in Greater Gothenburg), Värmlands, Örebro, Västmanlands, Dalarnas and Gävleborgs län
South County Region	Jönköpings, Kronobergs, Kalmar, Gotlands, Blekinge och Skåne län (excl. municipalities in Greater Malmö)

Appendix 3

Table A3: Calculation of Tobin's q

One- and two-dwellings for Greater Stockholm							
Year	**Market value**	**Berger appreciation rate**	**Adjusted market value**	**Production cost**	**QPI (1=2015)**	**Adjusted prod. cost**	**Q**
2000	2 083	1,34	2 787	2 384	0,99	2 416	1,15
2001	2 306	1,35	3 114	2 369	0,96	2 466	1,26
2002	2 457	1,36	3 348	2 625	1,00	2 622	1,28
2003	2 539	1,38	3 491	2 832	1,00	2 844	1,23
2004	2 692	1,39	3 735	3 045	1,00	3 056	1,22
2005	2 742	1,40	3 838	2 930	1,01	2 915	1,32
2006	3 077	1,41	4 344	3 069	1,02	3 020	1,44
2007	3 476	1,42	4 950	3 300	1,08	3 048	1,62
2008	3 477	1,44	4 995	4 204	1,07	3 926	1,27
2009	3 518	1,45	5 097	4 548	0,98	4 634	1,10
2010	3 783	1,46	5 527	4 100	1,04	3 937	1,40
2011	3 809	1,47	5 612	4 512	1,08	4 176	1,34
2012	3 843	1,49	5 709	3 860	1,00	3 868	1,48
2013	4 271	1,50	6 398	4 286	1,03	4 153	1,54
2014	4 646	1,51	7 016	4 660	1,03	4 524	1,55
2015	4 983	1,52	7 586	4896	1,00	4 896	1,55

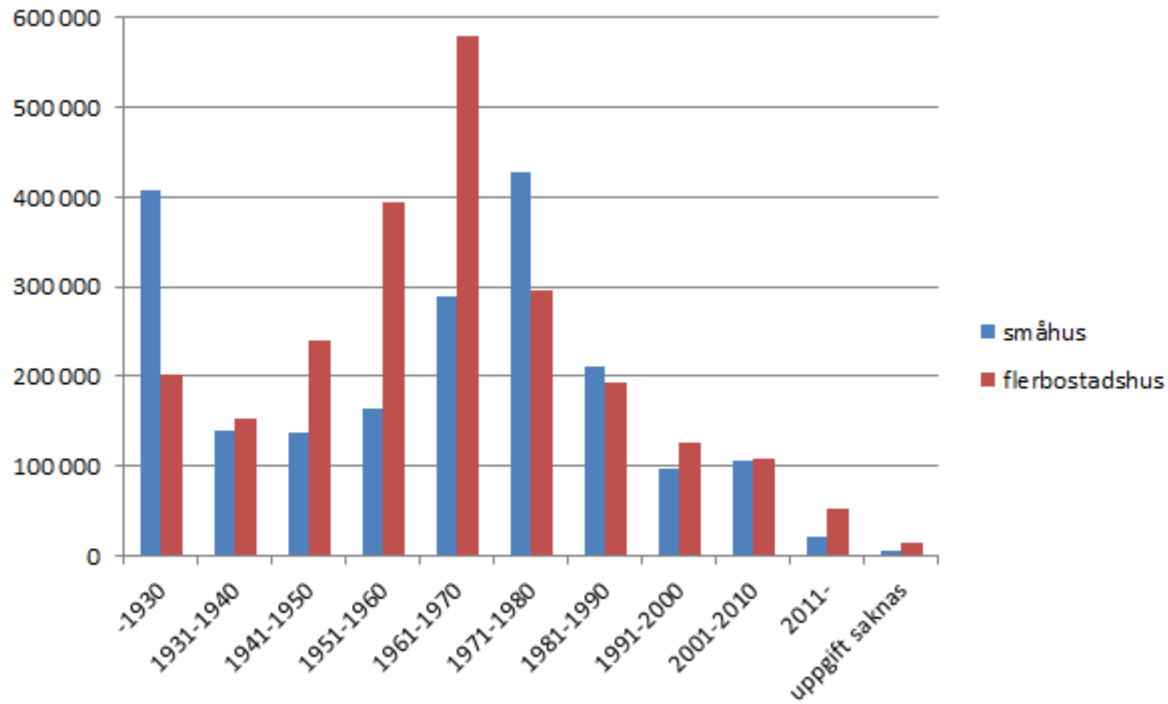
$$Adjusted\ market\ value = Market\ value * Berger\ appreciation\ rate$$

$$Adjusted\ production\ cost = \frac{Production\ cost}{QPI} = \frac{Building\ cost + Land\ cost}{QPI}$$

$$Q = \frac{Adjusted\ market\ value}{Adjusted\ production\ cost}$$

Appendix 4

Graph from Statistics Sweden, depicting the age of the total housing stock as of 2012.



Appendix 5

Unit root test, MacKinnon one-sided p-values are shown in the table.

Significance levels: ***p<0,01, **p<0,05, *p<0,1

Table A5: Augmented Dickey-Fuller test

Ln Dwelling Starts			
One- or two-dwellings		Multi-dwellings	
Level	1st Difference	Level	1st Difference
0,3232	0,0665*	0,3819	0,00***
Ln Q			
One- or two-dwellings		Multi-dwellings	
Level	1st Difference	Level	1st Difference
0,159	0,00***	0,535	0,00***

Ln Population Density	
Level	1st Difference
0,877	0,00***
Ln Income	
Level	1st Difference
0,2296	0,0326**

Appendix 6

Optimal lag structure determined by applying Akaike's information criterion (AIC) to an unrestricted vector autoregression (VAR) model.

Maximum lag length = 2.

Table A6: Optimal Lag Length

	One- or two-dwellings	Multi-dwellings
Region	Lags	Lags
Greater Stockholm	1	1
Greater Gothenburg	1	2
Greater Malmö	2	2
North Region	1	1
Mid-Region	2	1
South Region	2	2

Appendix 7

Johansen's Cointegration test, performed with the optimal lag length from table A6. Integers indicate the estimated number of cointegrating variables.

Table A7: Johansen's Cointegration Test

Region	Test type	No intercept or trend in CE No intercept in VAR	Intercept and no trend in CE No intercept in VAR	Intercept and no trend in CE Intercept in VAR	Intercept and trend in CE No intercept in VAR	Intercept and trend in CE Intercept in VAR
		One- or two-dwellings				
Greater Stockholm	Trace	0	0	0	0	0
	Max-Eig	0	0	0	0	0
Greater Gothenburg	Trace	0	0	0	0	0
	Max-Eig	0	0	0	0	0
Greater Malmö	Trace	0	0	0	0	2
	Max-Eig	0	0	0	0	0
North Region	Trace	0	0	0	0	0
	Max-Eig	0	0	0	0	0
Mid-Region	Trace	0	0	0	0	2
	Max-Eig	0	0	0	0	0
South Region	Trace	1	0	0	0	0
	Max-Eig	1	0	0	0	0
		Multi-dwellings				
Greater Stockholm	Trace	0	0	0	0	0
	Max-Eig	0	0	0	0	0
Greater Gothenburg	Trace	0	1	1	1	2
	Max-Eig	0	1	1	1	2
Greater Malmö	Trace	1	2	2	1	2
	Max-Eig	1	0	2	1	2
North Region	Trace	0	0	0	0	0
	Max-Eig	0	0	0	0	0
Mid-Region	Trace	0	0	0	0	0
	Max-Eig	0	0	0	0	0
South Region	Trace	1	1	2	1	2
	Max-Eig	1	1	2	1	2

Appendix 8

Estimated results from equation (5.4) and (5.5).

Sample period: 2000-2015

Significance levels: ***p<0,01, **p<0,05, *p<0,1

Table A8: Estimation results - ECM and OLS

Dependent variable: Δ Ln Dwelling Starts

Greater Stockholm									
One- or two-dwellings					Multi-dwellings				
Variable	**Coeff.**	**SE**	**t-stat.**	**p-value**	**Variable**	**Coeff.**	**SE**	**t-stat.**	**p-value**
C	0,1785	0,2299	0,7764	0,4539	**C**	0,5059	0,5039	1,0039	0,337
Δ Ln Q	1,5524**	0,5754	2,698	0,0207	**Δ Ln Q**	-0,2979	0,9944	-0,2996	0,7701
Δ Ln Pop. Dens.	0,1279	0,4715	0,2714	0,7911	**Δ Ln Pop. Dens.**	0,1999	0,8845	0,226	0,8253
Δ Ln Income	-6,7717	7,471	-0,9064	0,3842	**Δ Ln Income**	-13,555	15,9258	-0,8511	0,4128
Greater Gothenburg									
One- or two-dwellings					Multi-dwellings				
Variable	**Coeff.**	**SE**	**t-stat.**	**p-value**	**Variable**	**Coeff.**	**SE**	**t-stat.**	**p-value**
C	0,2257	0,2232	1,0113	0,3336	**Residuals(-1)**	-0,561*	0,2935	-1,9113	0,0824
Δ Ln Q	1,3494**	0,5619	2,4014	0,0351	**Δ Ln Q**	0,5452	0,5463	0,998	0,3379
Δ Ln Pop. Dens.	0,0089	1,0298	0,0087	0,9932	**Δ Ln Pop. Dens.**	-1,957	1,6838	-1,1621	0,2698
Δ Ln Income	-8,6637	7,301	-1,1867	0,2604	**Δ Ln Income**	0,6244	3,6511	0,171	0,8673
Greater Malmö									
One- or two-dwellings					Multi-dwellings				
Variable	**Coeff.**	**SE**	**t-stat.**	**p-value**	**Variable**	**Coeff.**	**SE**	**t-stat.**	**p-value**
Residuals(-1)	-0,2932	0,1769	-1,6577	0,1256	**Residuals(-1)**	-0,6593**	0,2663	-2,476	0,0308
Δ Ln Q	1,4494**	0,6277	2,309	0,0414	**Δ Ln Q**	1,6276**	0,6963	2,3373	0,0394
Δ Ln Pop. Dens.	-2,4032*	1,1252	-2,1357	0,056	**Δ Ln Pop. Dens.**	-1,2561	2,0847	-0,6025	0,559
Δ Ln Income	-1,216	2,063	-0,5894	0,5675	**Δ Ln Income**	-5,6257	4,6547	-1,2086	0,2522
North County Region									
One- or two-dwellings					Multi-dwellings				
Variable	**Coeff.**	**SE**	**t-stat.**	**p-value**	**Variable**	**Coeff.**	**SE**	**t-stat.**	**p-value**
C	0,0059	0,1927	0,0306	0,9762	**C**	0,5738	0,6496	0,8833	0,3959
Δ Ln Q	0,3463	0,3336	1,0378	0,3216	**Δ Ln Q**	-0,5368	0,7861	-0,6828	0,5088
Δ Ln Pop. Dens.	18,0817	12,653	1,429	0,1808	**Δ Ln Pop. Dens.**	0,5774	41,1347	0,014	0,9891
Δ Ln Income	1,2607	6,2686	0,2011	0,8443	**Δ Ln Income**	-14,4359	20,9042	-0,6906	0,5041

Mid-County Region									
One- or two-dwellings					Multi-dwellings				
Variable	**Coeff.**	**SE**	**t-stat.**	**p-value**	**Variable**	**Coeff.**	**SE**	**t-stat.**	**p-value**
Residuals(-1)	-0,4416**	0,1695	-2,6048	0,0404	**C**	0,2232	0,3482	0,641	0,5346
Δ Ln Dwelling Starts(-1)	0,7701**	0,2463	3,1261	0,0204	**Δ Ln Q**	0,8347	0,6807	1,2259	0,2458
Δ Ln Q	1,2017	0,9868	1,2178	0,269	**Δ Ln Pop. Dens.**	-7,6748	9,6637	-0,7942	0,4439
Δ Ln Q(-1)	-0,5821	0,9587	-0,6072	0,566	**Δ Ln Income**	-6,073	10,719	-0,5666	0,5824
Δ Ln Pop. Dens.	-1,5919	4,9037	-0,3246	0,7565					
Δ Ln Pop. Dens.(-1)	-3,882	4,6732	-0,8307	0,4379					
Δ Ln Income	-5,8489	5,0441	-1,1595	0,2903					
Δ Ln Income(-1)	6,1868	4,3944	1,4079	0,2088					

South County Region									
One- or two-dwellings					Multi-dwellings				
Variable	**Coeff.**	**SE**	**t-stat.**	**p-value**	**Variable**	**Coeff.**	**SE**	**t-stat.**	**p-value**
Residuals(-1)	-0,2784	0,1861	-1,4962	0,1627	**Residuals(-1)**	-0,5013	0,3013	-1,6637	0,1244
Δ Ln Q	-0,0925	0,4065	-0,2276	0,8242	**Δ Ln Q**	-0,362	0,812	-0,4459	0,6644
Δ Ln Pop. Dens.	-6,3245	6,275	-1,0079	0,3352	**Δ Ln Pop. Dens.**	-3,5435	11,31	-0,3133	0,7599
Δ Ln Income	0,0057	0,0121	0,4746	0,6443	**Δ Ln Income**	2,4407	4,3327	0,5633	0,5845

Appendix 9

Table A9: Granger Causality test

Significance levels: ***p<0,01, **p<0,05, *p<0,1

Null: Ln Q does not Granger Cause Ln Dwelling Starts

	One- or two-dwellings			Multi-dwellings		
Region	F-value	p-value	Lags	F-value	p-value	Lags
Greater Stockholm	0,5772	0,4621	1	0,3806	0,5488	1
Greater Gothenburg	2,3026	0,1551	1	1,9065	0,204	2
Greater Malmö	0,7416	0,5034	2	0,5525	0,5939	2
North Region	0,808	0,3864	1	0,9508	0,3488	1
Mid-Region	0,0006	0,9994	2	0,96	0,3465	1
South Region	1,5398	0,266	2	0,4931	0,6263	2

Null: Ln Dwelling Starts does not Granger Cause Ln Q

	One- or two-dwellings			Multi-dwellings		
Region	F-value	p-value	Lags	F-value	p-value	Lags
Greater Stockholm	1,1649	0,3017	1	5,72	0,034**	1
Greater Gothenburg	0,0228	0,8824	1	3,1007	0,0945*	2
Greater Malmö	0,9865	0,4099	2	1,009	0,4024	2
North Region	1,2509	0,2853	1	4,5615	0,054*	1
Mid-Region	0,0661	0,9365	2	0,5015	0,4924	1
South Region	0,0084	0,9916	2	4,1474	0,0529*	2