Bachelor's Thesis

Fundamental Drivers of Real Estate.

Which Factors Influence House Prices in Europe, North America and Asia-Pacific Region

Bachelor of Science in International Management

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Management Summary

House price developments represent a common field of study fostered by the high interest of financial institutions, scientific research analysts and policymakers since the substantial rise in residential property prices in recent decades. Therefore, there is a need to analyze fundamental factors that affect housing prices in advanced economies, assuming that not only one indicator is responsible for significant long-term developments.

This bachelor thesis investigated influential factors that are predominantly associated with property price dynamic movements on a long-term scale. The first section of this thesis concentrated on influential variables based on scientific publications. Further, a conceptual radial cluster model out of endogenous reasons (within a property sector) and exogenous reasons (macroeconomic fluctuations) presented an overview and was delivered through the literature findings.

In the second part of this thesis, an empirical analysis focusing on ten advanced economies from 1980 – 2017 investigated a small set of explanatory determinants. The purpose of this quantitative analysis was to evaluate through longitudinal data to what extend the chosen set of factors influences house price indices, to which degree correlations between variables exist and what the cross-country discrepancies are. A panel analysis was reasonably applied to monitor housing prices in specific countries over the defined time period. Furthermore, a correlation matrix was used to assess the strength of linear relationships in-between the five explanatory variables to residential property price indices in different environmental settings, thus, to be able to explore cross-national discrepancies. The five explanatory variables are annual long-term interest rate percentage, annual growth percentage of adjusted net national income per capita, GDP per capita, annual growth percentage of population and the unemployment rate.

Through the application of both methodologies, the literature review and the empirical analysis, a clearer understanding of the forces driving the real estate market has been established. The outcome of the literature research indicates that numerous factors are influencing the real estate sector over time. Fundamental drivers were found to be mostly of endogenous reasons due to the heterogenic characteristics of the real estate sector. Results of the second part of this thesis, the carried-out empirical analysis, reveal with

380 observations that there are statistically significant correlations between residential property price indices and the selected independent variables.

Overall, the study indicates that GDP per capita, interest rates and unemployment rates are strongly associated with house price developments among various environmental settings in the long run. Furthermore, the results showed significant demographic differences in housing price developments as well as in the interplay between explanatory variables. Hence, it is crucial to closely monitor both endogenous and exogenous long-term driving factors carefully when studying property price dynamics.

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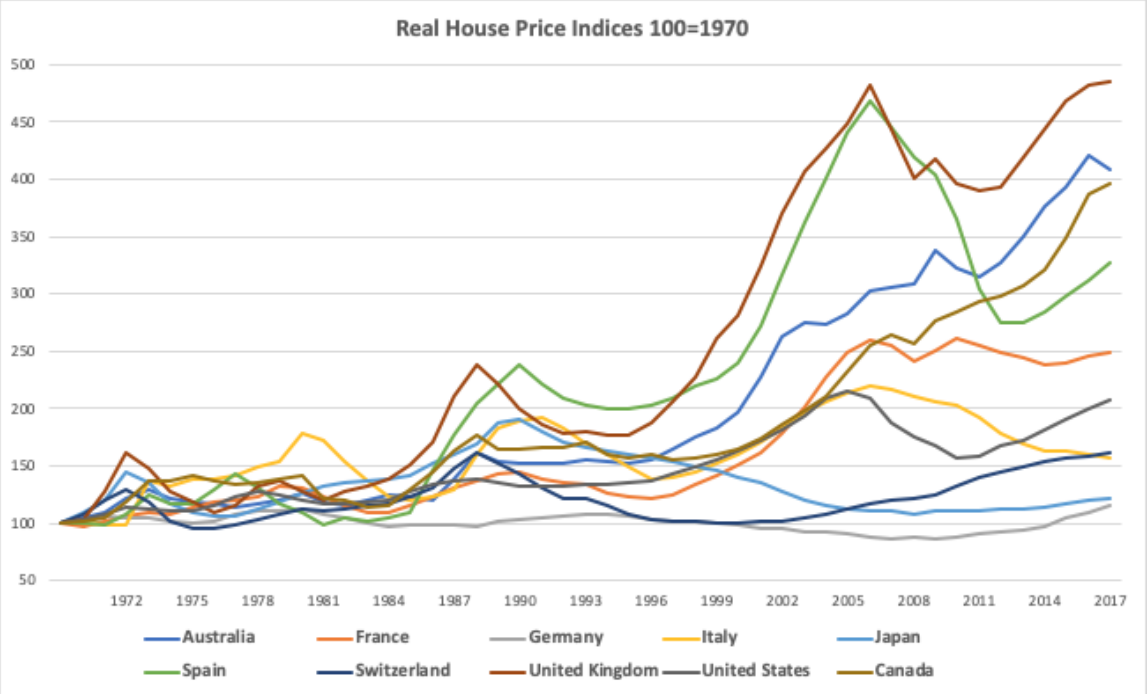
List of Abbreviations

BIS	Bank for International Settlements
FE	Fixed Effects
GDP	Gross Domestic Product
IMF	International Monetary Fund
MaP	Macroprudential
MLR	Multiple Linear Regression
OECD	Organization for Economic Co-operation and Development
RPP	Residential Property Prices
RPPI	Residential Property Prices Indices
VAR	Vector Autoregressive Model

1 Introduction

Real estate plays a crucial role in the life of a human being. Having a shelter is a basic human demand for survival and one of the physiological needs. According to the hierarchy of Maslow's pyramid, it is at the very bottom and thus of utmost importance (Vogt, 2018, p. 17). Similarly, institutions are dependent on shelter: They need infrastructure as it serves as the fundament for their business operations. Furthermore, shelter in the form of real estate serves as a global, long-term investment choice. Financial institutions such as pension funds and insurance companies invest large parts of their portfolios in real estate assets outside their domestic markets. According to Baum (2009, p. 323) and Case, Goetzmann and Rouwenhorst (2000, p. 2), global real estate investments represent an excellent opportunity for both portfolio diversification and revenue growth. The real estate sector is a critical driver in macroeconomic activities, wealth and financial stability. What factors influence housing prices is therefore a common topic in financial literature and scientific publications.

Figure 1: Real House Price Indices



Source: adapted from OECD (2019)

Over the last 47 years (1970-2017), a diverse interplay between highs and lows in housing prices has taken place in developed economies. These patterns can be explained by "regular cyclical fluctuations in output, employment and incomes" (Jowsey, 2011, p.

113), which move real estate markets. Nevertheless, experience indicates that housing prices can shift away from their long-term equilibrium due to various micro- and macroeconomic factors (Geng, 2018). As Figure 1 illustrates, this phenomenon is widespread as real house price indices indeed record a general state of growth from 1970 until 2017 in almost all advanced economies. An on average increase by 69.3% is observed. Furthermore, it is clear, evaluating the respective countries in Figure 1, that prices develop and shift much faster in certain nations than in others.

1.1 Problem Statement

What exactly drives housing prices, does a co-movement in various cultural settings exist and what are cross-country discrepancies? These are topics in need of profound understanding and elaboration of knowledge about vital influencing factors over a long-term period.

Undoubtedly, there is no single indicator explaining every reason for property price developments. Subsequently, a diverse and complex set of factors cause house price fluctuations in advanced economies. Also, these determinants exercise varying effects on different markets. Assumptions could be that various economic landscapes, political agendas and cultural diversification influence the real estate sector. According to Baum (2009), the rapid internationalization of organizations has transformed the entire marketplace of global property investments. Indirect money transfer in long-term overseas asset portfolios of various financial institutions has accelerated since 1980 due to the general globalization evolution of the economy (Jowsey, 2011). The impact of this globalization process has increased the co-movement between the international business markets and as a result, also reduced the diversification benefits of international real estate investments (Baum, 2009, p. 343). On the other hand, the worldwide so-called "glocalization" trend i.e., long-term investments from foreign investors contribute to smoother and less real estate cycles as this institutions tend not to overbid the price for a property at a peak, nor to rush sale in a slump (Pittini, Dijol, Turnbull & Whelan, 2019, p. 21). Through the diverse responsiveness in real estate markets around the globe and the broad usage of properties; as an investment, business operation ground or for residential property purposes, an "international harmonization" is required to expand further the understanding of house price changes in advanced economies and explain different conceptual fundaments (Eurostat, 2013, p. 12).

The variety of information and diverse scientific publications do not provide a simple model for property price pattern evaluation, yet they act as a toolbox for further observations. In favor of a closed analysis, this thesis avoids an empirical evaluation of all potential macroeconomic and other factors, therefore examines exclusively five significant measurement indicators resulting from the extensive literature review. The primary purpose is to provide a structured overview of core residential property price influences and illustrate the diverse effect of key drivers on various market environments in advanced economies. This thesis serves as a fundament to assist in closing knowledge gaps about this topic. Furthermore, the empirical analysis illustrates cross-country discrepancy developments due to varying reactions to the stated determinants.

1.2 Research Questions

This thesis analyzes the core influencing factors of residential property prices. Firstly, it provides a general overview of determinants that influence housing prices in advanced economies. Drivers are structured according to the basis of their origin of influence, as it is assumed that the development of property prices is influenced by macro- and microeconomic factors and is therefore also driven by supply and demand. Secondly, through a cross-country empirical analysis over time, the impact of a small set of five house price influencing determinants is carried out, assuming that multiple factors are responsible for significant long-term changes. Accordingly, two specific research questions are addressed throughout this bachelor thesis:

- Which factors influence residential property prices?
- Which cross-country discrepancies exist?

As already stated, this thesis consists out of two parts: It elaborates through relevant scientific literature various areas of influencing factors. To present a clear thesis structure, the grouping of determinants is by their origin, namely endogenous and exogenous factors. While endogenous explanations encounter real estate drivers within one specific housing market, exogenous factors explain macroeconomic indications *(see 3.1 Radial Cluster Model).* In the second part, empirical evidence investigates the factors in an empirical analysis to shed light on the statistical significance of the chosen variables and to illuminate cross-country discrepancy factors. The empirical framework consists of descriptive statistics, a multiple linear regression (MLR), a panel regression with fixed effects (FE) model and an illustration of relationship between chosen variables through a

correlation matrix. The implementation of a panel approach is most important, as the time factor is taken into account when assessing the relationships of the explanatory variables, which gives more precise results than the MLR method. The empirical analysis will consist out of five explanatory variables namely; interest rate, GDP per capita, income per capita, population growth and unemployment rate for ten advanced economies among Europe, North America and Asia Pacific Region during a long-term period of 38 years 1980: Q1 – 2017: Q4.

This bachelor thesis is structured as follows: Chapter 2, the literature review, will shed light on the state of work of scientific publications on house price influencing factors as those determinants act out of a variety of subject areas and influence property prices from a wide range of backgrounds. The literature research structure is according to the nature of those determinants (i.e., endogenous and exogenous factors). Besides, the section covers a brief recap of influential factors in the cross-country and cultural settings and illustrates the discrepancies. In addition, the literature review covers standard methodologies used in scientific publications. The methodological approach in chapter 3 presents the self-created radial cluster model, which provides an overview of all explained determinants from the studied literature. Furthermore, this selection presents the sources and composition of explanatory variables for the empirical analyses. Chapter 4 elaborates empirical evidence of influencing factors through multiple analyses such as descriptive statistics, multiple linear regression, panel regression and a correlation matrix. The panel data evaluation assesses both cross-sectional and time-series data as these data points intermix. The final chapter concludes this thesis, declares encountered restrictions as well as it gives an outlook on future research topics.

2 Literature Review

To further understand the role of property price influencing factors, this thesis identifies their origin as fundamental drivers appearing in various economic subject areas. The following chapter elaborates an evaluation of significant factors from the scientific literature.

Property prices are a popular topic of study due to their high significance for a household's wealth, investment decisions of financial institutions and their general influencing role as a contributor to economic growth. According to the Bank of International Settlements (BIS), residential investments in advanced economies have contributed 6% of the GDP on average over the last 50 years (Kohlscheen, Mehrotra & Mihaljek, 2018, p. 2). Despite the relatively small contribution percentage, Eurostat (2013) described that a significant drop in house prices has "a detrimental impact on the health and soundness of the financial sector" (p. 18). Furthermore, all industrialized economies have property cycles that are strongly linked to business cycles (Jowsey, 2011, p. 114).

One definition of the term property cycle is the "recurrence of fluctuations that characterize the equilibrium of real estate markets" (Manganelli, 2015, p. 12). In many developed countries around the world, residential real estate markets have experienced large cyclical fluctuations in prices and volumes (Englund & Ioannides, 1997, p. 172). Cyclical fluctuations in those markets affect the economic cycles, thus the financial sector. BIS characterized property market cycles as having long swings. Hence, for 33 years (1970-2003), two full cycles were monitored (Tsatsaronis & Haibin, 2004, p. 66). However, among the literature viewpoints concerning property price influencing factors differ widely. A combination of global and local economic variables influences the co-cyclicality of the property sector and the whole world economy (Case et al., 2000, p. 3).

Altogether, this topic's importance is self-evident due to numerous studies and scientific working papers, which have dealt with that research area. Depending on the nature of the exact investigated topic in the real estate pricing sector and applied research frameworks, the results of fundamental long-term drivers of house prices in advanced economies vary considerably. It is generally assumed that house prices are predictable from their own historical patterns under supplementary factors (Manganelli, 2015). However, a correct set of variables to carry out proper market research represents a topic of debate among

authors of scientific publications. Indeed, none of the examined papers for this bachelor thesis determine the same set of property price influencing variables. Summarizing the findings of all studied literature results in a broad set of critical indicators that influence the real estate sector.

One suggestion is to collect information about variables that define the demand and supply of house prices (Manganelli, 2015, p. 38). In a similar way, the following sections group relevant determinants to explain house price movements into endogenous classifications (within a property sector due to successive changing patterns of demand and supply) and exogenous classifications (macroeconomic fluctuations such as monetary policy or inflation), which represent their origin of influence *(see 3.1 Radial Cluster Model).* The research question "which factors influence residential property prices" is therefore answered throughout the upcoming literature review.

2.1 Endogenous Factors

Endogenous explanations encounter real estate influencing factors within one specific housing market (Jowsey, 2011, p. 138). According to the handbook on Residential Property Price Indices (RPPI), shifts of house prices happen through significant changes of supply constraints (availability of housing stock; e.g., constructing a new property) and demand conditions (general developments; e.g., decision to buy a house) in a country (Eurostat, 2013, p. 16; Igan & Loungani, 2012, p. 16). There is a comprehensive agreement that prices are affected by demand fundamentals and restricted by supply constraints. Like other markets, "the responsiveness of supply affects the impact of demand on prices" (Banerji, Shi, Hilbers & Hoffmaister, 2008, p. 8). Consequently, delays in obtaining building permits display that housing supply is gradually responding to the long-run demand. It is reasonable to assume that the interplay between supply and demand responses appears to be relevant in establishing a framework for house price forecasting.

2.1.1 Supply Classification

According to various studies (Banerji et al., 2008; Chauhan & Mak, 2015; Geng, 2018; Knoll et al., 2017), key supply factors appear to be both availability and prices of building land, reflecting indirectly construction costs as well as dwelling restrictions. Correspondingly explains Banerji et al. (2008, p. 9), those structural policies such as labor

market, competition, land and zonal policies, affecting all the construction costs, thus the supply side of housing. Supply arrangements are originating from two groups; second-hand (private owners and investors) and new (developers) market participants (Manganelli, 2015, p. 16). These two groups, active on the supply side, help generate demand for properties on the other.

Land Prices and Construction Costs

Knoll et al., (2017, p. 29) points out that while construction costs have stagnated in recent decades, the sharp rise in prices for residential building land has increased global property prices. Likewise, their findings suggest that 80% of the increase in house prices between 1950 and 2012 can be explained by land prices only (p. 6). On the other hand, construction costs, such as workers' wages and material costs, also appear to be of high relevance, as a study in 2009 discovered that a 1% increase in construction costs causes a 1.3% rise in house prices (Adams & Füss, p. 45). The authors conclude that the possibility of higher construction costs could lead to fewer new construction sites, followed by a smaller or stagnating housing stock.

Restrictions & New Dwelling Approvals

Various parameters influence the value of building land. The study conducted by Girouard, Kennedy, Van den Noord and André in 2006, discusses supply constraints in the sense of planning restrictions, building land availability and competition within the sector, which may all play a significant role in slowing down house investment growth (p. 31). Consequently, the authors underpin this statement with an example of the United States' approval situation, where limitations of supply (e.g., land use restrictions) are linked with fewer permits for new dwelling constructions (p. 6). Furthermore, the number of new dwellings shows, according to that study, a strong correlation with the prices for real estate transactions. In the same way, other authors have claimed that new dwelling approvals are among the primary indicators of property price indices forecasting indicators (see Chauhan & Mak, 2015, p. 1). It is therefore widely believed that the occurrence of influences on the value of building land, such as dwelling restrictions, provoke a limitation in housing stock, leading to an increase in property prices and restraining housing investment growth.

Housing Stock

Hence, it seems of equal importance to also analyze housing stock as an influencing factor for real estate prices. The literature underpins the importance of housing stock as a significant influencing driver of residential property prices (Anundsen, 2019, p. 1590; Kohlscheen et al., 2018, p. 17). The number of housing stock influence property prices in a long-term time frame, which is undoubtedly useful when choosing appropriate supply factors for a pricing framework. Besides, Jacobsen and Naug (2005) mentioned that the supply of housing determines house prices, i.e., measured by the housing stock, which represents as a stable ground due to the time of a house construction (p. 31). Indeed, a similar suggestion proposes that housing stock will adapt to demand over time. As a result, they believe a house price framework should contain long-term critical factors for development analyses. Their study suggests that an increase in demand will only accelerate real estate prices, but no shift in the housing stock will be observed. According to their model, a price decline by 1¾% in the long term leads to an increase in the housing stock of 1% (p.35).

Likewise, the IMF suggests in a research paper that, while the total number of housing stock as well as the amount of residential investments grew, an appearance of "relative unresponsiveness of housing supply to price increases" were registered (Banerji et al., 2008, p. 24). It is suggested that increases of available housing stock could contribute to loosening up supply constraints; therefore a negative correlation to real house prices are seen as the "demand-side effects are often predominant" (Bricongne et al., 2019, p. 22; Philiponnet & Turrini, 2017, p. 16). The model of Anundsen suggests that housing stock can feasibly be included to identify imbalances of house prices (2019, p. 1604).

All evaluated supply factors above are, according to the literature, essential contributors to property price explanations. In fact, some countries conduct a regular survey to receive a broad direction about house price movements and housing stock. However, this surveillance does not serve as a prediction tool for future price movements (Eurostat, 2013, p. 106).

2.1.2 Demand Classification

Several demand-related determinants influence property prices in a given location. The components of the demand side in an endogenous framework can be divided into sociological, demographic and economic groups. However, the economic side is undoubtedly linked to technological and political factors from a broader perspective and is not limited to a specific market only. In his textbook about housing market analysis in real estate investing, Manganelli (2015, p. 18) states, when focusing on a particular housing market, besides macroeconomic factors, the integration of non-economic factors is of significant importance too. The upcoming section introduces a detailed analysis of Manganelli's demographic and sociological factors (2015, p. 19). However, economic determinants are evaluated in Chapter 2.2 Exogenous Factors due to their broader range than at only one specific location level, as already mentioned above.

Demographic Demand

The demographic demand element of a real estate analysis includes significant determining factors. According to Manganelli (2015), shifts in demand result from changes in population (number and size of households) as the author believes families, not individuals, are the relevant benchmark units due to their characteristics of "the first real consumers of real estate" p. 18. The author further states that compositions of families play an essential role causing gradual shifts in demographics, as the current and future situation depends on age and number of individuals. Furthermore, it is suggested that population movements will influence housing demand too. For example, does a journal article in the Economic Bulletin published by the Norges Bank in Norway assumes that "net migration to central areas has been positive in recent years" (Jacobsen & Naug, 2005, p. 33). It is further mentioned that this has affected regional house prices in several forms but might also have modified mean house prices for the whole nation.

In contrast, Banerji et al. (2008, p. 14) point out in their study, covering three sets of European countries in 1985 - 2006, that overall population growth correlated with house prices only to a limited extent. In the same way, Igan and Loungani (2012, p. 15) state that the statistically significant relationship between population growth and house prices is more difficult to determine due to the inertia of demographic changes. However, the author notes that, especially in the long run, house prices are mainly determined by local fundamentals such as population growth and income levels. As a result, income and

population growth are causing house prices to rise. However, there is a tendency for housing prices appreciation to slow down as these prices climb faster than income growth and consequently affordability deteriorates.

Socio-Cultural Demand

Several studies indicate local socio-cultural demand characteristics such as income level and income growth as crucial determinants in order to explain movements in real estate prices (see Banerji et al., 2008; Chauhan & Mak, 2015; Geng, 2018; Igan & Loungani, 2012; Jacobsen & Naug, 2005; Philiponnet & Turrini, 2017; Tsatsaronis & Haibin, 2004).

Similarly, Kishor and Marfatia (2016, p. 240) state that household income is among the variables that have the most significant impact on house prices. Likewise, suggestions are made by the results of Chauhan and Mak (2015, p. 1). Corresponding with their research findings, the strongest correlation with real estate prices existed in the price-to-income calculation. The ratio between house price and income is related to the cost of a typical upscale 100 square meter housing unit compared to the country's GDP per capita (Global Property Guide, n.d.). It is acknowledged that this ratio reveals to be substantially higher in developing or low-wage countries than in advanced high-wage economies. Furthermore, long-term averages provide a signal of whether house price developments are subject to a potential correction, as their growth rate exceeds the income growth rate of a typical family household to such a degree that housing may become an expensive difficulty (Philiponnet & Turrini, 2017, p. 7). Girouard et al. (2006, p. 6) provide another analytical perspective regarding the changes in this ratio. According to their report, real house prices have been fluctuating around an upward trend since 1970, which is generally believed to be a result of rising demand for housing in connection with higher per capita income and the growing population.

The impact of favorable low-interest rates leads to increase the demand for real estate properties, as the cost of large mortgages can be realized within a regular household budget, while high-interest rates trigger a reverse reaction (Tsatsaronis & Haibin, 2004, p. 68). The report further states that due to the high nominal interest rates, the repayment of the mortgage capital is postponed, and the real value of the repayment is increased in the early phase of the loan repayment period, thereby reducing the demand for housing. The author’s empirical analysis reports that historically low-interest rates have accounted for the most substantial component of booming real estate markets in most developed

countries in recent years. Furthermore, interest rates have the potential to play a dual role, as they determine mortgage rates that shape the cost of financing, whereas the risk-free interest rate provides an estimate of opportunity costs (Banerji et al., 2008, p. 7).

A more mixed picture emerges from a Scandinavian Economics Journal conducted in 2019 by Mr. Anundsen, which analyses methods for detecting house price bubbles (2019). There were strong indications of a housing market bubble in the United States, the origin of which dates back to 2000. In contrast, the paper further notes that neither Norway nor Finland explicates a definitive overvaluation for the same sample of indicators and terms used in the study. Instead, the results suggest that favorable changes in interest rates, income trends and housing supply can be attributed to this house price boom.

In contrast to the bubble detection study explained above, Adams and Füss conducted a comparison between various countries in an "integrated equilibrium framework" (2009, p. 38). Their goal was to predict house prices on an international level but also finding out differences among countries' divergences. A conclusion drawn by the study was, that macroeconomic shocks, which can be triggered by unexpected changes in interest rates, have a delayed impact on house prices, depending on the speed of the spread mechanism, resulting in changes to the demand to own houses (Adams & Füss, 2009, pp. 39-41).

In an empirical analysis, Nneji et al. (2013, p. 173) deal with the cyclical fluctuations of real estate prices in industrial countries. The authors assume that one of the main determinants of these fluctuations are interest rates. An explanation for this connection of interest rates to cyclical real estate movements is happening while opening up an economy. The liberalization process may lead to an increase in interest rates sensitivity, thus to a substantial increase in house prices. Sensitivity gains are followed by a subsequent rise in interest rates, which, as explained above, ends in a decline in property prices. It could be the case that the linkage of interest rates to macroeconomic drivers influence economic growth in a way, large cyclical fluctuations in house prices emerge.

Variation in the labor market leads to changes in income expectations, which in turn influence housing demand (Jacobsen & Naug, 2005). An increase in unemployment reshapes various factors concerning real estate prices. Firstly, unemployment reduces disposable income, followed by a decrease in the demand for property, which leads to falling house prices (Belej & Cellmer, 2014, p. 14; Savva, 2018, p. 91). Grum and Kobe

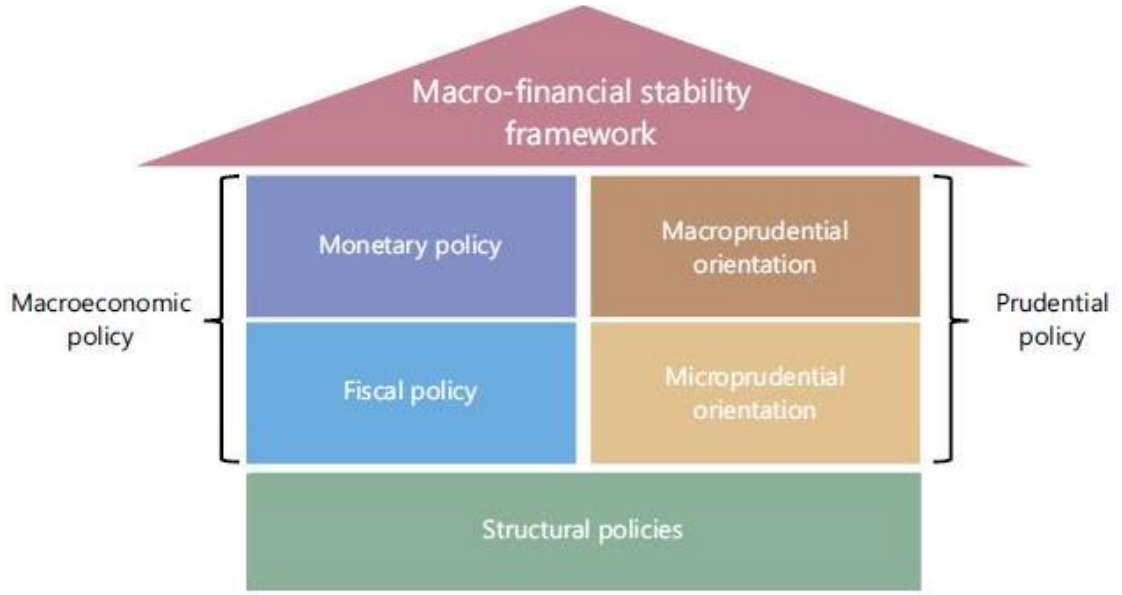
Govekar (2016) suggest that in their conducted study of five European capitals, unemployment was linked as a the most critical factor to residential property prices. In the same way do Belej and Cellmer (2014, p. 11) claim that results recorded a sharply negative correlation between transaction prices and unemployment rate. On the contrary, another study did not found any consistency between unemployment and median house prices in the conducted study (Chauhan & Mak, 2015, p. 6).

Contrary to the evidence suggesting that endogenous, i.e., in a specific location demand-side and supply-side factors are fundamental determinants of house prices, the relationship proves to be ineffective because price elasticities change over time due to an expressly wide range of influences. Hence, it indicates that a broader view and the inclusion of macroeconomic factors is most likely inevitable.

2.2 Exogenous Factors

The prospective understanding of property price developments has become an "integral part of macro-financial" research (Geng, 2018, p. 20). The sound functioning trough mitigating systemic risk and macroeconomic costs of the finance industry acts as a fundament in order to develop and healthy affect the real estate market. Accordingly, through the finance industry, property prices are influenced by "macroeconomic, prudential, and structural policies" (Banerji et al., 2008, p. 9).

Figure 2: Macro-Financial Stability Framework



Source: Borio (2018)

Figure 2 visualizes the macroprudential (MaP) framework's vital elements, which was presented at the 88th annual general meeting speech in Basel, Switzerland (Borio, 2018). According to Mr. Borio, head of the Monetary Economic Department of the Bank of International Settlements (BIS), MaP stability frameworks are a critical new element of post-crisis financial reforms. In particular, the speech emphasizes that MaP measures require to be incorporated into a broader macro-financial stability framework, which includes not only strong microprudential regulation but also monetary, fiscal and structural policies.

These areas are covered in the next section as follows: MaP influences, which include macroeconomic factors such as the impact of monetary policy, gross domestic product and the mortgage market. Followed by microprudential influences that contribute only little to the financial system or the macro economy as a whole. Microprudential tools focuses at the assessment of risks individual financial institutions face on a stand-alone basis which explain supervisory, regulatory policies and fiscal policy. Which altogether are closely related to inflation measures.

A definition of the term macro by European Central Bank (2017) indicates policies or measures that relate to the financial system as a whole or a significant part of it, rather than to an individual financial institution. In other words, the MaP policy is supposed to help ensure that a prudent approach is adapted to risks that could become systemic, i.e., risks that affect the entire financial system. On the contrary, microprudential interventions are referred to as supervisory or regulatory policies for individual financial institutions. Moreover, it is further explained that the word "prudential" comes from prudence, which is a different term for caution, implying sound practices and limiting risk-taking. The last term mentioned above, the structural policies, are covered in more detail by elaborating on the impact of construction costs in the endogenous supply-side perspective *(see 2.1.1 Supply Classification).* Owing to structural policies such as labor market, competition, land, and zonal policies, which ultimately influence construction costs and, therefore, the supply side of housing. Structural policies can influence the real estate sector through artificially constrained land supply, therefore amplify property prices (Borio, 2018).

2.2.1 Macroprudential Influences

A crucial interplay represents the nexus between macroeconomic influences and real estate price movements. The significance of exploring the interdependent connection between and within housing markets and the macroeconomy is the focus of the study of a research paper exaggerated by Leung, (2004). The author underlines that it is only recently that this connection has been gaining increasing recognition. As the term macroprudential is already explained above (see 2.2 Exogenous Factors), one particular task of these policies is to limit risk across the whole financial sector by improving prudential standards of operation that enhance stability and reduce risks (Mankiw & Taylor, 2017).

However, the main functionality of all macroeconomic factors is to overview and to help ensure stability e.g., avoid excessive fluctuations in economic activity. Stability is stimulated by several interventions, known as monetary policies, which are applied by a nation's central bank to influence the money supply (Mankiw & Taylor, 2017, p. 559). Subsequently, the connection can be explained in a circle as house prices carry information that is relevant to the monetary policy, which in turn is an essential determinant of interest rates such as mortgage and risk-free rates, which as a result generate house price shifts (Sutton et al., 2017, p. 4). Lastly, Kohlscheen et al. (2018, p. 17) predict that MaP policy could influence the dynamics of real estate investment in the future more than ever before.

Monetary Policy

A joint research topic is the degree of influence of monetary policy on house prices, as it is included in various empirical analysis models and frameworks (Borio et al., 1994; Girouard et al., 2006; Igan & Loungani, 2012; Nneji et al., 2013).

One study examined the “regime-related effects of changes in short-term interest rates, the maturity spread, inflation and GDP on house prices” in the United States between 1960 and 2011 (Nneji et al., 2013, p. 172). This specific study serves as a source for information gathering to explain how selected economic factors influence price changes in the residential property market, depending on whether the housing market is a “boom”, “steady-state” or “crash” regime (p. 172). It appears that the chosen macroeconomic determinants in the conducted study disconnected from the real estate market during a bust regime; therefore, the housing market shows insensitivity to all applied determinants.

Inasmuch, the study suggests that monetary policy does not act as a catalyst in instigating an economic lift. However, the results suggest that monetary policy could be used as a tool to enforce a shift away from the boost performance of the real estate sector.

Opinions on the extent to which the monetary authorities' influence on property price developments should be responsive are diverse. While some argue that central banks should only observe, others advocate another option such as financial authorities should turn the course by adopting a tighter monetary stance in light of the unusually rapid rise in real house prices (European Central Bank, 2005, p. 58).

Mortgage Market

From a policy perspective, the interconnection between property prices and the financing structure, such as mortgage markets, is fundamental since buying a house usually requires external financing. Therefore the financing conditions play a significant role, i.e., mortgage loan costs and borrowing conditions (Tsatsaronis & Haibin, 2004, p. 65). As stated above, deregulation and open economic markets are influenced by supervisory and regulatory policies. These policies, on the other hand, naturally also control the mortgage market. Various authors have addressed the study of housing market changes caused by the structural changes in the financial system.

Nguyen explains more specifically that the deregulation and innovation process has taken place in the mortgage market (2013, p. 166). From the results of this study, it appears that advanced OECD countries have moved towards more liberalized housing finance markets. Moreover, housing investment tends to be associated with higher volatility in Anglo-Saxon and Nordic economies, where the mortgage market was significantly deregulated before the financial crisis in 2008. According to the author, it may be relevant that a period after 1980 had to be chosen for the study, as most of the mortgage market deregulation started in those years (Nguyen, 2013, p. 163). Furthermore, another study indicates that this deregulation process made it easier for borrowers to obtain mortgages. As a result, house prices increased faster than before, which led to a “transition to the boom regime” (Nneji et al., 2013, p. 176).

Gross Domestic Product

Numerous authors assume GDP to be one of the most influential exogenous control variable due to its strong influence on the real estate market (Adams & Füss, 2009; Belej & Cellmer, 2014; Otrok & Terrones, 2005; Sutton et al., 2017; Tsatsaronis & Haibin, 2004). Admittedly, GDP can summarize much information more directly than by taking multiple measurements such as household income, unemployment and wages (Tsatsaronis & Haibin, 2004, p. 71). Specifically, one paper indicates that this factor's significance is explained by its high volatility of residential investment to GDP (Kohlscheen et al., 2018, p. 2). Just as residential investments are highly volatile to GDP, an example also further indicates a robust positive relationship between GDP and the transaction price of 1 square meter of an apartment (dwellings) resulting from a study quoted in Olsztyn, a regional city in Poland. The same study further concludes that among other variables, GDP counted as a key indicator (Belej & Cellmer, 2014, p. 10).

It appears that GDP growth contributes to house price adjustments. GDP growth tends to be profoundly statistically significant, but GDP also acts as a global factor, showing international correlation (Adams & Füss, 2009; Sutton et al., 2017). Both papers propose that the correlation depends in particular on the degree to which the country is an open economy. One way of illustrating this is the collapse of office prices at the beginning of the 1990s and the crash of residential property prices in 2008 was noticeable in nearly all countries around the world. Along similar lines, Sutton et al. (2017), claim that GDP growth has driven house price growth in mature economies outside the United States nearly one-to-one, with the consequence that the coefficient between the two was 0.95 and thus declared to be highly significant.

2.2.2 Microprudential Influences

In this section, attention is turned to the cost and ease of financing house acquisitions, which are influenced by various financial institution policies, all of which have a substantial effect on purchase prices. So-called supervisory and regulatory instruments usually define the capital requirements for granting loans and the lending limits for borrowers. In addition, these policies also cover the legal framework governing the use of securities, i.e. “regulations on foreclosure and eviction” (Banerji et al., 2008, p.9). Some authors point out that price movements have been comparatively higher or at least more interfering in countries where a deregulation process has taken place due to

significant structural changes in the financial system (Borio et al., 1994, p. 67; Nguyen, 2013, p. 163).

Fiscal Policy

One explanation of fiscal policy can be the context of financial institutions like central banks' decisions on the overall level of government purchases and tax arrangements. Through fiscal policy, authorities can manipulate the performance and behavior of the market economy by influencing savings, investment and growth over the long term (Mankiw & Taylor, 2017, p. 692).

In respect of the real estate sector, some authors have argued that taxation and subsidies have a fundamental impact on the economy, thus on the real estate market (Banerji et al., 2008; Savva, 2018). Examples could include property taxes, the tax-deductibility of individual costs (e.g., mortgage interest payments), and the state as mentioned earlier subsidies for housing. The authors also note that fiscal policy influences households' disposable income through changes in the tax burden. The study by Crowe, Dell Ariccia, Igan and Rabanal points out that fiscal policy measures, e.g., changes in taxes on homeownership, could regulate abundances in the housing market (2011). These "fiscal tools" could introduce reforms of the transaction tax on residential property or change the tax-deductibility of mortgage interest (Crowe et al., 2011, pp. 12–14).

A broader perspective is offered by Pittini et al. in their report. They explain that the coordination of economic policies through the European Semester constitutes an important monitoring instrument for providing recommendations on fiscal and economic policy to the Member States (2019, p. 43). In order to enhance financial stability, the primary objective of this coordination is to avoid an excessive public deficit and no private household indebtedness. Furthermore, Savva (2018, p. 93) finds that housing policies are useful because they can contribute to a stable economic climate. If feasible, housing policies help to increase a household's income and reduce unemployment. In addition, the author suggests continuing to innovate in the mortgage markets by lowering lending rates. On the last point, it recommended that while inflation should be kept low, measures for positive economic growth should be maintained.

Structural policies and Inflation

The importance of the government to control microprudential influence has already been mentioned. Concerning inflationary situations, more prudential regulatory and supervisory policies are advocated, as long periods of inflation are followed by a growth deceleration in prices and may encourage mismatches between house prices and the determinants of property values (Savva, 2018, p. 93). Banerji et al. (2008, p. 20) made the point that real estate investments in the 1980s were used as a hedge against inflationary market conditions, as the study deducted the highest homeownership rates in Southern Europe, where long periods of inflation prevailed. For that reason, it may be essential to obtain more information on the relationship between property prices and inflationary economic market developments.

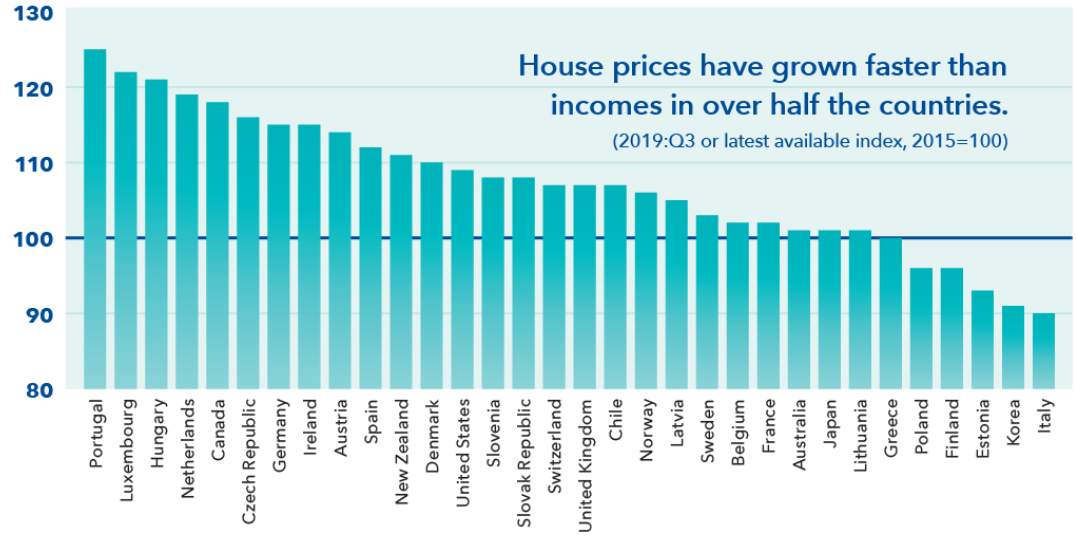
It emerges from the studied literature that Tsatsaronis and Haibin (2004) have focused in detail on inflationary market scenes and their impact on the real estate sector. Not only Banerji et al. (2008) indicate a higher attractiveness of the real estate sector during inflation, but also Tsatsaronis and Haibin suggest that higher inflation contributes to the attractiveness of real estate as a "vehicle for long-term savings" (2004, p. 73). The empirical framework presented in their article is designed to analyze the main drivers of aggregate house prices in advanced economies. According to their study results, inflation predominates as the main factor, but the individual aspects of the national markets also play an important role. They further discovered that this substantial influence of inflation seems to be more critical when house prices are measured in real terms.

2.3 Cross-Country Factors

In order to analyze co-movement factors and to what extent they influence house prices simultaneously across countries, various studies have addressed this research topic. However, local factors explain significantly more house price movements in percentage terms than macroeconomic fluctuations (see Beltratti & Morana, 2010; Case et al., 2000). According to Case et al. (2000), international property correlations are partly due to the shared vulnerability to swings in the global economy. One study points out in their results that house price discrepancies are characterized substantially by different levels of per-capita income and therefore contributing to higher price levels in those countries (Bricongne et al., 2019, p. 25).

In fact, the global housing watch department of the international monetary fund (IMF) highlights, which is visible in Figure 3, that firstly house prices have grown faster than households' income around the world and second, that there is a considerable difference between analyzed countries in 2019 (International Monetary Fund, 2020b).

Figure 3: House Price-to-Income ratio 2019



Source: International Monetary Fund (2020b)

In a similar way, findings of Beltratti and Morana (2010, p. 534) indicate that global supply-side shocks are significant drivers for property price co-movement fluctuations in the G-7 area. While investigating the linkage between macroeconomic fluctuations and international house prices, the authors suggest that global macroeconomic shocks cause 40 % of the overall movements.

It is useful to draw attention to the notoriously complex behavior of real estate markets. Heterogeneity comes from the fact that no two properties are exactly identical, prices are negotiable and property sales are infrequent (Eurostat, 2013, p. 157). In a similar sense, indicates Banerji et al. (2008, p. 11) the importance of local factors on a country-specific basis. The authors explain that demographics, legal frameworks and social preferences help to illuminate the heterogeneity differences between the individual countries.

A discrepancy degree can also be found due to prudential policies which are "far from uniform" among European countries (Banerji et al., 2008, p. 11). In this context, the results of a study conducted by Tsatsaronis and Haibin (2004) reveal that there are significant differences between countries both in business practices but also in the regulatory framework of mortgage financing. As an example, they point out that interest

rates in countries such as the United States and Japan are usually fixed for more than five years or until maturity. In contrast, in countries such as the United Kingdom and Australia, interest rates are linked to market rates and renegotiated regularly. In these countries, it appears that the impact of short-term interest rates on house prices has been much more substantial. Kohlscheen et al. (2018, p. 17) suggest, on the other hand, that institutional factors are a reason for the fluctuating housing supply, thus the influence on house prices. The authors further note that such factors cannot easily be included in a cross-country study but are essential in the analysis of country-specific investment dynamics.

To identify whether to use international real estate as a portfolio diversification tool is outside the scope of this thesis. However, when glancing at investment dynamics, it may be useful to understand the degree of correlation in house price cycles across nations. Igan and Loungani (2012), p. 7, as well as Kishor and Marfatia (2016, p. 237), indicate changes in the correlation of these cycles, which turn to be global as price shifts converge more often simultaneously. The scientific literature about portfolio diversification through international investments by Jowsey (2011) indicates evidence that "the correlation between international real estate markets is surprisingly high and international property returns move together" (p. 395). On the contrary, study results of international diversification by Case et al. (2000, p. 12), provide evidence, that portfolio volatility is reduced by international property investment.

Overall, the literature indicates that various factors bring house prices to a co-movement across countries, such as the connection to the global economy. On the other hand, main drivers are, to a certain extent, locally fundamental. The heterogeneity of a specific real estate sector fosters cross-country discrepancies and how house prices react to factors differently in various markets due to demographic, cultural and prudential policy structures.

2.4 Brief Method Review

The following section will provide a short recap on the three most commonly used empirical methods applied in the studied literature; multiple linear regression, vector autoregressive model and panel cointegrated analysis. Numerous different models were applied throughout the encountered literature, depending on considered factors as well as content and research deliverables.

Multiple Linear Regression

The application of a multiple linear regression model (MLR) is among the most common tools for empirical analysis in economics because this method allows to "explicitly control for many factors that simultaneously affect the dependent variable" (Wooldridge, 2013, p. 68) and of further importance, MLR models can accommodate several explanatory variables which are correlated. Some authors suggests that this model is suitable for quantitative analyses of significant correlations of macroeconomic control variables and the relationship with real estate prices in terms of diverse cultural settings (Belej & Cellmer, 2014; Grum & Kobe Govekar, 2016). In particular, Grum and Kobe Govekar (2016) specified that using MLR models, made it possible to work out the relationship between macroeconomic factors such as unemployment, the stock index, a country's current account balance, industrial production and GDP with the prices of residential property, and thereby could also point out in their study the relationship and impact on different cultural environments among countries in Europe.

Vector Autoregressive Model

Another option to analyze housing price changes under the influence of macroeconomic factors is the vector autoregressive model (VAR). This model is particularly useful for describing the dynamic behavior of economic and financial time series and for making forecasts (Zivot & Wang, 2003). Igan and Loungani (2012) examined the determinants of house price movements along with characteristics of housing cycles in 20 advanced economies with a VAR analysis to assess the exposure of vital macroeconomic determinants such as GDP, consumption, and residential investment to house price shifts. Dynamic joint behavior of influences on a limited number of critical determinants to house prices such as national income, interest rates and stock prices were also analyzed in a small-scale VAR model by Sutton (2002, p. 54). In the author's view, the main

advantages of this approach are that all variables are treated as endogenous, thereby the dynamical response of the variable are only minimally restricted. Another study similarly used the VAR model to capture key aspects of dynamic interaction between inflation-adjusted real estate prices and selected mortgage variables, based on a minimum set of assumptions about the overall economic composition (Tsatsaronis & Haibin, 2004, p.72).

Panel Data

A panel data or longitudinal data set gives several opportunities as, for example, the benefit of having multiple observations of the same countries and at the same time, which allows controlling for specific unobserved characteristics. The second advantage of panel data is the ability to examine the importance of delays in behavior or the outcome of decision making, which through economic policymaking, are expected to be relevant (Wooldridge, 2013, p. 39). Adams and Füss (2009) applied a panel cointegration analysis, which provided a feasible assessment of macroeconomic impacts on house prices in 15 countries over 30 years. The panel structure provided an opportunity to identify groups of countries with similar elasticities, but it also allowed the analysis of indications of international housing market movements. Additionally, Philiponnet and Turrini (2017, p. 15) conducted a country-specific study, as they state that real estate markets are heterogeneous. Nevertheless, the authors note that only limited time series on property prices for some countries are available, which led to little statistical significance and imprecise estimates for these countries. They further state that a solution for this issue is to use the cointegration relationship estimate across a panel.

3 Methodology

This paragraph introduces the methodological procedure for an empirical analysis. Studied factors from the literature review are collected and illustrated in a radial cluster model. Based on this model, five explanatory determinants, which contribute to explain residential property price changes, will be selected as explanatory variables. Furthermore, this section also elaborates an appropriate methodological approach to carry out empirical evidence.

3.1 Radial Cluster Model

Following the reviewed determinants from the examined literature, a radial cluster model of the fundamental drivers has been established to provide a structured overview. An improvement is achieved through this model, as it provides a self-explanatory structured summary of factors influencing property prices.

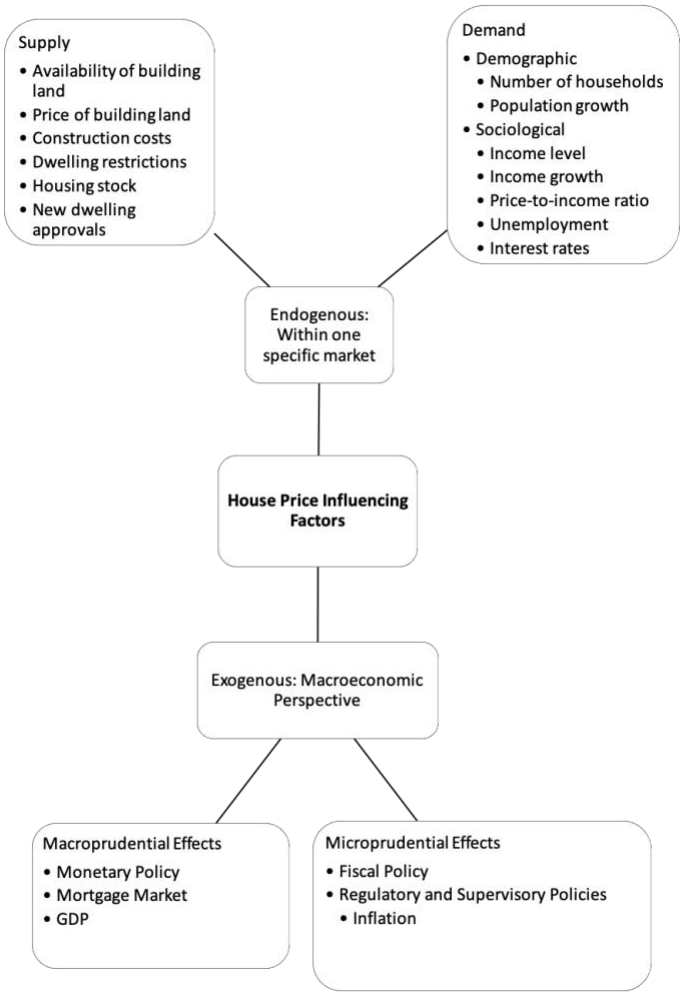


Figure 4: Influencing Factors

3.2 Methodological Approach

The main objective of the empirical analysis in this bachelor thesis is to examine the relationship between RPPI (Y) and five influencing variables (X) in ten advanced economies over 38 years. Additionally, cross-country discrepancies among those factors are highlighted. The evaluation includes a long-term behavior assessment of housing prices from 1980 to 2017 *(see 3.3.1 Sample Composition and Data Source)*. Explanatory variables are chosen, as mentioned above, based on the radial cluster model *(see 3.1 Radial Cluster Model)* and on the availability of long-term data series.

Assuming that determinants from within a specific market (endogenous factors) influence housing prices more significantly than macroeconomic impacts (exogenous factors), four out of the five variables are chosen to be analyzed from the demand side within a respective real estate market. This empirical study adopts the following control variables:

- Four endogenous factors; long-term interest rate, national income per capita growth percentage, population growth percentage and unemployment rate.
- The fifth variable is an exogenous factor; namely, GDP per capita.

In the first step, the variables used in this analysis are summarized on a country basis through descriptive statistics. Graphs visualize particularities of RPPI developments throughout the period in respective nations. Second, an MLR model is applied for every country to analyze the interdependence among the chosen set of variables and to identify co-movements among included nations of the study. An MLR model is suitable for ceteris paribus (which means “other factors being equal”) analysis since it allows to predict and understand various factors that simultaneously influence a dependent (Y) variable (Wooldridge, 2013, p. 12).

However, the MLR model turns out not to fit the data set most precisely due to the neglect of the time factor. Therefore, an evaluation of panel data (time series), controls multiple observations along the 38 years of the same variables and countries for unobserved characteristics through fixed effects (FE). Finally, a correlation matrix illustrates cross-country discrepancy patterns. This approach enables to identify variables which correlate with house price indices for the selected countries the most.

3.3 Selection of Key Control Variables

Form the previous literature part, it is clear that the choice of control variables is a complex matter because numerous factors influence property prices over time *(see Chapter 2 Literature Review)*. Explanatory variables (X), namely interest rates, income per capita, GDP per capita, unemployment rate and population growth, were chosen according to their significant contribution to house price dynamics suggested in the studied literature and availability of long-term data series.

Several authors came to the result that interest rates have played an important role in recent house price developments (Banerji et al., 2008; Jacobsen & Naug, 2005; Kohlscheen et al., 2018; Otrok & Terrones, 2005; Sutton, 2002; Sutton et al., 2017). Amongst the most reliable correlated indicators in the conference paper of Chauhan and Mak (2015) was found to be a household's income. The study of Nneji et al. (2013) found that changes in GDP affect house price dynamics significantly over time. Similarly, a high positive correlation relationship was observed to house prices and GDP in the study of Belej and Cellmer (2014). In terms of unemployment, the study of Belej and Cellmer (2014), as well as Grum and Kobe Govekar (2016), came to statistically significant results, which indicates this factor to be relevant in a cross-country analysis. Lastly, population growth and the number of households are relevant determinants which affect demographical changes. Chauhan and Mak (2015) indicate that the population is a "primary driver of demand for residential properties" (p.7).

3.3.1 Sample Composition and Data Source

This part of the thesis provides an overview of the sample composition and data source. Data series used in this study cover ten advanced economies; Europe (United Kingdom, Spain, Italy, Switzerland, France and Germany), North America (the United States and Canada) and Asia Pacific (Australia and Japan). These specific countries were chosen because of the availability of long-term data series of housing prices at a yearly frequency. Data collection covers a long-term set of 38 years from 1980: Q1– 2017: Q4. Table 1 provides information about studied indicators and sources of the used data series. The data was retrieved from Federal Bank of St. Louis, International Monetary Fund, OECD Data and World Bank Indicators (Fred, Federal Bank of St. Louis, 2016; International Monetary Fund, 2020a; OECD, 2020; World Bank, 2019).

Table 1: Factor Description

Code	Indicator Name	Long Definition	Source
realindices	Real House Price Indices	The real house price is given by the ratio of nominal price to the consumers' expenditure deflator in each country, both seasonally adjusted, from the OECD national accounts database.	OECD, Housing prices indicator (2019). Data retrieved in November 29, 2019.
intrate	Long-term interest rates	Long-term interest rates refer to government bonds maturing in ten years. Long-term interest rates are generally averages of daily rates, measured as a percentage. Low long-term interest rates encourage investment in new equipment and high interest rates discourage it. Investment is, in turn, a major source of economic growth.	OECD, Long-term interest rates indicator (2020). Data retrieved in April 21, 2020. Fred, Federal Bank of St. Louis (2016) Data retrieved in May 6, 2020
perinc	Adjusted net national income per capita (annual % growth)	Adjusted net national income is gross national income (GNI) minus consumption of fixed capital and natural resources depletion.	World Bank, (2019): Economic Policy & Debt: National accounts. Data retrieved in April 21, 2020.
popgro	Population growth (annual %)	Annual population growth rate. Population is based on counting all residents regardless of legal status or citizenship. Annual population growth rate for year t is the exponential rate of growth of midyear population from year t-1 to t, expressed as a percentage.	World Bank, (2019): Population source. Data retrieved in April 09, 2020.
gdppcap	GDP per capita (current US$)	GDP per capita is gross domestic product divided by midyear population. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in current U.S. dollars.	World Bank, (2019): National Accounts data and OECD National Accounts data files. Data retrieved in April 09, 2020.
unrate	Unemployment, total (% of total labor force)	Unemployment refers to the share of the labor force that is without work but available for and seeking employment. Definitions of labor force and unemployment differ by country.	International Monetary Fund (2020)Data retrieved in May 6, 2020.

3.3.2 Expected Signs of Key Control Variables

As reported in the literature review, an extensive set of variables affect house prices. This section elaborates, based on general economic theory, expected signs of effects from these variables on property prices i.e., if variables have a positive or negative impact on residential property prices.

The expectation concerning housing prices and interest rates is that they will be inversely dependent. This assumption is based on the fact that an increase of interest rates limits the availability of financial resources, leading to a decline in the demand for real estate, which in turn is expected to cause a property price drop.

A negative correlation with the unemployment rate is anticipated since similar behavior expectations are assumed like the interest rate. One reason could be that in general, countries with a high unemployment rate have a lower demand for properties, as financial possibilities are limited, which in turn again expects to cause a property price drop.

On the contrary, the co-integration of GDP and the annual growth of adjusted national income per capita to explain real estate prices is made due to the basic fact that income has to be increased to be able to buy a property and therefore, a positive correlation is expected for both variables. Notably, in the long run, both variables are expected to significantly correlate with real estate indices. However, the inert reaction of real estate prices could lead to different moving patterns. Furthermore, the analysis of GDP and income represent both indicators to understand the economic state development pattern of respective countries.

In terms of population growth, a positive affection on house price changes is anticipated due to two distinct assumptions. The first is the slow natural growth among the population over a long-term period and second is due to an increase in immigration, which can happen very fast and unexpected.

The following equation summarizes the discussion from above of RPPI changes due to expected influences:

$$\underset{}{\textit{Change in RPPI}} = \underset{- \quad - \quad + \quad + \quad +}{\textit{(intrate, unrate, gdppcap, perinc, popgro)}}$$

4 Empirical Evidence

This chapter elaborates empirical evidence and presents findings of the interplay between explanatory variables (X) and explained (Y) variable residential property price (RPP). The analysis begins with a data description section and an emphasis on significant facts derived from the data. Subsequently, an MLR model is applied in each country, to evaluate the interplay between selected (X) variables and (Y) property price indices. A panel regression draws attention to the two-dimensional nature (cross-sectional and longitudinal) of the data set since the MLR model has the limitation to neglected time. For this reason, multiple observations over the longitudinal data of the same variables and countries are controlled for unobserved characteristics through fixed effects (FE). Finally, a cross-country discrepancy analysis is carried out through correlation matrices to identify the degree of association of those key indicators (X) on residential property prices (Y) in the observed economies. Subsequently, a correlation matrix will visualize the discrepancy patterns for each country.

4.1 Descriptive Statistics

The dependent or explained (Y) variable is real residential house price indices (basis year 100=2015), measuring property prices over time. The independent or explanatory (X) variables are:

- total percentage of annual long-term interest rate [intrate]
- the annual growth percentage of adjusted net national income per capita [perinc]
- GDP per capita (current US$) [gdppcap]
- the annual growth percentage of the population [popgro]
- total percentage of unemployment rate measured by the total labor force [unrate].

The nature of the provided data collection calls for some attention due to biased assumptions. There are three pre-acceptances made by using the empirical methods stated above:

1. Collected data is accurate and correct.
2. The relationship between the chosen set of variables (X) and property prices (Y) exists.
3. None of the explanatory variables (X) are perfectly correlated to one another, leading to no multicollinearity existence.

Excessive multicollinearity can cause a multiple regression analysis to become significant, but none of the regression coefficients would achieve such a result when examined in isolation (Lucerne University of Applied Sciences and Arts, n.d.). Multicollinearity test assesses through an inverted correlation matrix of the explanatory variables the main diagonal values. Values between five and ten indicate that a significant correlation might exist, meanwhile a value greater than ten show highly correlation (EXFINSIS Expert Financial Analysis, 2019). This study execute a correlation matrix not only to verify for non-multicollinearity reasons but also to analyze cross-country differences of the various variables in respective countries *(see 4.4 Cross-Country Discrepancies & Appendix 7: Country-Specific Correlation Matrix).*

The panel data set consists out of 380 observations (N=10, T=38). The analyzed dataset is balanced, which means that all countries have measurements in observed periods. The summary statistics of the described (Y) variable in Table 2 reveals that during the period from 1980:Q1 - 2017:Q4 overall mean values of covered advanced economies indicate large swings in residential property prices because indices moved between a minimum of 27.18 and 165.86 units *(*for a country perspective see *Appendix 1: House Price Indices*). Table 2 shows that explanatory factors represent, on average, 7.84% in the unemployment rate, GDP per capita 29'815 US$ and 0.63% annual population growth. However, large differences exist between the studied countries.

Table 2: Overall Descriptive Statistics

```
> describe(Y)
   vars   n  mean    sd median trimmed   mad   min    max  range skew kurtosis   se
X1    1 380 83.59 29.43  86.25   83.04 28.77 27.18 165.86 138.68 0.12    -0.42 1.51
> describe(X)
        vars   n     mean       sd   median  trimmed      mad     min      max    range  skew kurtosis     se
unrate     1 380     7.84     4.42     7.50     7.33     3.26    0.20    26.10    25.90  1.47     3.19   0.23
intrate    2 380     6.22     4.12     5.07     5.82     3.57   -0.36    20.22    20.58  0.86     0.11   0.21
perinc     3 380     1.52     2.42     1.81     1.65     2.15   -8.86     8.13    16.99 -0.62     1.24   0.12
popgro     4 380     0.63     0.51     0.60     0.62     0.54   -1.85     2.06     3.91  0.05     0.73   0.03
gdppcap    5 380 29815.09 15893.79 26471.93 28394.19 16074.82 4478.50 88415.61 83937.11  0.96     1.13 815.33
```

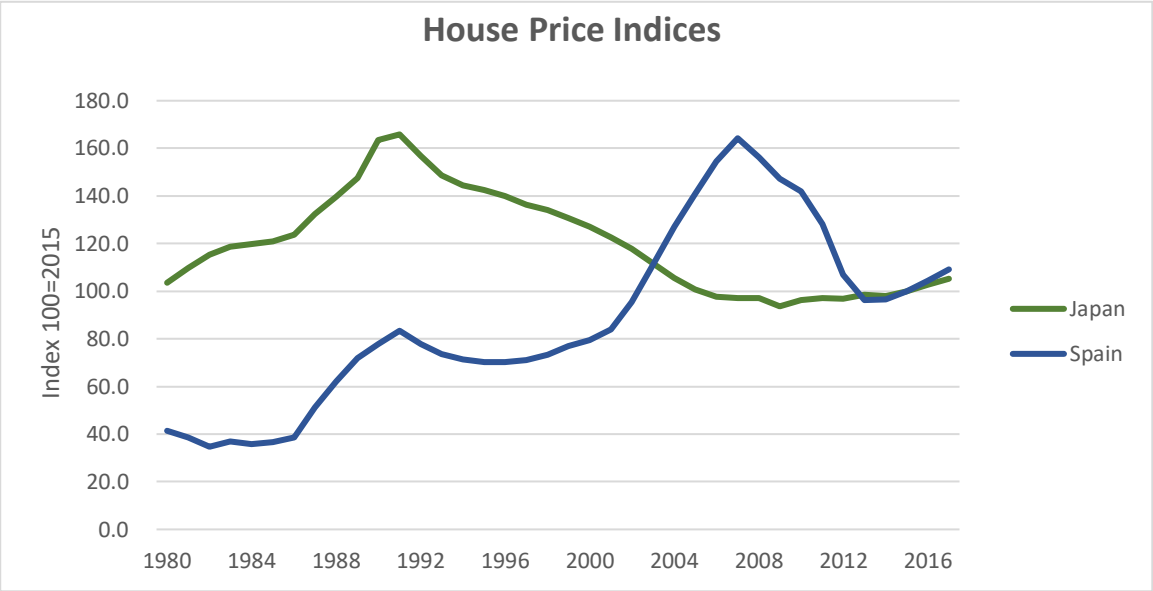
Source: RStudio

4.1.1 House Price Developments

There are as well striking differences in mean values of house price developments between studied countries under the 38-year observation period (*see Appendix 1: House Price Indices).* While Australia, Canada, France, the United Kingdom and the United States indicate significant but gradual growth rate developments, other countries, for example Japan and Spain, record exceptional house price changes.

The annual growth rate of Japan and Spain from 1980: Q1 to the fourth quarter of 2017 are presented in Figure 5. Looking at the entire time period, house prices reached two extreme peaks 1991 (165.9) in Japan and 2007 (164.2) in Spain (the basis year is 100=2015). One of the highest economic growth rates in the world with an 8% annual increase percentage on average was in Japan from 1960-1980. Speculation emerged due to this favorable economic growth combined with loose monetary conditions. However, the two together have led to a great asset price bubble in the country, which finally burst in 1991. Results were economic stagnation and deflation, which is generally known as "Japan's lost decade" (Global Property Guide, 2009). In 2007 another extreme asset bubble-bursting point happened, amongst other economies, in Spain, as the country was one of the worst affected of all European nations in 2007-08. In fact, 2007 revealed property prices in the Mediterranean country, which were nearly 200% higher than in 1997 (Borsi, 2009). Both economic and speculative forces caused the burst because they lead to an overshot by 2007, and prices began to fall drastically until a robust recovery was noticed in 2015.

Figure 5: House Price Index JPN & ESP



Source: Data retrieved from OECD

Countries like Italy, Germany and Switzerland, show very moderate growth changes over the observation period, excluding short-term bumps, as house price indices changed to a maximum of 33 units *(see Appendix 1: House Price Indices).*

4.1.2 Explanatory Variables Development

There are significant differences in explanatory variables between evaluated countries *(see Appendix 2: Descriptive Statistics)*. For example, the average unemployment rate reaches 17.44% and 9.30% on average in Spain and Italy. Spain is the top country by unemployment rate (percentage of total labor force). The top five countries besides Spain are Italy, France, Canada and Australia which account together for 73% of the overall unemployment among the ten countries. By contrast, Japan exposes only 3.50% and Switzerland 2.51% on average.

Interest Rate

Likewise, Switzerland and Japan indicate the smallest numbers in terms of interest rates with 3.31% and 2.83%. The highest on average interest rate countries are Australia with 8.02% and Spain 8.16%.

Population Growth

Moreover, population growth indicates disparities across nations. Australia and Canada show the highest demographic growth rates with an average of 1.39% and 1.08% annually, while Italy displays 0.19% and Germany 0.15%, respectively. Annual growth of adjusted net national income per capita shows the highest numbers in the United Kingdom (UK) (2.09%) and United States (USA) (1.81%). Italy (0.69%) and Switzerland (0.98%) occupy the last two places by this ranking.

GDP per Capita

The highest average GDP per capita annually since 1980 has Switzerland with $48'217 and USA with $34'731. However, in the year 2017, Switzerland's and USA's GDP per capita nearly doubled to the 38-year average with values of $88'416 and $59'928. Italy and Spain occupy the last places in the table on average ($23'576, $18'209), but also in 2017 ($40'778, $35'366).

Unemployment Rate

Only Japan and Switzerland indicate over the analyzed time period, on average low unemployment rates and high-income levels. Canada, USA, UK, Germany and Australia reveal medium income as well as unemployment rate levels. France, Italy and Spain report most severe average unemployment rates and weak GDP per capita (for exact figure insight *consult Appendix 2: Descriptive Statistics)*.

Derived from the summary statistics of low-income countries like France, Spain and Italy *(see Appendix 3: Summary Statistics Low-Income Countries)*, results indicate that these economies are slowly catching up with the rest of the observed nations. All three countries record substantial enhancement in GDP per capita amounts over the years and rising growth rates in net national income per capita. This trend is visible due to changes in the first quartile (the median value of the lower half of the data set of a country) to the third quartile (the median value of the upper half of the data set). If GDP per capita turns out to significantly correlate with residential house price indices, major upward shifts in housing prices could, among other variables, be derived from this economic development. Nonetheless, summary statistics show, on the contrary, rising unemployment rates in all three countries, which can endanger the economic health of a country (Simpson, 2020).

4.2 Multiple Linear Regression

This section examines the degrees of the suitability of selected control variables (X). A multiple linear regression model (MLR) identifies the strength of the effect that the explanatory variables have on the dependent (Y) variable (Wooldridge, 2013). By using an MLR, the connection between the selected explanatory variables: unemployment rate, interest rate, national income per capita growth rate, population growth and gross domestic product per capita to the explained variable property price indices is determined. Therefore, the regression specification to explain property price (Y_i) variations is:

$$\textit{Property Price Indices}_i = \beta 0 + \beta 1 \textit{unrate}_i + \beta 2 \textit{intrate}_i + \beta 3 \textit{perinc}_i + \beta 4 \textit{popgro}_i + \beta 5 \textit{gdppcap}_i + u_i$$

While the former variable (Y) reflects the explained variable, the latter (X) denotes the explanatory variables and (*i*) monitors the various countries in the set. The error term (u) represents unobserved variables that might affect RPP in advanced economies. Numerous factors within the unobserved error term could influence property prices besides the five listed above. Other examples of variables that influence the real estate sector can be found in the literature review *(see 3.1 Radial Cluster Model)*.

4.2.1 Linear Regression Interpretation Theory

An MLR allows us to make numerous interpretations, which is visible in *4.2.2 MLR Interpretation*. The scientific blog of Rego (2015), is used as an interpretation guide for this section.

Residuals

The first element in the model shows residuals, which represent the difference between the response values observed and the response values predicted by the model. Asymmetrical distribution across the five summary scores (Min, 1Q, Median, 3Q, and Max) to the average value zero indicates that the data points forecast in the model come near the points observed.

Coefficients

The coefficient estimates in this analysis (see Figure 6) contains six rows; the first is the intercept. Rows two-six are the slope effects of an increase of one unit, e.g., the unemployment rate, decreases the house price indices by 5,531 units adjusting for the other four variables. According to the MLR model, an increase in the unemployment rate by one unit subsequently decreases the property prices on average by β1. However, this requires that all other factors are being equal, also called ceteris paribus assumption, which is vital to isolate multiple explanatory variables (X) affecting the explained variable (Y) (Hall, 2018). The coefficient standard errors measure the average amount by which the coefficient estimates differ from the average response variable's actual mean values. The standard errors can furthermore be applied to calculate confidence intervals as well as statistically test the hypothesis of the existence of a relationship between explanatory variables and house price developments. The impact of the single variables is visible through the t-values. These values represent the hypothesis that the slope for the respective variable is 0; in other words, how many standard deviations are the coefficient estimates away from zero. Among all five variables, interest rate indicates the highest degree of impact on real house price indices with a negative correlation of -7.273. The stars (asterisks) indicate the degree of influence of the explanatory variable on the explained determinant.

Residual Standard Error & R Squared

The next item of the model shows the residual standard error, which measures the quality of the MLR. The residual standard error is the average amount by which the independent variables deviate from the actual regression. It gives an idea of how far observed house price indices (Y) are from the predicted price indices Y-hats. The degrees of freedom are observation points that went into the estimation of the parameters used after taking into account these parameters. R square and adjusted r square provide a measure of the

consistency of the model with the actual observation points. In an MLR, r-squared generally increases as more variables are included to the model. Therefore, the adjusted r-square is preferred because it adjusts the number of variables considered.

F-Statistic

Indicators like the f-statistics and p-values represent an overall test of significance of the model, which means results did not happen by chance. This means the further the f-statistic is away from 1, the better the relationship between the predictor and the explanatory variables. In other words, one or more of the independent variables is related to the dependent variable.

4.2.2 MLR Interpretation

The MLR model results in Figure 6 indicate different outcomes than expected for the annual growth percentage of the population and adjusted net national income per capita *(see 3.3.2 Expected Signs of Key Control Variables)*.

Figure 6: Multiple Linear Regression

```
Call:
lm(formula = realindices ~ unrate + gdppcap + popgro + perinc +
    intrate, data = MLR)

Residuals:
    Min      1Q  Median      3Q     Max
-40.546 -17.637  -1.578  13.023  87.938

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  1.192e+02  6.842e+00  17.416  < 2e-16 ***
unrate      -5.531e-01  3.071e-01  -1.801   0.0725 .
gdppcap      1.823e-05  1.247e-04   0.146   0.8838
popgro      -1.212e+01  2.584e+00  -4.689 3.86e-06 ***
perinc      -2.070e+00  5.238e-01  -3.953 9.24e-05 ***
intrate     -3.370e+00  4.633e-01  -7.273 2.08e-12 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 23.99 on 374 degrees of freedom
Multiple R-squared:  0.3441,    Adjusted R-squared:  0.3354
F-statistic: 39.25 on 5 and 374 DF,  p-value: < 2.2e-16
```

Source: RStudio

The annual percentage of population growth [popgro] seems to correlate negatively with property price changes in this model. Assumptions are made, that a panel analysis will change this result trough the integration of the time factor, as no economic evidence can be found to explain this result. Also, the annual growth percentage of adjusted net national income per capita [perinc] indicates a reversed interdependence outcome than stated above, whereas a positive correlation was expected, a significant negative connection results, with a t-value of -3.953, from the empirical analysis. The different outcomes in the findings from the MLR study could be due to the neglect of the time value. An MLR analysis for each year of the observed period could overcome this limitation. Instead, in the upcoming analysis *(see 4.3 Panel Regression),* the factor time is considered in the assessment of the relationship trough fixed effects. It is expected that the overall impact of influencing factors will change significantly.

The findings of the conducted MLR model suggest that interest rates, national income per capita and population growth represent a significant influence on explaining movements in property prices. Overall, the adjusted r-squared illustrates that approximately 33.54% of the variation in real house price indices can be explained by the five chosen variables altogether. Adjusted r-squared improves the r-squared result because it adjusts for the number of independent variables in the multiple linear model. Alternatively, to get more accurate statistical tests, a country dummy variable as an independent variable can be entered in the model *(see Appendix 6: Country-Specific Fixed Effects using Dummy Variables)*. As appendix 6 illustrates the countries as individual dummy variable model, the differences across countries mediate the effects of the explanatory variables. By adding a dummy for each nation, it is possible to control for unobserved heterogeneity by "estimating the pure effect of the independent variables" (RStudio pubs Statistics, n.d.).

However, this approach presupposes that the relationship between the dependent and independent variables are constant in all ten countries. European Social Survey (ESS) proposes another approach; run separate regression analyses for each of the examined economies (2004). *Appendix 4: Multiple Linear Regression Cross-Country* shows the differences among studied countries. The amount of variance explained (the r-squared value) by the model varies among the country set. The most powerful fit represents Spain with 96.22% whereas for Switzerland only 46.29% is explained by this model.

4.3 Panel Regression

By monitoring housing prices of specific countries over a certain time period, the possibility arises to observe how measured variables impacted the real estate sector over time and how these variables can shift a long-term property price equilibrium. A standard linear regression does not account for the fact that cross-sectional and time-series data are being intermixed in some cases (Grogan, 2018). Panel data, on the other hand, accounts for both types of data, which means that the same cross-sectional units (countries) are observed over a given time period (Wooldridge, 2013, p.10). The author states that panel data has two advantages. First, several observations of the same country set allow to control for unobserved characteristics of these nations. The second benefit is that through the longitudinal data, importance of lags in behavior can be studied.

Monitoring property price indices in different countries (*i*) over 38 years (t), indicates that a panel method application is feasible. Therefore, the error term is split into two components: time-varying unobserved factors (u) and (c), which represent time-constant unobserved factors. For example, the political system of a country, geographical aspects, fundamental needs, culture and traditions are time-constant determinants that do not change over the observed time. A positive effect by implementing to the explanatory (X) variables an unobservable time-constant factor (c), allows removing that entire bias. Accordingly, a multiple linear regression model is extended by two variables [year] and [unobserved time-constant factor]:

$$\textit{Property Price Indices}_{it} = \beta 0 + \beta 1 unrate_{it} + \beta 2 intrate_{it} + \beta 3 perinc_{it} + \beta 4 popgro_{it} + \beta 5 gdppcap_{it} + \beta 6 \text{year}_t + c_i + u_{it}$$

A Hausman specification test is used to choose whether to apply fixed effects (FE) or random effects (RE). The test observes if there is "correlation between unique errors and the regressor in the model" (Glen, 2017).

Figure 7: Hausman Test

```
> phtest(random, fixed)

        Hausman Test

data:  realindices ~ intrate + perinc + popgro + gdppcap + unrate
chisq = 90.897, df = 5, p-value < 2.2e-16
alternative hypothesis: one model is inconsistent
```

The null hypothesis state that the preferred model is random effects (no correlation between unique errors and the regressor), therefore an alternative is the fixed effects estimations (Glen, 2017). In other words, if the null hypothesis is rejected, the application of the FE model is feasible. However, the null hypothesis is denied in this case because of a p-value approach with 95% confidence or 5% significance testing. In general, the null hypothesis is rejected when the p-value is less than the test's level of significance. Applied to the observed panel data in this study, figure 7 indicates a very small p-value (less than 0.05), which leads to a FE estimation.

FE parameters have a constant (fixed) nature across units (countries), which is in contrast to the RE model. In a RE model all or some variables are unpredictable (random) (Glen, 2017). Through FE, the impact of variables that vary over time can be analyzed, as the model explores the relationship between (Y) and (X) within a country. Furthermore, each country has its distinct characteristics that influence the explanatory variables. Therefore, a FE model is applied to receive consistent estimates. FE estimators help to deal with missing variables that are serially uncorrelated. Therefore, EF estimator is efficient when the unobserved factors that impact the dependent variable (i.e., idiosyncratic errors) are serially uncorrelated, and no assumptions are made regarding the correlation between unobserved effect *ui* and the explanatory variables (Wooldridge, 2013, p. 501). The FE creates an average of all included variables for every country, which are deducted from the original function (Y_{it}) and finally, the variance between those differences is regressed. The striking discrepancies in the output of the explanatory variables of the panel regression analysis discovers that the assumptions made by the MLR model above may be misleads evaluations.

Results of the FE regression model in Figure 8 deviate from the outcomes predicted by economic theory assumption in *3.3.2 Expected Signs of Key Control Variables*. However, the outcome indicates that only adjusted income per capita growth percentage reveals a different correlation degree than expected (negative instead of positive).

Figure 8: Fixed Effects

```
Oneway (individual) effect Within Model

Call:
plm(formula = realindices ~ intrate + perinc + popgro + gdppcap +
    unrate, data = countries, model = "within", index = c("country",
    "year"))

Balanced Panel: n = 10, T = 38, N = 380

Residuals:
     Min.   1st Qu.    Median   3rd Qu.      Max.
-48.05560  -8.70276  -0.97084   9.18255  51.89501

Coefficients:
           Estimate  Std. Error t-value  Pr(>|t|)
intrate -1.95726064  0.31686947 -6.1769 1.745e-09 ***
perinc  -0.80669292  0.33726524 -2.3919 0.0172684 *
popgro  10.69183034  2.81408623  3.7994 0.0001699 ***
gdppcap  0.00047518  0.00008513  5.5818 4.649e-08 ***
unrate  -2.67697629  0.40383159 -6.6289 1.218e-10 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Total Sum of Squares:    187170
Residual Sum of Squares: 81935
R-Squared:      0.56225
Adj. R-Squared: 0.54546
F-statistic: 93.7613 on 5 and 365 DF, p-value: < 2.22e-16
```

Source: RStudio

On the other hand, population growth percentage now clearly correlates positively with a slight significant t-value of 3.799, which is a clear improvement compared to the MLR analysis above. The result of the FE regression demonstrates that the adjusted r-squared value of the model is 0.545. Therefore the explanatory degree of independent variables improved, as the model explains 54.55% of the variance of the dependent variable ("House price indices"), whereas before the MLR model only revealed 33.54%. Furthermore, the t-values changed significantly. All explanatory variables, except annual growth of adjusted net national income per capita, are highly significant.

Especially the value of population growth changed the most, as in the MLR model it had a significant negative relation (-1.212), whereas in the FE analysis it states a significant value of 10.69. An additional meaningful change can be observed with the impact of the unemployment rate. Through the MLR-model unemployment rate stated a negative impact on house price indices with a weak t-value of -1.801. However, persuasive explanation for (Y) term can be observed with a t-value of -6.6289. Furthermore, adjusted

net national income per capita growth percentage lost on relevance through not significant t-value of -2.391. As expected, GDP per capita represents the highest positive t-values among the set with a correlation of 5.58 (in MLR, only 0.146).

The appendices present further results from the panel analyses. *Appendix 5: Fixed Effects* highlights results in the first five columns to the findings of the pooled ordinary least squares (OLS), which do not compute a difference between time and cross-sectional data. However, OLS are included to illustrate the relevance of including multiple determinants and the time factor to explain the dependent variable (Y). By squaring all residuals a measure is generated which is a fitted value for how much of the variation in (Y) can be explained by the applied model (Wooldridge, 2013, p. 30). Whereas the last column refers to the FE analysis, which is more appropriate for panel data as explained above. Overall, the inclusion of additional variables from the MLR improves the ability to explain house price movements across advanced economies.

4.4 Cross-Country Discrepancies

In this section, cross-country correlation matrices will be evaluated to assess the strength of linear relationships between variables in different environmental settings, thus exploring cross-national discrepancies. In other words, it outlines the varying influence of the explanatory variables on property prices, looking at different economic environments.

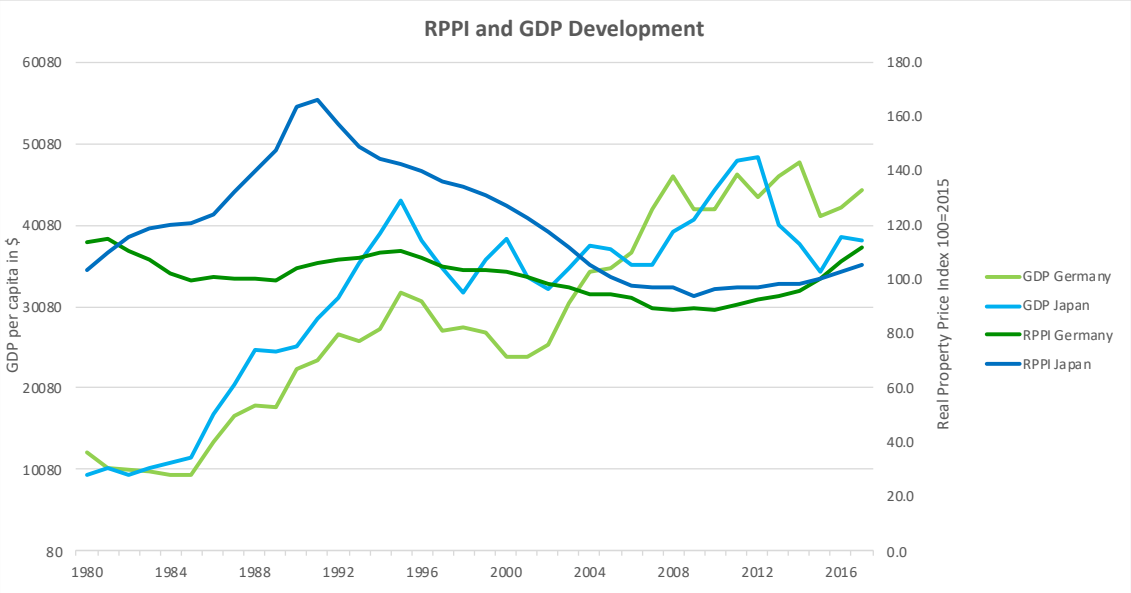
If the primary output equals zero in a correlation matrix, then there is no linear relationship, thus if the output is higher than zero, one variable tends to increase as the other increases. If the output is less than zero, one variable tends to decrease as the other variable decreases. The closer the variables correlate to -1 or 1, the stronger the relationship between these two variables. This analysis helps to indicate discrepancies among the set of advanced economies and the interplay between explanatory variables.

While one factor influences real house price indices more in one country than the other, explanatory variables vary among each other as well in different economic environments. *Appendix 7: Country-Specific Correlation Matrix* illustrates both the exact numeric correlation between adapted variables and gives an overview of discrepancies of the studied countries. It is apparent from the table in Annex 7 that generally, there is no strong correlation between two variables. This is an indication that no multicollinearity exists *(see 4.1 Descriptive Statistics).* This disclosure is evident as the absolute values in general

are not greater than 0.9. However, a deviation from that fact is seen in the correlation between GDP per capita and real house price indices, which are very high in some countries (Australia, Spain, UK) with correlation values above 0.9. In fact, among all adopted explanatory variables, the strongest positive correlation to real house price indices was observed with GDP per capita. In eight out of ten countries, values between 0.307 and 0.929 are reported (strongest in Australia and Spain). Surprisingly, Germany and Japan reveal a negative correlation with -0.507 and -0.405, respectively.

Figure 9 highlights the negative correlation between RPPI and GDP per capita in US$ with the visualization of the variables' developments in respective countries. Even though that Japan's GDP and RPPI (in dark blue) follow similar growth patterns from 1980-1991, the real estate sector bubble may have caused this negative correlation *(see Figure 5: House Price Index JPN* & ESP*)*. GDP indicates a relatively fast recovery from 2000 on, while RPPI levelled out much later in 2008.

Figure 9: RPPI & GDP Development JPN and DEU

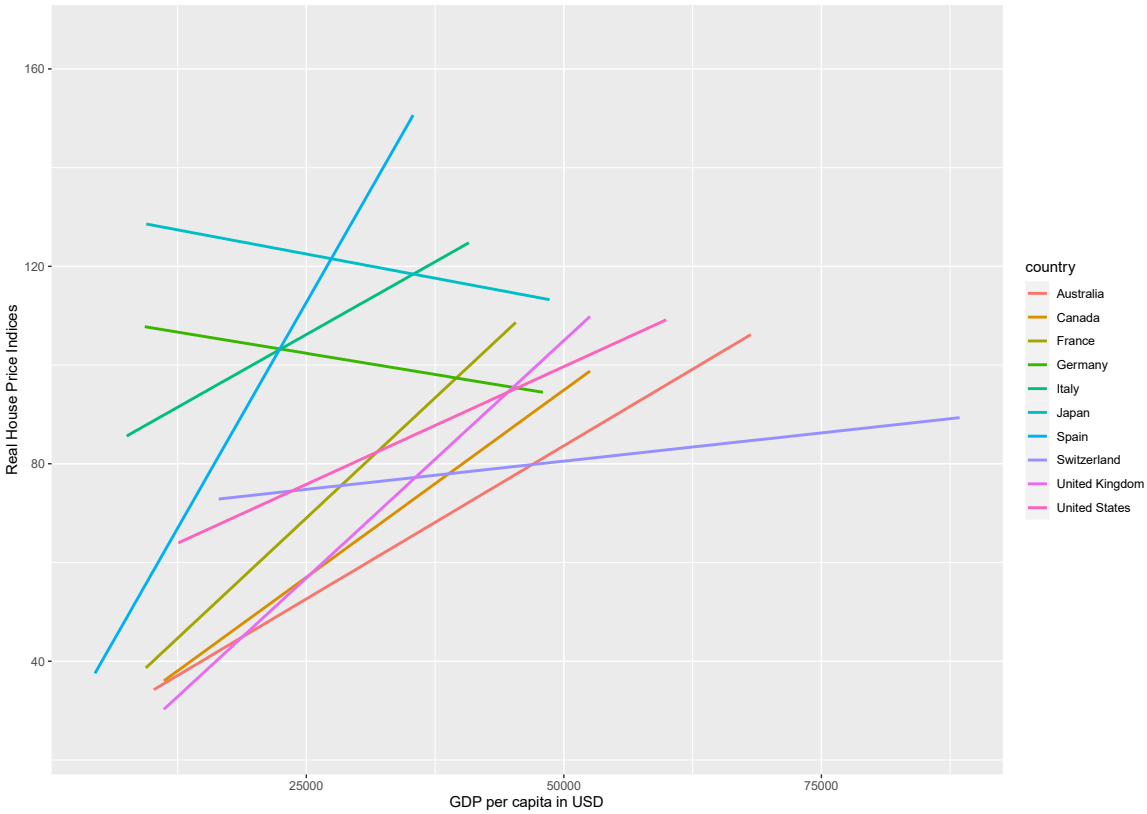


Source: adapted from OECD (2019)

Assumptions for a negative correlation between the two indicators in the case of Germany vary substantially to the hypotheses of Japan. The Germany's RPPI development (in dark green) indicate only minor movements. Overall, Europe has a strongly growing to booming housing market, with the exception of Germany, which is experiencing steady negative trends until 2010 (Vogler, 2015, p. 43). On the contrary, Germany's GDP per capita fluctuated substantially in recent years, it tended to increase through 1998 – 2017

period ending at 44’349 US$ in 2017. There was general consensus among economists that the unification of West and East Germany in 1989 would lead in a “economic miracle” through structured political-economic acceleration brought East Germany back on its long-term economic course (Leaman, 2009, p. 104). This keen appreciation of the German GDP per capita during the observed period could have led to a negative correlation between RPPI and GDP. However, a positive correlation could be expected for both countries when the chosen observation period is selected over a longer period than 38 years.

Figure 10: RPPI & GDP Correlation



Source: *RStudio*

Figure 10 visualizes the interdependence of GDP per capita in US$ and RPPI (Index year 100=2015) in a multileveled scatterplot. This graph is useful for displaying the relationship between the two variables, as each cornflower-blue colored dot indicates an individual data point. Each country's colored regression line indicate that countries have different directions for the relationship between RPPI and GDP. Visible, as mentioned before, the negative correlation in Germany and Japan. However, this illustration assists

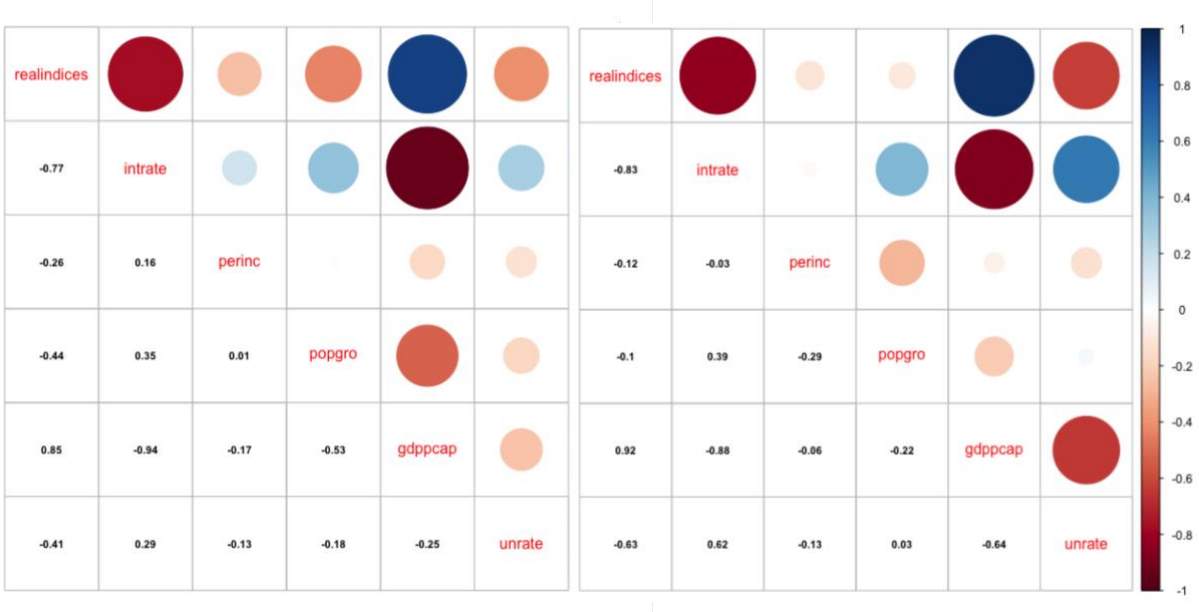
to underline the strong positive correlation between GDP per capita and housing prices in general.

Canada, France, Spain and USA, show strongest correlation between the variables RPPI and GDP per capita (0.892, 0.854, 0.924, 0.877) as well as interest rates (-0.882, -0.808, -0.828, -0.834). The biggest influence of prices in real estate and unemployment was observed in UK, where one unit's change in the unemployment rate causes a change in the housing price index for 0.800 units.

Besides, countries with the most similar trends of correlation between the variables are Canada and the USA. They report similar correlation patterns, as can be seen in Tables 3 and 4. Both countries show almost simultaneous significant affection in terms of interest rate and GDP per capita to real house price indices, but they also indicate equal reactions between all other variables.

Table 3: USA

Table 4: CAD



Source: RStudio

Overall it is visible from the tables *in Appendix 7: Country-Specific Correlation Matrix* that countries reveal different correlation degrees on residential real estate prices influences by the given set of explanatory variables. From these varying reactions it can be concluded that there are transnational discrepancies between the advanced economies, which are attributable to endogenous and exogenous drivers.

5 Conclusion

This thesis is providing new insights into house price developments and the origin of influential factors. It addresses several explanatory variables which demonstrate that there are multiple determinants which contribute to explain property price movements. In consideration of the empirical results, it can be stated that the observations of the chosen set of influential variables are essential for financial institutions such as pension funds and banks, scientific research analysts and policymakers. The empirical evidence reveals that the significance degree between the selected determinants associated with residential house price indices is to a similar extent than it was expected from the economic theory. Furthermore, it highlights that the variables, especially in the long run, profoundly influence property price developments, leading to price shifts away from the long-term equilibrium.

The first research question, on which factors influence residential property prices, is answered throughout an extensive literature review. Factors are explained in an endogenous (within a property sector due to successive changing patterns of demand and supply) and exogenous (macroeconomic fluctuations such as monetary policy or inflation) structure and summarized in a conceptual radial cluster model. This model served as the basis to choose a small set of explanatory variables for an empirical analysis. The second research question, which elaborates cross-country discrepancies, is answered through the empirical evidence of a panel analysis and a correlation matrix.

The main findings in this thesis are based on the empirical results of GDP per capita, interest rates and unemployment rates, which are the most significant factor associated with house price developments among analyzed variables. Results of the empirical estimation confirm that population growth and GDP per capita are responsible for the increase in property price developments. On the other hand, interest rates, unemployment rates and surprisingly, income per capita growth all adversely affect housing prices. Interestingly, the abundant heterogeneity of the real estate markets is visible through the fact that price developments vary significantly in different market environments even though observed countries are all designated to be in a similar economic state of health. Overall, the findings are an essential takeaway from the conducted panel regression analysis and correlation matrix since they highlight historical co-movements between

influential factors and house prices, which in turn serves as the basis for a future house price development outlook.

5.1 Limitations

There are three potential limitations in this thesis that could be addressed in future research. Firstly, numerous housing price drivers could not be considered in this study due to the limited number of variables used in the empirical analysis. Additional quantitative analyses from the findings presented in the radial cluster model could be used to promote more clarity on the completeness of the explanatory factors for real estate price movements. The second limitation concerns the nature of the data sample and the methodology used, which does not entirely reflect the general economic theory. Some deviations were encountered for example in the correlation between GDP per capita and RPPI in Japan and Germany. These research results are subject to lead to the third limitation, which assumes that insufficient long sample size for statistical measurements in terms of years were applied. However, this limitation also amplifies that the ability to provide more in-depth contextual evidence is not given. A longer time frame than the 38 years may have presented contrary empirical evidence as property prices indicate long swings and some countries had distorted property prices due to real estate bubbles or political-economic movements. The recovery to average equilibrium prices takes time as house prices natural inertia delays the impact of macroeconomic and endogenous factors.

5.2 Future Research

Deriving from this thesis results, many house price dynamics and important factor areas were touched on a superficial level, which may serve as the basis for further research. The majority of real estate price drivers remain unknown despite the conducted empirical research. These explanatory variables could be further analyzed in a more extensive empirical study among the chosen countries to find out how these factors differently influence property prices. Therefore, future research could focus on an in-depth analysis of discrepancy determinants in various demographic environments.

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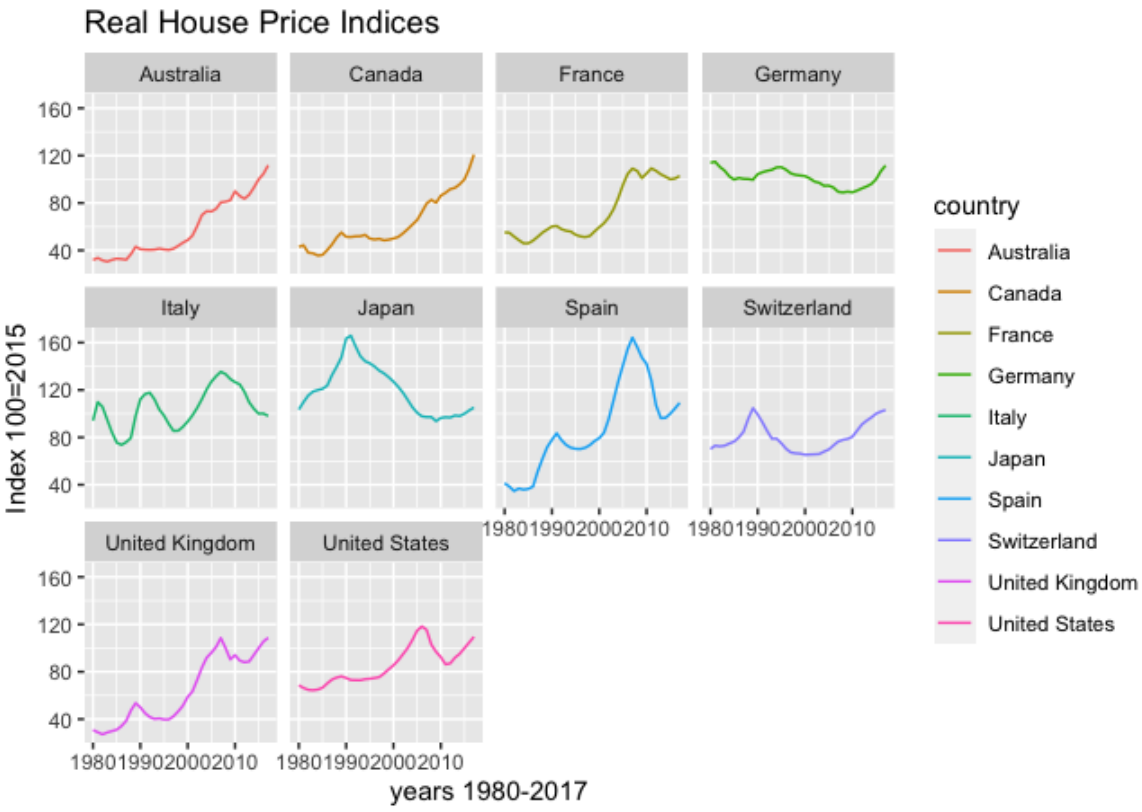
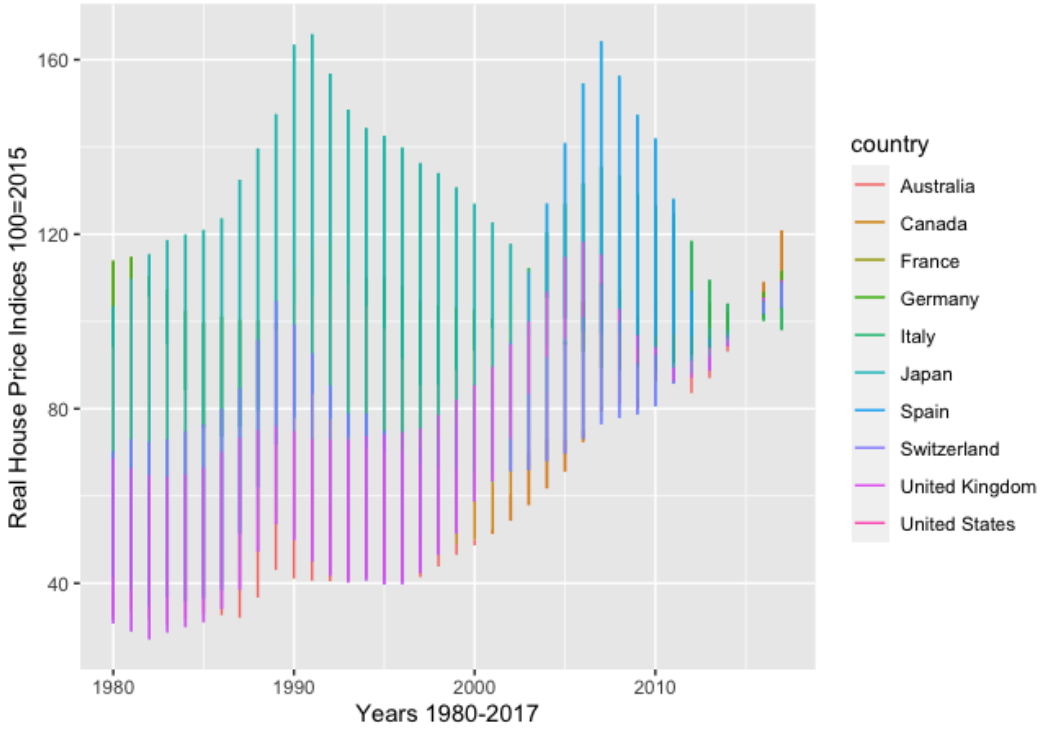
7 Appendices

7.1 Appendix 1: House Price Indices





7.2 Appendix 2: Descriptive Statistics

```
> describe(Australia)
             vars  n     mean       sd   median  trimmed      mad      min      max    range  skew kurtosis      se
realindices     1 38    58.06    24.76    45.18    56.13    19.63    30.52   111.80    81.28  0.55    -1.17    4.02
intrate         2 38     8.02     3.95     6.16     7.94     3.92     2.34    15.38    13.04  0.40    -1.32    0.64
perinc          3 38     1.91     1.90     2.29     1.96     1.89    -1.63     5.49     7.12 -0.37    -1.09    0.31
popgro          4 38     1.39     0.29     1.36     1.38     0.29     0.62     2.06     1.44  0.06     0.20    0.05
gdppcap         5 38 29382.20 18287.52 20926.00 27651.48 13635.26 10194.32 68150.11 57955.79  0.84    -0.77 2966.63
unrate          6 38     6.93     1.77     6.35     6.82     1.70     4.30    10.90     6.60  0.60    -0.70    0.29
> describe(Canada)
             vars  n     mean       sd   median  trimmed      mad      min      max    range  skew kurtosis      se
realindices     1 38    62.44    22.29    51.89    60.42    13.89    35.65   120.91    85.26  0.89    -0.34    3.62
intrate         2 38     6.67     3.78     5.73     6.47     4.10     1.25    14.99    13.74  0.43    -0.88    0.61
perinc          3 38     1.49     2.78     1.83     1.71     2.22    -7.39     6.42    13.80 -1.01     1.14    0.45
popgro          4 38     1.08     0.19     1.07     1.07     0.16     0.75     1.79     1.05  1.36     3.09    0.03
gdppcap         5 38 28579.46 13540.96 22033.95 27902.52 11916.53 11170.56 52542.35 41371.78  0.51    -1.29 2196.63
unrate          6 38     8.33     1.68     7.65     8.23     1.19     6.00    12.00     6.00  0.67    -0.83    0.27
> describe(France)
             vars  n     mean       sd   median  trimmed      mad      min      max    range  skew kurtosis      se
realindices     1 38    72.84    23.73    59.86    71.94    14.69    45.95   109.25    63.30  0.46    -1.63    3.85
intrate         2 38     6.58     4.25     5.17     6.29     3.71     0.47    16.29    15.82  0.71    -0.44    0.69
perinc          3 38     1.22     1.75     1.48     1.24     1.45    -4.15     4.83     8.98 -0.46     0.82    0.28
popgro          4 38     0.52     0.13     0.51     0.52     0.08     0.22     0.75     0.54 -0.10    -0.43    0.02
gdppcap         5 38 26962.44 11281.08 24451.07 26976.97 15730.34 9419.70 45334.11 35914.42  0.05    -1.31 1830.03
unrate          6 38     9.13     1.09     9.00     9.17     0.96     6.30    10.90     4.60 -0.24    -0.42    0.18
> describe(Germany)
             vars  n     mean       sd   median  trimmed      mad      min      max    range  skew kurtosis      se
realindices     1 38   101.18     7.35   100.90   101.16     9.27    88.88   114.83    25.94 -0.07    -1.05    1.19
intrate         2 38     5.12     2.63     5.03     5.19     2.71     0.09    10.13    10.04 -0.20    -0.92    0.43
perinc          3 38     1.63     2.06     2.02     1.73     2.00    -4.23     5.61     9.84 -0.52     0.15    0.33
popgro          4 38     0.15     0.48     0.15     0.17     0.34    -1.85     0.87     2.72 -1.62     6.01    0.08
gdppcap         5 38 28532.24 12258.18 27020.33 28585.24 14563.53 9313.17 47959.99 38646.82 -0.04    -1.26 1988.54
unrate          6 38     7.33     1.88     7.80     7.38     1.63     3.40    11.00     7.60 -0.28    -0.73    0.31
> describe(Italy)
             vars  n     mean       sd   median  trimmed      mad      min      max    range  skew kurtosis      se
realindices     1 38   104.51    17.10   103.83   104.55    18.67    73.65   135.39    61.74  0.03    -0.98    2.77
intrate         2 38     8.45     5.25     5.53     8.06     5.37     1.49    20.22    18.73  0.59    -0.87    0.85
perinc          3 38     0.96     2.24     1.29     1.11     1.97    -4.71     5.56    10.27 -0.64     0.28    0.36
popgro          4 38     0.19     0.29     0.07     0.15     0.09    -0.17     1.16     1.33  1.57     2.17    0.05
gdppcap         5 38 23575.80 10162.53 22133.88 23617.54 13290.08 7556.52 40778.34 33221.82 -0.07    -1.20 1648.58
unrate          6 38     9.30     1.69     8.90     9.29     1.78     6.10    12.60     6.50  0.17    -1.10    0.27
> describe(Japan)
             vars  n     mean       sd   median  trimmed      mad      min      max    range  skew kurtosis      se
realindices     1 38   120.00    21.03   118.23   118.34    26.92    93.67   165.86    72.19  0.51    -0.95    3.41
intrate         2 38     2.83     2.18     1.75     2.68     1.69    -0.07     8.15     8.21  0.67    -0.77    0.35
perinc          3 38     1.45     2.48     1.58     1.53     2.11    -5.28     6.64    11.92 -0.37     0.60    0.40
popgro          4 38     0.24     0.28     0.24     0.23     0.29    -0.19     0.78     0.97  0.26    -0.97    0.05
gdppcap         5 38 31381.94 11292.56 35148.47 31932.18 6160.88 9465.38 48603.48 39138.10 -0.76    -0.59 1831.90
unrate          6 38     3.50     1.05     3.40     3.47     1.33     2.00     5.40     3.40  0.24    -1.35    0.17
> describe(Spain)
             vars  n     mean       sd   median  trimmed      mad      min      max    range  skew kurtosis      se
realindices     1 38    87.83    37.30    78.67    86.10    39.37    34.71   164.25   129.54  0.38    -0.84    6.05
intrate         2 38     8.16     4.92     5.69     8.00     5.19     1.39    16.91    15.52  0.39    -1.37    0.80
perinc          3 38     1.67     2.72     1.89     1.73     2.68    -3.90     6.18    10.09 -0.26    -0.98    0.44
popgro          4 38     0.59     0.58     0.43     0.56     0.31    -0.33     1.85     2.18  0.92    -0.15    0.09
gdppcap         5 38 18208.87 9534.63 15593.65 18072.19 13827.25 4478.50 35366.26 30887.76  0.14    -1.36 1546.72
unrate          6 38    17.44     4.97    18.15    17.55     5.34     8.20    26.10    17.90 -0.27    -1.07    0.81
> describe(Switzerland)
             vars  n     mean       sd   median  trimmed      mad      min      max    range  skew kurtosis      se
realindices     1 38    80.13    12.26    77.18    79.34    12.41    65.33   104.69    39.35  0.58    -1.01    1.99
intrate         2 38     3.31     1.80     3.37     3.35     1.75    -0.36     6.45     6.81 -0.31    -0.68    0.29
perinc          3 38     0.98     3.31     1.57     1.12     2.56    -8.86     8.13    16.99 -0.50     1.04    0.54
popgro          4 38     0.78     0.30     0.74     0.78     0.41     0.24     1.27     1.03  0.10    -1.27    0.05
gdppcap         5 38 48217.23 22747.62 41436.77 47556.66 21985.96 16499.15 88415.61 71916.46  0.34    -1.14 3690.15
unrate          6 38     2.51     1.45     2.80     2.50     1.63     0.20     5.20     5.00 -0.11    -1.26    0.24
> describe(UK)
             vars  n     mean       sd   median  trimmed      mad      min      max    range  skew kurtosis      se
realindices     1 38    63.75    28.32    52.49    62.97    32.80    27.18   108.72    81.54  0.24    -1.64    4.59
intrate         2 38     6.84     3.74     5.44     6.67     4.17     1.24    14.88    13.65  0.35    -1.02    0.61
perinc          3 38     2.09     2.44     2.09     2.22     1.84    -4.71     6.28    11.00 -0.59     0.44    0.40
popgro          4 38     0.42     0.26     0.32     0.43     0.23    -0.04     0.79     0.83  0.18    -1.42    0.04
gdppcap         5 38 28579.46 13540.96 22033.95 27902.52 11916.53 11170.56 52542.35 41371.78  0.51    -1.29 2196.63
unrate          6 38     7.59     2.24     7.40     7.50     2.97     4.40    11.80     7.40  0.35    -1.19    0.36
> describe(USA)
             vars  n     mean       sd   median  trimmed      mad      min      max    range  skew kurtosis      se
realindices     1 38    85.12    15.93    80.32    84.13    17.32    64.43   118.30    53.87  0.51    -1.02    2.58
intrate         2 38     6.22     3.29     5.75     5.97     3.41     1.80    13.91    12.11  0.64    -0.52    0.53
perinc          3 38     1.81     2.12     2.25     1.90     1.53    -3.35     7.14    10.49 -0.40     0.62    0.34
popgro          4 38     0.97     0.19     0.94     0.96     0.14     0.63     1.39     0.76  0.39    -0.61    0.03
gdppcap         5 38 34731.30 14244.21 33683.62 34505.29 19297.13 12574.79 59927.93 47353.14  0.12    -1.34 2310.72
unrate          6 38     6.33     1.62     5.90     6.22     1.70     4.00     9.70     5.70  0.62    -0.65    0.26
```

7.3 Appendix 3: Summary Statistics Low-Income Countries

```
> summary(France)
  realindices        intrate           perinc            popgro           gdppcap          unrate      
 Min.   : 45.95   Min.   : 0.4679   Min.   :-4.1536   Min.   :0.2154   Min.   : 9420   Min.   : 6.300  
 1st Qu.: 53.62   1st Qu.: 3.6855   1st Qu.: 0.2016   1st Qu.:0.4515   1st Qu.:18690   1st Qu.: 8.500  
 Median : 59.86   Median : 5.1670   Median : 1.4828   Median :0.5146   Median :24451   Median : 9.000  
 Mean   : 72.84   Mean   : 6.5842   Mean   : 1.2220   Mean   :0.5180   Mean   :26962   Mean   : 9.132  
 3rd Qu.:100.93   3rd Qu.: 9.0726   3rd Qu.: 2.1716   3rd Qu.:0.5655   3rd Qu.:36875   3rd Qu.:10.225  
 Max.   :109.25   Max.   :16.2917   Max.   : 4.8256   Max.   :0.7538   Max.   :45334   Max.   :10.900  
> summary(Italy)
  realindices        intrate           perinc            popgro            gdppcap          unrate      
 Min.   : 73.65   Min.   : 1.486   Min.   :-4.7144   Min.   :-0.16988   Min.   : 7557   Min.   : 6.10  
 1st Qu.: 93.58   1st Qu.: 4.312   1st Qu.:-0.1842   1st Qu.: 0.02827   1st Qu.:16975   1st Qu.: 8.05  
 Median :103.83   Median : 5.534   Median : 1.2888   Median : 0.06858   Median :22134   Median : 8.90  
 Mean   :104.51   Mean   : 8.448   Mean   : 0.9589   Mean   : 0.19011   Mean   :23576   Mean   : 9.30  
 3rd Qu.:117.44   3rd Qu.:12.644   3rd Qu.: 2.1761   3rd Qu.: 0.29281   3rd Qu.:32256   3rd Qu.:10.85  
 Max.   :135.39   Max.   :20.220   Max.   : 5.5555   Max.   : 1.15925   Max.   :40778   Max.   :12.60  
> summary(Spain)
  realindices        intrate           perinc            popgro            gdppcap          unrate      
 Min.   : 34.71   Min.   : 1.393   Min.   :-3.90149   Min.   :-0.3277   Min.   : 4478   Min.   : 8.20  
 1st Qu.: 70.22   1st Qu.: 4.264   1st Qu.: 0.04532   1st Qu.: 0.2557   1st Qu.:11346   1st Qu.:13.82  
 Median : 78.67   Median : 5.686   Median : 1.88644   Median : 0.4302   Median :15594   Median :18.15  
 Mean   : 87.83   Mean   : 8.161   Mean   : 1.66698   Mean   : 0.5931   Mean   :18209   Mean   :17.44  
 3rd Qu.:108.63   3rd Qu.:12.206   3rd Qu.: 3.55673   3rd Qu.: 0.7067   3rd Qu.:27702   3rd Qu.:21.20  
 Max.   :164.25   Max.   :16.909   Max.   : 6.18378   Max.   : 1.8511   Max.   :35366   Max.   :26.10  
```

7.4 Appendix 4: Multiple Linear Regression Cross-Country

```
> summary(Australia)

Call:
lm(formula = realindices ~ unrate + gdppcap + popgro + perinc + 
    intrate, data = MLR)

Residuals:
     Min       1Q   Median       3Q      Max 
-14.5511  -3.2430  -0.2777   4.3151  21.6297 

Coefficients:
             Estimate Std. Error t value Pr(>|t|)    
(Intercept) 80.8188933 12.8613976   6.284 4.78e-07 ***
unrate      -3.1845605  0.9627452  -3.308 0.002331 ** 
gdppcap      0.0005902  0.0001437   4.107 0.000259 ***
popgro       3.4273013  5.4490152   0.629 0.533829    
perinc      -1.4561890  0.7102523  -2.050 0.048608 *  
intrate     -2.4937674  0.5928763  -4.206 0.000196 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 7.53 on 32 degrees of freedom
Multiple R-squared:   0.92,     Adjusted R-squared:  0.9075 
F-statistic: 73.58 on 5 and 32 DF,  p-value: < 2.2e-16
```

```
> summary(Canada)

Call:
lm(formula = realindices ~ unrate + gdppcap + popgro + perinc + 
    intrate, data = MLR)

Residuals:
   Min     1Q Median     3Q    Max 
-7.992 -4.820 -2.675  1.412 30.362 

Coefficients:
             Estimate Std. Error t value Pr(>|t|)    
(Intercept) 22.748887  18.293237   1.244   0.2227    
unrate      -0.274891   1.187039  -0.232   0.8183    
gdppcap      0.001200   0.000233   5.148 1.29e-05 ***
popgro      16.150037   9.017932   1.791   0.0828 .  
perinc      -0.344254   0.556149  -0.619   0.5403    
intrate     -1.393514   0.888450  -1.568   0.1266    
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 8.546 on 32 degrees of freedom
Multiple R-squared:  0.8728,    Adjusted R-squared:  0.8529 
F-statistic: 43.92 on 5 and 32 DF,  p-value: 2.087e-13
```

```
> summary(France)

Call:
lm(formula = realindices ~ unrate + gdppcap + popgro + perinc + 
    intrate, data = MLR)

Residuals:
     Min       1Q   Median       3Q      Max 
-14.6067  -4.1748   0.2164   5.3822  12.4701 

Coefficients:
             Estimate Std. Error t value Pr(>|t|)    
(Intercept) 89.4411957 26.5977440   3.363 0.002014 ** 
unrate      -6.8735191  1.6839912  -4.082 0.000278 ***
gdppcap      0.0020087  0.0002586   7.767  7.4e-09 ***
popgro      -9.7315112 10.8170432  -0.900 0.375029    
perinc      -0.0722354  0.7617263  -0.095 0.925040    
intrate     -0.4357298  0.7551733  -0.577 0.567981    
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 7.031 on 32 degrees of freedom
Multiple R-squared:  0.9241,    Adjusted R-squared:  0.9122 
F-statistic: 77.91 on 5 and 32 DF,  p-value: < 2.2e-16
```

```
> summary(Germany)

Call:
lm(formula = realindices ~ unrate + gdppcap + popgro + perinc + 
    intrate, data = MLR)

Residuals:
    Min      1Q  Median      3Q     Max 
-8.2312 -3.8063 -0.5918  2.6597 12.5277 

Coefficients:
             Estimate Std. Error t value Pr(>|t|)    
(Intercept)  1.130e+02  7.996e+00  14.131 2.63e-15 ***
unrate      -1.086e+00  4.815e-01  -2.256   0.0310 *  
gdppcap     -2.436e-04  1.383e-04  -1.762   0.0877 .  
popgro       4.386e+00  1.910e+00   2.296   0.0284 *  
perinc      -3.591e-01  4.249e-01  -0.845   0.4044    
intrate      5.922e-01  6.442e-01   0.919   0.3649    
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 5.222 on 32 degrees of freedom
Multiple R-squared:  0.5635,    Adjusted R-squared:  0.4953 
F-statistic: 8.262 on 5 and 32 DF,  p-value: 4.235e-05
```

```
> summary(Italy)

Call:
lm(formula = realindices ~ unrate + gdppcap + popgro + perinc +
    intrate, data = MLR)

Residuals:
    Min      1Q  Median      3Q     Max
-11.468  -5.647   1.644   4.865   9.738

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) 85.4161394 12.9324351   6.605 1.91e-07 ***
unrate      -3.5597620  0.7154177  -4.976 2.13e-05 ***
gdppcap      0.0017598  0.0002665   6.603 1.92e-07 ***
popgro      -4.2604469  4.9521578  -0.860  0.39601
perinc      -1.8570673  0.7125451  -2.606  0.01378 *
intrate      1.5745461  0.4473394   3.520  0.00132 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 6.546 on 32 degrees of freedom
Multiple R-squared:  0.8733,    Adjusted R-squared:  0.8535
F-statistic: 44.12 on 5 and 32 DF,  p-value: 1.96e-13
```

```
> summary(Japan)

Call:
lm(formula = realindices ~ unrate + gdppcap + popgro + perinc +
    intrate, data = MLR)

Residuals:
    Min      1Q  Median      3Q     Max
-34.264  -7.388  -1.250   9.751  24.263

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) 61.2691209 22.9790803   2.666 0.011925 *
unrate      -8.2956653  4.0603008  -2.043 0.049349 *
gdppcap      0.0019995  0.0005058   3.953 0.000399 ***
popgro      67.1371624 24.4355998   2.748 0.009781 **
perinc       1.0115440  1.0855612   0.932 0.358409
intrate      2.6956154  2.5765405   1.046 0.303300
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 15.03 on 32 degrees of freedom
Multiple R-squared:  0.5585,    Adjusted R-squared:  0.4895
F-statistic: 8.094 on 5 and 32 DF,  p-value: 5.029e-05
```

```
> summary(Spain)

Call:
lm(formula = realindices ~ unrate + gdppcap + popgro + perinc +
    intrate, data = MLR)

Residuals:
    Min      1Q  Median      3Q     Max
-12.815  -4.142  -1.004   3.880  16.468

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  6.4762230 13.5448521   0.478 0.635807
unrate      -0.6578229  0.4341053  -1.515 0.139500
gdppcap      0.0040045  0.0002834  14.128 2.65e-15 ***
popgro      15.1013213  3.8658064   3.906 0.000455 ***
perinc       1.3929305  0.5484222   2.540 0.016144 *
intrate      1.0573305  0.5205337   2.031 0.050606 .
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 7.252 on 32 degrees of freedom
Multiple R-squared:  0.9673,    Adjusted R-squared:  0.9622
F-statistic: 189.3 on 5 and 32 DF,  p-value: < 2.2e-16
```

```
> summary(Switzerland)

Call:
lm(formula = realindices ~ unrate + gdppcap + popgro + perinc +
    intrate, data = MLR)

Residuals:
     Min       1Q   Median       3Q      Max
-14.3604  -5.8455   0.6684   4.9564  19.4377

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) 65.4632291 11.7718430   5.561 3.88e-06 ***
unrate      -3.7331056  1.5727812  -2.374   0.0238 *
gdppcap      0.0001514  0.0002656   0.570   0.5726
popgro      22.0145255 10.9492838   2.011   0.0529 .
perinc       0.4755325  0.4939490   0.963   0.3429
intrate     -0.2375398  2.0801807  -0.114   0.9098
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 8.985 on 32 degrees of freedom
Multiple R-squared:  0.5355,    Adjusted R-squared:  0.4629
F-statistic: 7.378 on 5 and 32 DF,  p-value: 0.0001069
```

```
> summary(UK)

Call:
lm(formula = realindices ~ unrate + gdppcap + popgro + perinc +
    intrate, data = MLR)

Residuals:
    Min      1Q  Median      3Q     Max
-9.2284 -4.2743 -0.9916  3.4897 11.9842

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) 37.3545085 10.8896226   3.430  0.00168 **
unrate      -3.1659629  0.6644608  -4.765 3.93e-05 ***
gdppcap      0.0004491  0.0002755   1.630  0.11292
popgro      75.8980762 15.6118302   4.862 2.97e-05 ***
perinc       0.3347377  0.5500300   0.609  0.54710
intrate      0.7013177  0.7573379   0.926  0.36136
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 6.095 on 32 degrees of freedom
Multiple R-squared:  0.9599,    Adjusted R-squared:  0.9537
F-statistic: 153.4 on 5 and 32 DF,  p-value: < 2.2e-16
```

```
> summary(USA)

Call:
lm(formula = realindices ~ unrate + gdppcap + popgro + perinc +
    intrate, data = MLR)

Residuals:
   Min     1Q Median     3Q    Max
-8.374 -5.062 -2.133  2.855 18.658

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) 63.6743841 26.5425532   2.399  0.02244 *
unrate      -2.7252371  0.8639833  -3.154  0.00349 **
gdppcap      0.0010951  0.0003161   3.465  0.00153 **
popgro      -5.3851716  9.3818411  -0.574  0.56998
perinc      -1.3195544  0.6048460  -2.182  0.03659 *
intrate      1.3282387  1.2166331   1.092  0.28310
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 7.471 on 32 degrees of freedom
Multiple R-squared:  0.8097,    Adjusted R-squared:  0.7799
F-statistic: 27.23 on 5 and 32 DF,  p-value: 1.188e-10
```

7.5 Appendix 5: Fixed Effects

Comparing Pooled and Fixed-Effects

	Dependent variable:					
	Real House Price Indices					
	pooled OLS					With Fixed Effects
	(1)	(2)	(3)	(4)	(5)	(6)
Interest rate	-3.604***					-4.654***
	(0.251)					(0.593)
National income per capita		-1.927***				-0.983**
		(0.473)				(0.402)
Population growth			25.998***			6.255**
			(3.340)			(3.008)
GDP per capita				0.001***		0.001***
				(0.0001)		(0.0002)
Unemployment rate					-4.147***	-2.620***
					(0.482)	(0.456)
Year 1980						12.223*
						(6.595)
Year 1981						11.874*
						(6.615)
Year 1982						8.387
						(6.670)
Year 1983						8.122
						(6.810)
Year 1984						1.984
						(6.859)
Year 1985						-5.560
						(7.160)
Year 1986						-4.459
						(7.161)
Year 1987						-1.318
						(7.346)
Year 1988						4.793
						(7.020)
Year 1989						8.902
						(6.942)
Year 1990						3.933
						(7.131)
Year 1991						-0.098
						(7.423)
Year 1992						-6.025
						(7.849)
Year 1993						-3.644
						(7.868)
Year 1994						-7.684
						(7.971)
Year 1995						-14.728*
						(8.216)
Year 1996						-18.866**
						(8.481)
Year 1997						-24.578***
						(8.804)
Year 1998						-25.571***
						(8.723)
Year 1999						-22.860***
						(8.473)
Year 2000						-26.233***

Year 2001						-23.015***
						(8.590)
Year 2002						-22.697**
						(9.136)
Year 2003						-20.186**
						(9.446)
Year 2004						-20.867**
						(9.750)
Year 2005						-17.537*
						(9.783)
Year 2006						-17.477*
						(10.042)
Year 2007						-27.808***
						(10.515)
Year 2008						-25.336**
						(10.545)
Year 2009						-20.975*
						(10.984)
Year 2010						-26.945**
						(11.627)
Year 2011						-32.467***
						(11.681)
Year 2012						-33.431***
						(11.704)
Year 2013						-33.615***
						(11.788)
Year 2014						-30.496***
						(11.573)
Year 2015						-30.482***
						(11.617)
Year 2016						-26.552**
						(11.690)
Observations	380	380	380	380	380	380
R^2	0.358	0.043	0.141	0.375	0.167	0.628
Adjusted R^2	0.341	0.017	0.118	0.359	0.144	0.571
F Statistic	205.776*** (df = 1; 369)	16.581*** (df = 1; 369)	60.579*** (df = 1; 369)	221.817*** (df = 1; 369)	73.956*** (df = 1; 369)	13.204*** (df = 42; 328)
Note:						*p<0.1; **p<0.05; ***p<0.01

7.6 Appendix 6: Country-Specific Fixed Effects using Dummy Variables

```
> summary(fixed.dum)

Call:
lm(formula = realindices ~ intrate + perinc + popgro + gdppcap +
    unrate + factor(country) - 1, data = countries)

Residuals:
    Min      1Q  Median      3Q     Max
-48.056  -8.703  -0.971   9.183  51.895

Coefficients:
                              Estimate Std. Error t value Pr(>|t|)
intrate                     -1.957e+00  3.169e-01  -6.177 1.75e-09 ***
perinc                      -8.067e-01  3.373e-01  -2.392  0.01727 *
popgro                       1.069e+01  2.814e+00   3.799  0.00017 ***
gdppcap                      4.752e-04  8.513e-05   5.582 4.65e-08 ***
unrate                      -2.677e+00  4.038e-01  -6.629 1.22e-10 ***
factor(country)Australia     6.505e+01  7.664e+00   8.488 5.35e-16 ***
factor(country)Canada        7.383e+01  7.185e+00  10.276  < 2e-16 ***
factor(country)France        9.280e+01  6.438e+00  14.414  < 2e-16 ***
factor(country)Germany       1.170e+02  5.483e+00  21.338  < 2e-16 ***
factor(country)Italy         1.335e+02  6.274e+00  21.274  < 2e-16 ***
factor(country)Japan         1.186e+02  4.566e+00  25.982  < 2e-16 ***
factor(country)Spain         1.368e+02  9.010e+00  15.188  < 2e-16 ***
factor(country)Switzerland   6.293e+01  6.024e+00  10.447  < 2e-16 ***
factor(country)United Kingdom 8.105e+01  6.168e+00  13.140  < 2e-16 ***
factor(country)United States  8.885e+01  6.771e+00  13.121  < 2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 14.98 on 365 degrees of freedom
Multiple R-squared:  0.9725,    Adjusted R-squared:  0.9714
F-statistic: 861.6 on 15 and 365 DF,  p-value: < 2.2e-16
```

7.7 Appendix 7: Country-Specific Correlation Matrix

```
> AUS <- read_excel("Documents/SE6_ZHAW/Bachelor Thesis/Countries seperate for R/Australia.xlsx")
> cor(AUS, use = "complete.obs", method = "spearman")

             realindices     intrate       perinc     popgro     gdppcap     unrate
realindices  1.000000000 -0.93390962 -0.007112376  0.2611883  0.92909509 -0.7225237
intrate     -0.933909618  1.00000000 -0.023963234 -0.1559252 -0.91311960  0.6183673
perinc      -0.007112376 -0.02396323  1.000000000 -0.1832804  0.02965313 -0.1329610
popgro       0.261188314 -0.15592516 -0.183280446  1.0000000  0.23164460 -0.4396256
gdppcap      0.929095087 -0.91311960  0.029653135  0.2316446  1.00000000 -0.6652432
unrate      -0.722523724  0.61836728 -0.132961013 -0.4396256 -0.66524316  1.0000000
>
> CAN <- read_excel("Documents/SE6_ZHAW/Bachelor Thesis/Countries seperate for R/Canada.xlsx")
> cor(CAN, use = "complete.obs", method = "spearman")

            realindices     intrate      perinc      popgro     gdppcap      unrate
realindices  1.00000000 -0.88160630 -0.15286136  0.02615166  0.89232958 -0.66765241
intrate     -0.88160630  1.00000000  0.03753146  0.29992341 -0.93325309  0.66513379
perinc      -0.15286136  0.03753146  1.00000000 -0.40781267 -0.01586607 -0.06504601
popgro       0.02615166  0.29992341 -0.40781267  1.00000000 -0.23470839  0.14991244
gdppcap      0.89232958 -0.93325309 -0.01586607 -0.23470839  1.00000000 -0.69853284
unrate      -0.66765241  0.66513379 -0.06504601  0.14991244 -0.69853284  1.00000000
>
> FRA <- read_excel("Documents/SE6_ZHAW/Bachelor Thesis/Countries seperate for R/France.xlsx")
> cor(FRA, use = "complete.obs", method = "spearman")

             realindices     intrate      perinc      popgro    gdppcap       unrate
realindices  1.000000000 -0.80829412 -0.28197833  0.04978663  0.8540322  0.007887823
intrate     -0.808294124  1.00000000  0.09880731  0.15964548 -0.9089616 -0.453549847
perinc      -0.281978335  0.09880731  1.00000000 -0.05503884 -0.1683992  0.297327122
popgro       0.049786629  0.15964548 -0.05503884  1.00000000 -0.1918153 -0.595859328
gdppcap      0.854032170 -0.90896159 -0.16839917 -0.19181530  1.0000000  0.380368374
unrate       0.007887823 -0.45354985  0.29732712 -0.59585933  0.3803684  1.000000000
>
> DEU <- read_excel("Documents/SE6_ZHAW/Bachelor Thesis/Countries seperate for R/Germany.xlsx")
> cor(DEU, use = "complete.obs", method = "spearman")

            realindices     intrate      perinc      popgro     gdppcap      unrate
realindices   1.0000000  0.59601707 -0.22420396  0.41656636 -0.50672940 -0.17263676
intrate       0.5960171  1.00000000 -0.03140387  0.05744611 -0.86891345  0.06386245
perinc       -0.2242040 -0.03140387  1.00000000 -0.09486815 -0.04628515  0.08730425
popgro        0.4165664  0.05744611 -0.09486815  1.00000000  0.04015757 -0.44605131
gdppcap      -0.5067294 -0.86891345 -0.04628515  0.04015757  1.00000000 -0.10833614
unrate       -0.1726368  0.06386245  0.08730425 -0.44605131 -0.10833614  1.00000000
```

```
> ITA <- read_excel("Documents/SE6_ZHAW/Bachelor Thesis/Countries seperate for R/Italy.xlsx")
> cor(ITA, use = "complete.obs", method = "spearman")
            realindices    intrate     perinc     popgro     gdppcap      unrate
realindices   1.0000000 -0.3675457 -0.7875041  0.7290732  0.67304957 -0.42480984
intrate      -0.3675457  1.0000000  0.2716927 -0.2220155 -0.80326075 -0.27754973
perinc       -0.7875041  0.2716927  1.0000000 -0.7463617 -0.55049787  0.30185586
popgro        0.7290732 -0.2220155 -0.7463617  1.0000000  0.50235255 -0.45426187
gdppcap       0.6730496 -0.8032608 -0.5504979  0.5023526  1.00000000  0.07149506
unrate       -0.4248098 -0.2775497  0.3018559 -0.4542619  0.07149506  1.00000000
>
> JPN <- read_excel("Documents/SE6_ZHAW/Bachelor Thesis/Countries seperate for R/Japan.xlsx")
> cor(JPN, use = "complete.obs", method = "spearman")
            realindices    intrate     perinc     popgro    gdppcap     unrate
realindices   1.0000000  0.6320512  0.1837181  0.6017070 -0.4047489 -0.5164013
intrate       0.6320512  1.0000000  0.1410516  0.8802320 -0.6703507 -0.7357615
perinc        0.1837181  0.1410516  1.0000000  0.2296750 -0.1775905 -0.2823505
popgro        0.6017070  0.8802320  0.2296750  1.0000000 -0.8071999 -0.6449814
gdppcap      -0.4047489 -0.6703507 -0.1775905 -0.8071999  1.0000000  0.6174911
unrate       -0.5164013 -0.7357615 -0.2823505 -0.6449814  0.6174911  1.0000000
>
> ESP <- read_excel("Documents/SE6_ZHAW/Bachelor Thesis/Countries seperate for R/Spain.xlsx")
> cor(ESP, use = "complete.obs", method = "spearman")
            realindices     intrate      perinc      popgro     gdppcap      unrate
realindices   1.0000000 -0.82755225 -0.31371047  0.22267206  0.92406171 -0.27542422
intrate      -0.8275522  1.00000000  0.07867382 -0.06773170 -0.84046395  0.08768474
perinc       -0.3137105  0.07867382  1.00000000 -0.43363607 -0.32377722  0.08100712
popgro        0.2226721 -0.06773170 -0.43363607  1.00000000  0.07692308 -0.68221134
gdppcap       0.9240617 -0.84046395 -0.32377722  0.07692308  1.00000000 -0.03765737
unrate       -0.2754242  0.08768474  0.08100712 -0.68221134 -0.03765737  1.00000000


> CHE <- read_excel("Documents/SE6_ZHAW/Bachelor Thesis/Countries seperate for R/Switzerland.xlsx")
> cor(CHE, use = "complete.obs", method = "spearman")
            realindices     intrate      perinc     popgro    gdppcap     unrate
realindices   1.0000000 -0.11565817 -0.22639238  0.6533538  0.3069264 -0.1370703
intrate      -0.1156582  1.00000000 -0.01477186 -0.3618558 -0.8332421 -0.4920080
perinc       -0.2263924 -0.01477186  1.00000000 -0.3644819 -0.1375424  0.2307861
popgro        0.6533538 -0.36185578 -0.36448189  1.0000000  0.6537914  0.1332385
gdppcap       0.3069264 -0.83324215 -0.13754240  0.6537914  1.0000000  0.6110139
unrate       -0.1370703 -0.49200796  0.23078611  0.1332385  0.6110139  1.0000000
>
> GBR <- read_excel("Documents/SE6_ZHAW/Bachelor Thesis/Countries seperate for R/United Kingdom.xlsx")
> cor(GBR, use = "complete.obs", method = "spearman")
            realindices    intrate     perinc     popgro    gdppcap     unrate
realindices   1.0000000 -0.8719772 -0.2951089  0.9363169  0.9034905 -0.7999782
intrate      -0.8719772  1.0000000  0.1436700 -0.8824817 -0.9207791  0.6583097
perinc       -0.2951089  0.1436700  1.0000000 -0.3752052 -0.3185250  0.1018174
popgro        0.9363169 -0.8824817 -0.3752052  1.0000000  0.9457271 -0.6795490
gdppcap       0.9034905 -0.9207791 -0.3185250  0.9457271  1.0000000 -0.6350997
unrate       -0.7999782  0.6583097  0.1018174 -0.6795490 -0.6350997  1.0000000
>
> USA <- read_excel("Documents/SE6_ZHAW/Bachelor Thesis/Countries seperate for R/United States.xlsx")
> cor(USA, use = "complete.obs", method = "spearman")
            realindices    intrate       perinc       popgro    gdppcap      unrate
realindices   1.0000000 -0.8343364 -0.249808513 -0.384396542  0.8772295 -0.51502719
intrate      -0.8343364  1.0000000  0.192034139  0.512638144 -0.9765839  0.22620029
perinc       -0.2498085  0.1920341  1.000000000  0.001641317 -0.1878761 -0.08167736
popgro       -0.3843965  0.5126381  0.001641317  1.000000000 -0.4903162 -0.23025131
gdppcap       0.8772295 -0.9765839 -0.187876135 -0.490316227  1.0000000 -0.31061483
unrate       -0.5150272  0.2262003 -0.081677356 -0.230251315 -0.3106148  1.00000000
```

7.8 Appendix 8: RStudio Codes

Descriptive Statistics

```
manodata <- read_excel("Documents/SE6_ZHAW/Bachelor Thesis/EmpPanel.xlsx")
attach(manodata)
Y <- cbind(realindices)
X <- cbind(intrate, perinc, popgro, consinf, gdppcap, unrate)
describe(manodata)
describe(Y)
describe(X)
#overview house price indices to years all countries in one
ggplot(manodata, aes(x=year, y= realindices, group=year, color=country)) +
  geom_line() +
  xlab("Years 1980-2017") + ylab("Real House Price Indices 100=2015") + labs(fill = "")
#overview house price indices to years in countries separately
ggplot(manodata, aes(x=year, y=realindices, group=country, color=country)) +
  geom_line() +
  facet_wrap(~ country) +
  ggtitle("Real House Price Indices") +
  xlab("years 1980-2017") + ylab("Index 100=2015") + labs(fill ="")
#Multilevel Scatterplot

ggplot(manodata, aes(x=gdppcap, y=realindices, colour=country)) +

  geom_point(alpha=0.4, colour="cornflowerblue") +

  geom_smooth(method ="lm")+

  xlab("GDP per Capita in USD") + ylab("Real House Price Indices")
```

Panel Data analysis

```
#Fixed Effects model
fixed <- plm(data= pdata, realindices ~  intrate + perinc + popgro + gdppcap + unrate, model = "within")
summary(fixed)
#Random Effects model
random <- plm(data= pdata, realindices ~  intrate + perinc + popgro + gdppcap + unrate, model = "random")
summary(random)
#Hausman test for FE versus RE model decision
phtest(random, fixed)
#visualization option poold OLS and fixed effects with stargazer
stargazer(fe,fe1,fe2,fe3,fe4,fixedall, type="html", out = "Desktop/fixedeffectyear.htm",
        dep.var.labels = c("Real House Price Indices"),
```

column.labels = c("", "", "pooled OLS", "", "", "With Fixed Effects"),title="Comparing Pooled and Fixed-Effects",

omit="as.factor",

covariate.labels = c("Interest rate", "National income per capita", "Population growth", "GDP per capita", "Unemployment rate",

"Year 1980", "Year 1981", "Year 1982", "Year 1983", "Year 1984", "Year 1985", "Year 1986", "Year 1987", "Year 1988", "Year 1989", "Year 1990", "Year 1991", "Year 1992", "Year 1993", "Year 1994","Year 1995", "Year 1996", "Year 1997", "Year 1998","Year 1999", "Year 2000", "Year 2001", "Year 2002", "Year 2003", "Year 2004", "Year 2005","Year 2006", "Year 2007", "Year 2008", "Year 2009", "Year 2010", "Year 2011", "Year 2012", "Year 2013","Year 2014", "Year 2015", "Year 2016", "Year 2017"))

Correlation Matrix

```
library(readxl)

library(corrplot)

Countryset <- read_excel("Documents/SE6_ZHAW/Bachelor Thesis/Countries seperate for R/Australia.xlsx")

#correlation matrix in numbers

cor(Countryset, use = "complete.obs", method = "spearman")

#correlation matrix half numbers half colorcorrplot

forcorrplot <- cor(Countryset)

corrplot.mixed(forcorrplot, lower.col = "black", number.cex= .7)
```