THE IMPACT OF MACROECONOMIC AND DEMOGRAPHIC FACTORS ON RESIDENTIAL PROPERTY PRICES IN THE SELECTED EUROPEAN COUNTRIES

by

Tetiana Savchenko

A thesis submitted in partial fulfillment of the
requirements for the degree of

MA in Business and Financial Economics

Kyiv School of Economics

2023

Thesis Supervisor: ___________________________ Professor Yulia Kuntsevych

Approved by ____
Head of the KSE Defense Committee, Professor [Type surname, name]

____

____

____

Date ___________________________________

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

GDP – Gross Domestic Product

CPI – Consumer Price Index

ECB – European Central Bank

OECD – Organisation for Economic Co-operation and Development

ADF – Augmented Dickey-Fuller

CHAPTER 1. INTRODUCTION

The importance of housing equity in Europe can not be overestimated, as it accounts for about 60% of household wealth according to ECB and OECD. The dynamics of the business cycle and expectations for macroeconomic performance are significantly influenced by shifts in the housing market[1]. Despite its relatively small size in the economy (representing 6% of GDP from Q1 1997 to Q1 2018 in nominal terms), residential investment is known for its high volatility compared to other GDP expenditure components[2].

Over time, European housing markets have witnessed fluctuations in housing prices due to events like Global Financial Crisis in 2007, European Sovereign Debt Crisis, COVID-19 crisis. While economic growth, inflation, unemployment rates, and demographic shifts have all been potential drivers of housing prices, further analysis might be helpful in identifing the specific factors contributing to European residential property price dynamics (within the context of these potential drivers).

This research delves into the dynamics of housing prices across various clusters within the European housing market. It aims to uncover the underlying relationships between housing prices, socio-economic factors, and other key determinants

This study tests three central hypotheses. The first hypothesis indicates that housing prices in European countries are significantly influenced by macroeconomic factors. It argues that economic indicators such as inflation rates, unemployment rates and GDP growth play an important rolein shaping housing price dynamics. The second hypothesis focuses on demographic factors and their impact on houseprices. This means that changes in population composition, for example age distribution, gender

---

[1] Piazzesi, M. and Schneider, M., "Housing and Macroeconomics", *Handbook of Macroeconomics*, Vol. 2B, 2016.

[2] Battistini, N., Le Roux, J., Roma, M., & Vourdas, J. (2018). The state of the housing market in the euro area. ECB Economic Bulletin, Issue 7/2018.

demographics and total population size, will have a significant impact on housing price changes in Europe. The third hypothesis examines the idea that the impact of macroeconomic and demographic factors on housing prices is varing across countries. These differences are driven by each country's economic circumstances, which recognize the unique characteristics of real estate markets in different regions. This diversity leads to the potentially important impact of these factors on real housing prices.

To rigorously assess these hypotheses, a multifaceted methodology is employed. This research utilizes both a panel data models and clustering techniques. the employed panel data model enables a thorough exploration of how macroeconomic and demographic factors influence housing prices in diverse European countries. This approach takes into account variations over time and across different regions.

Moreover, the countries under investigation are categorized into four separate clusters, depending on key indicators such as the CPI, unemployment rate, population density, and income per capita. Separate regression analyses are conducted within each cluster to investigate hypothesis 3. This approach enables a nuanced exploration of how variations in macroeconomic and demographic factors interact with distinct housing market characteristics.

The core research question revolves around the intricate relationships between housing prices and an array of predictor variables within each cluster. These predictor variables encompass factors such as age group distributions in the population, total population figures, the CPI, per capita income, and per capita GDP.

Findings from this research reveal pivotal determinants influencing housing prices. The analysis unveils intricate associations between housing costs and population composition, inflation rates, unemployment levels, GDP per capita, and income per capita.

The implications of this research extend to a spectrum of stakeholders. Policymakers can harness these insights to formulate housing policies tailored to regional demographics, thus fostering inclusive and sustainable housing markets. Real estate developers can align their projects with the preferences and needs of different demographic groups, enhancing marketability and affordability. Investors are empowered with a comprehensive understanding of housing price determinants and market dynamics, facilitating informed decision-making in their investment strategies.

In summary, this research aims to enhance the comprehension of the factors influencing housing prices in Europe. Through a comprehensive and intricate analysis, it seeks to expand our existing knowledge and provide data-driven insights that can guide future research and decision-making in this crucial domain.

CHAPTER 2. RELATED STUDIES

Understanding what factors affect European housing prices is of great significance in its role within the European economy. This literature review provides a thorough look into research conducted regarding macroeconomic and demographic influences on housing prices across Europe, identifying key determinants and their dynamics while discussing any studies which confirm or challenge existing hypotheses, leading to greater comprehension on this subject matter.

Posedel and Vizek (2009) undertook an exhaustive examination of house price developments across European countries. Employing VAR analysis and multiple regression models, they delved into the factors driving house price inflation. Their findings provide substantial evidence in favor of the hypothesis that macroeconomic factors exert significant influence on real house price variance. Specifically, GDP, housing loans, interest rates, and construction were identified as key contributors to the dynamics of housing prices. They also state that there are similarities in effects in all groups of European countries examined.

Adams and Füss (2010) expanded the horizons of understanding regarding the long-term impact of macroeconomic variables on international housing prices. Through their analysis spanning 15 countries over three decades, their research confirmed the pivotal role played by macroeconomic factors. Factors such as economic activity, construction costs, and long-term interest rates were found to be instrumental in shaping housing prices, further solidifying the hypothesis that macroeconomic variables are integral to comprehending housing price dynamics.

Stepanyan et al. (2010) directed their focus towards housing market dynamics in selected Former Soviet Union countries. Their empirical analysis illuminated the extent to which house price developments were explained by fundamental factors, including GDP, remittances, and external financing. This discovery underscores the profound influence of demographic factors, particularly in transitional economies, lending credence to the hypothesis that demographics play a crucial role in housing price dynamics.

In their research, Goodhart and Hofmann (2008) identified a strong connection between house prices, monetary variables, and the macroeconomy overall. They observed that this relationship was more pronounced during the period from 1985 to 2006, especially when house prices were booming.

The study by Bhattacharya and Kim (2011) revealed that economic fundamentals, including employment, real construction costs, and the real user cost of housing, significantly influenced real housing prices across 20 metropolitan areas in the U.S. Their findings underscored the importance of maintaining solid economic fundamentals to support home prices and the need to consider regional variations in these effects.

In contrast to the prevailing belief that housing prices and income are inherently cointegrated, Joshua Gallin's (2003) research challenges this hypothesis. Using extensive national-level data spanning 27 years, Gallin employs standard tests for cointegration and finds no evidence to support the view of a long-term relationship between house prices and income.

Vyacheslav Mikhed and P. Zemčík (2007) delve into the justifiability of high and rapidly decreasing U.S. house prices by fundamental factors such as personal income, population, house rent, stock market wealth, building costs, and mortgage rates. They also panel data stationarity tests that consider cross-sectional dependence. Contrary to previous panel studies of the U.S. housing market, they consider multiple fundamental factors. Their results, although demonstrating greater statistical power in panel data unit root tests, lead to the same conclusion as univariate tests: house prices do not consistently align with these fundamentals. Particularly noteworthy is the finding that real estate prices appear to deviate from their fundamental value, sometimes taking decades to revert to it, as exemplified by the most recent housing market correction.

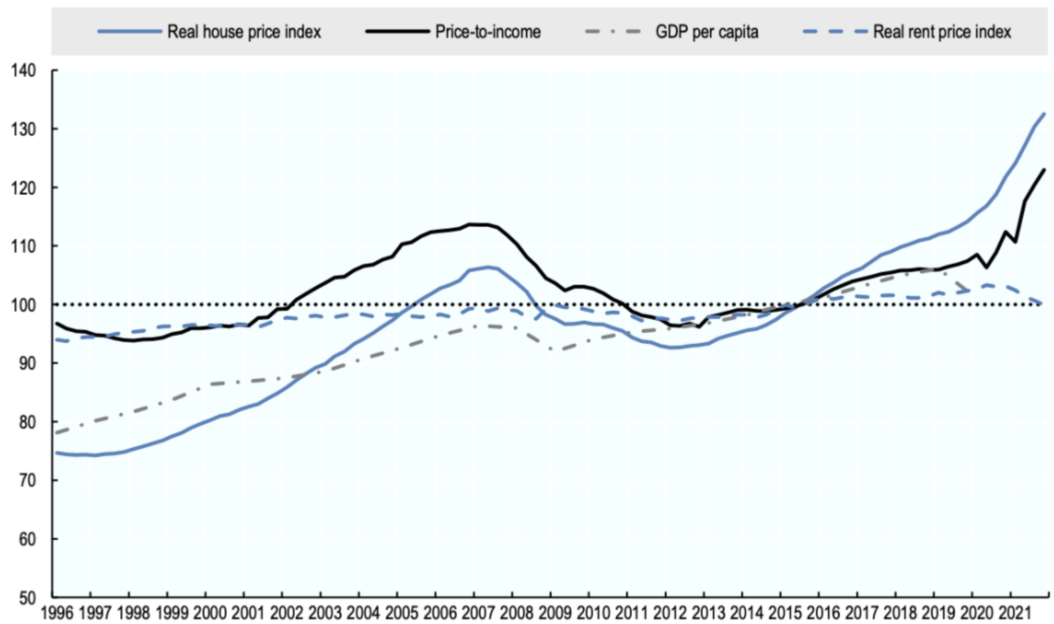
Navigating the extensive and diverse literature on housing prices and their intricate connection with macroeconomic and demographic factors calls for a heightened awareness of the inherent complexities and challenges within this realm of research. Scholars such as Gallin (2004) caution against the potential pitfalls of multicollinearity, emphasizing the imperative of avoiding bias, especially when conducting region-specific analyses. The intricate nature of housing markets necessitates an approach that is not only comprehensive but also profoundly nuanced when striving to unravel the intricate interplay between macroeconomic and demographic factors and their impact on housing prices.

Girouard et al. (2006) embarked on an exploration of housing price trends within OECD economies, unearthing unique insights. They shed light on the unprecedented size and duration of real house price increases across countries, prompting discussions about potential overvaluation in select regions. This study underscores the necessity of considering variations in housing market characteristics across countries, thus challenging us to scrutinize the hypothesis from the perspective of regional disparities in housing market dynamics.

From the OECD analysis though we can see that Real House Prices index, Price-to-Income, GDP per capita, and Real rent prices index indeed go together through the years, indicating that there might be some direct relationship between them. The correlation between Real House Prices index, Price-to-Income ratio, GDP per capita, and Real Rent Prices index suggests that housing prices are influenced by economic growth, affordability of housing, and rent vs. buy decisions. However, these are just the hypotheses and further analysis is needed to validate them.

Figure 1. Development of house prices, OECD average, 1996-2021. Source: OECD[3]

[3] Source: OECD. Housing Prices. Retrieved from [https://www.oecd.org/els/family/HM1-2-Housing-prices.pdf].



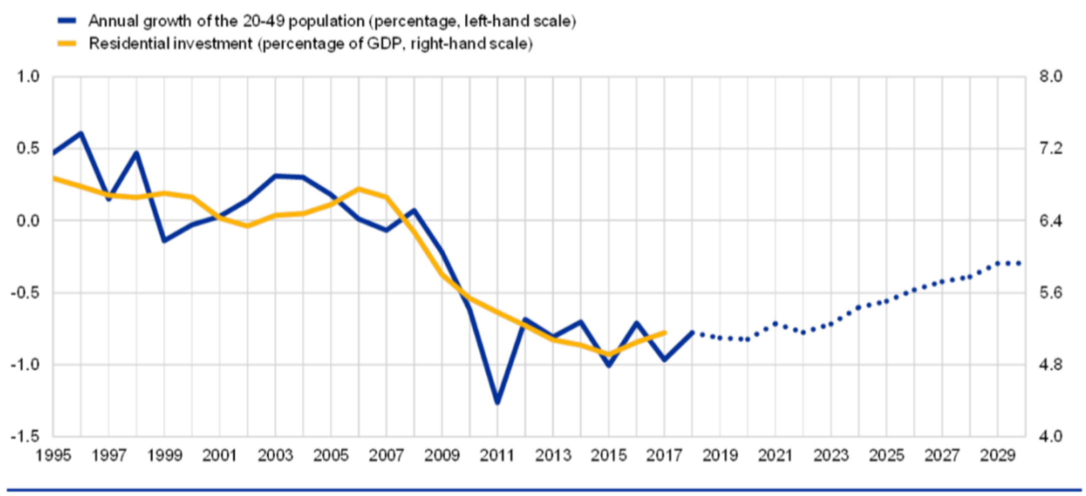
In addition to the the mentioned factors, the Consumer Price Index and unemployment rate are also crucial indicators that can potentially impact housing prices. High CPI values, indicative of inflation, can lead to an increase in housing prices as the cost of raw materials for building houses rises. Furthermore, during periods of high inflation, real estate often becomes a popular investment choice as a hedge against inflation[4]. This might be the reason for price increasings. On the other hand, the unemployment rate can negatively affect housing prices. High unemployment rates can result in decrease of housing prices as less people have the income necessary to purchase a home.

The "The state of the housing market in the euro area" ECB Economic Bulletin article on the other hand, gives some ground to assert that population variable might also be influencing housing prices. The graph below (Figure 2) shows a positive correlation between population growth and residential investment. This means that as population

[4] CoreLogic. (2023). Home Price Insights: October 2023. Retrieved from [https://www.corelogic.com/intelligence/us-home-price-insights-october-2023/].

growth increases, so too does residential investment. This is consistent with the hypothesis that demographic factors influence housing prices. One way that population growth can influence housing prices is by increasing the demand. As the population grows, there are more people who need a place to live. This can drive up the prices of residential property and lead to increased construction of new homes[5]. Another way that population growth can influence housing prices is by affecting the supply of land for housing development[6]. With higher population, there is less and less land available for new housing development.

Figure 2. Population growth and residential investment in the euro area. Source: Eurostat and ECB calculations[7]



The age distribution of a population can influence housing prices in several ways. A population with a high proportion of young adults might increase demand for starter homes and rental properties, while economies with a higher fraction of old people

---

[5] Gevorgyan, K. (2019). Do demographic changes affect house prices? *Journal of Demographic Economics, 85*(4), 305-320. doi:10.1017/dem.2019.9

[6] OECD (2018), *Rethinking Urban Sprawl: Moving Towards Sustainable Cities*, OECD Publishing, Paris, https://doi.org/10.1787/9789264189881-en.

[7] Source: Battistini, N., Le Roux, J., Roma, M., & Vourdas, J. (2018). The state of the housing market in the euro area. ECB Economic Bulletin, Issue 7/2018.

in the overall population have lower house prices[8]. Gender distribution can also influence housing prices, but the effects are usually less direct and can be influenced by other social and economic factors. For example, rising female participation in the workforce and increasing economic independence could lead to increased demand for housing from single women, potentially driving up prices[9].

While there is compelling evidence supporting the significant influence of both macroeconomic and demographic factors on housing prices, this review also illuminates the need to account for regional variations and the intricacies inherent in this complex relationship. This foundational knowledge will guide our empirical analysis in the subsequent chapters, further illuminating this critical subject matter.

---

[8] Gevorgyan, K. (2019). Do demographic changes affect house prices? *Journal of Demographic Economics, 85*(4), 305-320. doi:10.1017/dem.2019.9

[9] Pinto, I. (2023). The cost crisis: A gendered analysis. UK Women's Budget Group

CHAPTER 3. METHODOLOGY

The methodology for testing the hypotheses in this study involved of panel data through regression analysis and clustering. It is believed to assess the impact of macroeconomic and demographic factors on housing prices in European countries.

To study the factors influencing housing prices in European countries and to address the hypotheses stated in this study, a series of regression analyses were conducted. The primary base model, employed to investigate the first and second hypotheses, is a linear regression with fixed effect containing both, macroeconomic and demographic independent variables.

To test the hypothesis 1 (macroeconomic variables having a significant effect on housing prices) and hypothesis 2 (macroeconomic variables having a significant effect on housing prices) a linear hypothesis test was conducted on both group of variables, which also allows to make conclusions about the size of the effect.

$\log(housing\_prices) = \beta 1(\log(pop\_15\_64)) + \beta 2(\log(pop\_fem)) + \beta 3(pop\_dens) + \beta 4(cpi) + \beta 5(income\_pc) + \beta 6(unemp\_rate) + \beta 7(\log(gdp)) + \beta 8(country)1 + \ldots + \beta k(country)1 + \varepsilon$

In this equation:

- The dependent variable, log(housing_prices), represents the natural logarithm of real residential property prices.
- The independent variables include:
    - log(pop_15_64): The natural logarithm of the population aged 15-64 years
    - log(pop_fem): The natural logarithm of the female population
    - pop_dens: Population density
    - cpi: The Consumer Price Index
    - income_pc: Income per capita
    - unemp_rate: The unemployment rate
    - log(gdp): The natural logarithm of Gross Domestic Product

- The regression coefficients, β1 to β7, are associated with each independent variable, denoting the change in log(housing_prices) when the respective independent variable changes by one unit, while holding all other variables constant.
- The country coefficients, β8 to βk, represent the fixed effects of each country. These coefficients capture the impact of country-specific factors on housing prices that are not included in the other variables.
- The error term, represented as 'ε', accounts for unexplained variation in log(housing_prices), capturing the variability in housing prices that cannot be attributed to the included independent variables.

To test the third hypothesis, a cluster analysis using the K-Means algorith was imposed. It grouped countries based on specific indicators of economic stability, such per capita income, CPI, unemployment rate, and thepopulation density. These indicators were chosen for their potential to serve as benchmarks for assessing the economic stability of different regions:

- Income per capita: High per capita income can reflect the economic prosperity of a region. It might indicate purchasing power of residents, which could increase the demand for housing and increase house prices.
- CPI: It's often used as a measure of inflation. Lower inflation rates can signify more stable economic conditions. This, as a result, may create a favorable environment for real estate investment, and lead to an increase in housing prices.
- Unemployment rate: The decline in unemployment primarily reflects the state of the labor market and economic stability. A stable labor market increases the number of people who can afford to buy a residential property. This consequently increases demand and raises housing prices.
- Population density: Higher population density can indicate higher demand for housing due to limited space. This high demand, especially in urban areas, can result in higher property prices.

K-means clustering is an unsupervised machine learning algorithm that aims to partition data into k clusters based on similarity. The objective of k-means clustering is to minimize this sum of squared distances. The equation for the K-Means algorithm can be represented as follows:

$$\text{argmin S} \sum_{i=1}^{k} \sum_{x \in S_i} x - \mu_i \ ||^2$$

- S' are the 'k' clusters
- 'x' represents data points in each cluster 'S_i'
- 'μ_i' is the centroid of cluster 'S_i'
- The "argmin" part indicates that we're searching for the set of clusters S that minimizes the sum of squared distances.

An interaction model was developed to explore the varying impacts of macroeconomic and demographic factors across these clusters. The regression equation for this model is similar to the one used for the first and second hypotheses, with the inclusion of interaction terms, where "cluster" represents the cluster assignments.

log(housing_prices) = β1(log(pop_15_64)) + β2(log(pop_fem)) + β3(pop_dens) + β4(cpi) + β5(income_pc) + β6(unemp_rate) + β7(log(gdp)) + β8(cluster) + β9(log(pop_15_64)*cluster) + β10(log(pop_fem)*cluster) + β11(pop_dens*cluster) + β12(cpi*cluster) + β13(income_pc*cluster) + β14(unemp_rate*cluster) + β15(log(gdp)*cluster) + + β16(country)1 + … + βk(country)1 + ε

In this extended model:

- The dependent variable, log(housing_prices), represents the natural logarithm of real residential property prices.
- The independent variables include:

  • log(pop_15_64): The natural logarithm of the population aged 15-64 years.

  • log(pop_fem): The natural logarithm of the female population.

• pop_dens: Population density.

• cpi: The Consumer Price Index.

• income_pc: Income per capita.

• unemp_rate: The unemployment rate.

• log(gdp): The natural logarithm of Gross Domestic Product (GDP).

- The country coefficients, β8 to βk, represent the fixed effects of each country.
- The regression coefficients, β1 to β15, are associated with each variable, including the main effects and interaction terms.
- The country coefficients, β8 to βk, represent the fixed effects of each country. These coefficients capture the impact of country-specific factors on housing prices that are not included in the other variables.
- The error term, represented as 'ε,' accounts for unexplained variation in independent variable.

The interaction terms, such as log(pop_15_64 * cluster), introduce the notion that the relationships between housing prices and the corresponding independent variables can differ across different clusters. These interaction terms allow for an assessment of cluster-specific variations in the effects of the independent variables on housing prices.

Linear hypotheses tests were conducted for each group of interaction terms cluster (cluster., cluster2, cluster3, cluster4) to assess the significance of these interactions and identify any specific variations.

The final step of the analysis entails conducting distinct regressions for each cluster. This step is crucial for gaining a deeper understanding of the intricate relationships between variables within individual economic stability groups. The model for cluster regressions is the same as the first regression:

log(housing_prices) = β1(log(pop_15_64)) + β2(log(pop_fem)) + β3(pop_dens) + β4(cpi) + β5(income_pc) + β6(unemp_rate) + β7(log(gdp)) + β8(country)1 + … + βk(country)1 + ε

The separate regressions enable identification of unique relationships between macroeconomic and demographic factors and housing prices within each cluster. These analyses unveil whether specific variables exert a more pronounced influence in particular groups. However, this approach does not facilitate accurate comparisons across clusters, as it treats each cluster as a separate unit. Hence, it doesn't account for interactions between them.

By employing this methodological approach, the study aims to provide insights into the relationships between macroeconomic and demographic factors and housing prices, considering both the aggregated European context and the distinctive characteristics of individual country clusters. This multifaceted analysis enables a comprehensive exploration of the factors driving housing price dynamics across European countries.

CHAPTER 4. DATA

Research undertaken here seeks to investigate the effect of demographic and macroeconomic factors on housing prices across Europe. It relies on two hypotheses for its research; first is that macroeconomic have some significant impact on residential property prices, while the second one states the same about demographic factors.

This study investigates 31 European countries using both economic and demographic indicators from 1992-21, collected via World Development Indicators's FRED database. The countries included in the study were selected to represent a wide range of economic statuses, so that it is going to be representable and more insights could be gained. However, the selection of countries was constrained by lack of data, as reliable data for all chosen indicators were not available for all European countries. Variables collected include:

- Total population ages 0-14: This variable represents all the people between the ages of zero and fourteen. This estimate includes all residents, regardless of citizenship or legal status.
- Total population between 15 and 64 years old: This variable represents total population between 15 and 64 years old.
- Total population aged 65 and over: This variable represents total population aged 65 and older, based on de facto population definition.
- Population, female: This variable represents the female population, irrespective of citizenship or legal status.
- Population, male: This variable represents all males, regardless of citizenship or legal status.
- Total population: This variable gives the total population according to the de facto definition. It includes all residents.
- Consumer price index (2010 =100): The consumer index reflects changes to the cost of acquiring goods and services by an average consumer. It is

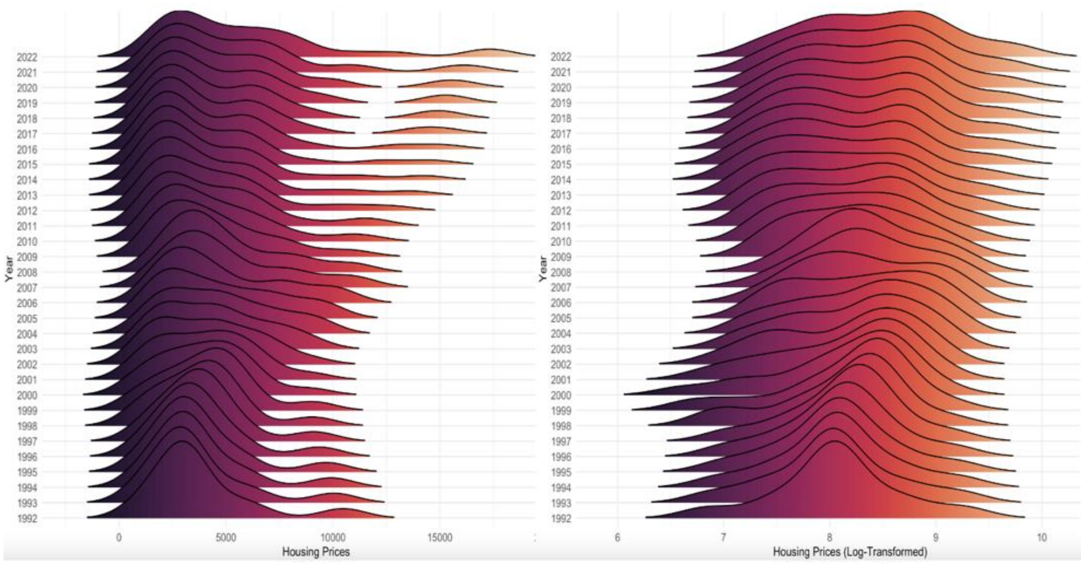
calculated by using the Laspeyres Formula and represents averages over a period of time.

- Adjusted net income per capita (constant US$ 2015): This variable represents adjusted net income, which is gross national income, minus consumption of capital fixed and depletion of natural resources. The values are in constant 2015 US dollar.
- Total Unemployment (% of total workforce) (modeled ILO estimate). This variable represents the total rate of unemployment as a percent of the total workforce.
- GDP (constant 2015 US$). This variable represents gross domestic product at the purchaser's price. It is the sum of the gross value added in the economy by all producers, minus product taxes and subsidies. The values are expressed as constant 2015 US dollar.
- GDP per capita (constant US$ 2015): This variable represents GDP per capita. It is calculated by dividing the GDP by the mid-year's population. It is a measure of the economic output per person, expressed in constant 2015 US dollar.
- Real interest rate (%): A real interest rate is the lending rate adjusted for inflation, as measured by the GDP-deflator. It is the effective interest rate after inflation.
- Population density (people/sq). This variable shows the population density by dividing mid-year population by land area in square kilometers. It gives an idea of the concentration of population in a certain area.
- Real Residential Property Prices (constant US$ 2015 per sq.m.): Coverage includes all types of new and existing dwellings in the whole country. The series is deflated using CPI.

The Federal Reserve Bank of St. Louis Economic Data Database and Global Property Guide were utilized to collect property prices across 31 European nations.

As a part of exploratory analysis, it might be useful to plot the chosen variables. The plot below shows the distribution of Real Residential Property Prices through the years. The right graph shows original housing prices, while left one shows them log-transformed.

Figure 3. Real Residential Property Prices Distribution through years (Original vs Log-Transformed)



Notably, the density ridge lines appear to be more consistent and less variable across the years compared to the first plot. The log-transformation has reduced the skewness in the data, making the distribution of housing prices more symmetrical. The log-transformation made data more constant across the years.

On Figure 4 the heat maps depict the change in income per capita and GDP among countries across years. While GDP seems to be almost constant through the years, income per capita is more volatile. All the countries have similar GDP, except for United Kingdom, Germany, and France. The income per capita seems to be higher in Switzerland, Norway, and Luxemburg.

Figure 4. Income per capita (USD) and GDP (USD) in the observed countries thought the years 1992-2021

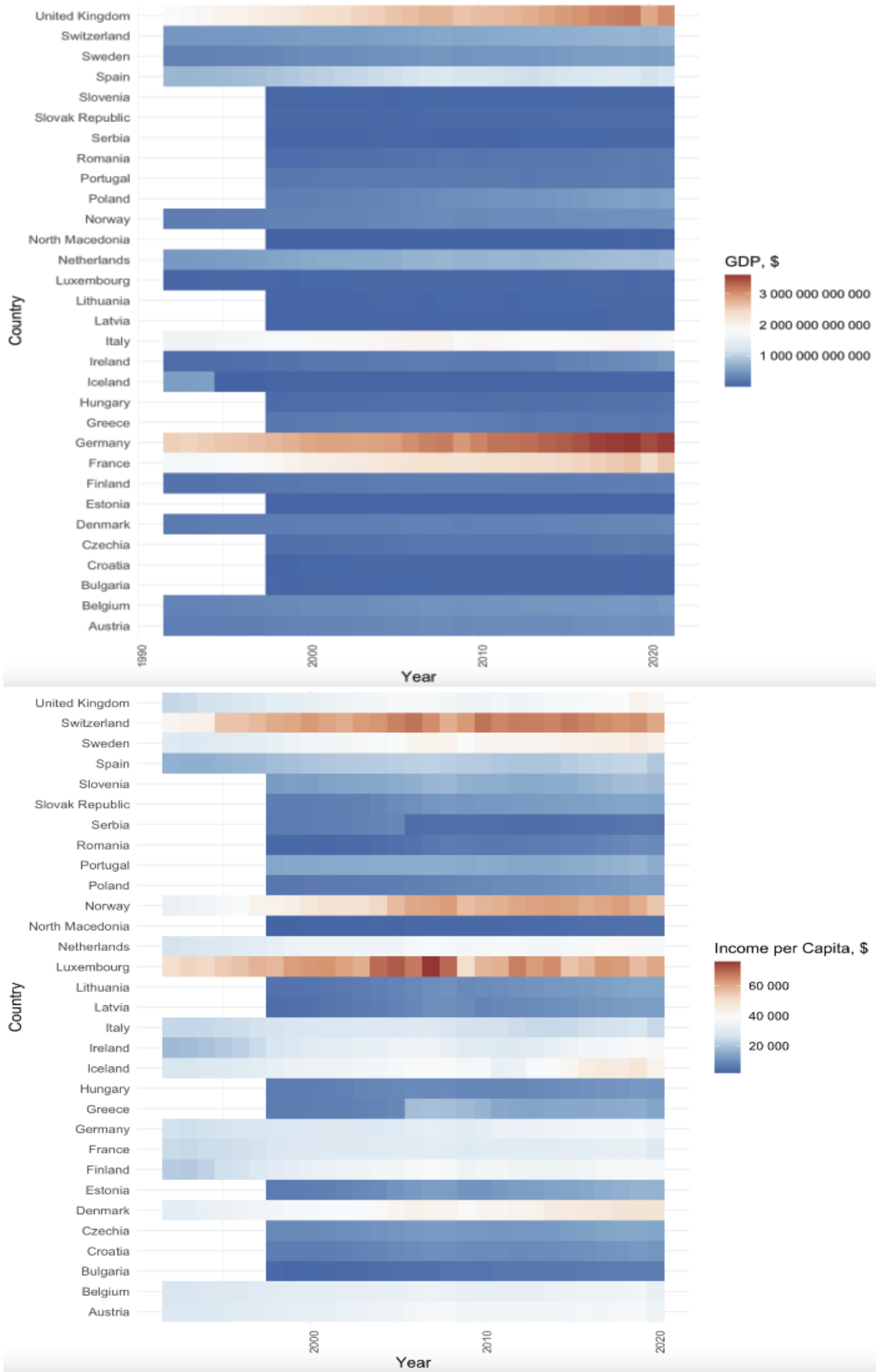
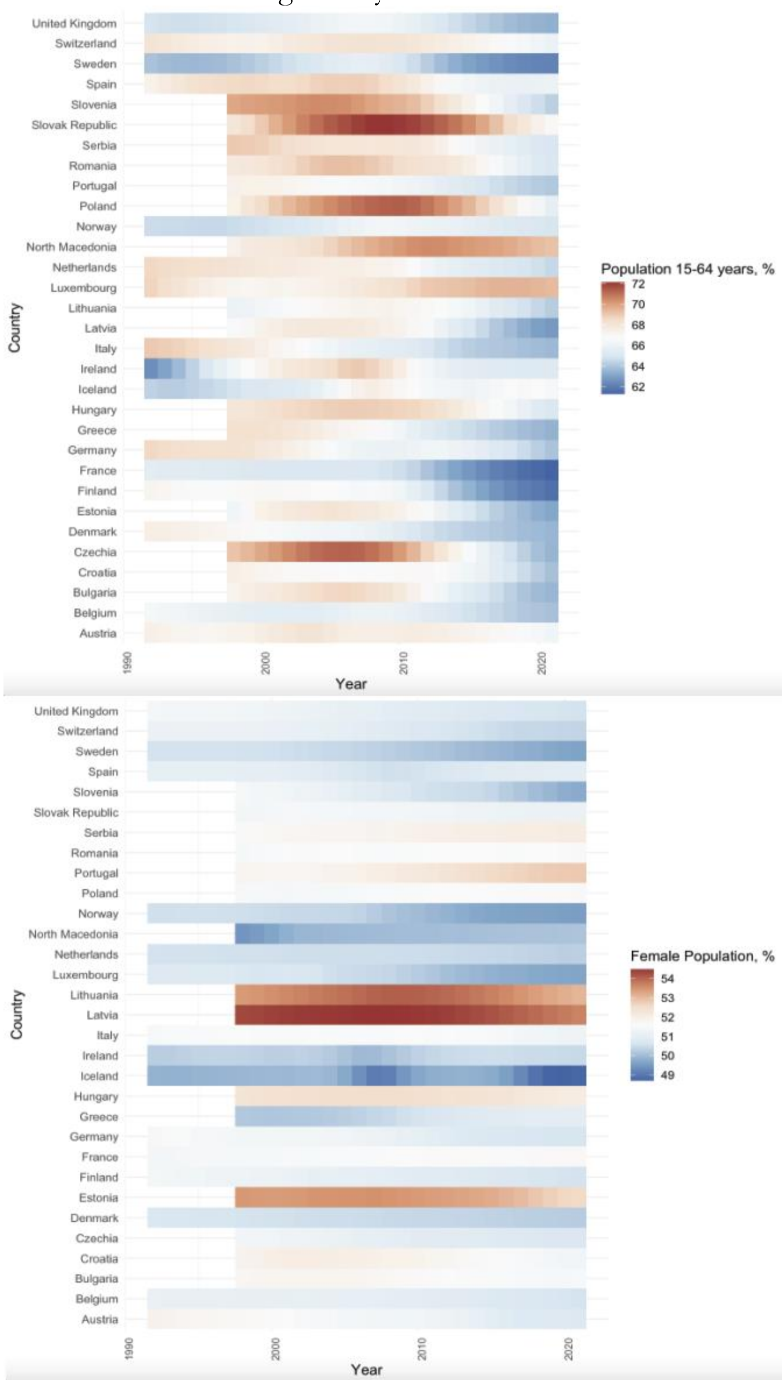


Figure 5. Female population and adult population in % in the observed countries thought the years 1992-2021



From the Figure 5, it can be seen that the peak in the percent of adult population (15-64 years) was between 2000 and 2010 with Slovak Republic, Czechia, and Poland having the highest proportion of those. From the next plot a conclusion can be drawn that Lithuania, Latvia, and Estonia are the countries with the highest proportion of female population. There are no drastic changes in female population in observed countries according to the graph.

Figure 6. Population density (people/sq.km) in the observed countries thought the years 1992-2021

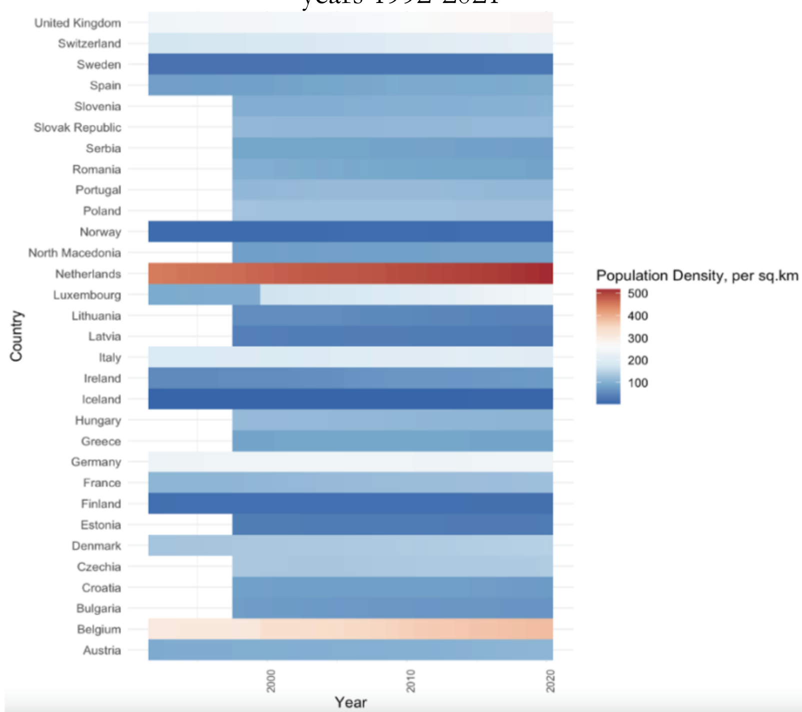
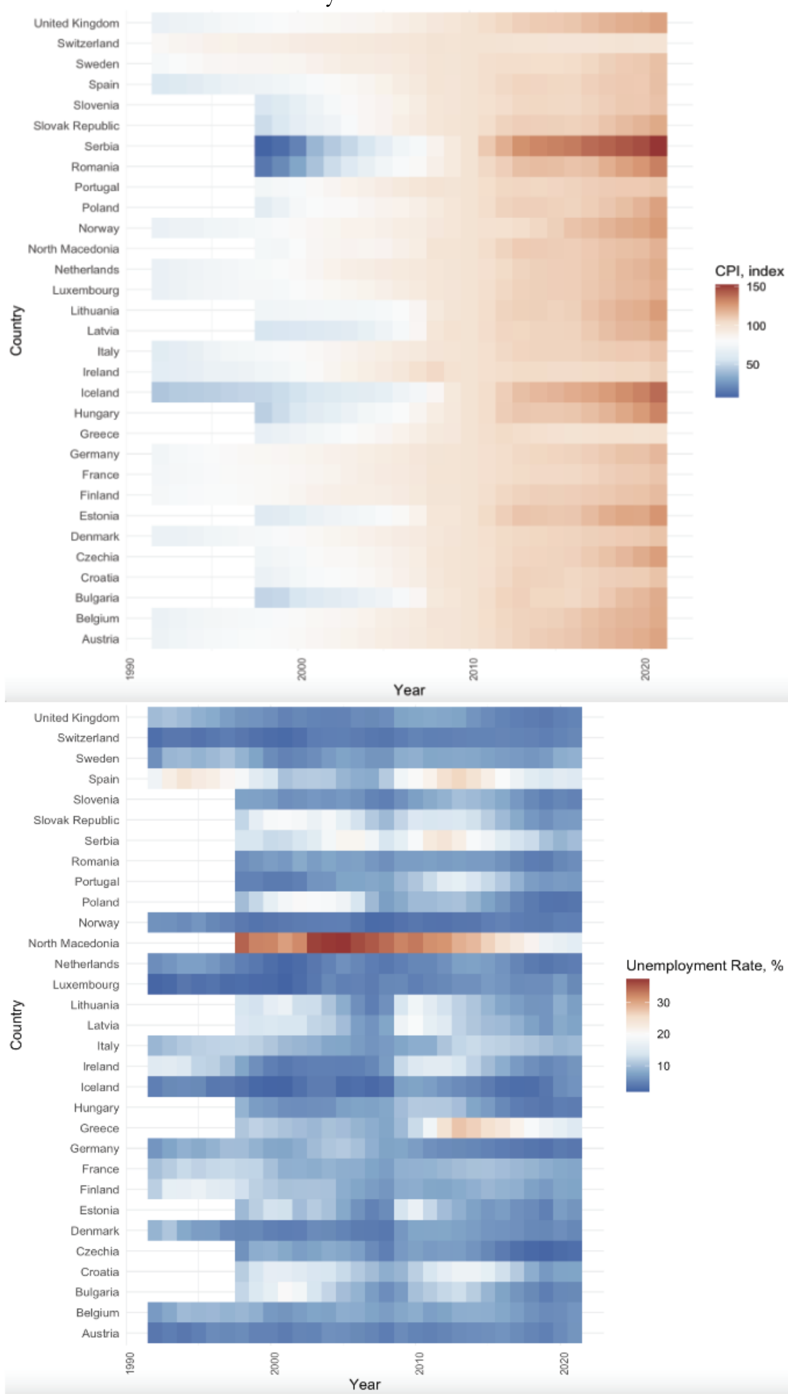


Figure 5 demonstrates the population density in the observed countries thought the years was stable with Netherlands having the highest population density, while Germany, Luxemburg, and Italy having the lowest.

From the Figure 6 it can be seen that the highest relative CPI growth detected in Serbia, Romania, Iceland, and Hungary. Unemployment rates are pretty high in North

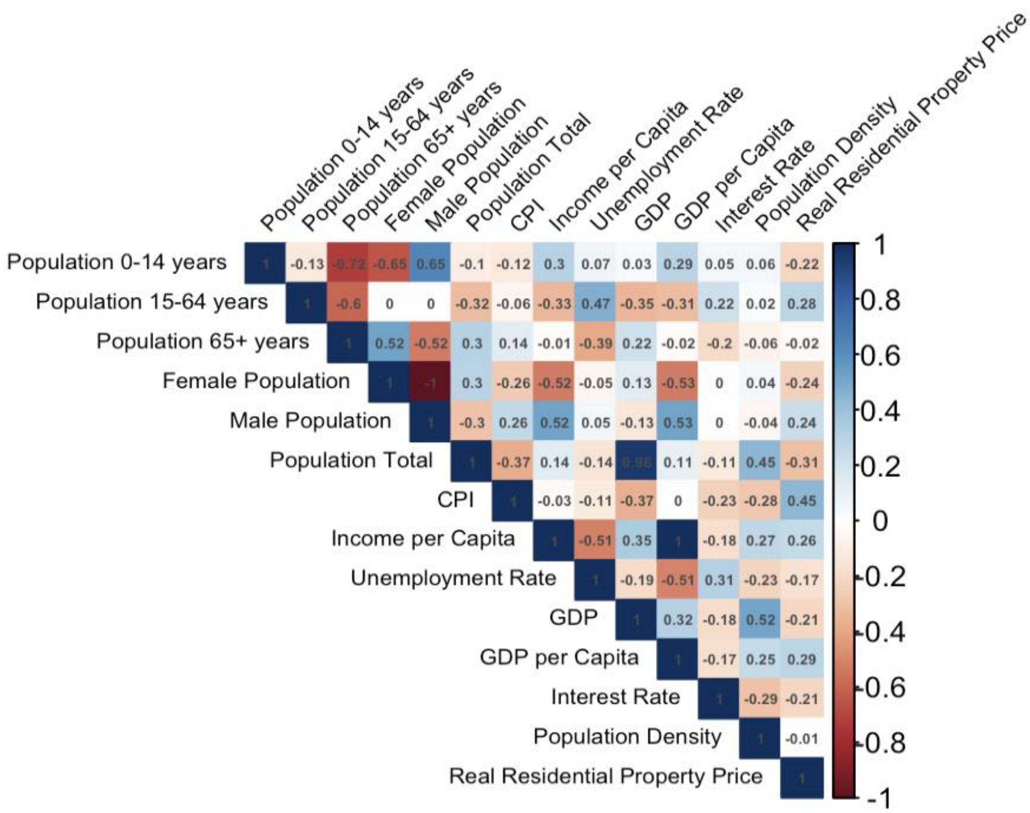
Macedonia, while other countries having relatively stable unemployment rates. However, Greece and Spain unemployment rate increasing in the last decade.

Figure 7. CPI (index) and unemployment rate (%) in the observed countries thought the years 1992-2021



As our correlation matrix shows us, there are strong correlations among independent variables within our dataset - something which should be taken into consideration when building new models to avoid multicollinearity. Population distribution variables show negative correlation and income per capita has strong relationships to GDP per capita - both factors being related highly with total population of countries and total housing price fluctuations of housing market in general. Housing Prices dependent variable shows strong relationships to population between 0-14 years old population as well as GDP per person income per person as well as GDP per capita per capita figures.

Figure 8. Correlation matrix



Clustering analysis using the K Means algorithm was carried out to better comprehend and capture each country's individual traits and features, such as population density, consumer price index (CPI), per capita income and unemployment rates. The clustering only grouped countries into clusters by taking means of the parameters previously listed. This way, there were created 4 clusters of same countries for different years.

Cluster 1 countries could be categorized as economically stable with moderate population density. They may have diverse economic activities and relatively lower living costs. Cluster 1 represents a group of countries with moderate population density, relatively low CPI, moderate income per capita, and a relatively low unemployment rate. These countries have a balanced economic and population profile.

Cluster 1, economically stable with moderate population density:

- Average population density: 145.55393 people per square kilometer
- Average Consumer Price Index (CPI) : 94.28697
- Average income per capita: $36,454.555
- Average unemployment rate: 6.225364%
- Countries: Austria, Denmark, Finland, Iceland, Netherlands, Sweden, United Kingdom

Cluster 2 countries could be characterized as economically challenged, with lower income levels, higher unemployment rates, and a lower cost of living compared to other clusters. Cluster 2 includes a larger number of countries with lower population density, lower CPI, lower income per capita, and a relatively high unemployment rate. These countries might face economic challenges and higher unemployment rates.

Cluster 2, economically challenged, with lower income levels, higher unemployment rates:

- Average population density: 86.95868 people per square kilometer
- Average Consumer Price Index (CPI) : 84.89102
- Average income per capita: $9,341.195

- Average unemployment rate: 11.363772%
- Countries: Bulgaria, Croatia, Czechia, Estonia, Greece, Hungary, Latvia, Lithuania, North Macedonia, Poland, Portugal, Romania, Serbia, Slovak Republic, Slovenia

Cluster 3 countries are characterized as economically well-off, with higher income levels, lower unemployment rates, and a relatively high cost of living.It represents a small group of countries with moderate population density, relatively high CPI, significantly higher income per capita, and a low unemployment rate. These countries are economically prosperous.

Cluster 3, economically well-off, with high income levels, low unemployment rates:

- Average population density: 135.94589 people per square kilometer
- Average Consumer Price Index (CPI) : 94.96945
- Average income per capita: $58,512.613
- Average unemployment rate: 4.118290%
- Countries: Luxembourg, Norway, Switzerland

Cluster 4 countries can be characterized as having moderate economic conditions, with a relatively larger population and slightly lower income levels compared to Cluster 3. Cluster 4 consists of countries with higher population density, slightly lower CPI, lower income per capita, and a moderate unemployment rate. These countries have a balanced economic profile with a larger population.

Cluster 4, moderate economic conditions, with a relatively larger population and slightly lower income levels compared to economically well-off countries:

- Average population density: 173.80269 people per square kilometer
- Average Consumer Price Index (CPI) : 93.90646
- Average income per capita: $28,057.387
- Average unemployment rate: 9.944570%
- Countries: Belgium, France, Germany, Ireland, Italy, Spain

Cluster means provide insight into the unique characteristics each cluster exhibits regarding population density (as measured by CPI), income per capita and unemployment rates. After being used to gather this information, these results are then utilized in further analyses that examine how macroeconomic and demographic influences impact housing prices within each of these clusters (by building models for them all).

The regression analysis is going to be used to examine how macroeconomic and demographic factors impact residential property prices across Europe. In order to check the robustness of the variables used in the regression analysis, an Augmented Dickey-Fuller test was conducted. The ADF test evaluates the stationarity of time series data and is commonly employed to determine the need for differencing or transformation.

The ADF test results are presented in the Table 1, with p-values for various lags:

Table 1.p-values for ADF tests on different variables

	Lag						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Population 0-14 years	0,09	0,09	0,09	0,09	0,09	0,09	0,08
Population 15-64 years	0,08	0,08	0,07	0,06	0,06	0,05	0,05
Population 65+ years	0,07	0,06	0,06	0,05	0,05	0,05	0,05
Female Population	0,09	0,08	0,08	0,07	0,07	0,06	0,06
Male Population	0,09	0,09	0,08	0,07	0,07	0,07	0,06
Population Total	0,09	0,08	0,08	0,07	0,07	0,06	0,06
CPI	0,01	0,01	0,01	0,01	0,01	0,01	0,01
Income per Capita	0,01	0,01	0,01	0,01	0,01	0,01	0,01
Unemployment Rate	0,01	0,01	0,01	0,01	0,01	0,01	0,01
GDP	0,48	0,38	0,36	0,35	0,36	0,35	0,33
GDP per Capita	0,01	0,01	0,01	0,01	0,01	0,01	0,01
Interest Rate	0,01	0,01	0,01	0,01	0,01	0,01	0,01
Population Density	0,04	0,03	0,03	0,02	0,02	0,02	0,02
Real Residential Property Price	0,01	0,01	0,01	0,01	0,01	0,01	0,01

It was observed that some of the original variables performed non-stationarity. To address this, the logarithm transformation was applied to those variables, to normalize their distribution and ensuring stationarity. The ADF tests were then repeated for these log-transformed variables, resulting in the following outcomes in Table 2.

Table 2. p-values for ADF tests on log-transformed variables

	Lag						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Log Population 0-14 years	0,03	0,03	0,03	0,03	0,02	0,02	0,02
Log Population 15-64 years	0,04	0,03	0,03	0,02	0,02	0,02	0,02
Log Population 65+ years	0,03	0,03	0,03	0,02	0,02	0,02	0,02
Log Female Population	0,04	0,03	0,03	0,03	0,02	0,02	0,02
Log Male Population	0,04	0,04	0,03	0,03	0,02	0,02	0,02
Log Population Total	0,04	0,03	0,03	0,03	0,02	0,02	0,02
Log GDP	0,04	0,03	0,03	0,03	0,03	0,02	0,02

CHAPTER 5. RESULTS

In this analysis, a panel data regression was conducted to examine the factors influencing real residential property prices across multiple European countries over time. This regression (Table 3) was intended to test hypotheses about macroeconomic and demographic factors having impact on residential property prices.

Table 3. Panel data model with fixed effect for all countries (hypotheses 1 and 2)

	Dependent variable: log(housing_prices)
log(pop_15_64)	3.575***
	(0.458)
log(pop_fem)	-3.078***
	(0.537)
pop_dens	0.009***
	(0.001)
cpi	0.003**
	(0.001)
income_pc	0.00003***
	(0.00000)
unemp_rate	-0.018***
	(0.003)
log(gdp)	0.184*
	(0.104)
Observations	639
R2	0.668
Adjusted R2	0.647
F Statistic	172.598*** (df = 7; 601)

The panel data regression model presented an R^2 value of 0.668, signifying that approximately 66.8% of the variance in housing prices can be accounted for by the included variables. This signifies a commendable level of explanatory capability within the model. Furthermore, the model demonstrated high statistical significance, as underscored by the substantial F-statistic of 172.598.

Among the variables considered, population aged in 15-64 years showed a strong and statistically significant positive association with housing prices, reflected by its coefficient of 3.575. This suggests that an increase in the working-age population positively impacts housing prices. Female population displayed a negative coefficient of -3.078, although its statistical significance was not established. Additionally, population density showed a small negative coefficient, indicating that higher population density is modestly correlated with lower housing prices.

The CPI demonstrated a notable positive relationship with housing prices, implying that inflation has a discernible influence on housing prices within the analyzed countries. Similarly, income per capita displayed a positive association, signifying that higher income levels are linked to higher housing prices. The unemployment exhibited a negative coefficient of -0.018, suggesting that lower unemployment rates correspond to higher housing prices. Notably, GDP displayed a positive association with a coefficient of 0.184, albeit with a lower level of statistical significance.

The model provides strong evidence in support of hypothesis of macroeconomic variables having impact on residential property prices. Specifically, the positive relationship between income per capita, CPI, and GDP with housing prices indicates that these macroeconomic factors have a substantial impact on housing prices. Higher income levels, increased inflation, and a robust GDP positively affect housing prices within the analyzed countries.

The model partially supports the hypothesis of demographic variables having impact on residential property prices. While adult population (15-64 years) displayed a strong and statistically significant positive association with housing prices, implying the impact of demographic factors on property prices, female population exhibited a negative relationship that was not statistically significant. Furthermore, population density displayed a small negative coefficient, suggesting a modest effect of population density on housing prices. Based on the results of the linear hypothesis tests, it is obvious that both demographic and macroeconomic factors have significant impact on housing prices.

However, the chi-square statistic, which measures the goodness of fit of the model, is higher for the macroeconomic variables compared to the demographic. This could indicate that the macroeconomic variables might have a stronger impact on housing prices compared to the demographic.

The third hypothesis stated that countries have varying impact on residential property prices based on their economical states (which were determined by dividing countries on clusters.

Table 4. Panel data model with fixed effect and interaction for all countries (hypotheses 3)

	Dependent variable: log(housing_prices)
log(pop_15_64)	5.462***
	(0.816)
log(pop_fem)	-1.081
	(1.260)
pop_dens	-0.003
	(0.002)
cpi	0.002
	(0.003)
income_pc	-0.00000
	(0.00001)
unemp_rate	-0.020**
	(0.008)
log(gdp)	1.218***
	(0.330)
log(pop_15_64):cluster2	-2.206**
	(1.056)
log(pop_15_64):cluster3	-3.310
	(3.068)
log(pop_15_64):cluster4	-1.808*
	(1.052)

log(pop_fem):cluster2	-0.235
	(1.662)
log(pop_fem):cluster3	4.554
	(3.403)
log(pop_fem):cluster4	4.309**
	(1.679)
pop_dens:cluster2	-0.023*
	(0.014)
pop_dens:cluster3	-0.013
	(0.009)
pop_dens:cluster4	0.017***
	(0.002)
cpi:cluster2	-0.009***
	(0.003)
cpi:cluster3	-0.011
	(0.011)
cpi:cluster4	-0.003
	(0.004)
income_pc:cluster2	0.0001***
	(0.00002)
income_pc:cluster3	0.00001
	(0.00001)
income_pc:cluster4	0.0001***
	(0.00002)
unemp_rate:cluster2	0.018*
	(0.009)
unemp_rate:cluster3	-0.024
	(0.029)
unemp_rate:cluster4	-0.023**
	(0.010)
log(gdp):cluster2	-0.434
	(0.402)
log(gdp):cluster3	-0.388
	(0.573)
log(gdp):cluster4	-4.213***
	(0.512)

Observations	639
R2	0.804
Adjusted R2	0.784
F Statistic	85.018*** (df = 28; 580)

The panel data regression model has produced notable results, revealing a substantial R^2 value of 0.804. This statistic indicates that approximately 80.4% of the variance in housing prices can be accounted for by the included variables, signifying a robust level of explanatory power. The F-statistic, which is 85.018, demonstrates high statistical significance, reinforcing the model's validity.

The model also investigates the variation in the effect of explanatory variables among clusters. Linear hypothesis tests were conducted to examine the hypotheses regarding these cluster-specific effects. The results of these tests reveal statistically significant variations in the effects of specific variables on housing prices among different clusters. This suggests that the impact of certain factors on housing prices may differ depending on the cluster to which a country belongs.

Table 5. Linear hypothesis tests p-values for each group of clusters' interaction terms

Cluster	**p-value**
Cluster 1	<2.2e-16***
Cluster 2	3.012e-13***
Cluster 3	0.0003947***
Cluster 4	<2.2e-16***

The analysis was also conducted on four distinct clusters identified in the dataset to explore the difference in effects on prices. The results of the regression analysis for each cluster are presented below:

Table 6. Linear regression results for the first cluster

Cluster 1	Dependent variable: log(housing_prices)

log(pop_15_64)	5.661***
	(0.707)
log(pop_fem)	8.633
	(5.869)
log(pop_dens)	-8.667*
	(5.190)
log(gdp)	1.292***
	(0.287)
cpi	-0.0002
	(0.002)
income_pc	-0.00001
	(0.00001)
unemp_rate	-0.025***
	(0.008)
Observations	174
R2	0.898
Adjusted R2	0.890
F Statistic	201.075*** (df = 7; 160)

In Cluster 1, the analysis displayed significant explanatory power, as indicated by an R^2 value of 0.898, signifying that 89.8% of the property price variation is accounted for by the included factors. The model's statistical significance was confirmed by the high F-statistic of 201.075.

Among the variables, adult population of 15-64 years emerged as a highly significant driver, with a coefficient of 5.661, reflecting a strong positive relationship with property prices. Female population displayed a substantial but statistically insignificant negative relationship. Population density exhibited a significant negative coefficient, suggesting that regions with higher population density tend to have lower property prices. Furthermore, GDP displayed a highly significant and positive association, indicating that GDP is linked to higher property prices within Cluster 1. The CPI and unemployment rate both showed significant negative coefficients, indicating that lower inflation rates and reduced unemployment rates correspond to higher property prices in this cluster.

Table 7. Linear regression results for the second cluster

Cluster 2	Dependent variable: log(housing_prices)
log(pop_15_64)	3.254***
	(0.717)
log(pop_fem)	5.259**
	(2.382)
log(pop_dens)	-7.915***
	(2.209)
log(gdp)	0.745***
	(0.244)
cpi	-0.007***
	(0.002)
income_pc	0.0001***
	(0.00002)
unemp_rate	-0.002
	(0.004)
Observations	222
R2	0.560
Adjusted R2	0.513
F Statistic	36.308*** (df = 7; 200)

In Cluster 2, the analysis uncovered a respectable level of explanatory power, characterized by an R^2 value of 0.560, which suggests that 56% of the variation in property prices can be attributed to the included variables. The model's statistical significance is reinforced by the substantial F-statistic of 36.308.

Within this cluster, certain variables exhibited significance. Population of 15-64 years and female population both displayed significance with positive coefficients, indicating a positive relationship with property prices. Population density showed a significant negative coefficient, implying that areas with higher population density tend to have lower property prices. GDP demonstrated a highly significant and positive association, suggesting that an increase in GDP positively influences property prices within Cluster 2. The CPI and income per capita also proved to be highly significant factors. A negative coefficient for CPI suggests that lower inflation rates are linked to higher property prices, while a positive coefficient for income_pc implies that higher income levels correspond to elevated property prices within this cluster. Notably, the unemployment rate did not reach statistical significance in this context, suggesting that it may not be a strong determinant of property prices within Cluster 2.

Table 8. Linear regression results for the third cluster

Cluster 3	Dependent variable: log(housing_prices)
log(pop_15_64)	0.033
	(1.348)
log(pop_fem)	-7.557
	(6.873)
log(pop_dens)	8.758
	(5.901)
log(gdp)	0.635***
	(0.229)
cpi	0.006**
	(0.002)
income_pc	0.00001**
	(0.00000)
unemp_rate	-0.054***
	(0.014)
Observations	69
R2	0.963
Adjusted R2	0.958
F Statistic	221.461*** (df = 7; 59)

In Cluster 3, the model revealed a high level of explanatory power, underscored by an impressive R^2 value of 0.963, indicating that 96.3% of the variation in property prices is effectively explained by the considered variables. The model's statistical significance is firmly established by a substantial F-statistic of 221.461.

Exploring the variables within this cluster, it was observed that population of 15-64 years did not exhibit statistical significance, implying a limited impact on property prices. Female population showed a strong but statistically insignificant negative relationship, suggesting that higher female populations may have a negative influence on property prices. In contrast, population density displayed a significant positive coefficient, indicating that areas with higher population density tend to have higher property prices within this cluster.

The GDP exhibited a highly significant and positive association, implying that GDP positively influences property prices. Both the CPI and income per capita displayed significance within this context. A positive coefficient for CPI suggests that higher inflation rates are associated with higher property prices, while a positive coefficient for income_pc implies that higher income levels correspond to elevated property prices in Cluster 3. Additionally, the unemployment rate was highly significant, with a negative coefficient indicating that lower unemployment rates are associated with higher property prices within this cluster.

Table 9. Linear regression results for the forth cluster

Cluster 4	Dependent variable: log(housing_prices)
log(pop_15_64)	3.286***
	(0.858)
log(pop_fem)	-1.829
	(1.475)
log(pop_dens)	6.675***
	(0.935)
log(gdp)	-3.003***
	(0.501)
cpi	0.002
	(0.002)
income_pc	0.0001***
	(0.00002)
unemp_rate	-0.047***

	(0.006)
Observations	174
R2	0.706
Adjusted R2	0.684
F Statistic	55.143*** (df = 7; 161)

The model for cluster 4 displayed a noteworthy level of explanatory power, boasting an R^2 value of 0.706, indicating that approximately 70.6% of the property price variation is attributed to the considered variables. The model's statistical significance was corroborated by a substantial F-statistic of 55.143.

Among the variables, population of 15-64 years emerged as a highly significant factor, with a coefficient of 3.286, indicating a strong positive relationship with property prices within this cluster. Female population revealed a significant but statistically insignificant negative relationship, hinting at the potential negative influence of higher female populations on property prices. Population Density displayed a highly significant positive coefficient, signifying that areas with greater population density tend to exhibit higher property prices in Cluster 4. However, GDP took an interesting turn, featuring a highly significant but negative association. The CPI and income per capita both played notable roles, demonstrating significance. The unemployment rate also emerged as highly significant, featuring a negative coefficient.

CHAPTER 6. CONCLUSIONS AND RECOMMENDATIONS

A detailed examination of the relationship between macroeconomic and demographic factors and their influence on residential property prices across European countries was conducted. Through a panel data regression analysis, a few hypotheses about the impact of these factors on residential property prices were tested.

The analysis revealed a strong and significant connection between housing prices and several key variables. There was a positive relationship between housing prices and macroeconomic factors. These findings indicate that higher income levels, increased inflation, and a strong GDP positively influence housing prices in the analyzed countries. Furthermore, there was found negative relationship between housing prices and the unemployment rate. This proves the hypothesis that macroeconomic variables have a significant impact on residential property prices.

Regarding demographic factors, the research provided mixed results. While higher adult population presence exhibited a strong and statistically significant positive association with housing prices, signifying the influence of demographic factors, the proportion of female population showed a negative relationship that was not statistically significant. Additionally, population density displayed a small negative coefficient, indicating only a modest effect on housing prices. These findings partially support the hypothesis of demographic variables impacting residential property prices, highlighting the importance of considering regional variations and demographic structures.

Moreover, the third hypothesis, which posited varying impacts on residential property prices based on the economic states of countries, was tested. The results confirmed variations in the effects of macroeconomic and demographic factors on housing prices among different clusters.

These findings can be valuable for businesses and policymakers. Based on the results, the following recommendations are provided:

- For Real Estate Developers: Developers should consider macroeconomic conditions and demographic characteristics when making investment decisions.

Regions with higher income levels and strong economic growth (as reflected in GDP) might be have more perspectives and are likely to provide better opportunities for property development. Additionally, being aware of variations between different countries can help them tailor their strategies to different market segments.

- For Investors: Investors in the real estate market should monitor macroeconomic indicators closely. High inflation and low unemployment rates usually correlate with higher property prices. This knowledge can be helpful to investors in the process of making decisions regarding the timing and location of their investments.
- For Policymakers: Policymakers should take these findings into account during policy development. Ensuring a stable economic environment with low unemployment and controlled inflation can contribute to a more predictable and prosperous real estate market.

While this research has provided valuable insights into the factors affecting residential property prices in Europe, several avenues for future work in this area are worth exploring:

- Regional Specificity: Future studies could delve deeper into regional-specific analyses, considering the unique characteristics and dynamics of individual countries or cities.
- Dynamic Analysis: Conducting a dynamic analysis to explore how these relationships change over time, especially in response to economic shocks or demographic shifts, would enhance our understanding of the long-term trends in residential property markets.
- Comparative Studies: Comparative studies that explore differences in housing market behavior across continents or between developed and developing regions could offer insights into how these relationships evolve in varying economic and demographic contexts.

- Policy Evaluation: Evaluating the effectiveness of different housing and economic policies in managing property price fluctuations and their impact on socio-economic factors would be beneficial for policymakers and researchers.

In conclusion, this study has contributed to understanding of the effect of macroeconomic and demographic factors on residential property prices in Europe. The ability to understand the relationship between these factors and housing prices might be a powerful instrument, as it might promote stability and sustainable growth in the European real estate market.

REFERENCES

1. Adams, Zeno & Füss, Roland. (2010). Macroeconomic Determinants of International Housing Markets. *Journal of Housing Economics*. 19. 38-50. 10.1016/j.jhe.2009.10.005.
2. Égert, Balázs & Mihaljek, Dubravko. (2007). Determinants of House Price Dynamics in Central and Eastern Europe. *Focus on European Economic Integration*. 1. 52-76.
3. Gallin, Joshua, The Long-Run Relationship between House Prices and Rents (September 2004). Available at SSRN: https://ssrn.com/abstract=633082 or http://dx.doi.org/10.2139/ssrn.633082
4. Girouard, Nathalie & Kennedy, Mike & van den Noord, Paul & André, Christophe. (2006). Recent House Price Developments: The Role of Fundamentals. *OECD Economic Outlook*. 78. 10.1787/864035447847.
5. Mei-Se Chien, Chien-Chiang Lee, & Sin-Jie Cai. (2014). A Panel Cointegration Analysis for Macroeconomic Determinants of International Housing Market. https://doi.org/10.5281/zenodo.1093548.
6. Petra Posedel & Maruska Vizek, 2009. "House price determinants in transition and EU-15 countries", *Post-Communist Economies, Taylor & Francis Journals, vol. 21(3*), pages 327-343.
7. Stepanyan, Vahram and Poghosyan, Tigran and Bibolov, Aidyn, House Price Determinants in Selected Countries of the Former Soviet Union (April 2010). *IMF Working Paper No. 10/104*, Available at SSRN: https://ssrn.com/abstract=1594549.
8. U.S. Bureau of Economic Analysis, retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/GDP, October 3, 2023.

9. World Development Indicators, The World Bank Group, 2023, https://databank.worldbank.org/source/world-development-indicators.
10. Piazzesi, M. and Schneider, M., "Housing and Macroeconomics", *Handbook of Macroeconomics*, Vol. 2B, 2016.
11. Vyacheslav Mikhed & Petr Zemcik, 2007. "Do House Prices Reflect Fundamentals? Aggregate and Panel Data Evidence," CERGE-EI Working Papers wp337, The Center for Economic Research and Graduate Education - Economics Institute, Prague.
12. Goodhart, Charles & Hofmann, Boris. (2008). House Prices, Money, Credit, and the Macroeconomy. Oxford Review of Economic Policy. 24. 180-205. 10.1093/oxrep/grn009
13. Bhattacharya, R., & Kim, S. W. (2011). Economic fundamentals, Subprime lending and housing prices: Evidence from MSA-level panel data. *Housing Studies*, *26*(6), 897-910. https://doi.org/10.1080/02673037.2011.593126
14. Piazzesi, M. and Schneider, M., "Housing and Macroeconomics", *Handbook of Macroeconomics*, Vol. 2B, 2016.
15. Battistini, N., Le Roux, J., Roma, M., & Vourdas, J. (2018). The state of the housing market in the euro area. ECB Economic Bulletin, Issue 7/2018.
16. Gevorgyan, K. (2019). Do demographic changes affect house prices? *Journal of Demographic Economics, 85*(4), 305-320. doi:10.1017/dem.2019.9
17. Pinto, I. (2023). The cost crisis: A gendered analysis. UK Women's Budget Group
18. Source: OECD. Housing Prices. Retrieved from [https://www.oecd.org/els/family/HM1-2-Housing-prices.pdf]. CoreLogic. (2023). Home Price Insights: October 2023. Retrieved from [https://www.corelogic.com/intelligence/us-home-price-insights-october-2023/]. Gevorgyan, K. (2019). Do demographic changes affect house prices? *Journal of Demographic Economics, 85*(4), 305-320. doi:10.1017/dem.2019.9

19. OECD (2018), *Rethinking Urban Sprawl: Moving Towards Sustainable Cities*, OECD Publishing, Paris, https://doi.org/10.1787/9789264189881-en.
20. Source: Battistini, N., Le Roux, J., Roma, M., & Vourdas, J. (2018). The state of the housing market in the euro area. ECB Economic Bulletin, Issue 7/2018.

APPENDIX A

MODELS' ROBUSTNESS TESTS

Table 1.A. Test for individual effects, Hausman test, Studentized Breusch-Pagan test for the regression on Table 3

Test	p-value	H0
F test for individual effects	< 2.2e-16	There are no individual effects
Hausman test	< 2.2e-16	The preferred model is random effects
Studentized Breusch-Pagan test	0.087653	Homoskedasticity, or constant variance of the errors

Table 2.A. Test for individual effects, Hausman test, Studentized Breusch-Pagan test for the regression on Table 4

Test	p-value	H0
F test for individual effects	< 2.2e-16	There are no individual effects
Hausman test	< 2.2e-16	The preferred model is random effects
Studentized Breusch-Pagan test	0.056392	Homoskedasticity, or constant variance of the errors

Table 3.A. Test for individual effects, Studentized Breusch-Pagan test for the clusters' individual regressions (Table 5-9)

Cluster 1		
Test	p-value	H0
F test for individual effects	< 2.2e-16	There are no individual effects
Studentized Breusch-Pagan test	5.326e-02	Homoskedasticity, or constant variance of the errors

Cluster 2		
Test	p-value	H0
F test for individual effects	< 2.2e-16	There are no individual effects
Studentized Breusch-Pagan test	2.185e-04	Homoskedasticity, or constant variance of the errors

Cluster 3		
Test	p-value	H0
F test for individual effects	< 2.2e-16	There are no individual effects
Studentized Breusch-Pagan test	0.055463	Homoskedasticity, or constant variance of the errors

Cluster 4		
Test	p-value	H0
F test for individual effects	< 2.2e-16	There are no individual effects
Studentized Breusch-Pagan test	0.051018	Homoskedasticity, or constant variance of the errors

APPENDIX B

MODELS’ LINEAR HYPOTHESIS TESTS

Table 1.B. Linear Test Hypothesis for Demographic factors (Table 3)

<table>
<tr><td colspan="4">Hypothesis:
log(pop_15_64) = 0
log(pop_fem) = 0
pop_dens = 0</td></tr>
<tr><td colspan="4">Model 1: restricted model
Model 2: log(housing_prices) ~ log(pop_15_64) + log(pop_fem) + pop_dens + cpi + income_pc + unemp_rate + log(gdp)</td></tr>
<tr><td>Res.Df</td><td>Df</td><td>Chisq</td><td>Pr(>Chisq)</td></tr>
<tr><td>604</td><td></td><td></td><td></td></tr>
<tr><td>601</td><td>3</td><td>194.06</td><td><2.2e-16***</td></tr>
</table>

Table 2.B. Linear Test Hypothesis for Macroeconomic factors (Table 3)

<table>
<tr><td colspan="4">Hypothesis:
cpi = 0
income_pc = 0
unemp_rate = 0
log(gdp) = 0</td></tr>
<tr><td colspan="4">Model 1: restricted model
Model 2: log(housing_prices) ~ log(pop_15_64) + log(pop_fem) + pop_dens + cpi + income_pc + unemp_rate + log(gdp)</td></tr>
<tr><td>Res.Df</td><td>Df</td><td>Chisq</td><td>Pr(>Chisq)</td></tr>
<tr><td>605</td><td></td><td></td><td></td></tr>
<tr><td>601</td><td>4</td><td>547.74</td><td><2.2e-16***</td></tr>
</table>

Table 3.B. Linear Hypothesis Test For Cluster 1 (Table 4)

<table>
<tr><td>Hypothesis:
log(pop_15_64) = 0
log(pop_fem) = 0</td></tr>
</table>

pop_dens = 0 cpi = 0 income_pc = 0 unemp_rate = 0 log(gdp) = 0			
Model 1: restricted model Model 2: log(housing_prices) ~ log(pop_15_64) + log(pop_fem) + pop_dens + cpi + income_pc + unemp_rate + log(gdp) + log(pop_15_64) * cluster + log(pop_fem) * cluster + pop_dens * cluster + cpi * cluster + income_pc * cluster + unemp_rate * cluster + log(gdp) * cluster			
Res.Df	Df	Chisq	Pr(>Chisq)
587			
580	7	1027.1	<2.2e-16***

Table 4.B. Linear Hypothesis Test For Cluster 2 (Table 4)

Hypothesis: log(pop_15_64):cluster2 = 0 log(pop_fem):cluster2 = 0 pop_dens:cluster2 = 0 cpi:cluster2 = 0 income_pc:cluster2 = 0 unemp_rate:cluster2 = 0 log(gdp):cluster2 = 0			
Model 1: restricted model Model 2: log(housing_prices) ~ log(pop_15_64) + log(pop_fem) + pop_dens + cpi + income_pc + unemp_rate + log(gdp) + log(pop_15_64) * cluster + log(pop_fem) * cluster + pop_dens * cluster + cpi * cluster + income_pc * cluster + unemp_rate * cluster + log(gdp) * cluster			
Res.Df	Df	Chisq	Pr(>Chisq)
587			
580	7	73.412	3.012e-13***

Table 4.B. Linear Hypothesis Test For Cluster 3 (Table 4)

Hypothesis:
log(pop_15_64):cluster3 = 0
log(pop_fem):cluster3 = 0
pop_dens:cluster3 = 0
cpi:cluster3 = 0
income_pc:cluster3 = 0
unemp_rate:cluster3 = 0
log(gdp):cluster3 = 0

Model 1: restricted model
Model 2: log(housing_prices) ~ log(pop_15_64) + log(pop_fem) + pop_dens + cpi + income_pc + unemp_rate + log(gdp) + log(pop_15_64) * cluster + log(pop_fem) * cluster + pop_dens * cluster + cpi * cluster + income_pc * cluster + unemp_rate * cluster + log(gdp) * cluster

Res.Df	Df	Chisq	Pr(>Chisq)
587			
580	7	26.591	0.0003947***

Table 5.B. Linear Hypothesis Test For Cluster 4 (Table 4)

Hypothesis:
log(pop_15_64):cluster4 = 0
log(pop_fem):cluster4 = 0
pop_dens:cluster4 = 0
cpi:cluster4 = 0
income_pc:cluster4 = 0
unemp_rate:cluster4 = 0
log(gdp):cluster4 = 0

Model 1: restricted model
Model 2: log(housing_prices) ~ log(pop_15_64) + log(pop_fem) + pop_dens + cpi + income_pc + unemp_rate + log(gdp) + log(pop_15_64) * cluster + log(pop_fem) * cluster + pop_dens * cluster + cpi * cluster + income_pc * cluster + unemp_rate * cluster + log(gdp) * cluster

Res.Df	Df	Chisq	Pr(>Chisq)
587			
580	7	193.63	<2.2e-16***