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Convergence on the Swedish housing market
a study of Stockholm, Gothenburg, and Malmo

Thomas Nigon

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Author	Thomas Nigon
Student number	S2753510
E-mail	T.h.nigon@student.rug.nl
Supervisor	Dr. A.J. van der Vlist
Assessor	Dr. X. Liu

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Abstract.

This paper examines housing price dynamics in Sweden over the course of 1998Q1-2020Q4 based on regional housing price data. This paper dives into the possibilities between the convergence or divergence between the regions of Stockholm, Gothenburg, and Malmo. To measure the convergence or divergence of these 3 biggest cities in Sweden a log-t-test is performed together with convergent grouping. Further, possible regional drivers for house price levels are considered in this paper, including: ‘construction activity, population and disposable income’ using a VAR-model to model the effect of the variables on each other. housing price drop which has had different effects concerning the three biggest cities in Sweden.

The findings are as follows: first, the VAR-model indicates that the construction variable notes a positive effect on the short term in Stockholm and Malmo, and an eventual positive effect in Gothenburg, where all cities eventually decline on the long term. The Population variable showed to be negative on the short run for Gothenburg and Malmo, and positive for Stockholm. This can be the result of differences in demographics attracted to the cities or a mismatch of housing supply and housing demand. For disposable income, there is a negative shock in the short term for Malmo and Gothenburg but a small positive one for Stockholm. This can be because of the difference in mortgage debt of those cities. Furthermore, this paper finds evidence for convergence between Stockholm and Gothenburg. The housing prices between these cities seem to convergence with each other in the time frame. However, further research will need to be conducted to shed a light on this result.

Keyword: Convergence, VAR-model, Sweden, Residential market

1. INTRODUCTION
1.1 Motivation

The housing market is an important sector in everybody's day to day lives. Housing is often the most expensive commodity that a person will ever own, so that in this market would affect a lot of people's day to day lives dramatically. A recent example would be the 2008 financial crisis where a lot of people defaulted on their mortgage and big banks such as Lehman brothers went under, where others needed government support in order to not fall (Amadeo, 2007). Because of this people's incomes dropped, and some people lost their homes. The ripples of the 'subprime mortgage crash' as it was later called was felt all over the world. Everywhere except for Sweden.

The Swedish housing market seems to be resilient against crashes. Proven by the global subprime mortgage crash, only seeing small declines in housing prices (Berglund & Mäkinen, 2019). The resilience in this time was admirable, considering the state of the other markets in Europe. These markets had applied what they had learned from the previous housing crisis and seemed quite resilient at the time (Dougherty, 2008). As Sweden's housing prices seemed to drop where everywhere else in Europe they soared (Dougherty, 2008). A research conducted by the Global property guide (2018) showed that the Swedish housing market had taken a big tumble as of 2016. Stricter mortgage restrictions, falling construction and increasing debt per capita seemed to indicate soaring housing prices. But the prices ended up dropping (Gustavsson et al.,2016).

The Swedish housing market shock of 2018 had a different influence on different regions within Sweden. The highest drop was measured by the city of Stockholm. The biggest city in Sweden was hurt about twice as much as the national average (7.2% compared to 3.3%). The other big cities in Sweden such as Gothenburg and Malmo were also hit. Gothenburg suffered a price drop of around 3.4% and Malmo only suffered a price drop of 0.7%.This big difference in the different cities because of this mortgage restriction begs the question as to if different regional housing markets can be defined within the Swedish housing markets. It is important to examine the sudden housing decrease within the Swedish housing market. Because the drop in housing was so recent and it seemed to only be affecting the Swedish housing market, there is a big knowledge gap in why it was so severe in Stockholm as compared to the rest of the country. It is therefore important to view if this effect is a result of the way in which the Swedish housing market is set up. Sweden shows much higher forms of regulation and debt per capita in their market than any other type of Real estate market. Lessons can be learned from this market about the effect of government regulation and could potentially be useful for policy makers from different countries in the future.

The focus of this research will be on examining the regional housing prices in Stockholm as compared to Malmo and Gothenburg where the effects seemed to be almost negligible and try to identify regional housing markets within the Swedish housing markets. This paper will focus on modelling housing prices from the Swedish housing market as a whole and the regional housing markets of Stockholm, Gothenburg and Malmo for the period leading up to the 2018 housing price drop, together with construction, population, and income. A lot has been written about the Swedish housing market, and its government regulation. However, there is a big knowledge gap as to why this drop happened within this period, which variables were involved and the relationship in severity between the different cities within price drops. This paper will look at the different variables to address convergence of housing prices or if they are to be classified as regional markets, since prominent literature has been quick to conclude that this is the case.

1.2 Literature review

This paper connects to the literature on regional house price dynamics. Previous literature on housing price dynamics suggests that multiple drivers are necessary to make a valid deduction on what can cause housing price fluctuations and market forming. Papers such as Meen (1996) include a standard set of variables and drivers (Meen ,1996).

The paper by Rapach & Strauss (2009) focusses more on housing stock, and vacancy rates. Other papers such as Chung & Thewissen (2011) focuses more on income and construction activity. All three papers try to understand the development of prices through different economic drivers, in all three papers the recurring drivers are 'construction activity, population increase or decrease, and disposable income'. The regional factors that will be examined in this paper will therefore also be construction, population, and disposable income in accordance with the literature.

Construction or new supply is important in explaining differences across regional house prices in the sense that it can measure elasticity of a market (Sørensen, 2013). The elasticity of supply can be explained with models like the four-quadrant model by DiPasquale-Wheaton (1992) or the Stock-flow model (DiPasquale-Wheaton, 1994) Which denotes the effects of construction activity on the housing market and the way in which the market will absorb the added housing in relation to housing price and it's demand. Shifts into demand due to income, increased mortgage loans or unemployment are key factors according to this model. All these factors are related to the construction activity increase or decrease (Lisi, 2015).

Another important driver in regional housing price dynamics is population increase or decrease as noted by the paper by Accetturo et al. (2014) which states that housing prices in these urban regions increases, except for the regions where immigrants tend to group. This effect is also found in the paper of Sá, (2015). Where in the UK market there is a flight of native population around areas where migrants tend to settle. The paper by Akbari & Aydede (2012) notes that this effect could also be attributed to the increased housing production because of expected increased demand. This effect is most notable in the city of Malmo where according to the Riksbanken (2015), despite the city's influx of new migrants there has not been a noticeable increase in housing on this market. This paper by Akbari & Aydede (2012) would be more in line with the four-quadrant model which states that an increase in population would always add to the demand for housing.

A driver that does seem to add to the demand for housing in any case would be the relative disposable income. Referring to the time series analysis concerning mortgage rates (Meen, 1996). A clear distinction can be made between Stockholm lending practices and Malmo lending where the debt to equity (DTE) ratio of Stockholmers seems to be way higher than that of people from Malmo, but also a higher Loan to value (LTV) can be observed. Furthermore, the state of the Swedish housing market regarding large indebtedness and a relatively inelastic housing market can create a discrepancy in supply and demand for the housing market (Sørensen, 2013).

Lastly, the macro-economic influence of a mortgage reform on housing prices and the effect of the lower mortgage rate cannot be understated in relation to the disposable income. As a paper by Wilhelmsson (2019) stated that the value of housing prices was not affected by the decisions. However, a paper by Lodén & Persson (2019). noted a difference in housing prices and especially in mortgage price deductions. These mortgage differences were implemented on the national mortgage market and could be a driving catalyst to the sudden drop in housing according to a paper by Li et al. (2017).

Considering the variables of construction, population, and disposable income, what is their inevitable effect on the regional differences in housing price over time. The eventual differences between regions can be denoted in the way that housing prices converge or diverge because of the difference between these macro-economic factors. A paper by Holmes (2007) also shows that convergence between housing prices can explain the regional differences to show the effects of macroeconomic drivers. Another example of a similar method to measure convergence would be about the US housing prices Montañés & Olmos (2013) which seems to try to quantify the same type of research. The paper by Holmes divides the analysis based on regions in the UK whereas Montañés & Olmos compare different cities in the US. The paper by Holmes identifies different individual hypotheses for convergence of housing prices, while Montañés & Olmos follow a method by Phillips & Sul (2007) which try to divide different individual cities into subgroups in order to check for unit root and possible convergence.

Converging or diverging prices are important to denote from a regional perspective, explanatory factors can be explained through regional differences in housing price drops; it is customary to look at the regional characteristics according to a paper by Tsatsaronis (2004). Within time series models this is done by a Vector autoregressive model, which is a model that compares multiple variables over a length of time. This type of model is often used to compare macro-economic or regional drivers within the context of time series as can be shown in papers by Ramajo et al. (2017) & Das et al. (2011). Further convergence should be explained when we look at the literature of Montañés & Olmos but also Clark & Coggin (2011). Which also tells us that increased valuation of regional housing prices or housing markets with ‘bubble tendencies’ might potentially alter the convergence of housing prices. Which allows for greater divergence in housing prices. When we look at the papers by Meen (1996), Rapach & Strauss (2009) and Thewissen (2011) we can start discerning the regional differences.

The differences between the regions over time in terms of housing price and the identified drivers can be shifted. Because overvaluation of housing can explain divergence it is important to identify its role. Research by Sørensen (2013) has identified the overvaluation of housing prices to be in the Stockholm housing market. The Riksbanken (2016) did add that overvaluation may not be present in the country, but that regional overvaluation does exist. Their research finds strong bubble tendencies in the Swedish housing market where housing indebtedness and relative slow income growth to housing prices occur. This might explain possible divergence within these regional housing markets.

1.3 Problem definition and research questions

To study the sudden decline in Swedish housing prices this research will cover the progression of housing prices within the cities of Stockholm, Malmo and Gothenburg. The housing prices will cover the entire property market, excluding the rental market. The data that this paper will use will be quarterly data on housing prices from 1998Q1-2019Q4.

The main problem that this paper will try to answer is: *Do housing prices in the cities of Stockholm, Malmo and Gothenburg converge or diverge over time, and what regional drivers can be linked to regional house price dynamics?*

The Swedish housing price dynamics seems to be different from other factors in Europe, raising the question of submarket formation in the Swedish housing market. Therefore, it is important to see why the increased effect seems to center around Stockholm. If there is a difference in a certain variable such as a much higher debt per capita, lower construction costs etc. then the deduction on why the effect happened in the first place can be narrowed down to the effect that initiated the price drop in the first place. To answer the main research, question the following sub-questions have been formulated:

1.3.1 What are the general supply and demand drivers?

The paper will try to emulate Meen (1996) who in his paper modelled the housing market in such a way that multiple factors are included in the analysis and different variables from the housing market are examined. The factors discussed are construction activity, population increase or decrease, and disposable income. The paper will briefly discuss mortgage restrictions, unemployment, and interest as by a paper by Chung & Thewissen (2011). These supply and demand variables for each of the cities will therefore be held by the four-quadrant model by DiPasquale and Wheaton (1992) to provide context within the development of regional supply and demand variables. The explanatory aspect of this sub-question is important as it can help explain the regional housing price dynamics.

1.3.2 What are the differences regionally between these supply and demand drivers in Sweden? at a given moment in time

The supply and demand drivers discussed in the previous section have shown the importance on a macroeconomic scale. However, to make a valid judgement between the regions. This paper would need to distinguish the different drivers that have been identified and show how they apply to the city at this moment in time in relation to construction, population, and disposable income. The city of Malmo for example has relative cheap housing compared to the city of Stockholm, therefore when we decide to use the metrics that compare housing prices to things such as debt or building costs we can get a skewed view if we do not take these things into account. Vis-a-vis we can explain and understand housing prices better given the full context of the housing price fluctuations given demand are important to consider in its fullest, therefore studying different metrics for debt for example. Furthermore, metrics such as income, unemployment and population growth could also give indications of where the city is in its regional cycle of Real estate. This in turn would prove important to see if the city follows national cycles or is more in line with its own cycle. Furthermore, it can help understand the results that will be presented from both the VAR model and the convergence model discussed.

1.3.3 What can explain the divergence or convergence of the housing prices over time?

Regional house price variation is addressed using pairwise conversion of housing prices. The method of conversion will follow the paper by Phillips and Sul (2007) which seeks to explain convergence of housing prices in pairing the convergent groups and the non-convergent groups together. This method is different from other methods in terms of convergence testing in that groups are formed dependent on convergence. To study the development of prices and the inevitable drop of prices in 2016. A comparison between the three cities and their drivers consisting of: 'Construction activity, population increase or decrease, and disposable income 'would shed light in differences between the cities.

The convergence or divergence between the three cities and Sweden will be examined by performing a vector autoregressive model which in turn will show the relationship between construction, population, and disposable income on the housing prices within that city. The degree of convergence can be explained by studying the three cities and the way their housing prices develop in relation to each other. given the appropriate demand has been met one would assume an increase in building and after take-up according to the four-quadrant model. This too could help with understanding the price mechanics.

1.4 Reading guide

To prepare for the quantitative data research, this paper will discuss the different variables and the reason as to why these are important in chapter 2. Chapter 3 will explain the data used, and where the data came from. The model and the method will also be discussed in this chapter. Chapter 4 will hold the results of the regression with the defined variables, in this chapter there will also be a discussion on the different results and how it relates to the literature. In chapter 5 there will be an answer given to the main question, furthermore limitations and possibilities for future research will be discussed.

2. THEORY
2.1 Supply and demand variables

To properly state and understand regional price dynamics we examine the conceptual model of DiPasquale and Wheaton (1992). This model is often referred to as the four-quadrant model (figure 1). The model shows for a certain housing market how changes in demand, construction, housing price valuation can change the supply and the demand of assets. The upper right square shows the demand for space of the four-quadrant model. This portion has rent on the vertical axis and the quantity of housing on the horizontal axis. The portion on the left shows the valuation for investors. showing the price of real estate in relation to the rent. The portion down on the left show's construction and the prices that construction would be able

to justify the building of new assets. The portion below on the right shows the adjustment of the stock as more supply is added in relation to assets. Because the model also explains what would happen if a change would happen within these factors and what would happen on the other variables as a result. Such that an increase in demand would raise prices of assets, which would result in more construction activity which would raise the number of assets within a market and stabilize the price after a while.

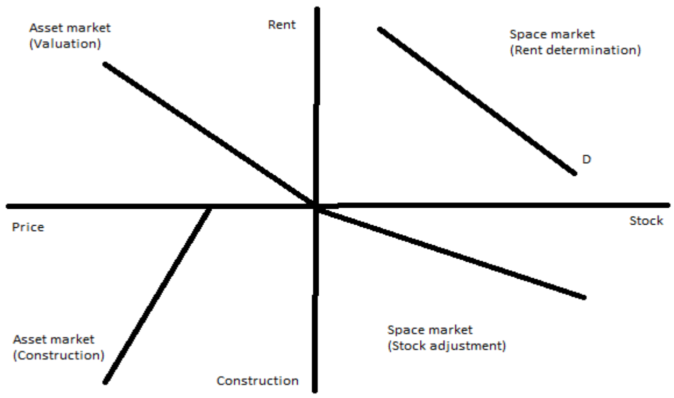

Figure 1, The four-quadrant model (DiPasquale & Wheaton, 1992)

Seeing as dynamic housing prices are important within the VAR-analysis, another model of DiPasquale and Wheaton can help explain the different states of each market at a certain point in time. The model is referred to as the 'Stock-flow model' (Figure 2). This model helps explain where the market is to move to an equilibrium where demand is equal to supply. And where the steady state of the market is equal to the change in
supply being 0. The model focuses on an equilibrium stock where these conditions are met, using the variables for demolition and responsiveness of the building market to fluctuations in demand.

Concerning the different types of variables that can have an impact on the regional house price fluctuations according to Meen (1996), Rapach & Strauss (2009) and Chung & Thewissen (2011). This paper will focus on the common drivers that these papers note. These being: Construction, population, and disposable income. The variables will also be held according to the four-quadrant model to understand the demand and supply dynamics on regional and national scale. The driver of 'disposable income' however, does not have a real basis in the four-quadrant model. For this driver, a comparison with the stock-flow model would be more accurate.

The variables Construction, population and disposable income' on the variable of housing prices will be compared. The comparison is based on time series of the different variables. In this case a normal regression would be insufficient, therefore a time series alternative would need to be incorporated. The VAR-model in this case lends itself to be used in macroeconomic context. Being a model that allows for comparison of different macroeconomic drivers such as papers by Dungey and Pagan (2000) & Cologni and Manera (2008) tend to show. The comparison will be time based so in this case the development through time in relation to the different variables included will allow for a valid comparison to be made.

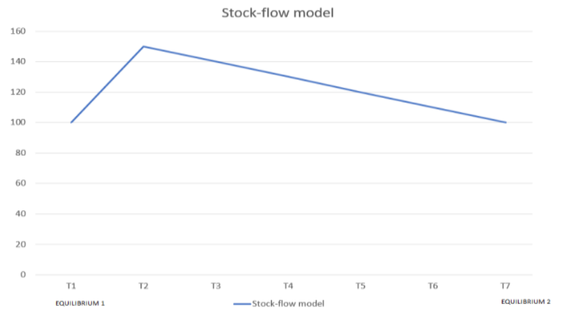

Figure 2, Stock-flow model (DiPasquale & Wheaton, 1994)

2.1.1 General regional construction

Construction activity is an important indicator toconsider when judging housing prices. Just as with the housing price boom in the run-up to the financial crisis of 2008. A paper by Glaeser et al. (2005) denotes the importance of construction activity on the soaring of housing prices. But how this paper stands out is that it focuses on the effects of building costs and regulations, Relating this to the four-quadrant model by DiPasquale & Wheaton. Glaeser et al. refer to the construction activity picking up or slowing down when there is incentive in prices to do so. Or if the yields are acceptable to the construction company and demand is present.

The stock-flow model by DiPasquale and Wheaton adds construction responsiveness to demand changes. The level of adjustment or the elasticity within construction depends on different legal guidelines, incentives for building companies to produce according to Green et al. (2005). Relating to supply elasticity in these markets is the construction costs and activity. Construction activity can thus be haltered or improved based on the incentives or restrictions that are put on the sector. Within economies that have a flexible housing stock such as North America there are mostly private incentives to stimulate housing, and lower restrictions on buildings (Saiz, 2007). However, in more rigid housing such as the UK we can see more planning restrictions and more civil incentives for larger building companies to adjust the housing stock, an increase in construction is always offset by an increase in demand (Levin and Pryce ,2009).

Financial incentives are also needed in regular development, to reduce the uncertainty of the development and provide adequate housing within a market. If we would refer to the four-quadrant model shown in figure 1. we can see that the slope of the line in asset market valuation reflects the Yields (shown by rent) could generate for a specific price. If the yields must go up for the same price generated, then the line will run steeper. This in turn would increase the rents that a property would generate but since most rents are fixed the prices of the property will increase. Greater yields can be needed when investors see greater risk in the project, in that sense asset pricing can also increase as a result.

Construction activity can better accommodate demand according to the model by DiPasquale and Wheaton. Responsiveness of the market or elasticity can therefore be an important facet when talking about economic shocks and bounce backs. A paper by de La Paz & White (2016), notes that inelastic markets have higher price run ups and longer drawn out crashes. The longer drawn out crashes can halter further economic growth as opposed to cities or regions with higher responsiveness to crashes according to a paper by Davidoff (2013).

An important facet to consider about construction elasticity is the growing demand and slimming extra supply of capped rental housing for starters. This type of market is not as profitable as the free market. Furthermore, this type of housing is preferred for starters in that they can acquire housing using years in a cue instead of monetary costs. This type of housing is important for starters in bigger cities, as often their income is not enough to pay for a new home. However, there is not a lot of incentive for developers to develop this type of housing unless monetary incentives are provided by the government.

The recent changes in demographics are of importance to new construction. Starters but also middle-aged demographics are switching to a more secular lifestyle. Where in cities there is a higher demand for apartment living as opposed to house living. This change is important for construction activity as with it come new challenges and considerations as to this type of demand change for people living within the urban landscape.

2.1.2 General regional population

The quantity and demand for housing is correlated by the amount of people searching for homes within a market. This factor is referred to as ‘the population’ of a housing market’. Ideally everyone would have a place to live when moving.

However, supply must meet demand when it comes to population changes. Differences in population and the way in which houses are ordained can have a significant effect on building types and housing prices. This effect was noted in papers such as Bujang et al. (2010), Case & Mayer (1996). Which also added that amenities one can find within a city are not easily added or removed, showing that certain age groups are drawn to markets based on certain amenities provided. The papers also note the inelasticity of housing and the coming of middle-aged demographics increases housing prices more so in an inelastic market for example.

An increase in population is often associated with an increase in housing price, however this is not always the case. The paper by Accetturo et al. (2014) Further states that housing prices in these urban regions increases, except for the regions where immigrants tend to group. This effect is also found in the paper of Sá (2015). Where in the UK market there is a flight of native population around areas where migrants tend to settle. The paper by Akbari & Aydede (2012) notes that this effect could also be attributed to the increased housing production because of expected increased demand. Showing that a housing market that is more elastic can see a reduction in price within the first years from an increase in population.

Adding to the idea of a greater population not always adding to demand as the DiPasquale and Wheaton model would suggest is a paper by Mulder (2006). The paper argues that demand does come from an increase in people willing to buy a house. But the paper brings on points about an increase in housing prices which may discourage starters from moving out of their parent's homes for example. This effect would lead to an increase in population but not necessarily housing demand. Furthermore, it may influence starters to not marry cohabit and have children. The availability of the housing sector is therefore just as important as the population that is attracted to a market according to this paper.

The increase in population however due to natural births or migration often results in a higher housing price for nations that can accommodate the increase regarding an increase in demand. If we compare similar research within different countries, we can see that within the Canadian and Swiss context there was a significant influence in Migration (Akbari & Aydede, 2012) & (Wilhelmsson, 2008). For every 1% of population increase there seemed to be a direct correlation of 2.6% increase in housing price. The interesting thing is that this effect was seen in both countries who have inelastic supply of housing and a 15% difference in urbanization.

2.1.3 General regional disposable income

An important demand variable for housing consumption is the income of its residents after mortgage debt. What helps reduce the debt that people have is a reduction in mortgage expenses. An example of lowering the costs can be through a lower interest rate on the mortgage. The lower interest rate is favorable for housing price growth according to a paper by Allen & Gale (2000). A lower interest rate generally means that people are willing to make greater purchases faster. Thus, the housing market is one that would benefit greatly from a reduced or negative interest rate (Stroukal & Kadeřábková 2016). This would be the consensus regarding reduced interest rates and increased mortgage payments. However, a paper by Muellbauer and Murphy (1997) found no empirical evidence that dropping interest rates had not had a significant effect on housing price volatility in the English market.

However, in some instances interest rates do influence the housing price volatility. Contradicting the research of Muellbauer and Murphy (1997) is the research by Kuttner & Shim (2016). which studies the relatively smaller more supply elastic market of New Zealand. In this paper a correlation between interest rates and housing prices was found. A paper by Glaeser et al. (2008) seems to confirm this. The paper suggests that countries with more supply elastic have shorter boom and bust cycles. more inelastic supply markets seem to have larger price run-ups (more than 5 years) and longer downturn effects of an inevitable price downturn. What this means in relation to the model by DiPasquale and Wheaton is that a more elastic supply would mean less steep price run ups and less debt per capita for the residents within that housing market. As the stock and price level can adjust more freely to the demand.

Disposable income measures the ability for the population to be able to afford housing. In recent years, one factor is the interest rates. The housing market has not only been camping with an increased value compared to income. It has also been experiencing an increase in the debt per capita. In relation to the stock-flow model this would result in an increase in demand in the short term, as people have higher sums of money to spend as loans are getting higher. This increase in the debt per capita puts the people in the housing market at a greater risk of default, and housing prices tend to increase in the long run. According to the stock-flow model housing prices will return to the equilibrium. The default risk increases when more people accept higher housing loans, often resulting in a form of risky loans and big payments for the tenant (Halonen et al.,2019). However, these huge sums of debt are affordable and acceptable to the general

When looking at the demand for housing, it is not only important to see in what way debt is accumulated. According to a paper by Adelino & Severino (2017) the relation to an increased debt within the housing crisis of 2008. Their paper noted the effect of increased debt because of the crisis did not significantly increase the loan to value ratio (LTV ratio) for the middle class because of heightening income ratios. The loan to value ratio measures the amount of the housing loan that the loan underwriter will borrow. This in turn would make the person leveraged depending on the percentage of LTV.

The two factors this paper considers are loan to value and debt in relation to income, the picture would be more complete if we would also consider the income. The debt to income ratio or DTI. Measures to total outstanding debt per month and divides it by the gross income per month. This in turn will help understand the leverage per capita of the people and how much of their income is spendable (Rostila et al.,2012).

A paper by Yan (2011) denotes the importance of instability in prices. Especially the unstable increase in prices. The paper further notes the importance of detecting unaffordable housing prices. Unaffordability rises from too little income and too much debt. Mccarthy and Peach (2004) different variables that indicate affordability can be used to measure unstable housing price rises. They add that the demand for housing is dependent on the buying power of purchasers which in term is related to income.

2.2 Application to Sweden

2.2.1 Application construction Sweden

The Swedish market has high regulations and relatively low construction activity especially within Gothenburg and Stockholm. The demand seems to be present in the Swedish housing market as a result of increased disposable income and higher population as is evident from the figures 13 and 19, but high regulations and expensive building costs seem to halt the production of additional units.

For construction we can see clear differences in building activity between the time of 1978 and 2020 for the cities of Malmo, Stockholm, and Gothenburg. If we look at figure 8, we can see that in 1978 the number of completed dwellings of the three cities were declining. This coincides with figure 6 that shows the low number of new building permits being issued at that time. The completed dwelling stock eventually stabilized for the three cities with multi-dwelling housing in Gothenburg and Malmo creating more of this type of housing as compared to before. However, during 1992 we can see that the housing crash of that time put a temporary stop to any type of building activity, seeing a great decline in completed dwellings after that point. Stockholm at this point has almost completely stopped building one-two dwelling housing, focusing mostly on apartments from that moment on. After this crash of the 90's we can see a gradual increase in building activity such as in figure 6 where the number of building permits increases, and for figure 7 where new residential buildings start. The new buildings in Malmo are especially apparent within this figure. Looking at figure 3, there is a clear increase in building activity after the 2012 double dip recession. Furthermore, a decline can be seen in recent years. What is notable about this figure is the relatively high construction activity in Malmo compared to Gothenburg, this shows the relative elasticity of the Malmo market

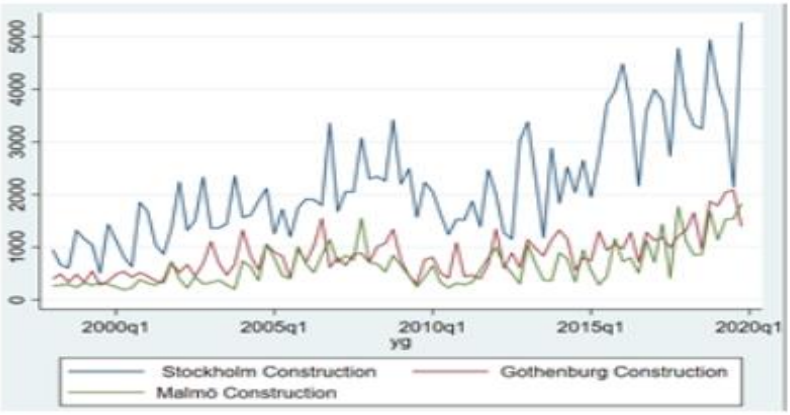

Figure 3, Total regional construction (Author's own creation, 2020)

The resilience of the 2008 financial crisis and the subsequent 2012 double dip recession is also apparent from these figures. Where other countries such as the Netherlands for example would subsequently lose 32% of their construction activity during that time (Ronald & Dol, 2011). We can see a much smaller drop regarding construction activity in Sweden during this time and subsequently a relatively fast bounce back to earlier levels of construction for residential housing. The drop within construction activity can be attributed to decrease in demand but also to increase in other factors, such as construction costs, planning permits and the rental market. This is important to note in the analysis in relation to how the data moves for further analysis.

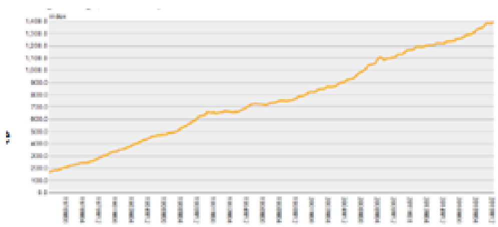
Figure 4, Factor price index for multi-dwelling buildings 1980=100 (Author's own creation, 2020)

The Swedish building costs have risen considerably over the last few years, because of the increased building regulations (Granath Hansson, 2019). This in turn decreases housing affordability and general welfare in terms of Swedish households. Figure 4 shows the increase in price for the construction of buildings for Sweden as a whole. This figure starts off in 1994 at 100 and finishes at 14 times the original value. The figure keeps into account the ‘ wage drift’ Which translates to real increases in wage in order to denote that building costs have increased despite the relative increase in wages and VAT. Figure 5 shows the relation between the building costs per square meter in relation to effective floor space. What this shows is that the price per square meter has been increasing over the last few years but especially in Stockholm. The prices of Gothenburg seem to also have risen until the point of 2016 at the time of the price drop, where they seem to be more in line with the Malmo prices.

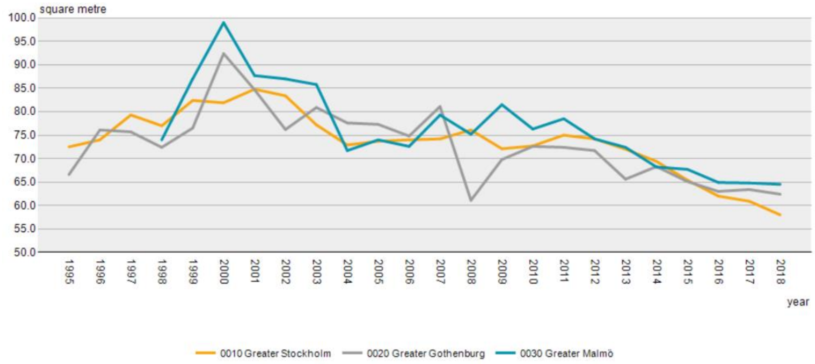

Figure 5, Regional useful floor space of residential buildings (Author's own creation, 2020)

Furthermore, acquisition and planning approvals take a long time. The average time for a planning approval in Stockholm ranges from 2-5 years. Meaning that the risk of exposure is higher resulting in a bigger need for higher yields. Looking at figure 6 we can see that the Market is Malmo is most elastic in approving planning permits for new residential projects. The same can be said for Gothenburg, even though this falls relatively in the middle both the cities of Malmo and Gothenburg can be viewed as being more affordable and more elastic in terms of planning regulations. However, Malmo is shown to be the most responsive when looking at real term construction activity per capita is we would look at figure 7 and 8.

Rising construction costs can be the result of many factors, in the Swedish housing market we can look at other factors relating to supply. An article by the Scandinavian markets have noted the almost monopolistic approach that housing companies have in Sweden. Noting a 18.86% profit on projects within urban regions and thus artificially keeping the demand low (London, 2015).The Riksbanken (2015) noted that there are several factors at play here. So that the subsidies for construction companies have been decreased, for construction companies this means that they have a greater risk embarking on construction projects and are thus asking for higher yields in return (London, 2015).

Finally, building rental properties with a capped rent is less profitable than tenant owned housing. This last factor has been a result of the Swedish government providing a lot of social housing. This means rental apartments with a cap on it in order for people to be able to afford living in Stockholm, this is preferred because of the high urbanization grade meaning a lot of jobs are centered within these cities (Olofsson et al.,2016). An example of restrictive policies in the Swedish housing market is that when the owner(s) of a rental building wants to convert the building for sale on the private market, over 70% of tenants must agree to the change. However, since most of the time this would result in higher rents for the tenants this is almost never the case, meaning a lot of shortages are also backed by the tenants living within these rental homes Source. These housing cooperatives make up a significant part of the market within Sweden, about 10% within the Stockholm housing market of single-let dwellings. The percentage is significantly lower for Gothenburg and Malmo which is mostly privately owned. For multi dwelling buildings the percentage increases dramatically. The percentage becomes 57% for Stockholm and about 38% for Gothenburg, and 46% for Malmo. Showing a greater flexibility in terms of supply of housing.

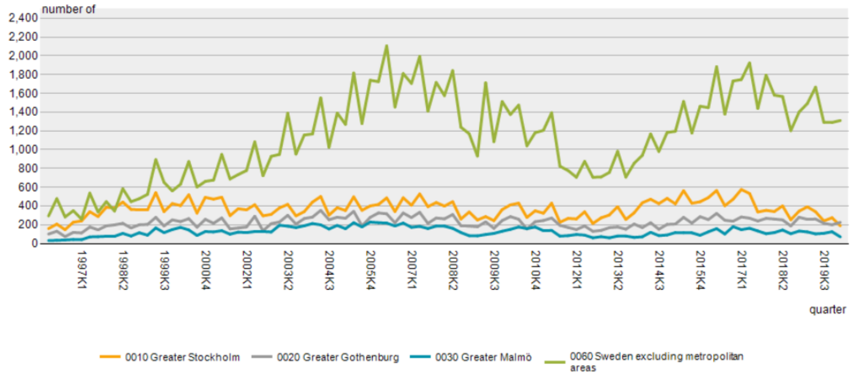

Figure 6, Regional approval of new planning permits (Author's own creation, 2020)

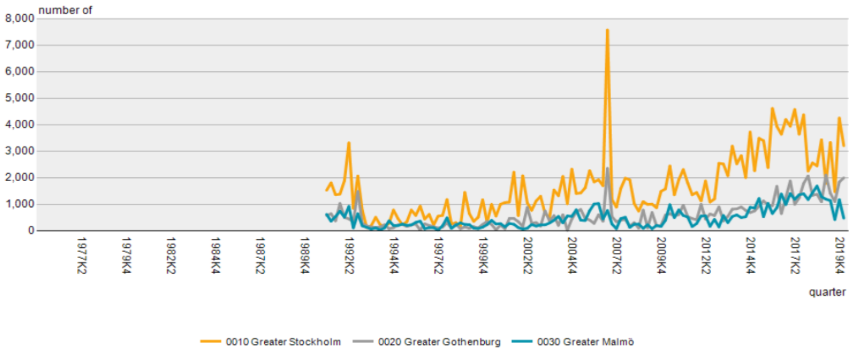

Figure 7, New residential building start per city (Author's own creation, 2020)

The problem with this type of home providing is that combining with a shortage of housing the waiting times can get very long, an article by Mundus adds 'The problem is, that the queue for first-hand contracts now has more than half a million people on it – seven times the number 15 years ago – and the average wait time is now more than nine years' (Moore, 2018) Because of these factors it's improbable for companies to start building extra residential buildings soon meaning that residential building has started to decline as we can see in figure 6. Baum and Hartzell (2012) note the different cycle in building, one can see that building development increases during a boom, because of the guarantee that prices will be rising within this boom if costs are held relatively stable. The slowing down of building activity could intensify regional housing price increases by project developers not seeing the prices going up any further and thus are less incentivized to invest in different projects. Other papers such as Holcombe and Powell (2009) support this notion.

The decline of building companies is also especially worrisome since many people have started to live on their own or have smaller household sizes in General (Silfwerbrand, 2019). Which quantifies into a more singular lifestyle. Because of this it is not uncommon for people to demand less living space. The Swedish housing market is already dominated by apartment living in Stockholm as can be seen in figure 8. The apartment stock of apartment living in Stockholm is greater than that of Gothenburg or Malmo. Also considering figure 7, we can see that there are not that many more buildings being built to accommodate for the new transition into a more single lifestyle. The new number of apartment or single living buildings being built in Malmo and Gothenburg seem to be insufficient regarding the new demand for people expecting to be living within smaller arrangements sooner or later.

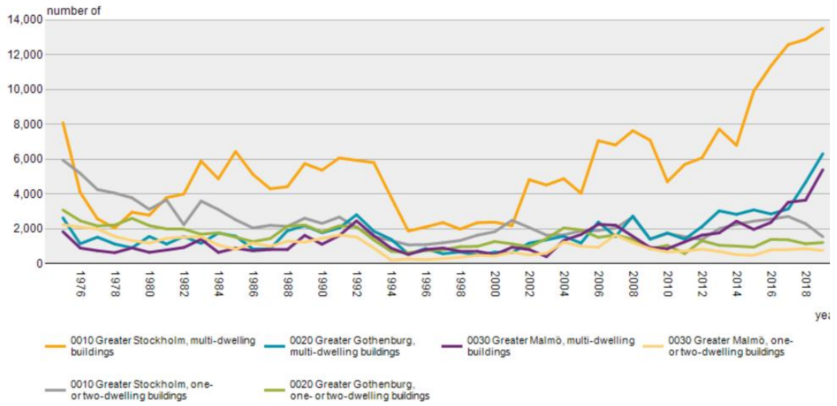

Figure 8, Regional completed dwellings (Author's own creation, 2020)

As we can see in figure 9. We can see the housing stock of the three cities as trying to fulfill the greater need of multi-dwelling housing into their cities. Housing demand seems to correlate much more strongly in Stockholm. However, the lines of Gothenburg and Malmo indicate a rapid and hardy response to the changes in demand since their population is less than that of Stockholm.

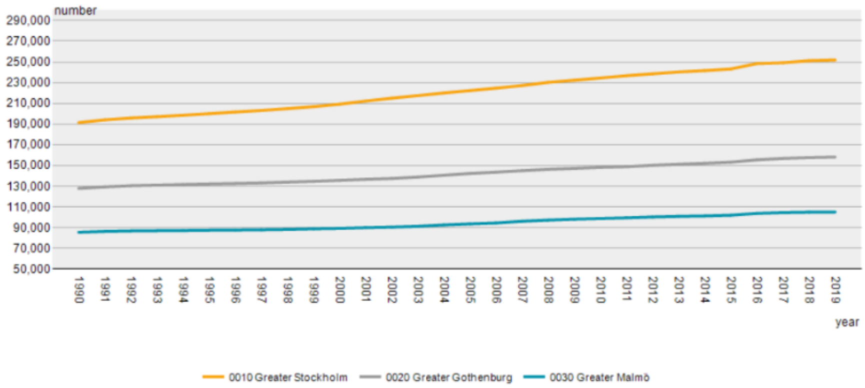

Figure 9, Regional tenant owned housing stock (Author's own creation, 2020)

2.2.2 Application Population Sweden

The demographic changes and eventual size of the population per city has changed drastically from the start of the housing crisis bust in the 1990's. From this point much of the population in Sweden was a Swedish citizen born within Sweden. What can be deducted from figure 4 is that demographics are changing to smaller households. Smaller households in turn require added multi-dwelling housing and show a relatively younger population that may not need the space or cannot afford a single-family housing. In this case we can link that to the explosion of single families living after the 2000 in the three cities but especially in Stockholm.

General population increase has been relatively mild for the three cities according to figure 10. With Stockholm adding about 200.000 people in a span of 20 years, Gothenburg adding about 100.000 people and Malmo adding 150.000 to its population. In relation to the population we can see that Malmo has added the most to its population in real terms, springing from 250.000 to close to 400.000 is almost doubling its initial population. Whereas Gothenburg and Stockholm added a smaller percentage to their population going from 500.000 to 600.000 and 800.000 to 1.000.000.

The population differences can be denoted to different extents to migration. The people that Malmo has attracted over the years are increasingly foreign born. Starting in 2000 the foreign-born population of Malmo was just over 18% and in 2020 this became over 34% of the population. Stockholm had a similar effect, starting at 21% in 2000 and rising to 35% in 2020. Gothenburg held the least amount of foreign born only increasing from 16% in 2000 to 25% in 2020. The differences in foreign born population can be because of certain possibilities such as work or cheaper housing (Anderson ,2014). Within Malmo we can see cheaper housing but lower possibilities for work, when we look at data and the figures, we can deduct that from 2006 onwards there is an increasing high number of foreign-born populations. Because of the relatively smaller population the effect discussed by Sá (2015) may have been larger than in Stockholm as a result, more foreign born would mean lower housing prices because of association to 'bad' neighborhoods or the building of more housing.

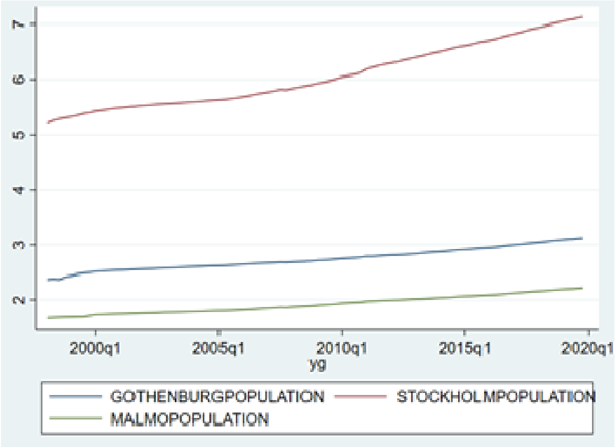

Figure 10, Total regional population size (x1000000) (Author's own creation, 2020)

Different demographics can alter the demand for housing within housing markets. When comparing the regional buying power of the population in relation to the demographics we can see clear differences between the defined submarkets. While in Stockholm there seems to be a high concentration of work but also higher rents. This can be because of the relatively inelastic supply that the housing has not responded to such a degree as in Malmo or the effect of Sá (2015) Being not as pronounced because of the size difference. The regional unemployment within the three cities is following the cyclical trends of the economy. Although in the later years from 2016 onwards we can see unemployment starting the rise, especially in Malmo. Furthermore, we also see a reduction in total hours worked for the average person in Malmo (Figure 11). The population within Malmo therefore seems to have lower buying power and

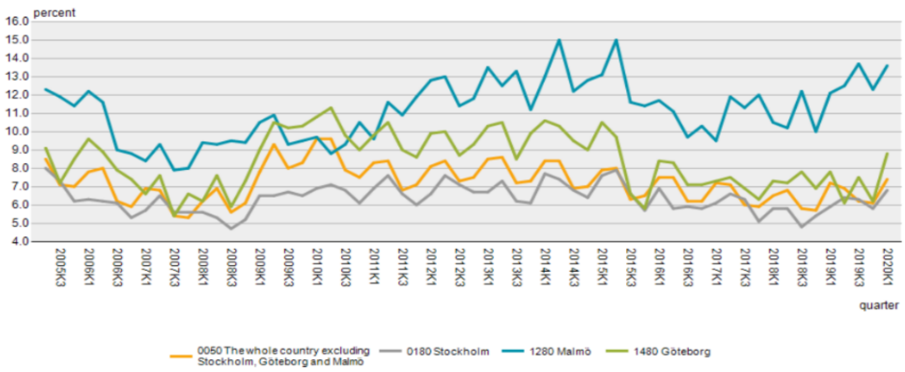

Figure 11, Total regional percentage of unemployment (Author's own creation, 2020) lesser opportunities to find work, which has a negative effect on the demand of the housing within that submarket.

Unemployment is detrimental to the buying power of an economy (Diamond, 2011). The buying power of the average Swede has begun to decrease, the reason for this is also the low inflation or even negative inflation by the Swedish government. Sweden is not in the Eurozone and has therefore full authority over its own currency and how much to distribute within the Economy. The negative interest rates allowed for the Swedish crown continues to plummet against the euro, with over 10% of its value lost within the last 2 years as we can see in figure 12.

Figure 12, Value of Swedish crown (Vertical) vs Euro (Horizontal) (Author's own creation, 2020)

The demand for housing in these cities is elevated in Sweden. As it is one of the most urban areas in the European union with 87% of its inhabitants living in urban areas. That is about 12% higher than the EU average of 2019 (Riksbanken, 2019). Which makes the housing markets of Stockholm, Gothenburg and Malmo have a relatively higher demand than other parts of Sweden. This can also be seen when we look at figure 13, This figure shows the relative size of each city in actual terms.

The actual population of a city and the increase in such a population would suggest that housing prices would immediately go up. However, supply must meet demand and as noted before different demographics may be attracted to different types of housing. this is also the case in Sweden. The different demographic composition that a housing market attracts can influence the housing affordability of that market. An inelastic market for example would not be able to accommodate for a sudden influx of starters, or a richer demographic.

The demographics of the population between the three cities would be comparable. Within Stockholm there seems to be the oldest population with an average age of 39.5 years. Gothenburg follows suit with an average age of 39 years and Malmo has the relatively youngest population at 38 years according to Statistics Sweden

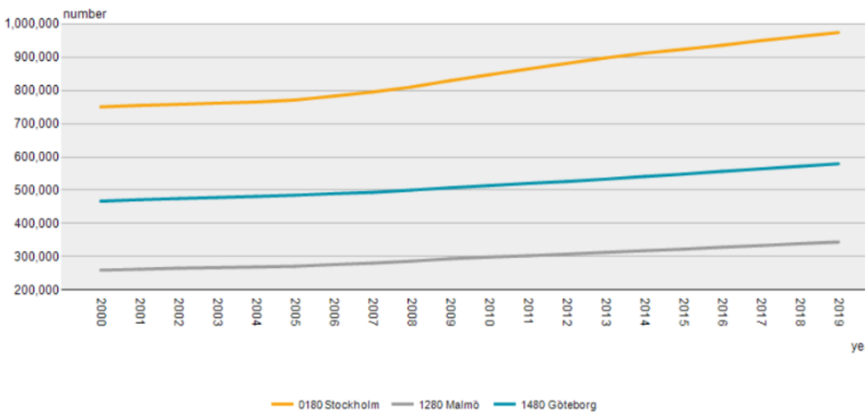

Figure 13, Regional population real terms (Author's own creation, 2020)

(2020). This shows that the cities are quite comparable in the demographics that are attracted to these places. A relatively younger population which are often satisfied with living in multi-dwelling housing. (Ghavidelfar et al., 2017).

Looking at figure 14, there is a clear draw to the city of Stockholm. Providing opportunity to work seems to be the most important factor for moving according to a paper by Colding et al. (2003).

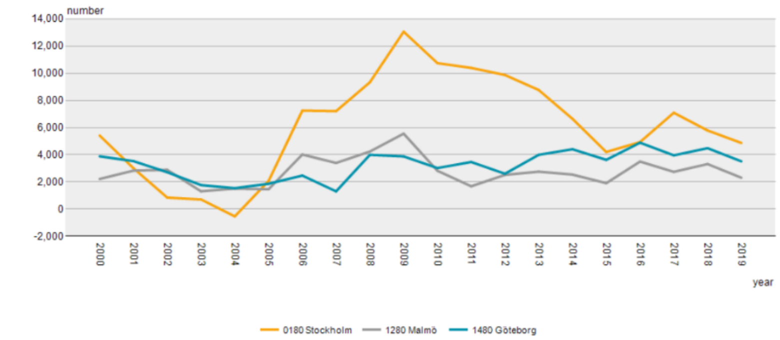

Figure 14, Regional yearly total population (Author's own creation, 2020)

Demographics are also composed of native- and foreign-born populations. When looking at foreign born population, most of the increase in population for Malmo has been because of foreign migration to the city which can be noted from figure 15. Stockholm closely follows and most of the increase in Gothenburg's population has been because of natural births (SCB, 2020). The Increase in foreign born could be an explanation as to why Malmo housing has been relatively stable in housing pricing even though it takes on large amounts of population growth and higher building in areas where migration is expected according to the paper discussed by Sá (2015). Furthermore, the higher construction flexibility in Malmo could also be noted as an expected increase in demand because of the increased migration and therefore create the relatively cheaper housing within Malmo as opposed to Gothenburg and Stockholm.

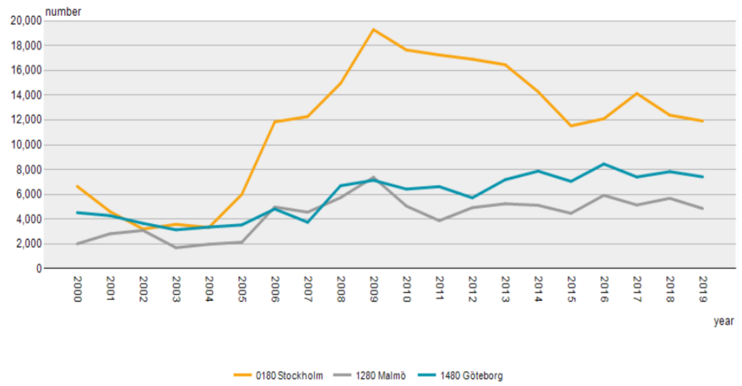

Figure 15, Regional net migration (Author's own creation)

The discussed migration effect in Malmo may not seem to be so big as opposed to Stockholm, but we must keep in mind the population is also smaller (Figure 13). From these figures we can also conclude that a lot is being built in Malmo and even Gothenburg in relation to their population. The one that seems to be lagging is Stockholm. From these developments and figures we can assume that not only is Swedish housing becoming more and more overvalued and Swedes are taking out more debt to abide by the housing standards put in place. This effect could increase default risk dramatically (Fischer et al.,2020).

Because of the overvaluation on the Swedish housing market, we can refer to the paper by Mulder (2006). The starters of the Swedish housing market are staying longer at their parents' place or must wait on average about 12 years to apply to social housing. According to Mulder (2006) the housing prices do not necessarily correlate strongly in tight housing markets such as Stockholm. And because of this social housing market, there can be even less incentive for building companies to develop new amenities.

2.2.3 Application disposable income Sweden

An increase in disposable income can increase demand for housing. The average Swede is one of the most indebted of the European Union. As mentioned, the demand is tied to disposable income of a market, which in turn is related to incentives for lending such as interest rates. If we look at figure 6, we can see the relative decrease for the interest rates over time.

What we can see from figure 6 is a relative increase for housing loans during 2008. This is increasing as it is part of the market cooling measures for the government during times of financial crisis. From that moment on the interest rate for housing loans has decreased to about 1%. And the repo rate of the Swedish central bank has become negative since 2015. This means free lending from the central bank to commercial banks within Sweden (Scheiber et al.,2016). For Swedes this meant an opportunity to take on increasingly more debt at a lower risk from 2008 onwards.

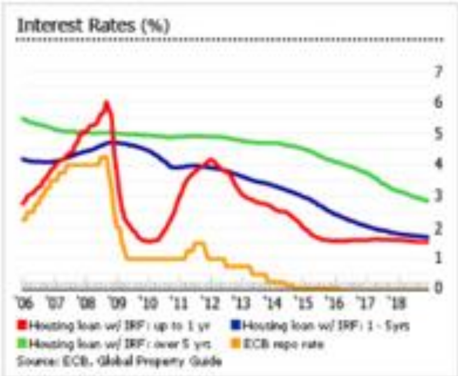

Figure 16, Swedish interest rates (Author's own creation, 2020)

The indebtedness of Swedish public is also a result of the historically low interest rate that the Swedish bank is giving on the mortgages, there was a negative interest rate for most of the years leading up to the inevitable correction in 2018 (figure 16). The Swedish people enjoyed lower interest rates which made them take out higher debts. Higher incomes also let them take out more debts which coincided with the housing boom. It is therefore not surprising that a restriction on mortgages put into place by the Swedish government would negatively affect these prices. Mortgage loans with over 50% of the value of the property had to be amortized by at least 1% each year annually. If the loan was still at 70% of the property value, the amortization had to be at least 2% each year. Mortgage loans with an LTV between 50% and 70% had to be amortized by 1% each year.

When the mortgage regulation was passed in 2018, it became the year that the market had such a big downturn. In turn this would make sense for Stockholm to be affected more than Malmo or Gothenburg since as we can see from figures 5 and 20 that Stockholm housing values and debts were the highest in Sweden. But what it does not yet explain is the difference between Gothenburg and Malmo, since those cities are quite comparable on fronts of housing prices and debt. The slowdown was national so one would suggest an equal drop in housing pricing since the three largest Swedish cities would be somewhat comparable, but this seems to be far from reality. The Swedish market has been relatively inelastic compared to other European countries such as Norway and the UK (Caldera & Johansson, 2013).

Before this regulation it was normal for Swedish residents to not amortize loans at all. Debt could simply be passed on to the next generation just paying the interest payments on the house (Hull , 2017). Furthermore, in 2018 new housing loan borrowers whose housing debt would exceed 4.5 times their gross income had to amortize 1% additional on the already required amortization.

The indebtedness of the Swedes makes them susceptible to such changes in mortgage regulations. To measure the indebtedness there are measures to show the height of the debt compared to personal equity. For example, the Loan to value ratio (LTV) which measures the mortgage amount opposed to the appraised value of the home Hull (2017). Furthermore, a metric that can be used to denote the differences between the three regions is called the Debt to income ratio (DTI ratio) which for homeowners can be calculated by dividing their total debt obligations by their personal income. The advantage is this method is that unlike the last method where mortgage value plays a crucial role compared to the home, the debt to equity ratio gives a clearer picture of total debt per capita

When we look at the different metrics for debt per capita, we start with the loan to value ratio on mortgages within Sweden. We can see in figure 17, the highest LTV is centered around Stockholm, Malmo and Gothenburg when we look at the data of the Riksbanken (2019) we see that the average LTV for Stockholm and Gothenburg is hovering around 60% While the LTV is Malmo is consistently around 65%.This difference in higher LTV ratios can be explained through the relatively cheap housing that can be found in Malmo. If we were to take into consideration the average prices of residential buildings within the three cities, we would get a much sharper image of the debt that the people in their respective cities are building up. This effect can be seen in figure 19. For this figure, a comparison needed to take place for one and two-dwelling buildings for permanent living. This is to show the relation with the most common form of housing in Sweden, there is also the most data on this aspect which makes it so it can be more easily compared with other variables, this data has been adjusted for inflation.

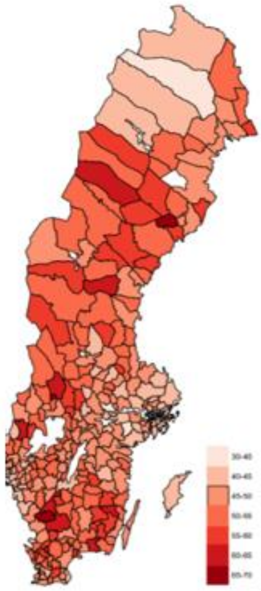

Figure 17, Regional LTV ratio Sweden (Riksbanken, 2016)

The housing prices in Stockholm can be causal or reactionary to the increased debt of this city. There is a clear higher value of debt in Stockholm compared to the other regions such as Malmo and Gothenburg in sense of value of housing and mortgage loans if we look at figure 18. This is again in line with the four-quadrant model, which denotes that increased demand in this case increased spending power in the form of loans. Can increase the pricing of real estate. Furthermore, the debt of a Stockholmer compared to someone from Gothenburg or Malmo is higher because of possible higher incomes.

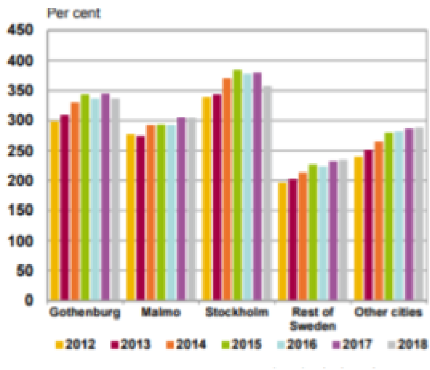

Figure 18, Regional DTI in Sweden (Riksbanken, 2019)

When we look at figure 18, we can see the debt to income ratio of the three regions compared to the rest of Sweden and other cities. What is striking is that in these three cities the Debt to income ratio is elevated, especially in Stockholm. This indicated a relative high debt in relation to income, meaning that mortgages have increased faster than the income of their respective cities. The debt to income ratio for Stockholm housing with new mortgages currently stands at around 356% Which is more than 3.5 times their annual income after tax. This is surprising since the income levels for Stockholm are also elevated compared to Malmo and Gothenburg.

Disposable income helps to understand the buying power and willingness to take on higher amounts of loans because of increasing housing prices. The progress of the loan to value ratio is also important in this aspect. The LTV ratio for the three cities managed to stay relatively the same during the period of 2008-2017 staying around the same 40% for Stockholm, and 45% for Malmo, and 42-43% for Gothenburg during this period. However, since we can see from figure 20 that the housing prices have increased in real terms, we can also conclude that the loans have therefore started mounting as well. The DTI of the regions therefore has increased from this period, showing an increase in debt for Stockholm, and Gothenburg in particular (figure 18). This increase means that the debt has been increasing faster than income. We can see this to be a flatter curve in both Gothenburg and slowly decreasing in Malmo. The rapid increase and then decrease could be a result of rising incomes within the Stockholm region, and a subsequent stalling of income in the Gothenburg and Malmo region as can be noted from Figure 19.

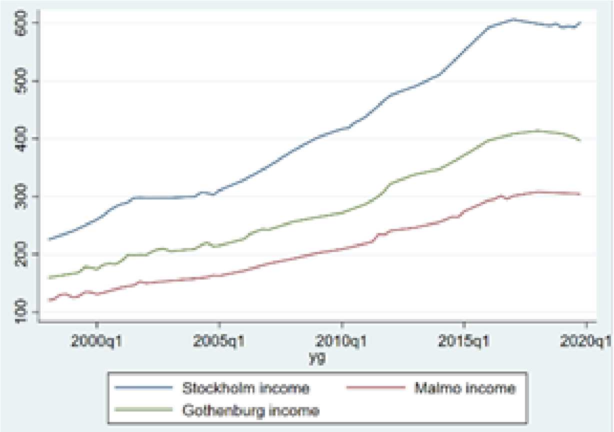

Figure 19, Total regional disposable income (Author's own creation, 2020)

Therefore, there needs to be a clear concession on the disposable income of these regions on the household level. When we add this figure, we can see a clear runup for the regions after 2005, and a slowing down of disposable income after 2015. What can be deducted from the figure is that the disposable income from Stockholm seems to react more strongly to booms and busts, having higher peaks and lower values than Gothenburg and Malmo.

3. DATA & METHOD
3.1 Descriptive analysis

The data come from databases by the SCB the data includes housing prices, construction, population, and disposable income. Summary statistics are provided in Table 1.

TABLE 1, SUMMARY STATISTICS OF REGIONAL HOUSING PRICE, CONSTRUCTION, POPULATION, AND INCOME (N=85)

Variable	Mean	Std. deviation	Min	Max
Stockholm housing price (STOCKHP)	3618.99	1320.43	1416	6176
Gothenburg housing price (GOTHHP)	2749.67	1089.11	1066	4745
Malmo Housing price (MALMHP)	2515.81	859.79	1010	4159
Stockholm construction (SCON)	2187.76	1059.713	509	5273
Gothenburg construction (GCON)	850.8	406.25	280	2083
Malmo construction (MCON)	643.85	395.41	189	1833
Stockholm population (SPOP)	6055751	561773.7	5197650	7127662
Gothenburg population (GPOP)	2740069	196446.4	2365980	3123666
Malmo population (MPOP)	1915393	161381.3	1662678	2221562
Stockholm income (SINC)	413.6	125.14	225.31	606.5
Gothenburg income (GINC)	280.73	83.59	159.45	413.7
Malmo income (MINC)	210.1	61.23	120.25	308.1

To accurately measure housing price convergence between the regions, the data needs to be identified and adjusted for proper testing. When we look at the different variables identified for the three cities. We can make a distinction between Housing price, Construction, population, and disposable income. The dataset for housing prices concerns the purchase price of newly purchased Real estate in 1000 Swedish crowns. The data is quarterly and is divided from 1998Q1-2019Q4 each variable has 88 observations. Swedish housing prices are also added within this database, this is done to put the housing prices of the three cities into perspective, it is not included in the divergence testing. The housing price data had not been adjusted yet for the inflation during the period of 1998-2019. Therefore, another dataset was added concerning the CPI. This dataset had started at 1980=100, to understand housing price differences these real prices are modelled in figure 20. Sweden in this graph refers to Sweden excluding the three cities of Stockholm, Gothenburg, and Malmo.

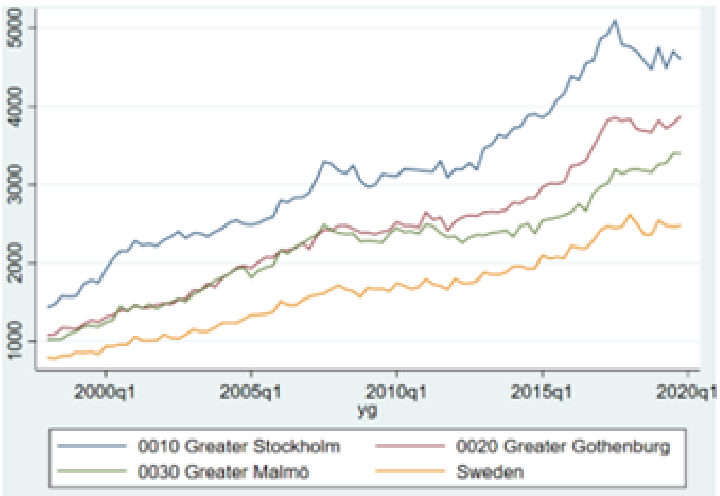

Figure 20, National and regional average housing prices sweden per 1000 SEK (Author's own creation, 2020)

Using the housing price data from the summary statistics (table 1), we can see that the average housing prices are higher in the three biggest cities than the Swedish average housing prices. Furthermore, we can see that Stockholm housing is relatively the most expensive housing having the highest lows and highs. Furthermore, we can see that the deviation of the cities is higher than the deviation for Sweden as a whole. This can be a result of the cities having relatively higher price run ups in the more inelastic markets according to the paper by Glaeser et al. (2008) From the data we can see that housing prices for Malmo and Gothenburg are almost identical from 1998Q1 up until

2005Q1. A small bump is noticeable within 2008 where the housing crisis made the prices rise more in Stockholm than in Malmo or Gothenburg. We can see further divergence of housing prices beyond this point.

Most time series convergence papers are carried out on national data. However, according to Meen (1996) Housing markets are more interconnected and should rarely be viewed in a more national context. Convergence or divergence between different regions or areas within a country is a useful tool to determine that the areas are housing markets within themselves, or if the housing submarkets are experiencing shocks together in a certain fashion. The difference between housing stock and the different supply and demand drivers over time is also used in the stock-flow model by DiPasquale and Wheaton. The timing of different markets in relation to demand variables such as income, population and construction can influence the eventual housing price. Such as that it is important to see where the markets are if development will take place in these areas.

Measuring convergence has been done in many different fashions before. Papers by (Kim & Rous 2012) or Kuethe & Pede (2011) show that the price convergence in the United States is often performed in the same type of river delta or state. A paper by Holmes et al. (2011), shows the difference in cities from the United States and compares them in a pairwise approach. This approach is often preferable to individual approaches in cases of a larger sample of cities. This is because firstly the pair-wise approach directly addresses the question of what proportion of the house price differentials is stationary. Second, the presence of unobserved common factors complicates the application of the panel unit root tests where cross-section dependence can lead to size distortion. The unit root tests employed, such as the Dickey-fuller test have attempted to allow for possible cross-section dependence through unobserved common factors.

A counterpoint that is often mentioned, is that the downside of using this method is that from the different areas, pairs are made. From these pairs the unit-root test is performed. To compare different cities on individual convergence. One such technique is described by Phillips & Sul (2007). Phillips and Sul noted other papers such as Carlino and Mills (1993) and Durlauf (1996). Stating that the standard unit root tests from these papers may ‘over-reject’ the unit root hypothesis. Furthermore, the technique used in these papers did not account for heterogeneity across regions, which is something that is important to measure in a national context. The test by Phillips and Sul (2007) does cointegrate these two concerns into its method. The Method they employed is a time-based model that holds into account heterogeneity across different variables such as countries or cities. The regression method that they introduce in their paper is the ‘log-t-test’. This method is used to verify the existence of convergence of a variable on the long run. If this is not the case, the method puts the different segments of the market into groups that have been noted to have convergence by the test. The panel data is thus clustered into clubs with similar convergence characteristics.

The method by Phillips and Sul has been used in relation to many variables in macroeconomics. Two other papers have used this analysis for housing price convergence, Çatık et al. (2017) & Ganioğlu& Seven (2017). Both papers look at convergence between cities in different countries. Both these papers employ the technique set out by Phillips and Sul (2007) to account for predicted heterogeneity within the variables. The paper by Ganioğlu& Seven (2017) for example, predicted a highly divided housing market within the Turkish housing market and therefore used this method. The heterogeneity between the sub-markets can be strengthened by the information discussed and is therefore applicable in this case as well.

As mentioned for the convergence test of regional housing prices, a log-t-test will be performed in Stata. This test will verify if convergence can be noted. After this initial t-test there will be a group test done. These groups will be formed based on a 5% confidence interval, if they are significantly converging then they are grouped within the same group After this the groups that are convergent with each other can be compared in terms of t-statistic and coefficients of the group. Other convergent groups are made if possible, showing different t-statistics for these hypothetical groups (Philips & Sul, 2007).

To explain the convergence or divergence of the regional housing prices, a VAR-model will be created for each individual city. These VAR models will then be compared in terms of impulse response graphs. These graphs will tell the influence of a one standard deviation shock from variable x on variable y. In this way there is a clear distinction between a short- and long-term effect, which can help explain convergence or divergence (Pesaran & Shin ,1998).

The relationship between housing price and the different drivers discussed is important to denote over time. To see the type of effect that construction, population, and debt would have on the housing prices through the years of 1978Q1 until 2019Q4. The relationship between these variables needs to be studied. The studied variables can best be described using a VAR-model. This is because there should be a causal relationship, and all the variables are prone to multiple shocks within the time series, therefore the simulation of shocks to this series is a crucial aspect. Furthermore, multiple drivers can be compared with housing price and with each other over time series.

The construction variable measures the finished new construction of both single-dwelling buildings and multi-dwelling buildings within the respective three regions. The data is quarterly and ranged from 1991Q1-2020Q2, the data used is therefore adjusted to 1998Q1-2019Q4. When we look at the construction variables, we can see that Stockholm in real terms has more buildings being constructed than Gothenburg and Malmo combined. This variable measures the amount of new one-two person dwellings and multi-dwelling buildings per year. As we can deduct from the data Malmo is creating the greatest number of new dwellings for their population where Stockholm and Gothenburg are similar in terms of elasticity in building. The big data point for Stockholm around 2006 was from a building project being conducted in Q3 of 2006. This point in time is skewing the data with the maximum, making Stockholm more inelastic than this descriptive analysis table may show. Furthermore, the data is very seasonal. This is because winters in Stockholm are stricter than in other countries, making construction during wintertime not favorable for the workers. The data also shows a small dip in the 2010’s which was after the financial crisis. Recently we can see an increase in completed dwellings.

Furthermore, the way that the population variable is identified is like that of the Construction and housing price variables. The population variable is the real population for every month 0-100 years for every city. The dataset spanned from 1998M1-2019M12. To get a good view of the differences in population the data had to be reverted to quarterly data. When we look at the data in figure 18, We can see from the first three variables measuring population that Stockholm has the biggest population of the three cities by far. On average Stockholm has more than two times the number of inhabitants as Gothenburg, and the differences become more apparent if we look at the max of population which is well over two times the size of Gothenburg.

Lastly, the disposable income variable is identified as the income of households per 1000SEK, the data was monthly and encompassed 1996M1-2019M12, this data is reverted to 1998Q1-2019Q4. Using this disposable income variable, we can make deductions about their buying power. This variable measures the income of residents after the paying of liabilities such as living and tax expenses. The disposable income for Stockholm is a bit short of being twice as much as the average in Gothenburg as we can see in figure 20. What we do see from this figure is that the disposable income in Malmo is higher than that in Gothenburg. This can be explained through the lower housing prices in Malmo therefore creating lower living expenses. The disposable income can be seen flatlining after the dotcom crash for example. The resilience of the Swedish housing market can also be seen after the mortgage crash of 2008, where there is barely an effect on the disposable income of the residents.

TABEL 2, CORRELATION MATRIX VARIABLES

Correlation	LNSPOP	LNGPOP	LNMPOP	LNSCON	LNGCON	LNMCON	LNSTHP	LNGHP	LNMHP	LNSINC	LNGINC	LNMINC
LNSTOCKPOF	1											
LNGOTHPOP	0.3707	1										
LNMALMPOP	0.5225	0.2005	1									
LNSTOCKCOI	-0.1253	0.08	0.1645	1								
LNGOTHCON	-0.1173	0.0533	-0.0218	0.2306	1							
LNMALMCON	-0.0396	-0.0371	-0.0293	0.2645	0.4154	1						
LNSTOCKHP	0.0311	-0.0085	-0.0615	-0.3469	-0.0955	-0.2204	1					
LNGOTHHP	0.0429	-0.033	0.0399	-0.1879	-0.1941	-0.0316	0.5218	1				
LNMALMHP	-0.0052	0.237	0.0233	-0.0755	0.0501	-0.2358	0.3739	0.4039	1			
LNSTOCKINC	0.1554	0.0631	0.0123	0.0365	-0.0822	-0.0137	0.1712	0.0112	0.0006	1		
LNGOTHINC	0.0741	-0.0187	-0.3122	-0.1688	-0.1643	-0.0973	0.1251	0.0453	-0.0365	0.4165	1	
LNMALMINC	0.1432	-0.1858	-0.1946	-0.1692	0.0797	0.0123	0.1969	0.2902	-0.0738	0.2583	0.3977	1

From Table 2 we can see the correlation that the different variables have on each other. From what we can see from this table is the influence that the different variables have on the housing prices from each respectable city. There is a negative correlation between housing price and construction for all the regions. The biggest one appears to be in Stockholm and the smallest one appears to be in Gothenburg, this can be because of the tighter housing market in Stockholm and the increasingly higher restrictions in Gothenburg as compared to housing price drops as construction takes place, this can be because of increased international demand which would increase housing prices that even if new stock is being added, the demand would still be overpowering (Barlow et al., 2003). For the population variable we can note a positive correlation between housing prices and population in Stockholm and Malmo but a negative one in Gothenburg, which can relate to the increasing mismatch between supply and demand of living. For disposable income, the biggest positive correlation is in Stockholm, possibly because of the leveraged population, and a negative weak correlation in Malmo. The strongest correlation seems to be between construction and housing pricing.

To ensure stationarity, this paper will be converting these variables into logarithms and take the first difference. Real estate variables that are used in time series modeling such as housing prices are naturally not naturally distributed so a natural log would help us to make sure of this (Polinsky & Ellwood 1979). Because the variables are natural logs and the data is adjusted in relation to inflation, one would assume this would be enough to counter unit root, this is not the case, however. To fully exclude unit-root, or a trend within the data a first difference can be taken (Hussain et al., 2008). Using these variables, a VAR-model will be formulated.

3.2 Empirical model

3.2.1 VAR-model

To understand the convergence or divergence a VAR model will be created, which will have different pre- and post-estimation to ensure a good model fit. To understand the VAR model better there needs to be an optimal number of lags. This optimal number of lags is found through a pre-estimation test. The varsoc function in stata allows us to compare 4 different types of estimation criteria. To make sure that the data is normally distributed with no autocorrelation between the variables. The natural logarithm for each if the variables are first computed. To prove stationarity for the variables a Dickey-Fuller test is executed. To improve stationarity of the variables for times series. The first difference is taken, and the variables are transformed into logs. All the variables are stationary given the dickey fuller test (Table 6-8)

To accurately predict and evaluate the VAR-model the following method is used. The optimal number of lags can be derived from the varsoc function. The varsoc function gives us 4 determinants of lags, but the focus will be on the AIC and FPE since the sample size is relatively small per variable with around 80 observations. These criteria are more suitable within this sample size as they minimize the underestimation and have a greater chance of recovering the true lag length (Liew ,2004). Furthermore, after the VAR model has been executed, there will be 2 tests done to ensure a good model fit.

To evaluate the three VAR- models, post-estimation testing is applied. The first test will be the Jarque-Bera test, which will look at the autocorrelation between the residual errors. If the model is not at least significant at a 5% significant level it cannot be rejected that there is autocorrelation between the residual errors and the model cannot be used. Furthermore, an eigenvalue stability condition will be performed, this model will try to see if all the variables are within the unit-circle. If they do not, then we cannot assume that the value decays to a fixed point and is therefore an unstable model.

The VAR-model used to compare the different metrics of construction, population, and disposable income in relation to the housing prices of the respective region. A VAR model with 4 variables will be specified as follows:

$$Y_t = c \;+\; F_1\, y_{t-1} + F_2\, Y_{t-2} + F_3 T_{t-3} + F_4 T_{t-4} + \epsilon_t, t = 1, \dots \dots \dots, T \qquad (1.1)$$

Or, specifically:

$$lnHP_c \;=\; \alpha_c \;+\; \textstyle\sum_{i=1}^{k} \quad + \beta_{ic} lnHP_{c\,t-i} + \sum_{j=1}^{k} \quad + \phi_{jc} lnCON_{c\,t-j} + \sum_{m=1}^{k} \quad + \kappa_{mc} lnPOP_{c\,t-m} + \sum_{o=1}^{k} \quad + \Delta_{oc} lnINC_{c\,t-o} + \epsilon_{1tc}$$

$$lnCON_c \;=\; \delta_c \;+\; \textstyle\sum_{i=1}^{k} \quad + \beta_{ic} lnHP_{c\,t-i} + \sum_{j=1}^{k} \quad + \phi_{jc} lnCON_{c\,t-j} + \sum_{m=1}^{k} \quad + \kappa_{mc} lnPOP_{c\,t-m} + \sum_{o=1}^{k} \quad + \Delta_{oc} lnINC_{c\,t-o} + \epsilon_{2tc}$$

$$lnPOP_c \;=\; d_c \;+\; \textstyle\sum_{i=1}^{k} \quad + \beta_{ic} lnHP_{c\,t-i} + \sum_{j=1}^{k} \quad + \phi_{jc} lnCON_{c\,t-j} + \sum_{m=1}^{k} \quad + \kappa_{mc} lnPOP_{c\,t-m} + \sum_{o=1}^{k} \quad + \Delta_{oc} lnINC_{c\,t-o} + \epsilon_{3tc}$$

$$lnINC_c \;=\; \sigma_c \;+\; \textstyle\sum_{i=1}^{k} \quad + \beta_{ic} lnHP_{c\,t-i} + \sum_{j=1}^{k} \quad + \phi_{jc} lnCON_{c\,t-j} + \sum_{m=1}^{k} \quad + \kappa_{mc} lnPOP_{c\,t-m} + \sum_{o=1}^{k} \quad + \Delta_{oc} lnINC_{c\,t-o} + \epsilon_{4tc} \quad (1.4)$$

Where $lnHP_c$ is the housing price variable for the specific cities, $lnINC_c$, $lnCON_c$and $lnPOP_c$ are the respective Construction, population and income variables. Furthermore, K denotes the optimal lag length. α_c,σ_c,δ_c and d_c denote the intercepts of the variables per city. β_{ic},ϕ_{jc},κ_{mc} and $\Delta_{oc}$are the short-run dynamic coefficients of the model's adjustment long term equilibrium. The ϵ_{Itc}terms are the error terms for the specific cities for lag t. The variable c denotes the city of Stockholm, Gothenburg, and Malmo, respectively.

3.2.2 Convergence model

To measure the actual convergence or divergence of the three cities, the method by Phillips and Sul (2007) will be used. The method is as follows: The different identified groups or in this case cities will be compared using a log-t-test which measures the convergence or divergence based on a systematic component and a time varying component. The more the different groups are similar in the time varying component the higher their respective log-t-statistic will be. The model begins with decomposing the panel data 'X_{it} ' together with time 'T' and region 'I' This can be written as:

$$X_{it} = \delta_i \, \mu_t + \epsilon_{it} \qquad (1.2)$$

Where μ_t in this case represents the permanent component or systematic components of X_{it} and δ_{it} is the transitory component or time varying factor. The model seeks to capture the evolution of the individual X_{it} in relation to μ_t by using the transitory component δ_{it} and the error ϵ_{it}. However, the model by Phillips and Sul (2007) modified the standard model specified within other papers where the systematic component stays rigid over the duration of the convergence test. The model specified in 1.2 by Phillips and Sul allows the systematic element of μ_t to evolve over time.

Furthermore we follow δ_{it} to have a random component which now absorbs ϵ_{it} this change allows for possible convergence behavior in δ_{it} over time in relation to μ_t.The time varying behavior of δ_{it} can be modeled as follows:

$$\delta_{it} = \delta_t + \epsilon_{it} L(t)^{-1} t^{-n} \qquad (1.3)$$

Where ϵ_{it} has become weakly dependent on t, and L(t) is a slowly varying function (also referred to as log t) for which L(t) tends to infinity and t goes to infinity.

The method of Phillips and Sul (2007) states that the convergence test does not rely on any assumption on trend stationarity of stochastic non-stationarity in X_{it} or μ_t. The null hypothesis is therefore:

$$H_0 = \delta_t = \delta$$

against the alternative

$$H_1 = \delta_t \neq \delta \; for \; all \; i$$

A rejection of the null hypothesis occurs at the different significant levels for standard t-tests. For a 5% significance level this would be Tb < -1.65.

An important note from the t-test is that even if the null hypothesis is rejected this does not mean that convergence is not present between the subgroups. This is because convergence may occur within subgroups of the panel, this means that multiple equilibria can be present at once. A solution to these multiple equilibria can be the identification of multiple 'clubs' or 'groups' the merging of different groups based on convergence is called club merging. Because of the potential presence of multiple equilibria this club merging tests will be performed to account for the different combinations of convergence. All combinations of regions will be tested for convergence.

The steps for club convergence are as follows.

1. Sorting individual cities (K) according to the last time series observation in the panel
2. Finding a core convergence group that yields the highest value of the log-t-statistic

Find k so that the test statistic of the log t regression tk > −1.65 for the subgroup with individuals {k, k+1}. If there is no k satisfying tk > −1.65, exit the algorithm, and conclude that there are no convergence subgroups in the panel.

3. Removing individuals for potential grouping

This means to add a group Gc with all remaining individuals not in the core group. This test will add each group into the core group and run the log-t-test, the core group will consist of the highest t-test value.

4. Performing the log-t-test for the remaining individuals which were not removed and checking the t-statistic for evidence of convergence.
5. Lastly, enacting the log-t-test for all pairs of the subsequent initial clubs to merge the clubs fulfilling the convergence hypothesis.

Chapter 4: Results

4.1 VAR-model

To understand the different identified drivers and the effect that a shock on those variables could have on the regional housing prices, we can look at the different variables identified and relate them to housing price developments within that region. The variables consist of ‘Construction, population and disposable income.’ A VAR-model can apply certain shocks to these variables in relation to other Variables. This can be related to both the Stock-flow model and the four-quadrant model by DiPasquale and Wheaton. The Stock-flow model has been helpful in looking at the difference of market variables through time to find out at what stage that housing market is. Furthermore, the principle of a shock being applied that changes the housing price is also relevant, this VAR-model will follow the same principle.

To identify if the variables can be used, we first need to perform a Dickey-Fuller test on the variables. The variables are not significant which means we cannot reject the null hypothesis of normality of the variables (Table 6). The next step will be to take the logarithm of these variables, which also yields the same results (Table 7). Next the variables have been transformed into logs and their first derivative is taken (Table 9). This is done to ensure normality of the variables. As we can see from table 8, the variables are all significant so we can use them within our VAR model.

The next step is to specify the appropriate model, there needs to be the correct number of lags. This is done through the ‘varsoc’ command in Stata. The lag lengths that are found with the dependent variable being ‘housing price Construction, population and disposable income’ for one of the three cities. The ‘varsoc’ command creates metrics to select the appropriate lag length. Because our variables are around 60 observations the ‘FPE’ statistic is used to specify the lag length. Since this metric is the best choice in reducing false lag length at lower observational counts. The optimal number of lags found for Stockholm and Malmo was 4. Whereas for Gothenburg the optimal lag length was 3.

The VAR model results (Figures 21,22,23) show the different variables and their effect on each other. For Stockholm we can see that all variables are significant, showing that construction has the highest significance followed by income. The variables have moderate R2's, however, since this is a time-series VAR-model a Granger causality test will be performed to more accurately show the effects that the different variables have on each other.

From the figures 21,22 and 23 we can gather the effect of the different variables on the housing price. The VAR basic model shows us the effect on the short term and the long term of the different variables. Figure 21 being Stockholm, figure 22 being Gothenburg and figure 23 being Malmo. The models show the effect of a shock of the variable (right) on a variable that does not experience the shock (left). This evolution of the model through different time periods is attributed to the shock experienced. The shock in this case is one standard deviation to the variable (left) which causes significant increase or decrease within that variable for the length of periods, after which the effect dissipates.

What we can gather from this effect is that the stock flow model by DiPasquale and Wheaton can be applied to this type of VAR-modelling. The eventual reaction of the market after a certain shock Is applied to which is related back to the original value. Using the VAR-model we can also look at the short and the long-term effects (up to 4 years) and whether the effect is positive or negative.

What can be observed firstly about the VAR-model is the R^2 and the Chi^2 . The construction and housing price for the regions is the highest. This can be because construction is a good indicator for changes in housing prices, population, and disposable income changes. Furthermore, from the VAR-analysis we can see that the variables all have a significant effect on each other of at least 95% significance. The R^2 for other variables is not very high. However, for these types of analysis the R^2 does not necessarily have to be high. The explanatory power of the model will be further examined by the Granger-causality test.

4.1.1 Construction

If we look at the figure 21 and at the D. LNSTOCKHP, LNSCON graph, we can see the effect that the construction variable would have on Housing within the three cities. We can see for the construction variable that in the short run, an increase in construction means a first increase followed by a decrease in housing price for Stockholm and Malmo, this follows the model by DiPasquale and Wheaton who suggest that an increase in Stock would also result in a decrease in housing price and the paper by Wamsler et al. (2014) Who suggested that initial investment would gather more demand to that area. This is because of the supply being larger. In the long run we can also see a decrease of housing with smaller peaks in between, probably showing the different cycles that the housing market goes through in terms of completed dwellings and housing prices. We can see that a shock in Construction for Stockholm has a long-term effect of 15 quarters or about 4 years before stabilizing. If we look at the effect on housing price on Construction for Stockholm, we can also see that a shock in housing price does affect the construction activity by slightly elevating it. This effect is also relatively long before stabilizing.

The model of Gothenburg shows a different side. Malmo is showing a higher increase than in Stockholm in the short run when there is a construction shock, followed by an eventual lighter decrease. Gothenburg is showing a slight decrease of the housing price in the short term when there is a shock in the construction, followed by an increase in housing price. The reason why there may be a decrease on the short run as opposed to an increase can be because of the stricter building regulations within Gothenburg. Furthermore, the investment climate within Gothenburg is more protectionist as compared to Stockholm and Malmo (Danakol, et al.,2017). This protectionist approach can make the short term FDI effects do not take into effect until after more is realized of the construction process, The deterring of FDI increases uncertainty which means that investment effect will succumb to the effects of short term negative effects such as construction until more certainty is achieved.

The short-term increase of Malmo and Stockholm is in line with the paper by Sa (2015) and can be explained as such. A shock in the building sector can be an expectation of increased demand for that area. Which would drive up the housing price for that sector. The housing market of Malmo is more elastic than that of Gothenburg and Stockholm, making it so that increased housing and development is more direct within that market. Planning and development within Gothenburg and Stockholm take more time to realize, showing little volatility in shocks and almost no positive effect of a shock in Construction as compared to Malmo where the planning regulations are relatively quick but like Stockholm they are exposed to outside investments and shifts in demand (Wamsler et al. 2014). This is in line with the graph of a one standard deviation shock in housing price to construction. This is also in line with the shorter shocks in the Gothenburg VAR-model, the relative smaller or belated influence of investment and the constant shocks in policy may have made the housing market more adaptable to shocks.

When we look at Malmo, we can see that the overall effect on housing prices is positive and peaks after about 5 steps. For Gothenburg and Stockholm, we can see an initial short term increase in construction for Gothenburg followed by a decrease within construction around step 2 and 6. For Stockholm the effect is more nuanced, not showing a greater construction during a one standard deviation shock in housing price. This also shows that the market for Stockholm and to a lesser degree Gothenburg, are more inelastic than Malmo. Malmo responds to the shock and can change construction more than Gothenburg and Stockholm, which is shown in the greater volatility which ends at around step 10.

In general, for Construction the variable shows a little increase in the short run for the more elastic market of Malmo, and a slight decrease followed by an increase for Gothenburg and a flattening followed by 2 decreases for Stockholm. This effect is always followed by a decrease in the long run for both cities. The negative effect in construction activity shocks compared to housing price on the long run seems to be the highest in Stockholm followed by Gothenburg, and lastly Malmo. This is in line with the relative flexibility of the housing market. Showing the downturn as being higher because the stock has increased, which deflates the most overvalued housing market.

4.1.2 Population

The next driver identified is population, what is apparent in the short run is that a shock of one standard deviation in population has a negative effect on the housing price for the three cities. The negative effect seems to have the shortest impact in Malmo, where it only persists for 2 periods until it reverts to a positive effect like in Gothenburg but with a much lower bottom. The negative effect seems to linger longer in Gothenburg after the most negative point, showing a longer time until the eventual positive effect of the population. For Stockholm, the dip seems to last even longer up until step 4. Showing a large decrease in housing price because of a one standard deviation shock in population.

The elasticity of the housing markets can again be the cause of these effects. The short lived negative effect and almost immediate bounce back of Malmo can be the cause of the relatively big number of multi-dwelling housing being built in response to smaller household sizes, Malmo is adjusting to the new demand that is being presented and can therefore absorb the population within the new housing stock generating additional demand. Whereas Stockholm and to a lesser extent Gothenburg cannot absorb the additional population and their demand into their housing stock that easily.

The initial increase is much more present and applicable in the long run. Except for the latter stage of the model. However, the effect remains positive on housing prices in the long run for the three cities. This effect can partly be explained through the population of Sweden being mostly Swedish born citizens. As we can deduct from the paper of Sá (2015), little effect will be negligibly affected by the grouping of a foreign-born population. If we are to look at Malmo for the same effect, we can see that the effect of population on housing prices is slightly negative on the short run, swiftly increases and after step 3 decreases more as time goes on before stabilizing.

A paper by Mulder (2006) also seems to further expand on this point. On the one hand population shows an increase in demand, this can be seen in the long run for all the cities. But, on the other hand the housing should also accommodate the needs of the population. A stable rental sector is necessary to provide people with places to live and not bind them to these places. But as can be expected from this is that considering the Swedish model, the prices of these places are too affordable compared to the location and do not necessarily reflect real market prices. Furthermore, the waiting times for Stockholm are so long that people are bound in relation to their rental homes since there will not be an opportunity to switch for several years.

A shock in population can therefore have a negative impact on housing within Stockholm, this housing market depends on population in order to drive demand for their housing that does not necessarily reflect the demographics of people joining that city. For Gothenburg there seems to be the same effect showing an increase in population to be correlated to a short-term decrease, but a long-term increase in housing prices. For Malmo, this effect is also shown but to a lesser extent. There seems to be a lower shift in housing prices during the population shock, but the effect slowly becomes negative and eventually remains in a positive situation. This can be explained through the relatively lower valued housing within Malmo and the responsiveness of the market through construction. An increase in population would not necessarily lower the prices within that market since the needs and wants of the population (foreign born and native) are catered to.

4.1.3 Disposable income

What is apparent from the figures is that income within Stockholm has a positive effect if there is a one standard deviation shock on housing price this is the same for Malmo. The conclusion that can be drawn from this is that if a shock from housing is to occur, there is usually a drop in disposable income for the people within Gothenburg. The effect being positive in Stockholm and Malmo shows that the average people in Stockholm are leveraged in debt, to show that a difference within the disposable income or income – debt mostly comprises mortgage debt. We can see that disposable income would therefore be raised. The short-term positive effect on housing prices with a shock in income for Malmo could be explained in that the relatively cheaper housing and lower disposable income because of higher unemployment and lower wages. Having one of the highest loan-to-value ratios in Sweden. This can explain that even if there is a lower disposable income, the people still take on relatively high amounts of debt. A shock to that debt could increase housing prices.

When we look at the effect of a one standard deviation shock in disposable income on housing prices, we can get another view of what is happening on these housing markets. A shock in disposable income seems to have a negative effect on the short run on housing prices for Malmo, and a positive effect on the short-run housing prices in Stockholm. What is remarkable is that a sudden shock in housing prices seems to have barely any effect in Gothenburg. Furthermore, in the long run a shock in disposable income seems to have a positive effect on the housing price for Stockholm, and relatively low gains for Malmo and Gothenburg.

What we can gather from this is that Stockholm has a high debt per capita, showing the reliance on the debt to fuel the increasing housing prices within that market. Furthermore, we can see in the short term that Malmo does not react negatively to a shock in disposable income. But we can see that disposable income reacts negatively to a sudden shock in housing price. This can be a result of the relatively cheaper housing, and the relatively high mortgage debt that these people have and the housing prices being less inflated. As a result, a shock in the income on short term can be beneficial to the housing prices. Since a negative shock could be a result of lesser disposable income because of higher mortgage obligations or a positive shock in which supply can more easily adapt to the demand.

The effect is also noticeable within the Gothenburg market, although to a lesser degree. Showing a negative effect on housing price, and eventually increasing and having a positive on housing price in the long run. Furthermore, the Malmo market seems to have a positive effect on the short term and take a small dip before eventually increasing on the long term. Showing a positive effect on income as housing prices become higher. This effect can be attributed to the more affordable housing of the two cities compared to the Stockholm market.

If we look at the effect of housing price shocks on disposable income, we can see the effect is the most pronounced in Stockholm when compared to Gothenburg and Malmo. There is a noticeable price dip for the Stockholm market, indicating overvaluation and higher housing prices than other markets (Mandell & Wilhelmsson, 2015). Stockholm shows an initial positive effect on income because of a shock in housing price. This can be the result of the overvaluation as has been discussed. The effect is quick to stabilize after 6 steps but has been positive. For both Gothenburg and Malmo, the effect of a housing price shock on disposable income is negative. Where eventually the effect stabilizes for Malmo after step 5 and for Gothenburg after step 6. The effect for Gothenburg seems to linger on the most which may be a result of the inelastic housing supply that Gothenburg has as compared to Malmo. The negative effect of disposable income can be explained through the relatively lower housing prices which as a result has lower mortgage debt and payment on the income within the respectable city. A shock in housing prices can thus as a result have a more drastic effect on the debt of the household since people within Malmo and Gothenburg are not as encumbered in debt as people in Stockholm would be.

4.1.4 Post-estimation VAR-model

To make sure that there is proper causality between the variables and that the effect is effective on one another, a granger-causality test is performed for the three cities (Table 3). The three cities will have the causality of relationships tested to see what the effect of construction, population and income have on housing prices within the respective city. From the tests we can gather that we cannot reject the 0-hypothesis for the three cities, therefore we can assume on a 95% confidence interval that there is causality between the variables defined.

TABLE 3, GRANGER CAUSALITY TEST FOR GOTHENBURG, STOCKHOLM, AND MALMO

Equation	Excluded	Chi2	Degrees of freedom	Prob > Chi2
Gothenburg				
D.lnGothenburg hou	D.lnGothenburgpop	7.8739	3	0.049
D.lnGothenburg hou	D.lnGothenburgCon	15.071	3	0.002
D.lnGothenburg hou	D.lnGothenburginco	0.04561	3	0.997
D.lnGothenburg hou	ALL	21.689	9	0.01
Stockholm				
D.lnStockholm hous	D.lnStockholmpopul	6.3235	4	0.176
D.lnStockholm hous	D.lnStockholmCons	10.951	4	0.027
D.lnStockholm hous	D.lnStockholmincom	8.823	4	0.066
D.lnStockholm hous	ALL	26.533	12	0.0099
Malmo				
D.lnMalmo housingprice	D.lnMalmopopu	3.3796	4	0.496
D.lnMalmo housingprice	D.lnMalmoCons	8.9784	4	0.062
D.lnMalmo housingprice	D.lnMalmoinco	8.7713	4	0.067
D.lnMalmo housingprice	ALL	22.219	12	0.035

4.2 Convergence testing

The convergence or divergence between the cities will be assessed based on the model by Phillips and Sul (2007) and will follow the method of Du (2017). Firstly, the xtset function is used to identify the panel variable and the time variable. Which in this case is the 'id' variable consisting of 1 for Gothenburg, 2 for Malmo, 3 for Stockholm. The time variable consists of the quarterly data from 1998Q1-2019Q4. The three cities will be compared to each other. This means that in total there are 3 series identified. The data used can be viewed in figure 20.

TABLE 4, LOG-T-TEST FOR THE REGIONS

Variable	Coefficient	Standard error	T-statistic
Log(t)	-0.3605	0.0167	-21.5470

Number of individuals is 4
Number of time periods is 88
The first periods are discarded before regression

First, the pfilter command is used to wipe out the cyclical component. A new variable lnpgdp2 is generated to store the trend component. The next step will be to run the log t regression for the convergence test (Table 4). The output reports the coefficient, standard error, and t statistic for log(t). Since the value of the t statistic (calculated as -6.2317) is less than -1.65, the null hypothesis of convergence is rejected at the 5% level. This tells us that all 3 variables are not convergent with one another, or there are submarkets to be defined.

To look at the different groups that have been identified the cyclical component is compared to the actual values of the 3 identified groups. From this we can find the convergence or divergence (Table 5). What we can deduct from this figure is that the first club of Stockholm and Gothenburg are convergent while we cannot find the same effect for Malmo. This could in turn be the effect of Malmo responding better to the Swedish housing shocks than the more inelastic markets of Gothenburg and Stockholm. Furthermore, we can see that Malmo is non-convergent. This means that this city shares no convergence with any of the other variables and their housing prices thus move significantly different from the other housing prices defined. From this we can gather that both the housing prices in Malmo are its own defined submarkets that respond to shocks and price turn-ups in their own market.

To further study this effect the next we will look at the coefficients of the 2 groups identified and their respective t-statistic (Table 5). As we can see from club 1 a positive t-statistic is identified, showing that there is convergence between the two groups considering it is above the defined bounds for the t-statistic (1.65). For the other group we can denote a negative t-statistic showing that no convergence could be identified for Malmo in relation to Gothenburg and Stockholm but is instead referred to as 'divergence'.

TABLE 5, DIVERGENCE OF GROUPS BASED ON CLUSTERING

Log(t)	Club 1 (Gothenburg & Stockholm)	Non-divergent group Malmo
Coefficient	0.080	-0.3
T-statistics	4.917	-2.27

The paper by Phillips and Sul (2007) further suggests converting additional groups and by adding certain groups together to form bigger groups, and eventually merge those larger groups together. However, since we have only defined one group this is not possible in this case. The potential convergence is noted between the housing market of Gothenburg and Stockholm, there is no convergence between Malmo or Stockholm and Malmo or between Gothenburg.

The divergence of Malmo can be expected, after all the housing market seems to stand on its own having much lower housing prices and subsequently lesser crashes. As can be noted in the recent crash of 2016. However, the inclusion of Gothenburg is a surprise. What can be concluded from the convergence of Stockholm and Gothenburg compared to the divergence of Malmo is that we can speak about 'regional global cities. A paper by Chien (2010) has noted within Taiwan. The paper notes the difference in Taipei compared to other regions and has noted a difference between this city and the way in which it responds to shocks.

The region around Stockholm and Gothenburg may have lower housing prices, and not respond to the same increase in housing prices when Stockholm or Gothenburg experience them simply because they lose their competitiveness compared to these cities. Cities such as Uppsala or Orebro, are becoming less favorable compared to living within Stockholm or Gothenburg. This can explain why Malmo is diverging from these housing markets. Because the spillover effects of Malmo can be felt in its neighboring regions. Furthermore, the elasticity of the housing market in Malmo creates more responsiveness to shocks.

To further understand the divergence of Malmo with the Swedish housing market, whereas Gothenburg and Stockholm were converging from these markets further research is required.

CHAPTER 5 – CONCLUSION

When we look at the converging or diverging of markets, using the model by Phillips and Sul for club convergence. We can see that Malmo is the only market that is diverging with the other markets. The markets of Gothenburg and Stockholm do not converge with Malmo and therefore we can conclude at a 95% confidence level that the housing prices of Malmo are diverging from both Stockholm and Gothenburg. When we look at the inflation adjusted housing prices in figure 20. We can see that this is in line with what can be observed. The prices from Gothenburg and Stockholm appreciate more and more in value therefore leaving Malmo behind.

To further study the effects of the drivers ‘construction, population, and disposable income’ , a VAR-model was performed which showed a significant influence of these variables on housing price. According to the data on regional construction, several conclusions can also be made. One of the main results from the model is that construction and responsiveness of the market plays a significant role in appreciating housing prices in these cities. What we can see for Malmo is that there is a more responsive housing market present. Because of the heightened building activity and the limited restrictions on building there can be an appropriate offset of housing stock because of the demand change within that city. For Gothenburg this is increasingly less so, having a relatively little construction since the financial crisis as can be seen on figure 15. For Stockholm the construction has always been far behind on the actual demand, this can be seen from the construction figures but it can also be seen on the long waiting lists for social housing which are averaging out at 12-years.

For regional population and disposable income, we can see an increase of mostly immigrants which causes the influx of new people moving into these three cities. The Swedish demographics nevertheless are getting relatively older and are living more alone. This in turn increases the need for other types of housing accommodations. The disposable income of this new demographic is highest in Stockholm followed by Gothenburg and lastly Malmo. Looking at figure 19, we can see a downturn for both Gothenburg and Stockholm in disposable income and a stalling for Malmo. This could be because of the mortgage reform as this would greatly increase the costs associated with the income.

The VAR-model tells us that construction in the short term increases the relative housing prices because of anticipated growth and eventually decreases housing prices because of adding to the existing stock. This effect is more prevalent in Stockholm and Gothenburg than in Malmo. Population seems to have a negative effect on the short run with a more positive effect on the long run which could indicate demand and supply side matching in accordance with the paper of Mulder (2006). For income, the VAR-model tells us that Stockholm especially is leveraged showing the highest increase in case of a shock to disposable income. Whereas Malmo has a higher debt to income ratio which because of having the lowest income is also relatively leveraged.

This points us to the conclusion that regarding leveraging, an increased population and a shortage in housing will inevitably ramp up the housing prices within a city. Which in turn means that a more rigid housing market will remain rigid. As in according to the 4-quadrant model which states an increase in demand followed by no increase in stock will ramp up the price. So does the housing market in Stockholm and Gothenburg increase its pricing. For Malmo this is less so the case since the market is responsive, allowing for cheaper housing which connects better to the residents of lower income groups.

So different subgroups can be identified, this is shown by the convergence of Gothenburg and Stockholm, who diverge more from the Malmo housing prices. This information can be used to look at effects that big government regulation and increased demand can have on a society with a high degree of urbanization. Therefore, this research could contribute to the Scandinavian housing market. Certain policies relating to construction, or mortgage payments could have a direct impact on the housing prices within a cramped housing market or create such a market.

Shortcomings and further discussion

The shortcomings of this research are from the defined subgroups and the VAR-analysis. Similar research papers show that multiple subgroups are defined, which in term makes it possible to see all the different combinations of potential subgroups and stand-alone markets. In this case achieving these subgroups would give a clearer view on whether Gothenburg and Stockholm are composed of their own housing markets or if there are similar other regions within Sweden to be found. Furthermore, microdata would be extremely useful in these types of analysis. Mutations from individual or already monthly data could be useful in the VAR analysis and give a clearer image of what a potential shock could do to the variables.

Also, tno explanatory statistical analysis about the convergence and divergence was performed. To truly examine the reason as to why housing markets are different from other housing markets there needs to be a statistical analysis which can help explain this phenomenon. This analysis could include more drivers for example, interest rates, or actual demographic differences, a deeper dive into the debt per capita and how it is composed. But also comparing richer neighborhoods in Stockholm as opposed to poorer neighborhoods in Stockholm for example. Perhaps there are submarkets to be divined within the individual cities as well, to just take the mean could leave out important distinctions. This could also help explain why Gothenburg was relatively fast in absorbing the different shocks of the VAR-model compared to Malmo and Stockholm.

Lastly the influence of a housing price bubble has not been explored, regional housing cycles or longer boom and bust cycles can alter the way in which subgroups can be identified. Therefore, it would be interesting to see if similar research can be done where regional housing price bubbles can be identified and be considered to test for convergence.

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APPENDIX

Equation	Parms	RMSE	R2	CHI2	P>CHI2
D.LNSTOCKHP	17	0.01986	0.430	62.60585	0.000
D.LNSTOCKCON	17	0.025076	0.699	192.6459	0.000
D.LNSTOCKPOP	17	0.031335	0.343	43.30013	0.0003
D.LNSTOCKINC	17	0.029212	0.509	85.89471	0.000

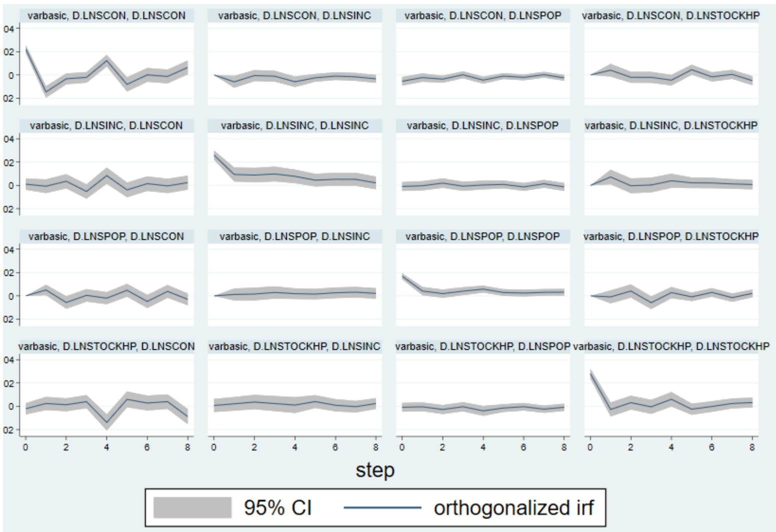

Figure 21, VAR-model Stockholm (Author's own creation, 2020)

Equation	Parms	RMSE	R2	CHI2	P>CHI2
D.LNGOTHHP	13	0.01763	0.436	64.85562	0.000
D.LNGOTHCON	13	0.025811	0.2657	30.39699	0.002
D.LNGOTHPOP	13	0.026855	0.2352	25.82966	0.0113
D.LNGOTHINC	13	0.012068	0.5928	122.2652	0.000

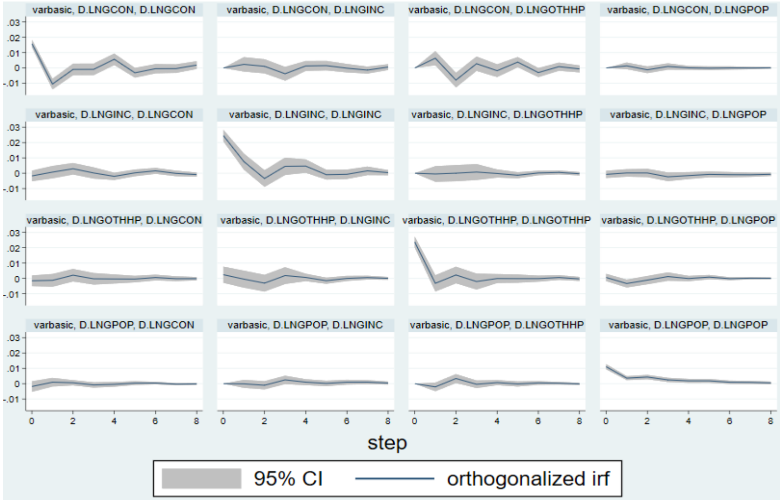

Figure 22, VAR-model Gothenburg (Author's own creation, 2020)

Equation	Parms	RMSE	R2	CHI2	P>CHI2
D.LNMALMHP	17	0.027547	0.6062	127.7725	0.000
D.LNMALMCON	17	0.018736	0.2488	27.49293	0.0363
D.LNMALMPOP	17	0.0238	0.3390	42.57217	0.0003
D.LNMALMINC	17	0.032487	0.2488	27.48264	0.0364

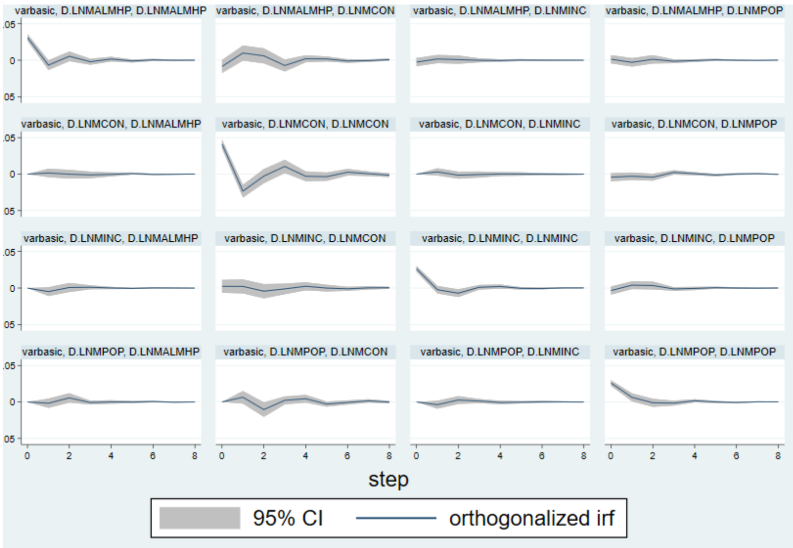

Figure 23, VAR-model Malmo (Author's own creation, 2020)

TABLE 6, DICKEY-FULLER VARIABLES.

Dfuller Stockholmconstr			
Test Statistic	1% critical Value	5% critical Value	10% critical Value
-1.007	-2.605	-1.950	-1.610
Dfuller Gothenburgconst			
Test Statistic	1% critical Value	5% critical Value	10% critical Value
-1.497	-2.605	-1.950	-1.610
Dfuller Malmoconstructio			
Test Statistic	1% critical Value	5% critical Value	10% critical Value
-1.833	-2.605	-1.950	-1.610
Dfuller Stockholmpopula			
Test Statistic	1% critical Value	5% critical Value	10% critical Value
21.625	-2.605	-1.950	-1.610
Dfuller Gothenburgpopu			
Test Statistic	1% critical Value	5% critical Value	10% critical Value
12.194	-2.605	-1.950	-1.610
Dfuller Malmopopulation			
Test Statistic	1% critical Value	5% critical Value	10% critical Value
17.284	-2.605	-1.950	-1.610
Dfuller Stockholmincome			
Test Statistic	1% critical Value	5% critical Value	10% critical Value
9.770	-2.605	-1.950	-1.610
Dfuller Gothenburgincon			
Test Statistic	1% critical Value	5% critical Value	10% critical Value
6.808	-2.605	-1.950	-1.610
Dfuller Malmoincome			
Test Statistic	1% critical Value	5% critical Value	10% critical Value
6.743	-2.605	-1.950	-1.610
Dfuller Stockholmhousin			
Test Statistic	1% critical Value	5% critical Value	10% critical Value
2.830	-2.605	-1.950	-1.610
Dfuller Gothenburghousi			
Test Statistic	1% critical Value	5% critical Value	10% critical Value
4.702	-2.605	-1.950	-1.610
Dfuller Malmohousingpri			
Test Statistic	1% critical Value	5% critical Value	10% critical Value
4.008	-2.605	-1.950	-1.610

TABLE 7, DICKEYFULLER OF LOGARITHM OF VARIABLES.

Dfuller LNSTOCKCON			
Test Statistic	1% critical Value	5% critical Value	10% critical Value
0.202	-2.605	-1.950	-1.610
Dfuller LNGOTHCON			
Test Statistic	1% critical Value	5% critical Value	10% critical Value
0.013	-2.605	-1.950	-1.610
Dfuller LNMALMCON			
Test Statistic	1% critical Value	5% critical Value	10% critical Value
0.010	-2.605	-1.950	-1.610
Dfuller LNSTOCKPOP			
Test	1% critical	5% critical	10% critical

Statistic	Value	Value	Value
20.282	-2.605	-1.950	-1.610
Dfuller LNGOTHPOP			
Test	1% critical	5% critical	10% critical
Statistic	Value	Value	Value
11.061	-2.605	-1.950	-1.610
Dfuller LNMALMPOP			
Test	1% critical	5% critical	10% critical
Statistic	Value	Value	Value
16.207	-2.605	-1.950	-1.610
Dfuller LNSTOCKINC			
Test	1% critical	5% critical	10% critical
Statistic	Value	Value	Value
11.090	-2.605	-1.950	-1.610
Dfuller LNGOTHINC			
Test	1% critical	5% critical	10% critical
Statistic	Value	Value	Value
6.836	-2.605	-1.950	-1.610
Dfuller LNMALMINC			
Test	1% critical	5% critical	10% critical
Statistic	Value	Value	Value
6.483	-2.605	-1.950	-1.610
Dfuller LNSTOCKHP			
Test	1% critical	5% critical	10% critical
Statistic	Value	Value	Value
4.157	-2.605	-1.950	-1.610
Dfuller LNGOTHHP			
Test	1% critical	5% critical	10% critical
Statistic	Value	Value	Value
5.565	-2.605	-1.950	-1.610
Dfuller LNMALMHP			
Test	1% critical	5% critical	10% critical
Statistic	Value	Value	Value
4.422	-2.605	-1.950	-1.610

TABLE 8, DICKEY-FULLER ON FIRST DERIVATIVE OF VARIABLE

Dfuller D.LNSTOCKCON			
Test	1% critical	5% critical	10% critical
Statistic	Value	Value	Value
-13.683	-2.605	-1.950	-1.610
Dfuller D.LNGOTHCON			
Test	1% critical	5% critical	10% critical
Statistic	Value	Value	Value
-14.592	-2.605	-1.950	-1.610
Dfuller D.LNMALMCON			
Test	1% critical	5% critical	10% critical
Statistic	Value	Value	Value
-13.913	-2.605	-1.950	-1.610
Dfuller D.LNSTOCKPOP			
Test	1% critical	5% critical	10% critical
Statistic	Value	Value	Value
-2.709	-2.605	-1.950	-1.610
Dfuller D.LNGOTHPOP			
Test	1% critical	5% critical	10% critical
Statistic	Value	Value	Value
-4.523	-2.605	-1.950	-1.610
Dfuller D.LNMALMPOP			
Test	1% critical	5% critical	10% critical
Statistic	Value	Value	Value
-3.059	-2.605	-1.950	-1.610
Dfuller D.LNSTOCKINC			
Test	1% critical	5% critical	10% critical
Statistic	Value	Value	Value

-2.757	-2.605	-1.950	-1.610
Dfuller D.LNGOTHINC			
Test Statistic	1% critical Value	5% critical Value	10% critical Value
-5.450	-2.605	-1.950	-1.610
Dfuller D.LNMALMINC			
Test Statistic	1% critical Value	5% critical Value	10% critical Value
-6.856	-2.605	-1.950	-1.610
Dfuller D.LNSTOCKHP			
Test Statistic	1% critical Value	5% critical Value	10% critical Value
-8.783	-2.605	-1.950	-1.610
Dfuller D.LNGOTHHP			
Test Statistic	1% critical Value	5% critical Value	10% critical Value
-8.505	-2.605	-1.950	-1.610
Dfuller D.LNMALMHP			
Test Statistic	1% critical Value	5% critical Value	10% critical Value
-9.221	-2.605	-1.950	-1.610