

DISAGGREGATING HOUSING MARKET DYNAMICS: EVIDENCE FROM A STOCK-FLOW MODEL
USING REGIONAL DATA ACROSS GERMANY

by

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ABSTRACT

DISAGGREGATING HOUSING MARKET DYNAMICS: EVIDENCE FROM A STOCK-FLOW MODEL USING REGIONAL DATA ACROSS GERMANY

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This Dissertation analyses the determining factors, segmentations and fundamental valuations of the German residential real estate market through the application of an advanced Stock-Flow-Model to data collected from different regions across Germany during the period from 2008 to 2024. The aim of this dissertation is to outline the intricate relationships between supply, demand, demographic changes, macroeconomic fluctuations and ongoing adjustments to policy and environmental standards to analyse its influence on the price formation within the German housing markets.

The study addresses three fundamental research questions concerning price determinants, market segment differentiation, and alignment with essential values. The methodological foundation of this dissertation rests upon the Stock-Flow Model, an advanced analytical framework employed to deconstruct the intricate dynamics of residential property valuation within the German context.

The results show that a strong negative influence on housing prices was consistently found to be exerted by interest rates across all model specifications. On the other hand, income consistently shown positive effects across models, though with varying degrees of magnitude. Single family homes have shown a higher income elasticity as they are considered a luxury consumer good. Demographic factors exhibited complex and sometimes counterintuitive effects on a regional basis.

Through its systematic comparison between different econometric approaches the dissertation makes several important methodological contributions to research around housing economics, and reveals the critical importance of addressing endogeneity concerns in housing market analysis.

This dissertation provides comprehensive empirical evidence of systematic segmentation within the German housing market, demonstrating that apartments and single-family homes operate as distinct market segments with different price determination mechanisms, economic sensitivities, and adjustment dynamics. The findings fundamentally challenge the common practice of treating housing markets as homogeneous and provide strong empirical support for differentiated analytical and policy approaches.

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CHAPTER I: INTRODUCTION

1.1 Background

The exploration of the dynamics governing house prices within Germany is widely recognised as a critical domain of academic research, underscoring the significant role of the housing market in maintaining financial stability and fostering economic growth. The study titled " Disaggregating Housing Market Dynamics: Evidence from a Stock-Flow Model Using Regional Data Across Germany " seeks to rigorously analyse the fluctuations in house prices through the application of an advanced Stock-Flow Model to data collected from various regions across Germany.

This research is propelled by the urgent necessity to disentangle the intricate interplay between supply and demand factors that influence residential real estate prices, especially in the context of demographic shifts, economic fluctuations, and continuous adjustments to policy and environmental standards. Demographic changes, including the ageing population, urbanisation trends, and migration patterns, significantly alter the demand for housing (Brombach et al., 201, pp. 281-285; Kuchler et al. 2023, pp. 163-167). Additionally, economic variables such as interest rates, income levels, and employment rates play a crucial role in shaping housing market dynamics (McQuinn/O'Reilly 2008, pp. 377-382; Wood/Stockhammer 2020, pp. 1-5).

The complexity of these interactions is further heightened by evolving policy measures and environmental regulations aimed at promoting sustainable development and mitigating climate change. Policies concerning housing subsidies, zoning laws, and energy efficiency standards directly impact both the supply and demand sides of the housing market (Rehdanz 2007, pp. 167-171). Understanding these multifaceted relationships is

essential for developing effective housing policies that can stabilise the market and support sustainable economic development.

Furthermore, this research delves into the regional variations within Germany, acknowledging that housing market dynamics can differ significantly across various locales due to unique regional economic conditions, population density, and local policy environments (Kholodilin 2020a, pp. 32-37; Kaas et al. 2020, pp. 128-132). By employing the Stock-Flow Model, this study offers a detailed examination of the equilibrium between housing supply and demand, providing insights into how different factors contribute to price fluctuations in distinct regions.

The insights gained from this research are not only academically enriching but also have practical implications for policymakers and market participants. A comprehensive understanding of the determinants of house prices can guide the formulation of policies that enhance market stability, affordability, and accessibility. Policymakers can leverage these findings to design interventions that address regional disparities, promote balanced development, and ensure that housing markets are resilient to economic and demographic changes.

1.2 Research Problem and Objectives

Over the past two years, the empirical findings indicate that prices for single-family homes in Germany have generally aligned with their fundamental equilibrium levels. In contrast, apartment prices have significantly exceeded the fundamental prices suggested by the model. This overvaluation is especially pronounced in urban areas, with the seven major cities experiencing the most significant discrepancies. The model reveals that while single-family homes in urban settings are only moderately above their fundamental levels, the overvaluation of apartments is stark, reflecting heightened demand pressures and

supply constraints in these densely populated areas. The distinct divergence in price dynamics between single-family homes and apartments underscores the heterogeneity of the German housing market. In major urban centres, factors such as limited land availability, stringent zoning regulations, and high demand from both domestic and international buyers contribute to the pronounced overvaluation of apartments. These findings highlight the critical need for targeted policy interventions that address the unique supply and demand conditions of different housing segments and regions (Kajuth et al. 2013).

From a macroeconomic perspective, house prices hold substantial significance due to their multifaceted impact on various economic dimensions. Primarily, house prices serve as allocative signals for residential investment, thereby influencing business cycle dynamics and long-term economic growth. House prices also affect household wealth, which in turn impacts private consumption spending. An increase in property values generally boosts homeowners' net worth, encouraging higher consumer spending, which can stimulate economic output and potentially lead to inflationary pressures. This wealth effect underscores the interconnectedness between the housing market and broader economic activity (Leung 2023, pp. 1-6).

Moreover, given that residential properties are often heavily leveraged, fluctuations in house prices can have profound implications for financial stability. A significant downturn in the housing market can lead to widespread defaults on mortgage loans, triggering a cascade of economic distress that can jeopardise the stability of the banking sector and the broader financial system.

1.3 Research Context: Germany's Housing Market

The phenomenon of financial stability was starkly illustrated during the global financial crisis, where the collapse of housing markets in the US and several EU member states precipitated severe economic downturns. In contrast to these experiences, the German housing market exhibited a different pattern during the financial crisis. Unlike many countries that experienced pronounced boom-bust cycles in property prices, Germany's house prices remained relatively stable. There was no significant boom preceding the crisis, nor was there a dramatic decline during its aftermath. It was only with the onset of economic recovery around 2010 that residential property prices in Germany began to appreciate notably (Drechsler et al. 2022, pp. 992-998). This conservative structure is further analysed in section 1.4 in the context of price stability.

Given this context, it is imperative to investigate whether the recent uptick in house prices, especially in large urban areas, signifies the onset of an overheating housing market or if these price increases can be attributed to underlying macroeconomic factors. Factors such as low interest rates, robust economic growth, increased demand due to urbanisation, and supply constraints in urban areas could be driving these price trends. A comprehensive analysis that disentangles these influences is essential for understanding the sustainability of current price levels and for formulating appropriate policy responses to mitigate potential risks.

Economically, Germany has experienced relatively stable growth, yet it faces challenges such as fluctuating interest rates, income disparities, and employment rates, which all impact housing affordability and investment. The regulatory environment, including policies aimed at promoting sustainable development and energy efficiency, adds another layer of complexity. These regulations often necessitate significant adjustments in

the housing market, influencing construction costs and housing supply (Reher 2021, pp. 475-485).

1.4 Methodological Approach

To address these multifaceted issues, this study employs a sophisticated Stock-Flow Model meticulously applied to regional datasets. The model is chosen for its robust capacity to analyse the patterns and trends in house prices across Germany, offering granular insights into the effects of supply and demand under varying external influences. The model's strength lies in its ability to capture regional disparities and to disaggregate national trends into more meaningful local phenomena, thus providing a clearer picture of the housing market dynamics at play. By utilising this advanced methodological framework, the research aims to uncover the nuanced impacts of demographic shifts, economic variables, and regulatory changes on housing prices.

This research is situated within the evolving landscape of the housing market, where broader socio-economic and demographic trends perpetually influence the equilibrium between supply and demand. The deployment of the Stock-Flow Model is particularly apt for this study due to its robust capacity to encapsulate the complexities of these interactions across various regions in Germany. This model offers a comprehensive lens through which the convergence of multiple factors shaping the housing market can be examined in detail.

The study acknowledges the market's susceptibility to fluctuations induced by policy shifts, environmental considerations, and demographic changes. By leveraging the analytical strengths of the Stock-Flow Model, the research aims to elucidate the underlying mechanisms driving house price trends in Germany, thereby enhancing our comprehension

of the market's responsiveness to a multitude of influencing factors (Muellbauer et al. 2008: 1-10).

The significant influence of the housing market on consumer confidence, spending behaviours, and the overall economic condition is particularly pronounced within the German context. Unlike certain Anglo-Saxon economies characterised by higher volatility, Germany's housing market is marked by a conservative approach to homeownership and housing finance. This conservative stance has historically provided a unique form of stability. However, recent developments and policy alterations have prompted increased scrutiny of this perceived stability. This necessitates a thorough investigation into the potential emergence of speculative bubbles and the sustainability of current price trends (Voigtländer 2014, pp. 583-594).

The German housing market's conservative nature is reflected in its lower homeownership rates compared to other advanced economies and a higher prevalence of rental housing. This distinct market structure is influenced by various factors, including cultural attitudes towards renting versus owning, robust tenant protections, and policies that favour rental housing development (Haffner et al. 2008, pp. 217-225).

This dissertation employs a sophisticated analytical framework that integrates a diverse array of socio-economic and demographic trends, elucidating their intricate interactions with regional market dynamics and their consequent influence on housing price trajectories. Urbanisation trends and migration patterns emerge as significant factors in this analysis, exerting substantial pressure on urban housing markets. Concurrently, the research scrutinises the impact of demographic shifts, particularly the phenomenon of ageing populations, on the qualitative aspects of housing demand. Economic factors are accorded particular attention within this analytical framework, recognising their pivotal role in shaping market behaviour. The research delves into the nuanced relationships

between employment rates, income levels, and housing market dynamics. The study employs advanced econometric techniques to quantify these relationships, providing empirical evidence of the strength and direction of these economic influences on housing prices. This model not only explains current market conditions but also possesses predictive capabilities, offering insights into potential future trajectories of housing prices under various socio-economic scenarios. (Dustmann et al. 2014, pp. 167-188).

1.5 Significance of the Study / Key Contributions

The dissertation addresses, with particular acuity, the policy-driven influences that shape and modulate the housing market. Of specific interest are those policies designed to promote energy efficiency and sustainable development—initiatives that, while indisputably necessary in the context of global climate imperatives, often engender unintended consequences within the housing sector. These consequences frequently manifest as increased construction costs and potential constraints on housing supply, creating a complex interplay between environmental stewardship and market dynamics. This research endeavours to elucidate the multifaceted impacts of such policies on the intricate ecosystem of the housing market. By employing rigorous econometric analyses and drawing upon a comprehensive array of data sources, the study aims to quantify and qualify the effects of sustainability-oriented policies on various market parameters, including but not limited to construction costs, supply elasticity, and overall affordability metrics. The imperative to understand these policy-driven market dynamics stems from the recognition that effective governance in the housing sector requires a nuanced and balanced approach. This approach must simultaneously address the pressing need for environmental sustainability and the equally critical requirement for housing affordability and accessibility. By dissecting the causal relationships between policy interventions and

market outcomes, this research aspires to contribute to the development of more sophisticated and efficacious policy frameworks. These frameworks, ideally, would harmonise the often-competing objectives of environmental sustainability and housing affordability. The ultimate goal is to inform policy formulation that can navigate the delicate balance between promoting energy-efficient, sustainable housing development and ensuring a robust, accessible housing market that meets the diverse needs of the population. Such approaches would not only address immediate environmental concerns but also ensure the long-term viability and equity of the housing market, thus contributing to broader societal well-being and economic stability (Kholodilin et al. 2020b: 32-42).

1.6 Policy Relevance and Practical Implications

By critically examining the efficacy of Germany's conservative approach in an era of rapid economic and technological change, this research aims to provide valuable insights into sustainable housing market practices and their implications for long-term financial stability (Voigtländer 2014, pp. 583-594).

Through a meticulous and comprehensive literature review, these diverse perspectives are integrated to construct a robust theoretical framework. This framework serves as the foundation for the application of the Stock-Flow Model to granular regional data within the German context. The methodological approach adopted herein is deliberately designed to facilitate a nuanced and in-depth examination of price dynamics. It offers a sophisticated analysis of the market's responsiveness to a constellation of influences, ranging from macroeconomic factors to microeconomic variables and policy interventions. This analytical framework not only contributes to the existing body of knowledge but also provides a novel lens through which to view the intricate mechanics of the German housing market. By bridging theoretical constructs with empirical data, this

research aspires to offer actionable insights that can inform evidence-based policy formulation and strategic decision-making in the real estate sector. (Bourassa et al., 2019: 534 pp.).

The methodological foundation of this dissertation rests upon the Stock-Flow Model, an advanced analytical framework employed to deconstruct the intricate dynamics of residential property valuation within the German context. This model's sophistication lies in its capacity to synthesise a comprehensive array of explanatory variables with fundamental equilibrium house prices, transcending simplistic market trend observations to elucidate the underlying determinants of price fluctuations. Through the utilisation of an extensive dataset encompassing diverse housing markets across Germany, the model adeptly delineates a nuanced topography of pricing mechanisms. It accentuates the idiosyncratic characteristics of individual districts while underscoring the paramount significance of regional heterogeneity in housing market analyses (Kajuth et al., 2013). This approach not only facilitates a more granular understanding of market dynamics but also illuminates the complex interplay between localised factors and broader economic forces shaping the German residential real estate landscape (Kajuth et al. 2013, pp. 1-8).

In addition, this research contributes to the broader discourse on housing economics by providing empirical evidence on the distinct dynamics of the German housing market. It offers a nuanced perspective that acknowledges the variability across different regions and market segments, thus enriching the theoretical frameworks used to analyse housing markets globally. By emphasising the importance of regional diversity, the study underscores the need for tailored policy approaches that consider local market conditions and specific regional challenges. The practical implications of this research extend to various stakeholders, including policymakers, industry practitioners, and financial institutions. For policymakers, the insights gained from this study can guide the design of

regulatory frameworks that enhance market transparency and protect against systemic risks. For industry practitioners, the detailed analysis of price dynamics offers a strategic advantage in making informed investment decisions. Financial institutions can also benefit from the model's predictive capabilities, which can improve risk assessment and management practices.

In conclusion, this thesis, through the application of the Stock-Flow Model, provides a comprehensive analysis of the German housing market. It highlights the critical factors influencing house prices and offers valuable insights for enhancing market stability and informing policy and industry strategies. This research not only advances the understanding of housing market dynamics but also contributes to the development of practical tools for managing housing market challenges in Germany.

1.7 Structure of the Thesis

This thesis is structured into five chapters that provide an in-depth analysis of the theoretical, methodological, as well as empirical background into the evaluation of German regional house and apartment prices. Chapter 1 provides the necessary background of the research subject and outlines its practical relevancy. Chapter 2 outlines the current state of research and addresses key influencing factors of the heterogeneous German real estate market, including demographic developments, the economic framework, political uncertainties, as well as environmental aspects.

Chapter 3 introduces the methodological approach regarding the three research questions, identifying segment-specific determinants and market dynamics through the stock-flow model with regional panel data. It also outlines the applied econometric techniques. Chapter 4 gives structure to the empirical results, providing evidence regarding the economic, demographic, and structural factors that influence the German residential

real estate market and identifies the potential disequilibria that may exist in different market segments.

Chapter 5 provides a discussion of these findings in relation to each research question and puts them in context with the broader academic literature. At last, Chapter 6 summarises the main findings, discusses the effects for policy-making in this market, and offers directions for future research.

CHAPTER II:
REVIEW OF LITERATURE

2.1 Theoretical Background

2.1.1 Demographic Changes and Their Impact on the Housing Market

The housing market is an intricate and multifaceted system, influenced by a diverse array of factors that collectively shape its dynamics. Among these, demographic changes stand out as particularly influential, playing a crucial role in determining housing demand and price movements. In Germany, the residential housing market has undergone significant fluctuations over recent decades, with demographic shifts emerging as a key driver of these changes. While much of the existing research on housing markets, particularly in the United States, has focused on the impact of mortgage credit expansions, the situation in Germany is notably different. In Germany, demographic trends such as ageing populations, immigration, fertility rates, and urbanisation have had a more pronounced and direct impact on the housing market. These demographic factors have not only influenced the supply and demand for housing but have also led to significant regional disparities in house prices, reflecting the varying demographic pressures across the country. This section delves into the ways in which these demographic factors have shaped the long-term trends in residential house prices in Germany. By examining the effects of increasing life expectancy, international immigration, declining fertility rates, and the ongoing urbanisation process, we can better understand the complex interplay between population dynamics and the housing market. Each of these factors contributes uniquely to the overall landscape of the German housing market, influencing both the demand for different types of housing and the regional variations in price levels. The analysis of these demographic trends is essential for understanding the future trajectory of the housing market in Germany, as these factors are likely to continue shaping the market for years to come.

Through this exploration, we aim to provide a comprehensive overview of the critical role that demographic changes play in the evolution of housing prices in Germany, offering insights into the challenges and opportunities that lie ahead. (Greenwald/Guren, 2019, pp. 1-10).

One of the most significant demographic shifts influencing the German housing market is the ageing population, a trend that has been accelerating due to increased life expectancy and declining birth rates. Germany, like many other developed nations, is witnessing a demographic transition where the proportion of elderly individuals is rapidly growing. This ageing population exerts a dual influence on the housing market. On one hand, older adults tend to remain in their homes longer, reducing the supply of available housing. On the other hand, there is an increasing demand for age-appropriate housing solutions, such as barrier-free apartments and assisted living facilities, which are in short supply. These factors contribute to a sustained demand in certain segments of the housing market, particularly in urban areas where access to healthcare and social services is better. The impact of an ageing population on house prices is nuanced. While it is often assumed that an older population might lead to a decrease in demand, and hence lower house prices, this effect is counterbalanced by the longer duration of homeownership and the increasing need for specialised housing. Furthermore, the desire to "age in place" — where older individuals prefer to stay in their own homes rather than moving to care facilities — further amplifies this demand, particularly in regions with higher concentrations of elderly populations (Hiller/Lerbs 2016, pp. 276–291).

International immigration has been a pivotal force in mitigating the effects of demographic decline in Germany, serving as a vital counterbalance to the country's ageing population and low fertility rates. Since the early 1990s, Germany has seen significant waves of immigration, with large numbers of people arriving from Eastern Europe, the

Middle East, Africa, and, more recently, other parts of the European Union. This sustained influx of immigrants has not only bolstered population growth in a country where natural population increase has been minimal, but it has also had profound implications for the housing market, particularly in urban areas. The arrival of immigrants has revitalised housing demand across many regions, with a particularly strong impact in Germany's urban centres. The urban concentration of immigrants has significantly increased the demand for rental properties and entry-level housing, which are typically more accessible to those new to the country. Immigrants often gravitate towards rental housing due to various factors, including the temporary nature of their initial stay, financial constraints, and the complexities of navigating property ownership in a new country. As a result, the demand for rental units has surged in many cities, leading to tighter rental markets and upward pressure on rental prices. Moreover, the demand for starter homes has also grown, as immigrants who settle more permanently begin to seek homeownership, further contributing to the dynamism of the housing market. This increased demand has not only alleviated some of the pressures caused by demographic decline but has also spurred growth in the construction and real estate sectors. The need to accommodate a growing and increasingly diverse population has led to the development of new housing projects, the renovation of existing properties, and the expansion of urban infrastructure. In many cases, this has also contributed to the revitalisation of neighbourhoods that had been in decline, as new residents bring economic activity and cultural diversity to these areas (Sanchis-Guarner 2023, pp. 1-10).

The effect of immigration on house prices is multifaceted. On the one hand, increased demand from immigrants can drive up prices, particularly in already densely populated urban areas. On the other hand, immigration also contributes to the labour force, potentially stabilising or even lowering construction costs by increasing the supply of

labour in the construction industry. This dynamic can lead to a more balanced housing market, where the increased demand is met with an adequate supply of new housing. Germany's fertility rate has been below the replacement level for several decades, leading to a gradual decline in the native-born population. This trend has significant implications for household formation and housing demand. Fewer births lead to smaller household sizes and, over time, a reduced number of new household formations. However, this trend is somewhat mitigated by the increased longevity of the population, meaning that while fewer new households are being formed, existing households remain in place for longer periods (Hiller/Lerbs 2016, pp. 276-285).

The impact of low fertility rates on the housing market is complex. While it might suggest a decrease in future housing demand, the reality is that other factors, such as increased life expectancy and immigration, have offset this potential decline. Moreover, smaller household sizes can actually increase the demand for housing units, as more units are needed to accommodate the same number of people who previously lived in larger, multi-generational households. Urbanisation is another critical factor shaping the German housing market. Over the past several decades, there has been a significant migration from rural areas to cities, driven by the search for better employment opportunities, educational facilities, and healthcare services. This urban migration has led to a substantial increase in housing demand in metropolitan areas, resulting in skyrocketing house prices in cities like Berlin, Munich, and Hamburg. The regional disparities in house prices in Germany are stark, with urban areas experiencing much higher price increases compared to rural regions. This divergence is exacerbated by the limited elasticity of housing supply in urban areas, where land is scarce and regulations are stringent. Consequently, as more people move to cities, the pressure on housing markets intensifies, leading to rapid price increases that are not mirrored in less populated areas (Hiller/Lerbs 2016, pp. 276-285).

2.2 Economic and Political Uncertainties and Their Impact on Real Estate Prices

2.2.1 Effects of Macroeconomic Factors on the Housing Market

The housing market is significantly influenced by various macroeconomic factors that play a crucial role in determining housing prices, demand, and supply. Understanding these factors is essential for policymakers, investors, and real estate professionals, as they impact the stability and growth of the housing market. In the context of Germany, a country with a relatively stable economic environment, these macroeconomic factors are particularly relevant in shaping housing market trends. Interest rates are among the most influential macroeconomic factors affecting the housing market. Central banks, such as the European Central Bank (ECB), use interest rates to control inflation and stabilise the economy. Low interest rates reduce the cost of borrowing, making mortgages more affordable, which typically leads to increased demand for housing and drives up prices, especially in markets with limited supply. Conversely, higher interest rates increase borrowing costs, which can dampen housing demand and put downward pressure on prices (Strobel et al. 2020, pp. 345-355).

In Germany, the prolonged period of low interest rates following the 2008 financial crisis has contributed to significant increases in housing prices, particularly in urban areas like Berlin, Munich, and Frankfurt (Christiano et al. 2014, pp. 27-35). Since interest rates have already risen, concerns have materialised regarding a potential cooling of the housing market, as higher borrowing costs have begun to reduce affordability and dampen demand.

Furthermore, the role of real estate collateral in bank lending and financial stability has become increasingly significant. Economic crises in advanced economies often begin with a severe overvaluation of asset prices, especially in housing and commercial real estate, coupled with poor lending practices and excessive credit growth by highly leveraged lenders (Müller/Verner 2021, pp. 2-10). During periods of economic stability, the value of

non-performing loans (NPLs), including those related to real estate, remains low. However, in times of financial crisis, rising NPLs can sharply increase banks' funding costs, reducing their efficiency and profitability. This often leads to tighter lending standards, potentially resulting in a credit crunch, falling GDP, or stagnant economic growth (Müller/Verner 2021, pp. 2-10).

The interaction between the credit cycle and the real estate market thus has critical implications for financial and macroeconomic stability. In Germany, the potential rise in interest rates could exacerbate these risks, particularly if it leads to a decline in housing prices. Such a scenario could trigger a negative feedback loop where falling housing prices increase NPLs, further tightening credit conditions and amplifying the economic downturn. Real estate markets are also central to the channels of monetary transmission and the broader macroeconomic stabilisation efforts. The importance of real estate in monetary transmission has gained attention since the Global Financial Crisis (GFC), with increased focus on the role of household balance sheets and bank lending standards in determining the effectiveness of monetary policy. In the Euro area, housing is the largest component of wealth for most households, significantly influencing consumption levels. Moreover, commercial and residential investment is one of the most volatile components of aggregate demand, further underscoring the sensitivity of the housing market to macroeconomic factors like interest rates and inflation (Nocera/Roma 2017, pp. 2-8).

The financial accelerator effect, where changes in real estate prices amplify economic shocks, is a key concern in this context. The GFC demonstrated how falling real estate prices could propagate through the financial system, exacerbating economic downturns. This effect was particularly evident in countries like the United States, Spain, and Ireland, where real estate price collapses were closely linked to broader financial instability. In Germany, however, the stability of real estate prices and conservative lending

practices have so far helped mitigate the impact of the crisis, although the recent rise in interest rates is beginning to pose a challenge to this stability. Inflation is another key macroeconomic factor that affects the housing market. High inflation increases the cost of goods and services, including construction materials and labour, which can drive up housing prices.

Additionally, inflation erodes the real value of money, making long-term fixed-rate mortgages more attractive to buyers. However, as inflation has risen rapidly, central banks have already responded by increasing interest rates, which is counteracting the positive effects of inflation on housing demand. Germany has historically benefited from low and stable inflation rates, which have supported steady growth in housing prices. However, recent inflationary pressures, driven by global supply chain disruptions and rising energy costs, have raised concerns about the future trajectory of housing prices and affordability (Dorofeenko et al. 2014, pp. 194-219).

Labour market conditions, including employment rates and wage growth, are critical determinants of housing demand. A strong labour market with low unemployment and rising wages generally leads to increased housing demand, as more people can afford to buy homes. Conversely, high unemployment or stagnant wages can suppress housing demand, as fewer individuals have the financial means to purchase property. Germany's housing market has been closely linked to the health of its labour market. Regions with strong labour markets, such as Bavaria and Baden-Württemberg, have experienced robust housing demand and significant price increases. These areas, characterised by high employment rates and above-average wages, have seen some of the most dynamic housing markets in the country, while regions with weaker labour markets have generally experienced slower growth (Strobel et al. 2020, pp. 345-355).

Economic growth, typically measured by Gross Domestic Product (GDP), is another important macroeconomic factor influencing the housing market. During periods of economic expansion, consumer confidence tends to rise, leading to increased investment in housing. Economic growth is often associated with job creation, wage increases, and overall economic prosperity, all of which boost housing demand. Conversely, during economic downturns, housing demand typically declines as job insecurity and lower income levels make home purchases less attractive. Germany's housing market has generally mirrored the country's economic performance. Periods of strong GDP growth have often coincided with increased housing market activity and rising prices, particularly in economically vibrant regions. However, economic uncertainties, such as global trade tensions or geopolitical risks, could potentially slow down economic growth and, by extension, affect housing demand and prices (Dorofeenko et al. 2014, pp. 194-219).

The interplay between housing expenditure and income inequality is a crucial aspect of understanding the broader economic landscape in Germany. Since the mid-1990s, income inequality in the country has been on the rise, a trend that becomes even more pronounced when examining income after accounting for housing costs. The increasing burden of housing expenses, particularly for low-income households, has significantly exacerbated existing income disparities. This trend underscores the critical role that housing markets play in shaping economic inequality, influencing not only current living standards but also long-term wealth accumulation and social mobility. Housing costs have increasingly contributed to the widening income gap in Germany. For households in the bottom income quintile, the proportion of income allocated to housing has surged from 27% in 1993 to 39% in 2013. This shift is particularly alarming given that it has been accompanied by a decline in the savings rate for these households, dropping from a modest 2% to -1% over the same period (Dustmann et al. 2021, pp. 1709-1715). This negative

savings rate indicates that lower-income households are not only struggling to save but are also potentially accumulating debt to meet their housing needs. In stark contrast, high-income households have seen a reduction in the share of income spent on housing, with the proportion falling from 16% to 14%. This divergence highlights a growing economic divide, where housing costs are disproportionately burdening those least able to afford them, thereby exacerbating overall income inequality (Dustmann et al. 2022, pp. 1709-1721).

Hence, the impact of housing expenditure on income inequality is particularly significant because housing is a fundamental necessity. Unlike other spending that can be adjusted or postponed, housing costs are relatively inflexible, leaving low-income households with little choice but to allocate a substantial portion of their income to securing shelter. This rigidity in housing expenditure means that any increase in housing costs directly reduces the disposable income available for other essential needs, further entrenching economic disparities.

Several interrelated factors have driven the disproportionate increase in housing expenditure among Germany's low-income households. One key factor is the shift in the cost dynamics between renting and homeownership. During the 1990s, rental prices in Germany rose significantly, influenced by the privatisation of previously public housing, a reduction in the availability of social rental housing, and increasing residential mobility. These changes were particularly detrimental to low-income renters, who constitute a significant portion of the bottom income quintile. Unlike homeowners who could benefit from falling mortgage interest rates, renters faced escalating costs, which contributed to the growing inequality in income after housing expenses. Demographic changes have also played a crucial role in this trend. The number of single-person households has increased, particularly among lower-income individuals, leading to a higher per capita housing

expenditure. This demographic shift has been compounded by migration patterns, particularly the movement from East to West Germany in the 1990s and the subsequent migration of low-income individuals to more expensive urban areas during the 2000s. These trends have further increased housing costs for those already struggling financially, deepening the divide in after-housing income inequality. Moreover, the decline in real incomes among the lower-income brackets has exacerbated the situation. As housing is a necessity, declining incomes force these households to allocate an even larger share of their diminished resources to housing, leaving less for other essential expenditures and savings. This compounding effect has made housing costs a critical driver of rising income inequality in Germany (Dustmann et al. 2022, pp. 1709-1721).

The long-term implications of rising housing expenditure are particularly concerning for younger generations. Successive cohorts are facing higher levels of inequality at any given age compared to previous generations, a trend that is closely linked to housing costs. Younger individuals, especially those at the lower end of the income distribution, are spending a larger share of their income on housing and are consequently saving less than their predecessors. This trend is likely to have significant implications for future wealth accumulation, as the reduced ability to save limits opportunities for investment and homeownership, which are key drivers of wealth building. For younger, low-income individuals, the increased burden of housing costs not only reduces their current disposable income but also limits their ability to invest in assets that could appreciate over time, such as real estate. This situation poses a risk of perpetuating and even exacerbating wealth inequality across generations. As these individuals age, they may find themselves with fewer financial resources and assets compared to previous generations, leading to a widening gap in wealth and economic security between different age cohorts (Dustmann et al. 2022, pp. 1709-1721).

Germany's experience with housing expenditure and income inequality, while distinct in some ways due to its historically moderate house price increases, mirrors trends seen in other advanced economies like the United States and the United Kingdom. In these countries, housing costs have similarly contributed to widening income inequality, particularly as the burden of housing expenses falls more heavily on low-income households (Moretti, 2013; Albouy et al., 2016). Germany's housing market is characterised by a higher proportion of renters, especially among low-income families, and stricter mortgage regulations that have traditionally kept homeownership rates lower than in the US or UK. Despite these differences, the rising share of housing expenditure among renters in Germany parallels trends in these other countries, underscoring a common challenge across different housing market structures. The findings highlight the need for targeted policy interventions to address the growing housing affordability crisis, particularly for low-income households. Without such measures, the ongoing increase in housing expenditure is likely to continue driving income inequality, limiting social mobility, and entrenching wealth disparities. Policymakers could consider a range of strategies, including expanding affordable housing supply, strengthening rent controls, and providing targeted support to low-income renters and prospective homeowners. These interventions could help mitigate the impact of rising housing costs on income inequality and promote more equitable economic outcomes across the population (Dustmann et al. 2022, pp. 1709-1721).

Government fiscal and monetary policies also play a significant role in shaping the housing market. Fiscal policies, such as government spending and taxation, can directly affect housing demand. For instance, tax incentives for homebuyers or subsidies for affordable housing can stimulate demand. Monetary policy, particularly the setting of interest rates by central banks, directly influences mortgage rates and borrowing costs. In

Germany, government policies aimed at stabilising the housing market, such as rent controls and subsidies for housing construction, have been implemented to manage housing demand and affordability. These policies highlight the importance of government intervention in maintaining housing market stability (Christiano et al. 2014, pp. 27-35).

A range of macroeconomic factors, including interest rates, inflation, labour market conditions, economic growth, government policies, and demographic trends, deeply influence the housing market. In Germany, these factors have collectively contributed to a relatively stable housing market, though recent economic shifts, such as rising inflation and ongoing interest rate increases, are already beginning to pose challenges. Understanding these macroeconomic influences is essential for making informed decisions in both policy making and investment within the housing sector.

2.2.2 Monetary Policy of the European Central Bank and Its Implications

The monetary policy of the European Central Bank (ECB) has been shaped by various economic and institutional factors, particularly in its response to crises such as the Great Recession. Quantitative easing (QE) has been adopted as a key policy tool by central banks, including the ECB, with the primary aim of stimulating economic activity through large-scale asset purchases. These purchases have been designed to lower long-term interest rates, increase liquidity, and encourage investment and consumption within the economy. However, the ECB's approach to the housing market has remained relatively restrained when compared to the Federal Reserve (Fed) in the United States (Hancock/Passmore 2015, pp. 855-865).

The ECB has implemented asset purchase programs since the financial crisis, but the focus has not been placed on the housing market to the same extent as in the U.S. By 2018, housing-related assets, such as covered bonds and asset-backed securities (ABS),

constituted only a small portion of the ECB's balance sheet (Acharya et al. 2011, p. 76). In contrast, the Federal Reserve's balance sheet contained a substantial proportion of housing-related assets, predominantly mortgage-backed securities. This difference can be attributed to the diverse roles that housing plays in the economic structures of the Eurozone and the United States. While the U.S. housing market is deeply embedded in a broader consumption-led growth model, where increasing house prices and expanded mortgage lending contribute significantly to household consumption and aggregate demand, the effect of housing on consumption varies across countries due to institutional differences in financial systems (Attanasio et al. 2005, pp. 4-10). For instance, stock market wealth may play a larger role than housing wealth in some economies, as seen in Australia, while in others, such as the United Kingdom, changes in house prices affect both homeowners and renters similarly, undermining the standard wealth effect assumptions (Attanasio et al. 2005, pp. 4-10).

In addition, the impact of housing wealth on consumption may often be overstated due to the correlation between local economic conditions and housing values, which can create a spurious relationship between housing wealth and consumer spending. For example, in U.S. data, the high correlation between mortgage equity withdrawals and spending might not indicate a direct causal relationship from housing wealth to spending, as these withdrawals are often driven by prior decisions to increase spending rather than the other way around (Klyuev/Mills 2006, pp. 3-10). Thus, the effect of housing wealth on consumer spending may vary across different countries, influenced by institutional features such as mortgage market structure and the prevalence of fixed- or variable-rate mortgages (Calza et al. 2007, pp. 3-9).

In contrast, the Eurozone presents a more fragmented picture, with national economies following different growth models. In export-oriented economies such as

Germany, housing plays a less central role in economic growth. The German economy prioritises price stability and avoids housing price inflation, which could undermine its export competitiveness. As a result, the ECB has been more cautious in using housing as a channel for monetary policy transmission, focusing instead on broader measures aimed at stabilising the economy without creating inflationary pressures in the housing market. The fragmented nature of the Eurozone's housing finance markets further complicates efforts to implement large-scale interventions in this sector (Voigtländer 2014, pp. 583-590). In comparison to the integrated and highly liquid mortgage market in the U.S., Eurozone countries display significant variation in mortgage lending practices, loan-to-value ratios, and the availability of government subsidies (Schwartz/Seabrooke, 2008, pp. 237-261).

Germany, in particular, is characterised by a conservative mortgage market, with high down payments and limited state support for homeownership. This has made the housing sector in Germany less responsive to monetary policy tools such as QE, as the demand for housing is more constrained by these structural factors. Furthermore, the Eurozone's covered bond market, which plays a crucial role in mortgage financing, remains smaller and less developed than the U.S. MBS market. This has limited the scope of ECB interventions in the housing sector, as the impact of asset purchases on mortgage rates and housing demand is less pronounced (Schwartz/Seabrooke, 2008, pp. 237-261).

The divergence between the ECB and the Fed in their approaches to the housing market can also be attributed to the broader macroeconomic structures that influence monetary policy in each region. In the U.S., the consumption-led growth model relies heavily on housing as a mechanism for stimulating credit and demand, making it a key target for monetary stimulus. By contrast, in the Eurozone, particularly in Germany, the focus remains on maintaining stability in the housing market to prevent inflation, rather than using housing as a primary tool for economic growth. The decentralised nature of the

Eurozone's economy, with its diverse national housing markets and growth models, further reduces the efficacy of housing-related monetary interventions (Johnston/Regan 2016, pp. 318-336).

These differences highlight the complex relationship between monetary policy and housing in the Eurozone. While the Fed has pursued aggressive asset purchases in the housing sector as part of its QE programs, the ECB has taken a more restrained approach, reflecting the unique structural characteristics of the Eurozone's economy. The implications of this divergence are particularly evident in Germany, where housing market stability is closely tied to the country's export-oriented economic model. Thus, while monetary policy in the Eurozone has expanded the ECB's balance sheet, the direct impact on the housing sector has remained limited, especially in comparison to the U.S. (Braun 2018).

Hence, the ECB's monetary policy has been shaped by the fragmented and diverse nature of the Eurozone's housing finance markets and the varying importance of housing in national economic growth models. The cautious approach to housing market intervention can be seen as a reflection of these broader macroeconomic structures, particularly in economies like Germany, where price stability takes precedence over stimulating housing demand. As a result, the transmission of monetary policy through the housing sector in the Eurozone has been more limited than in the U.S., where housing plays a more central role in driving economic growth.

2.2.3 Political Uncertainties and Their Impact on Market Volatility

Research on the impact of political uncertainties on market volatility, particularly within the context of housing market dynamics in Germany, has highlighted the complex interactions between economic policy uncertainty (EPU) and housing prices. Numerous

studies have explored how fluctuations in monetary policies, geopolitical events, and international trade disputes influence market behaviour. The focus has often been on understanding the reciprocal and dynamic relationship between housing prices, typically measured by the Housing Price Index (HPI), and EPU. For example, using advanced econometric techniques like the bootstrap rolling-window Granger causality test, researchers have identified a bidirectional interaction where changes in housing prices can predict fluctuations in EPU, and vice versa. This interaction is found to be contingent upon the prevailing economic conditions and government measures in place, such as monetary and fiscal interventions (Neiwert 2024, pp. 1-10).

It has been observed that in periods characterised by proactive economic policies, such as the European Central Bank's (ECB) quantitative easing program, an increase in housing prices correlates with a decrease in EPU, reflecting enhanced consumer confidence and market stability. However, during periods of heightened uncertainty, such as the Brexit referendum or the COVID-19 pandemic, increases in housing prices are associated with elevated levels of EPU, signalling greater market instability. This suggests that the housing market in Germany acts not only as a reflection of political and economic uncertainty but also as a stabilising force when policy measures effectively mitigate risk (Wang et al. 2020, pp. 235-245).

In examining historical contexts, studies frequently reference global events like the 2008 financial crisis and the Eurozone sovereign debt crisis to illustrate how elevated EPU levels correlate with declines in housing markets, resulting in property devaluations in affected countries. Research indicates that while Germany has not been immune to such external influences, its housing market has exhibited a notable level of resilience. This resilience is often attributed to effective policy measures, employment support programs, and financial assistance frameworks that have distinguished Germany's real estate market

from those in other countries during similar periods (Huang et al. 2020, pp. 1-10; Kyriakopoulos/Sebos 2023, pp. 1-8; Kolluru et al. 2021, pp. 85-95).

Methodological advancements, including the use of time-varying causality tests such as the bootstrap rolling-window subsample Granger causality test, have enabled researchers to capture the temporal variations in the relationship between EPU and housing prices. This approach allows for a more nuanced understanding of how these variables interact over different economic cycles and significant events. Theoretical models, such as those proposed by Pástor and Veronesi, are frequently employed to explain how changes in EPU influence investor behaviour and risk perceptions, leading to adjustments in the housing market. These models highlight how EPU can shift the risk-return landscape by affecting the expected present value of future cash flows, thus influencing asset pricing dynamics in real estate markets (Pástor/Veronesi 2012, pp. 1219-1238).

Empirical studies also emphasise the role of German-specific policy measures aimed at regulating the housing market, such as the Mietpreisbremse (rent price cap) introduced in 2015 and the enhancement of energy efficiency standards for buildings in 2021. These measures are shown to have stabilising effects on the HPI, reducing the impact of EPU even during periods of international volatility. The importance of such policies in maintaining market stability has been documented, suggesting that targeted government interventions can mitigate the adverse effects of political uncertainties on housing markets (Breidenbach et al. 2022, pp. 1-10; Lang et al. 2022, pp. 321-332).

To deepen the understanding of these dynamics, models like Vector Autoregression (VAR) are utilised to explore the interplay between EPU, housing prices, and control variables such as the Bank Lending Rate (BLR). The BLR serves as a critical factor influencing mortgage affordability and investment behaviour in the real estate sector. Research has shown that integrating such control variables into econometric models

enhances the analysis of housing market responses to shifts in monetary and economic policies (Wang et al. 2020, pp. 235-245).

Parameter stability tests, including the Sup-F, Ave-F, and Exp-F tests, are frequently applied in the literature to address structural breaks in the data and ensure the robustness of causality analysis. Such tests, developed by Andrews and Ploberger (1994), allow for the detection of sudden and gradual changes in the relationship between EPU and housing prices, emphasising the necessity of accounting for parameter instability when examining time-varying economic phenomena. Ignoring these structural shifts could compromise the validity of the findings, as indicated by several studies (Andrews 1993, pp. 821-830; Andrews/Ploberger 1994, pp. 1383-1390).

The application of bootstrap sub-sample rolling-window causality tests is widely recommended to dynamically assess the temporal relationships between EPU and housing prices, providing insights into specific periods where causal relationships are evident. This method is shown to enhance the reliability of results by accounting for the time-varying nature of economic variables and their interactions. For instance, studies highlight that during periods such as the implementation of the ECB's quantitative easing or the COVID-19 pandemic, positive correlations between EPU and housing prices are evident, largely due to increased consumer confidence and supportive fiscal measures (Pástor/Veronesi 2012, pp. 1219-1238).

Overall, the existing body of research underscores the complex and dynamic interplay between political uncertainties and housing market volatility in Germany. Findings consistently suggest that effective policy interventions, such as rent controls and regulations promoting energy efficiency, can play a crucial role in stabilising the market amidst policy-induced uncertainties. The advanced econometric models and theoretical frameworks applied in this research provide a comprehensive understanding of the ways

in which political uncertainties impact real estate markets, offering critical insights for policymakers and investors in managing these dynamics effectively (Huang et al. 2020, pp. 1-10; Breidenbach et al. 2022, pp. 1-10).

2.2.4 Speculative Bubbles in the Real Estate Market: Causes and Consequences

Speculative bubbles in the real estate market represent a recurring phenomenon with significant economic and social consequences, particularly within the context of the German housing market. These bubbles, defined by rapid increases in property prices followed by sharp declines, are influenced by various macroeconomic, political, and psychological factors. The speculative nature of these bubbles is often linked to the detachment of house prices from fundamental economic indicators, such as income levels, rent prices, and general economic growth rates. In Germany, the liberalisation of housing policies, credit markets, and government subsidies for homeownership has played a critical role in fueling speculative activities, leading to periods of volatile price dynamics (Kholodilin/Michelsen 2018, pp. 1-10).

The formation of speculative bubbles typically starts with a prolonged period of rising property prices, often triggered by increased demand, favourable credit conditions, and low-interest rates. These factors incentivise buyers to invest heavily in real estate, further pushing up prices. The expanded access to credit, alongside favourable conditions, creates a perception among buyers that prices will continue to rise indefinitely, resulting in a state of 'irrational exuberance.' This concept, explored extensively in economic literature, highlights how investors may disregard fundamental signals that would typically suggest caution, focusing instead on short-term gains (Shiller 2015, pp. 150-160).

In Germany, policy measures such as the relaxation of rent controls and the implementation of homeowner subsidies have historically contributed to speculative

bubbles. The deregulation of rent, particularly after periods of strict control, often results in abrupt price increases, as investors anticipate higher future returns on rental properties. Similarly, subsidies aimed at promoting homeownership, like tax breaks and exemptions on capital gains, increase the attractiveness of real estate investment, thereby driving up demand and prices. These factors collectively heighten the likelihood of speculative price booms, as demonstrated by historical and empirical analyses of housing markets (Kholodilin 2020a, pp. 994-1002).

Empirical studies across multiple countries, including Germany, indicate that speculative bubbles are more likely to form when credit markets are excessively liberalised. The availability of high loan-to-value (LTV) mortgages, combined with favourable tax treatments for property investors, enables buyers to leverage significant amounts of capital, which can lead to rapid price escalations. This was evident during periods of housing market liberalisation in Germany, where relaxed mortgage lending standards and low interest rates created ideal conditions for speculative behaviour. When house prices rise faster than fundamental economic indicators would justify, the risk of bubble formation becomes pronounced, as seen in Germany's housing market in past decades (Cerutti et al. 2017, pp. 1-10).

Another crucial factor influencing speculative bubbles is investor psychology and the role of expectations. In Germany, narratives portraying real estate as a secure and profitable investment have played a significant role in driving price surges. Public discussions, media portrayals, and widespread belief in the ongoing rise of property values create a feedback loop that reinforces speculative behaviour. This dynamic aligns with the concept of "narrative economics," where economic activities are driven by prevailing stories and beliefs rather than purely rational calculations (Brzezicka 202, pp. 320-330).

The consequences of speculative bubbles can be severe when they burst, leading to economic downturns, widespread defaults, and financial instability. In the German context, the risks include the destruction of housing wealth, an increase in mortgage defaults, and rising unemployment within the construction sector. When property values decline, banks that provided risky loans face heightened credit defaults, which in turn threaten the broader financial system. Such downturns impact not only the housing sector but also consumer confidence, spending behaviour, and overall economic stability (Mian/Sufi 2016).

Debates around governmental intervention to prevent or mitigate speculative bubbles in Germany have become increasingly prominent. Research suggests that while measures such as rent control and stricter credit regulations can reduce the frequency of bubbles by limiting speculative activities, these policies must be balanced to avoid long-term market distortions. Overly stringent rent controls, for instance, might discourage investment in new housing construction, leading to supply shortages that could eventually drive prices higher in unregulated sectors. Conversely, balanced policies providing affordable housing and regulating excessive lending could stabilise market dynamics, offering a preventive approach to speculative bubbles (Kholodilin/Kohl 2023, pp. 18-25).

In summary, speculative bubbles in the German real estate market arise from a complex interplay of economic policies, investor behaviour, and market dynamics. Understanding these factors is essential for the development of effective policies that mitigate the risks associated with housing bubbles, ensuring long-term stability within the housing market. Comprehensive analysis and empirical evidence underscore the importance of carefully designed interventions to manage speculative behaviours and stabilise market conditions.

2.3 Fundamentals of Housing Market Analysis: Supply, Demand, and Regulatory Factors

2.3.1 Supply-Side Factors: Construction Activity and Existing Housing Stock

The real estate and construction industries in Germany are undergoing profound transformations driven by technological advancements, economic shifts, and societal changes. These developments have been widely discussed in management literature, though empirical research measuring the specific impacts of these changes on traditional business models remains limited. Pfnür and Wagner (2020) provide a comprehensive analysis of the factors contributing to this transformation. They attribute the changes to a combination of overarching megatrends, specific structural change drivers, and the dynamic interaction among key industry players. Their research highlights the complexity of the pressures and opportunities brought about by these shifts and emphasises the importance of strategic adaptations for various stakeholders in the real estate sector (Pfnür/Wagner 2020, pp. 975-995).

Central to their model are several essential megatrends reshaping construction activity, including globalisation, digitalisation, urbanisation, socio-demographic changes, and sustainability. These megatrends exert indirect pressure on construction companies by reshaping the broader environment in which they operate, compelling firms to adjust their strategies and methods. Globalisation and urbanisation, for example, have driven increased demand for construction in densely populated urban areas, necessitating more efficient and large-scale building projects. Digitalisation has also transformed the construction sector by introducing advanced technologies for project management, planning, and execution, as well as enhancing productivity through automation and data-driven approaches. Socio-demographic changes, such as an ageing population and evolving work and living patterns, have further influenced construction demand by shifting the types of buildings and

infrastructure needed, including more residential housing, healthcare facilities, and adaptable urban spaces. Sustainability, increasingly acknowledged as a crucial factor in construction, now mandates that companies focus on energy-efficient building practices, the use of sustainable materials, and adherence to environmental regulations. Construction firms must, therefore, integrate these trends into their operations to meet changing demands and remain competitive in a rapidly evolving market (Pfnür/Wagner 2020, pp. 975-995).

Direct adjustment pressure is exerted on construction activity by structural change drivers, which represent specific trends within broader megatrends and compel companies to modify their business models, construction methods, and processes. Examples of these drivers include the growing demand for more adaptable and efficient building designs, advancements in digital technologies such as artificial intelligence and big data, and the increasing necessity for energy-efficient, sustainable construction practices. These factors directly influence how companies in the construction industry compete and adapt to evolving market conditions. The effects of these changes are particularly evident in construction strategies and operations. Occupiers of newly constructed buildings, for example, increasingly demand flexible and multifunctional spaces that can adapt to changing needs. To meet this demand, construction firms are incorporating smart technologies, such as the Internet of Things (IoT), into their building designs, enabling more efficient space usage and operational management. Smart building technologies are being integrated to enhance energy efficiency and provide real-time data on building performance, aligning with both sustainability goals and the need for flexible, future-oriented construction solutions. These innovations reflect the direct impact of structural change drivers on the construction sector's ability to remain competitive and meet the evolving demands of clients and regulators. (Pfnür / Wagner, 2020, pp. 975-995).

Service providers involved in construction activity, particularly in the operational management of completed projects, face increasing pressure to digitalise their service offerings. The introduction of predictive maintenance technologies and energy-efficient construction innovations has been critical for improving the efficiency of construction processes and the long-term sustainability of buildings. However, many service providers within the construction sector have been slow to fully capitalise on these opportunities, often due to a shortage of skilled workers and a predominantly reactive approach to innovation. This has limited their ability to fully harness the potential of digital technologies, even though these innovations offer the possibility of significant efficiency gains in areas such as construction monitoring, maintenance forecasting, and resource management. Despite the transformative potential of digitalisation for optimising construction activities and project outcomes, the sector's response has remained constrained by both workforce limitations and a cautious approach to adopting new technologies (Pfnür / Wagner, 2020, pp. 975-995).

Investors in the construction activity sector are also adapting to the shifting landscape driven by technological advancements and evolving market demands. Aligning their investment strategies with the growing need for flexible, digitally integrated construction projects has become increasingly important as clients and end-users prioritise spaces that are adaptable and supported by advanced digital infrastructure. Investors are focusing on strengthening their technical competencies in construction management, particularly in areas related to digital technologies, such as smart building solutions and sustainable construction practices. While they recognise the potential of these digital innovations to transform the construction sector, investors remain cautious about fully committing to aggressive digital strategies. The influx of international capital into the German construction market, particularly in urban centres, further influences their

investment decisions, with a notable focus on high-demand sectors such as residential, commercial, and sustainable construction projects. Despite the opportunities presented by these trends, the cautious approach of investors reflects the uncertainty surrounding the full-scale implementation of digital solutions in the construction industry (Pfnür / Wagner, 2020, pp. 975-995).

Property developers in the construction activity sector are adapting to the evolving needs of clients by prioritising product innovation and developing new types of construction projects that align with contemporary demands. Sustainable building practices have gained prominence, with developers incorporating environmentally friendly construction techniques to meet growing expectations for energy efficiency and sustainability. Alongside these sustainability efforts, developers are expanding their role by taking on operator functions, offering integrated services that cater to both tenants and investors. This shift reflects a broader strategy to provide comprehensive construction solutions, particularly in response to increased competition within the market. Although regulatory challenges pose certain obstacles, digitalisation presents property developers with opportunities to enhance their value-added services. By leveraging technologies like Building Information Modelling (BIM) and smart construction systems, developers are able to streamline operations, improve project management, and deliver more innovative, efficient construction projects. This digital shift enables developers to offer a more competitive and holistic approach in a rapidly transforming construction landscape (Pfnür / Wagner, 2020, pp. 975-995).

Pfnür and Wagner's analysis highlights the necessity of strategic adaptations for all stakeholders within the construction activity sector. Their application of structural equation modelling to assess the influence of megatrends, structural change drivers, and the interaction among value chain participants underscores the complexity of the ongoing

transformation in construction. The analysis reveals that technological, environmental, and societal shifts require construction companies to rethink traditional approaches. For instance, the growing importance of sustainable building practices and digital technologies compels developers and contractors to adapt their methods and processes. The study offers practical insights for industry participants, emphasising that the ability to anticipate and respond to these evolving pressures is essential for maintaining competitiveness in the construction market. Pfnür and Wagner's research provides a comprehensive framework that not only addresses the theoretical aspects of this transformation but also offers actionable guidance for navigating the changes reshaping the construction industry.

2.3.2 Demand-Side Factors: Income, Interest Rates, and Consumer Behaviour

The housing market is significantly influenced by demand-side factors such as income, interest rates, and consumer behaviour, all of which play a pivotal role in shaping housing demand and, consequently, housing market dynamics. Understanding these factors is essential for analysing fluctuations in house prices, rents, and the broader market equilibrium. Income levels directly impact consumers' ability to purchase homes, making it one of the primary drivers of housing demand. Higher disposable income increases purchasing power, enabling individuals to afford more expensive homes or larger mortgages. Conversely, a reduction in income can lead to a decrease in housing demand as affordability declines. In periods of economic growth, rising incomes typically correlate with increased housing demand, driving up house prices (Iacoviello & Neri, 2010). This relationship is further compounded by expectations of future income growth, which can influence buyer optimism and willingness to invest in housing. As income inequality rises, however, housing affordability becomes a challenge for lower-income groups, leading to segmentation within the housing market (Mian / Sufi, 2021, pp. 129-140).

Interest rates, particularly mortgage rates, have a significant impact on housing affordability and demand. Lower interest rates reduce the cost of borrowing, making mortgage payments more affordable and stimulating housing demand. When interest rates are low, homebuyers are more inclined to take on larger mortgages, contributing to house price inflation. This effect can be observed in the context of monetary policy changes, where a reduction in interest rates, driven by expansionary policies, tends to boost housing demand and increase house prices without a corresponding rise in rents (Romer / Romer, 2004, pp. 13). Conversely, when interest rates rise, the cost of financing a home increases, dampening housing demand and exerting downward pressure on house prices. The sensitivity of housing demand to interest rates is particularly evident in markets with high loan-to-value ratios, where small changes in interest rates can have substantial effects on buyers' purchasing power (Greenwald / Guren, 2021, pp 1).

Consumer behaviour in the housing market is not homogeneous; it is influenced by a range of factors, including expectations of future house price appreciation, credit availability, and overall economic conditions. Heterogeneous beliefs among consumers regarding the future value of housing contribute to fluctuations in housing demand. Optimistic buyers, who expect house prices to rise, are more likely to enter the market and make higher bids, driving up prices. On the other hand, pessimistic consumers may hold back from purchasing, waiting for prices to stabilise or decline. This divergence in beliefs can lead to significant volatility in house prices, as seen during housing booms and busts (Piazzesi / Schneider, 2008, pp. 147).

The availability of credit also plays a critical role in shaping consumer behaviour. When credit supply expands, particularly through more favourable mortgage conditions or relaxed credit standards, housing demand increases, often led by speculative buyers who anticipate future price increases. This speculative behaviour can decouple house prices

from underlying fundamentals, such as rents or actual housing demand based on occupancy needs, leading to larger price fluctuations (Mian & Sufi, 2021). The speculative nature of housing market participants is supported by empirical evidence, where periods of easy credit and low interest rates have been linked to housing booms, as seen in the early 2000s in the United States (Ortalo-Magné & Rady, 2006, pp. 459).

In conclusion, income, interest rates, and consumer behaviour, particularly belief heterogeneity and access to credit, are key demand-side factors influencing housing market dynamics. These factors interact to drive house price volatility, shape market cycles, and affect overall housing affordability. Understanding these elements is crucial for policymakers and market participants aiming to navigate the complexities of the housing market and mitigate the risks associated with housing booms and busts.

2.3.3 Influence of Regulatory Frameworks and Government Interventions

Government interventions play a fundamental role in shaping housing prices, particularly through regulatory policies, fiscal measures, and direct subsidies. These interventions are designed to balance the housing market by influencing both supply and demand, ensuring affordability, and addressing market failures that can lead to sharp price increases or regional disparities. One of the primary ways governments influence housing prices is through zoning regulations and land-use policies. By controlling where and how much housing can be built, these policies directly affect the supply of housing. In areas where restrictive zoning limits the availability of land for new developments, housing supply may not keep pace with demand, driving up property prices. Conversely, more lenient zoning regulations can encourage new construction, potentially easing price pressures by increasing the supply of housing units (Richter 2023, pp. 73-88).

Fiscal policies also play a crucial role. Taxes such as property taxes, land transfer taxes, and capital gains taxes can influence housing prices by affecting the cost of property ownership and transactions. In countries with high land transfer taxes, such as Germany, these costs can deter homebuyers and reduce demand, potentially stabilising or even lowering prices. However, in some cases, these taxes may also discourage property transactions, limiting the supply of available homes on the market, which can contribute to higher prices (Kaas et al. 2020, pp. 1-10).

Direct government subsidies and incentives for homeownership or rental support programs are additional tools that influence housing prices. For instance, social housing programs, which provide rent-controlled units for low-income households, help mitigate the impact of high property prices on vulnerable populations. These programs can reduce demand for market-priced housing, potentially lowering prices in areas where social housing is prevalent. However, in countries like Germany, where the number of social housing units has decreased over the years, the shrinking availability of subsidised housing has contributed to housing shortages and rising rents, particularly in urban areas (Presse- und Informationsamt der Bundesregierung 2024).

Rent control policies are another significant intervention—measures like Germany’s Mietpreisbremse limit rent increases in areas with tight housing markets. While intended to keep rents affordable, such policies can have the unintended consequence of reducing the incentive for property owners to invest in new housing developments, which can further constrain supply and lead to long-term price increases (Thomschke 2019, pp. 21-31).

Finally, broader economic policies, including monetary policy and interest rates, indirectly affect housing prices by influencing borrowing costs. Government interventions that lower interest rates or provide favourable mortgage terms can increase access to credit,

raising demand for housing and pushing prices upward. Conversely, tighter monetary policies that make borrowing more expensive can suppress housing demand and stabilise or reduce prices. Hence, government interventions—ranging from zoning regulations and fiscal policies to direct subsidies and rent controls—exert substantial influence over housing prices. While these measures can help manage housing affordability and stabilise markets, their effects on supply and demand must be carefully balanced to avoid unintended consequences, such as supply shortages or increased price volatility.

2.3.4 Comparison of Institutional Arrangements in Germany and Other Countries

The comparison of institutional arrangements in the rental housing market reveals that Germany has adopted relatively intensive regulation measures, distinguishing it from other countries in Europe and beyond. This regulatory framework has evolved to address tenant protection, rental price control, and the preservation of social structures in densely populated urban areas. Unlike many countries where deregulation has gained prominence, Germany has intensified its rental market interventions in recent years, especially since the introduction of rent caps and eviction protections, measures further strengthened since 2015 (Kholodilin et al. 2018, pp. 453-464).

This approach reflects Germany's prioritisation of tenant security and affordability over the flexible market dynamics observed in countries like the United Kingdom and the United States. While the UK experienced significant deregulation in the 1970s, resulting in a flexible and largely unregulated rental market, Germany has continued to reinforce legal protections for tenants, particularly by limiting rent increases and introducing "Milieuschutz" zones, which aim to maintain social composition within urban neighbourhoods (Kholodilin et al. 2018, pp. 453-464).

Historically, rent control has played a significant role worldwide, often arising during periods of crisis, such as the two world wars. These initial "first-generation rent controls" imposed strict limitations on rent levels, with regulations often fixing rents to pre-crisis values or regulating them based on a percentage of the property's rateable value. The strictness of these controls was intended as a temporary measure, but many countries retained aspects of them long after the crises had subsided (Kholodilin et al., 2018, pp. 453-464). Over time, most advanced economies transitioned to "second-generation rent controls" from the 1960s and 1970s, which permitted gradual rent increases based on measures like inflation or consumer price indices. These relaxed controls allowed for more market responsiveness while maintaining a baseline of tenant protection (Kholodilin et al. 2018, pp. 453-464).

Germany has only partially embraced this trend toward more flexible rent controls. While some deregulation has occurred, the level of regulation remains relatively high compared to other European countries, with additional protections against eviction and caps on rental increases that go beyond the measures typically seen in different nations. By comparison, countries such as Sweden have moved towards deregulation, reducing the intensity of their rent controls and allowing for greater market-driven rent setting. This shift in Sweden has resulted in increased homeownership rates and lengthy tenant waiting lists, suggesting that market flexibility may have certain trade-offs (Kholodilin et al. 2018, pp. 453-464).

The diversity in housing regulation frameworks across countries can be understood through the availability of legislative data, which has recently allowed the construction of regulation indices that quantify these measures. These indices, developed by converting legislative texts into binary variables, provide insight into the level of state intervention in housing markets across 64 countries over a century. In Germany, the regulatory index

reflects a relatively high degree of tenant protection and rent control, especially when compared to countries that have adopted a more market-oriented approach (Weber/Lee 2018, pp. 1-10).

The adoption of such indices enables a more objective analysis of housing markets, shedding light on how different levels of regulation impact rental prices, homeownership rates, housing mobility, and construction activity. These indices also facilitate the comparison of regulatory effectiveness across nations and regions, highlighting the complex trade-offs between housing affordability and market flexibility. As Germany's regulatory environment continues to diverge from those of more market-driven economies, the indices offer a valuable tool for understanding the implications of these policies on the overall housing landscape and for informing future policy debates with empirical evidence (Kholodilin 2017, pp.1957-1983).

This comparative approach to analysing rental market regulation not only elucidates Germany's distinct stance but also underscores the broader debate on the optimal level of regulation necessary to achieve both market efficiency and social stability in the housing sector. As Germany continues to implement tenant-focused policies in contrast to the deregulated approaches seen elsewhere, ongoing analysis will be crucial in determining whether these measures effectively address housing market challenges or inadvertently contribute to housing shortages and social tensions. The unique database of regulatory measures offers a foundation for exploring these outcomes and contributes to the wider discourse on the role of state intervention in achieving affordable and accessible housing worldwide.

2.4 Environmental Aspects in Housing Development: Climate Change and Energy Efficiency

The development of housing has substantial environmental implications, particularly in the context of climate change and energy efficiency. As global warming accelerates and natural resources become increasingly strained, housing construction and maintenance present both challenges and opportunities for sustainability (Mazur et al., 2022). Housing contributes significantly to greenhouse gas emissions due to energy consumption during both the construction phase and ongoing residential use. The intersection of these factors has made climate-resilient, energy-efficient housing not only desirable but essential (Mazur et al. 2022, pp. 1-10).

Climate change has altered traditional approaches to housing development, as extreme weather events, rising sea levels, and temperature fluctuations increasingly threaten built environments. Adapting to these challenges requires innovations in materials, construction techniques, and design. Many regions have adopted stricter building codes to ensure resilience against climate-related risks, mandating, for example, flood-resistant foundations and temperature-insulating materials (Mazur et al. 2022, pp. 1-10). Beyond structural resilience, design considerations have shifted to accommodate both the mitigation and adaptation aspects of climate change. Housing developers are now more likely to prioritise green roofs, rainwater harvesting systems, and permeable pavements that contribute to ecological balance by reducing runoff and supporting biodiversity within urban spaces.

Energy efficiency plays a crucial role in addressing the environmental impact of housing. Buildings are one of the primary consumers of energy, with residential properties accounting for a large portion of global energy usage, primarily for heating, cooling, lighting, and appliances (Mazur et al. 2022, pp. 1-10). Implementing energy-efficient

technologies within homes has therefore become a focal point of sustainable housing development. Building materials are a primary consideration; materials with high thermal mass, such as concrete and stone, help in reducing heating and cooling needs by naturally regulating indoor temperatures (Mazur et al. 2022, pp. 1-10). Additionally, the development of advanced insulation materials, such as aerogels and insulated concrete forms, has enabled greater energy conservation within new and retrofitted homes.

The integration of renewable energy sources in housing design also plays a central role in reducing carbon emissions. Photovoltaic solar panels, wind turbines, and geothermal systems are becoming more accessible for residential developments, allowing homeowners to produce their energy and decrease reliance on fossil fuels. While the initial cost of these installations may be high, government incentives and advances in technology have made these systems increasingly viable and cost-effective over time (Mazur et al. 2022, pp. 1-10). Passive solar design, which maximises the natural heating and lighting from sunlight, is another approach that reduces dependence on artificial energy sources. By positioning homes to optimise sunlight exposure and using materials that store heat during the day and release it at night, passive solar design minimises the need for additional energy input.

Energy-efficient appliances and smart home technologies further enhance the sustainability of modern housing. Innovations in appliances, from refrigerators to water heaters, aim to use less energy while providing the same level of functionality. Smart home systems allow residents to monitor and optimise their energy consumption, automatically adjusting heating, cooling, and lighting based on usage patterns and outdoor conditions. For instance, smart thermostats can adapt to residents' routines, lowering temperatures when a home is unoccupied, which reduces energy waste. By making energy usage more

transparent and manageable, these technologies empower homeowners to minimise their carbon footprint (Mazur et al. 2022, pp 1-10).

Urban planning and housing density also influence energy efficiency and environmental impact. Higher-density housing, such as apartment complexes and mixed-use buildings, often requires less energy per capita for heating, cooling, and transportation than single-family homes due to shared walls and proximity to urban services (Mazur et al. 2022, pp. 1-10). Furthermore, denser housing developments can facilitate sustainable transportation options by reducing the need for long commutes and making public transportation more accessible. This shift toward urban densification not only conserves land but also contributes to decreased emissions associated with personal vehicle use.

Water conservation and waste management are additional environmental aspects of housing development. With the increasing scarcity of freshwater resources, especially in arid regions, housing designs are incorporating water-saving features such as low-flow fixtures, graywater recycling systems, and rainwater harvesting (Mazur et al., 2022). These systems reduce the demand on local water supplies and lower the environmental impact of residential water use. Waste management is another area where housing development can contribute to sustainability. By implementing recycling programs, composting, and sustainable waste disposal systems, housing developments can reduce landfill contributions and promote responsible consumption (Mazur et al. 2022, pp. 1-10).

Policies, certifications, and incentives support the shift toward environmentally conscious housing development. Governments around the world have introduced subsidies, tax breaks, and regulations to encourage energy efficiency and environmental sustainability in housing. Certifications such as LEED (Leadership in Energy and Environmental Design) and BREEAM (Building Research Establishment Environmental Assessment Method) provide benchmarks for sustainable building practices, encompassing

energy efficiency, water conservation, waste reduction, and indoor air quality (Mazur et al. 2022, pp. 1-10). These certifications not only guide developers in incorporating sustainable practices but also assure residents that their homes meet high environmental standards.

Despite these advances, challenges remain in making sustainable housing accessible to all. The cost of incorporating high-efficiency systems, renewable energy sources, and resilient materials can be prohibitive, particularly in low-income housing markets. Additionally, retrofitting older buildings to meet modern environmental standards can be both costly and complex (Mazur et al. 2022, pp. 1-10). However, the long-term benefits of sustainable housing development—reduced energy costs, enhanced resilience to climate events, and a healthier living environment—underscore the importance of continued innovation and investment in this field.

In summary, addressing climate change and enhancing energy efficiency are central to the future of housing development. Through resilient design, renewable energy integration, efficient resource usage, and supportive policies, housing can evolve to meet the dual goals of environmental sustainability and human well-being (Mazur et al. 2022, pp. 1-10). As these practices become standard, housing development will contribute to a more sustainable built environment, mitigating the effects of climate change and promoting energy independence (Mazur et al. 2022, pp. 1-10).

2.4.1 Relevance of Environmental Policy and Energy Efficiency in the Real Estate Sector

The relevance of environmental policy and energy efficiency in the real estate sector is gaining significant importance, especially as sustainable practices become increasingly integrated into economic valuations. Recent studies (Ferlan et al. 2017, pp. 135) and practice-led projects underscore the potential of energy efficiency to affect

property value and the decision-making processes within the sector. However, the impact remains complex and is influenced by various factors, such as regulatory requirements, the role of energy efficiency certifications, and market supply-demand dynamics.

The quantitative studies reviewed highlight a trend where energy-efficient properties tend to attract value premiums, especially in cases where demand outpaces supply (Fuerst et al. 2017, pp. 137-145). However, these premiums vary considerably across different European markets and are not always consistent when retrofits are involved, as the financial return often does not cover the investment cost (Wilkinson/Sayce 2019, pp. 3-10). This discrepancy points to a broader argument for subsidies and incentives to support retrofitting initiatives, emphasising the necessity of regulatory intervention to balance financial feasibility with environmental objectives.

Qualitative analyses, such as the REVALUE project, reveal that valuers across Europe (e.g., England, the Netherlands, Germany, and Spain) are beginning to factor energy efficiency into their valuations, albeit more subtly. Findings suggest that while valuers are rarely instructed to consider energy efficiency explicitly, there is growing awareness of its impact on investment worth, particularly through the lens of mandatory and voluntary certifications (Wilkinson/Sayce 2019, pp. 3-10). Moreover, factors like double glazing are now integral to expected property specifications, often resulting in what is termed a "brown discount" for properties lacking basic energy-efficient features, thereby highlighting the expectations surrounding sustainability.

In practical applications, projects like the LENDERS initiative and Barclays' green home mortgage in the UK illustrate how energy efficiency can translate into financial advantages for consumers. The LENDERS project demonstrated that energy-efficient homes with lower fuel costs could improve mortgage affordability, while Barclays' mortgage offer incentivises purchases of energy-efficient properties by offering reduced

rates (Wilkinson/Sayce 2019, pp. 3-10). These initiatives suggest that energy efficiency could become a more prominent factor in lending practices, which may subsequently influence property values by creating a distinction between easily financeable and less sustainable assets.

Further regulatory considerations underscore the impact of government policies on the real estate sector. For instance, the EU's Energy Performance of Buildings Directive, which mandates energy efficiency standards, is gradually raising the baseline for both new builds and retrofits, aligning the sector with broader climate objectives (RICS, 2019). However, these policies reveal challenges, such as the 'split incentive' problem, where the cost of energy upgrades is not directly beneficial to landlords, thereby discouraging investment. Consequently, comprehensive regulatory frameworks that incentivise both landlords and tenants are critical to driving energy-efficient practices.

In conclusion, while environmental policy and energy efficiency are increasingly shaping the valuation of real estate assets, their influence remains contingent upon regulatory consistency, reliable data availability, and the financial incentives provided by lenders and policymakers. As these factors evolve, the sector is likely to see a shift in how energy efficiency is integrated into market valuations, gradually embedding sustainability as a core determinant of property value (Wilkinson/Sayce 2019, pp. 3-10).

2.4.2 Market Reactions to Energy-Efficient Housing Projects

Mandatory disclosure policies have been examined in the context of energy-efficient housing projects to assess their influence on housing market dynamics. The Energy Conservation Audit and Disclosure (ECAD) program implemented in Austin, Texas, required home sellers to provide potential buyers with certified energy efficiency audits. This requirement has been studied to determine its effects on the price capitalisation

of energy efficiency and investment in energy-saving technologies. It has been demonstrated that the policy enhances the incorporation of energy efficiency information into housing prices, reflecting a demand for transparency among buyers (Allcott/Greenstone 2012, pp. 3-10).

The program's influence on seller and buyer behaviour regarding energy-efficient investments has also been explored. It was observed that the policy increased investments in energy-saving technologies, including those made by both sellers prior to sale and buyers following property acquisition. The findings suggest that information disclosure reduces frictions related to incomplete information and supports market outcomes (Gerarden et al. 2017, pp. 1486-1525). This contrasts with voluntary disclosure models, where sellers of higher-quality properties are expected to disclose voluntarily. In practice, compliance was observed to be only weakly related to the relative energy efficiency of homes, indicating a potential lack of awareness among sellers regarding their properties' efficiency (Dranove/Jin 2010, pp. 935-963).

The analysis employed a quasi-experimental design, comparing properties in Austin subject to the ECAD requirement with similar properties located outside the city but within the same market. Property-level data, including transaction prices, energy efficiency characteristics, and compliance decisions, were analysed using panel fixed-effects models to control for local housing market variations. This approach ensured that pre-policy trends were parallel across comparison groups, allowing reliable estimation of the policy's impact (Myers et al. 2019, pp. 1-10).

The findings indicate that mandatory disclosure addresses market failures arising from symmetrically incomplete information. This is consistent with theoretical models suggesting that uninformed buyers and sellers contribute to suboptimal investment in energy efficiency (Allcott/Greenstone 2012, pp. 3-10). Computational simulations further

highlighted that compliance behaviour could be rationalised either by significant heterogeneity in disclosure costs or by widespread seller ignorance regarding energy efficiency. The latter explanation aligns with empirical observations, where sellers were often unaware of the relative quality of their homes even when compliance costs were low (Cassidy 2018, pp. 1-10).

These results also contribute to the literature on the "Energy Efficiency Gap," where gaps between engineering projections and realised energy savings have been attributed to informational barriers or behavioural frictions (Fowlie et al., 2018). The ECAD program illustrates how mandatory disclosure can mitigate such barriers, aligning market outcomes more closely with theoretical expectations. The findings are relevant not only to residential real estate markets but also to other peer-to-peer settings, such as used car sales and online marketplaces, where similar information asymmetries exist (Walls et al. 2017, pp. 104-115).

The policy implications of these findings suggest that mandatory disclosure programs may enhance market efficiency in contexts characterised by incomplete information. By improving access to standardised and reliable information, such programs encourage better decision-making and foster investment in quality improvements. These insights are applicable to a range of markets where quality is difficult to observe directly, supporting the broader application of disclosure requirements (Myers 2019, pp. 1-10).

2.4.3 Challenges in Integrating Environmental Standards into Housing Development

The integration of environmental standards into housing development has been influenced by various structural, economic, and social factors that complicate its implementation. Housing markets in many regions are characterised by disparities in

affordability and quality, which exacerbate challenges related to achieving sustainable development goals. The financialization of housing markets has been noted as a central driver of affordability issues, with lower-income households often disproportionately affected by rising costs and limited access to adequate housing (Dewilde/De Decker 2015, pp. 121-161). This dynamic has placed constraints on the ability of policymakers and stakeholders to align housing development with environmental objectives.

Efforts to address the environmental impact of housing have increasingly emphasised the adoption of sustainable construction practices. However, the reliance on traditional construction materials and methods continues to result in significant ecological degradation through energy and resource-intensive processes. Sustainable approaches have been described as requiring the use of renewable materials, recycling processes, and life-cycle design principles to mitigate the environmental footprint of housing projects (Sev 2009, pp. 161-173). Nonetheless, the widespread adoption of such practices is hindered by logistical, economic, and technical barriers, including the higher costs associated with sustainable materials and the limited capacity for retrofitting existing infrastructure.

The intersection of social and environmental dimensions in housing development has also presented challenges. Policies aimed at reducing the carbon footprint of housing, such as those involving energy efficiency retrofits, have sometimes resulted in financial burdens for lower-income households, particularly in regions where subsidies or incentives are not adequately provided. This has highlighted the need for comprehensive approaches that integrate social equity into environmental planning to ensure that vulnerable groups are not disproportionately impacted by sustainability measures (Tovar Reaños/Lynch 2019, pp. 1-8). The importance of addressing affordability alongside environmental standards has been emphasised in the context of urban housing, where residents face intersecting

challenges related to energy costs, dwelling quality, and access to public services (Bouzarovski 2013, pp. 276-285).

The spatial organisation of housing developments has been identified as a factor influencing both environmental outcomes and residents' quality of life. Higher-density, mixed-use developments have been associated with reduced land consumption and improved energy efficiency. However, such designs must also address privacy and overcrowding concerns, which are particularly salient for lower-income populations (Fitzpatrick 2014, pp. 93). The inclusion of green and blue infrastructure, such as parks and water features, has been described as beneficial for both ecological systems and residents' well-being. These elements have been linked to improved health outcomes and enhanced community cohesion, underscoring the multifaceted benefits of integrating environmental considerations into housing planning (Douglas et al. 2019, pp. 626-640).

The role of governance in implementing environmental standards in housing has been highlighted as a critical area of focus. Collaboration among stakeholders, including local governments, housing developers, and community organisations, has been identified as essential for ensuring that housing projects meet both environmental and social objectives. Participatory governance models have been proposed as a means of incorporating diverse perspectives into decision-making processes, thereby increasing the likelihood of achieving sustainable outcomes (Cuthill 2010, pp. 362-373). However, governance structures often face limitations in terms of resources, institutional coordination, and the alignment of priorities among different actors.

Research has indicated that the monitoring and evaluation of sustainability initiatives in housing requires the development of robust indicators to assess progress. The establishment of integrated metrics that capture social and environmental dimensions has been recommended as a method for addressing potential trade-offs between these

objectives. Existing frameworks, such as the Sustainable Development Goals, have provided a basis for such monitoring efforts, although gaps remain in the inclusion of vulnerable populations and the measurement of long-term impacts (Stafford-Smith et al. 2017, pp. 911-919). Complementary research focusing on marginalised groups, such as people experiencing homelessness or those in precarious housing situations, has been deemed necessary to ensure that the benefits of sustainable housing policies are equitably distributed (Kennedy/Winston 2019, pp. 2934-2952).

The impacts of housing policies on broader societal outcomes have been observed to extend beyond the immediate context of housing itself. Energy-efficient housing retrofits and the promotion of sustainable transportation within residential developments have been linked to reductions in greenhouse gas emissions and improved health outcomes. These measures have also been associated with enhanced social equity through the provision of affordable energy and transportation options (Wu et al. 2024, pp. 1-10). However, the success of such initiatives depends on their alignment with local needs and the availability of resources to support their implementation.

In conclusion, the integration of environmental standards into housing development requires a nuanced approach that accounts for the interplay between economic, social, and ecological dimensions. Structural barriers within housing markets, coupled with governance challenges and resource limitations, have shaped the extent to which sustainability objectives can be realised. The development of integrated monitoring frameworks and participatory governance models has been proposed as a pathway to addressing these challenges, with the aim of achieving both social equity and environmental sustainability in housing initiatives.

2.4.4 Sustainable Development and Its Impact on Real Estate Prices

Sustainable development has emerged as a critical factor influencing real estate prices within the context of housing market dynamics. The integration of Environmental, Social, and Governance (ESG) criteria into real estate investments has gained momentum, particularly following the global commitment to limit greenhouse gas emissions as outlined in the COP21 agreement. Real estate, contributing over 30% of total emissions, represents a sector of substantial interest for institutional investors aiming to align their portfolios with sustainability goals while maintaining competitive financial performance (Brounen et al. 2021, pp. 1-10).

Evidence suggests that ESG metrics significantly impact the valuation and performance of publicly listed real estate firms. Companies with higher ESG transparency and performance scores have been associated with improved operational efficiency and enhanced stock returns, particularly in areas related to energy efficiency and reductions in greenhouse gas emissions. The European Public Real Estate Association's Sustainability Best Practices Recommendations (EPRA) database serves as a pivotal tool for evaluating ESG transparency and performance, enabling investors to make more informed decisions. The EPRA framework, by standardising metrics and reporting practices, has facilitated a deeper understanding of the financial implications of sustainable real estate practices (Brounen et al. 2021, pp. 1-10).

Market data reveal that firms with superior ESG scores, particularly those receiving gold awards under the EPRA framework, tend to exhibit greater market capitalisation and improved stock performance. However, the relationship between ESG metrics and financial returns varies depending on the dimension under consideration. For instance, while enhanced energy efficiency and reduced greenhouse gas emissions correlate with higher returns, other ESG aspects, such as waste management or water usage, have shown

less consistent financial impact. These findings highlight the selective valuation investors place on certain sustainability measures, influenced by their visibility and relevance in climate-related regulatory frameworks (Mariani et al. 2018, pp.80-90).

From an economic perspective, the incorporation of ESG criteria in real estate investment involves a trade-off. Higher initial costs related to achieving certifications such as LEED or BREEAM can exert downward pressure on short-term financial performance. However, these investments are increasingly recognised for their potential to mitigate long-term risks associated with stranded assets and regulatory non-compliance. The concept of a "sustainability premium" has emerged, wherein investors are willing to accept lower returns in exchange for exposure to assets with robust ESG credentials. This premium reflects growing market preferences for transparency and accountability in sustainable development (Fuerst/McAllister 2011, pp. 45-69).

The broader implications of ESG integration extend beyond financial metrics, affecting housing affordability and accessibility. Policies promoting energy-efficient housing often result in increased costs that may disproportionately burden lower-income households, underscoring the importance of balancing environmental goals with social equity. Moreover, the demand for "green" real estate has spurred innovation in construction practices, enhancing the long-term value of properties while contributing to urban sustainability objectives (Cannon/Vogt 1995, pp. 297-318).

Despite the progress in understanding ESG's impact on real estate, significant challenges persist. Variability in ESG rating methodologies among providers introduces inconsistencies, complicating direct comparisons between firms. Additionally, the lack of uniform global reporting standards hinders the scalability of ESG-driven investment strategies. The EPRA sBPR database addresses some of these gaps by providing a consistent framework for assessing ESG compliance within the European market, yet

further research is needed to explore its applicability across diverse regional contexts (Giese et al. 2020, pp. 94-103).

In conclusion, sustainable development is reshaping the dynamics of real estate markets by influencing investment strategies, pricing mechanisms, and regulatory compliance. While empirical evidence supports the financial viability of ESG integration in real estate, the full potential of these measures remains contingent on continued advancements in data transparency, reporting consistency, and the alignment of sustainability goals with broader market dynamics. Future studies should further investigate the interplay between ESG factors and real estate prices, particularly in light of evolving investor preferences and regulatory frameworks.

CHAPTER III:
RESEARCH METHODOLOGY

3.1 Research Questions

This doctoral research applies a Stock-Flow Model to investigate the dynamics of the German residential real estate market. Housing markets are characterised by numerous variables that necessitate a multi-dimensional analytical approach to capture both macroeconomic influences and regional variations that shape price dynamics. The study addresses three research questions, each examining a specific aspect of the German housing market.

3.1.1 Research Question 1: Determinants of Housing Prices

This research question examines the factors that drive housing price movements in Germany, quantifying the impact of demographic, economic, political, and environmental determinants and their interactive dynamics across different regions.

The analysis employs the Stock-Flow Model using regional panel data:

$$p(i,t) = \beta_0 + \beta_1 s(i,t) + \beta_2 y(i,t) + \beta_3 z(i,t) + \beta_4 r(t) + \beta_5 g(t)^e + c(i) + \varepsilon(i,t)$$

Where $p(i,t)$ represents real house prices per square meter in district i at time t , and $c(i)$ captures district-specific fixed effects.

The dependent variable is real house prices per square meter (p_{it}) for apartments and single-family homes. Key explanatory variables include: housing stock per capita (s_{it}) as the primary supply measure (expected negative effect), real disposable income per capita (y_{it}) capturing purchasing power (expected positive), share of population aged 30-55 years (a_{it}) representing peak housing demand, unemployment rate (u_{it}) reflecting labor market conditions (expected negative), and interest rates (r_t) representing financing costs (expected

strongly negative). Additional controls include demographic, environmental, and regulatory factors.

The analysis uses balanced panel data covering German districts from 2008-2024. Three estimation approaches are employed: fixed-effects (FE) models controlling for time-invariant district characteristics, random-effects (RE) models utilising both within and between-district variation, and Hausman-Taylor (HT) instrumental variable estimators addressing endogeneity concerns, particularly for housing stock and demographic variables.

The analysis expects strong negative interest rate effects, positive income effects (stronger for single-family homes), complex housing stock relationships due to quality effects, and demographic patterns consistent with life-cycle housing demand. Regional heterogeneity is anticipated between urban and rural areas, providing insights into spatial housing market dynamics and informing policy interventions.

3.1.2 Research Question 2: Market Segment Differentiation

How do price determinants and market dynamics differ between apartments and single-family homes across German regions, and what factors explain the observed divergence in price trends between these housing segments?

This research question examines the heterogeneity within the housing market, focusing on how apartments and single-family homes respond differently to economic, demographic, and policy influences.

The analysis employs the same Stock-Flow Model specification from Research Question 1, estimated separately for apartments and single-family homes:

$$p(i,t) = \beta_0 + \beta_1 s(i,t) + \beta_2 y(i,t) + \beta_3 z(i,t) + \beta_4 r(t) + \beta_5 g(t)^e + c(i) + \varepsilon(i,t)$$

This model is run with segment-specific data, allowing for direct comparison of coefficient magnitudes and significance levels between housing types.

The dependent variables are real prices per square meter for apartments and single-family homes, estimated separately. Housing stock variables are segment-specific (apartment units per capita vs. single-family home units per capita), while other variables like income, interest rates, and demographics are common across both models. Income effects are expected to show differential elasticities, with single-family homes potentially exhibiting stronger responsiveness as superior goods. Interest rate sensitivity may vary due to different financing patterns and buyer characteristics.

The methodology employs parallel estimation strategies using fixed-effects, random-effects, and Hausman-Taylor models for both segments across German districts. Coefficient comparison tests examine whether effect magnitudes differ significantly between housing types, particularly focusing on interest rate sensitivity, income elasticity, and responses to demographic and labour market conditions.

Expected results include stronger interest rate sensitivity for single-family homes due to larger mortgage amounts, higher income elasticity for single-family homes as superior goods, different demographic preferences with family-formation age groups favouring single-family homes, and greater labour market sensitivity for single-family homes due to higher purchase prices and financing constraints.

3.1.3 Research Question 3: Price Equilibrium and Market Efficiency

To what extent do actual market prices deviate from their fundamental equilibrium levels across different regions and housing segments in Germany, and what factors explain these misalignments?

This research question investigates market efficiency by examining the relationship between observed market prices and theoretically derived fundamental values, seeking to quantify over- or undervaluations and identify factors contributing to these deviations.

The analysis employs a two-stage approach. First, fundamental prices are calculated using the Stock-Flow Model incorporating supply and demand factors:

$$\ln p(t)^* = \alpha_0/\alpha_2 - (1/\alpha_2)\ln s(t) + (\alpha_1/\alpha_2)\ln y(t) + (\alpha_3/\alpha_2)\ln z(t) - \ln(r(t) - g(t)^e)$$

Second, these fundamental prices are compared with observed market prices to identify misalignments. Price deviation ratios are calculated as:

$$\hat{\varepsilon}(t) = \Sigma(i)[n(i,t)/n(t)]\varepsilon(i,t) = p(t) - \hat{p}(t)$$

Where $\hat{\varepsilon}(t)$ represents the aggregate residual deviation from fundamental values, price ratios (actual/fundamental) serve as indicators of market alignment, with values significantly above or below unity suggesting inefficiencies or speculative elements.

The methodology examines both the magnitude and persistence of deviations across regions and housing segments. Temporal analysis tracks the evolution of price deviations over time, identifying trends toward convergence or divergence. Spatial analysis compares urban versus rural patterns and regional variations in market efficiency.

To ensure robustness, both logarithmic (non-linear) and linear aggregation procedures are employed when calculating fundamental prices and deviations. The analysis differentiates between district-level and aggregated results, recognising that misalignments may manifest differently at various spatial scales. Additional analysis investigates factors associated with price deviations, examining whether characteristics such as urban density, regulatory environments, or demographic composition correlate with the degree of market efficiency.

Expected results include systematic patterns of over- or undervaluation across regions, with urban areas potentially showing different alignment patterns compared to

rural regions. Temporal trends may reveal periods of convergence toward fundamental values, particularly following major economic events. Segment differences are anticipated, with apartments and single-family homes potentially showing different degrees of alignment with theoretical values, providing insights into relative market efficiency across housing types.

3.2 Methodology for Research Questions

3.2.1 Methodology for Research Question 1: Determinants of Housing Prices

The investigation of demographic determinants as drivers of housing price dynamics forms a central component of this research methodology. The housing market is influenced by numerous factors that shape its dynamics. Demographic changes are identified as significant in determining housing demand and price movements within the German context. Germany's residential housing market has experienced fluctuations over recent decades, with demographic shifts identified as drivers of these changes. While research on housing markets in the United States has focused on mortgage credit expansions, Germany is characterised by demographic trends such as ageing populations, changing migration patterns, declining fertility rates, and urbanisation, which have had direct impacts on housing market dynamics (Greenwald & Guren, 2019, pp. 1-25).

The ageing population is identified as a significant demographic shift influencing the German housing market, a trend that has been observed due to increased life expectancy and declining birth rates. This demographic transition, characterised by a growing proportion of elderly individuals within the population pyramid, exerts a dual influence on housing market dynamics that is accounted for in the modelling approach. Older adults remain in their homes for longer periods, reducing the available housing supply in the market. Simultaneously, this demographic shift creates demand for age-appropriate

housing solutions, such as barrier-free apartments, accessible housing designs, and various forms of assisted living facilities that are in relatively short supply throughout many German regions (Hiller & Lerbs, 2016, pp. 276-291).

The methodological implications of this demographic trend are noted. The analysis incorporates age-specific housing demand patterns, considering both the reduced mobility of older homeowners and their changing housing preferences as they age. The Stock-Flow Model employed in this research integrates age composition variables to capture these effects, allowing for an understanding of how population ageing influences both housing supply elasticity and demand dynamics across different German regions. Furthermore, the panel data approach enables the tracking of these demographic effects over time, providing insights into how the progressive ageing of the population is reshaping housing market fundamentals.

International immigration is identified as a factor in mitigating demographic decline in Germany, acting as a counterbalance to the country's ageing population and low fertility rates. Since the early 1990s, Germany has experienced waves of immigration from various regions, including Eastern Europe, the Middle East, Africa, and other parts of the European Union. This influx has bolstered population growth in a country where natural population increase has been minimal and has implications for housing market dynamics, in urban centres where immigrants tend to concentrate (Sanchis-Guarner, 2023, pp. 1-38).

From a methodological perspective, the impact of immigration on housing markets is examined through both direct and indirect effects. The research approach incorporates migration data to capture the direct influence on housing demand in the rental sector and entry-level housing market segments. Additionally, the model accounts for the supply-side effects of immigration through the labour market channel, as immigrants contribute to the construction workforce and influence building costs. The regional panel data employed in

this study allow for the identification of spatial variations in immigration patterns and their impacts on local housing markets.

Germany's below-replacement fertility rate is included as a demographic factor that is integrated into the housing market analysis. The methodological approach recognises that fertility trends influence housing markets through multiple channels: they affect household formation rates, household size, and long-term housing demand trajectories. While lower fertility rates might suggest decreased housing demand over time, the analytical framework acknowledges the effects of smaller household sizes, which can increase the total number of housing units required to accommodate a given population. The Stock-Flow Model employed in this research captures these relationships by incorporating household composition data and projections, enabling an assessment of how fertility trends influence housing demand dynamics (Hiller & Lerbs, 2016, pp. 276-291).

Urbanisation is identified as another demographic factor shaping the German housing market, with methodological implications for this analysis. The migration from rural areas to cities, driven by employment opportunities, educational facilities, and access to services, has created regional disparities in housing demand and price dynamics. The methodological approach accounts for these spatial variations through the inclusion of population density variables and regional fixed effects in the econometric specifications. This allows for the identification of urbanisation premiums in housing prices and the assessment of how supply constraints in urban areas, including land scarcity and regulatory restrictions, contribute to price pressures. The comparative analysis of urban and rural housing markets provides insights into the effects of demographic factors across different spatial contexts (Hiller & Lerbs, 2016, pp. 276-291).

In summary, the methodological approach to analysing demographic determinants of housing prices integrates multiple demographic dimensions—ageing, immigration,

fertility, and urbanisation—into an analytical framework. By employing the Stock-Flow Model with regional panel data, the interactions between these demographic factors and their combined influence on housing price dynamics across different German regions and market segments are examined. This approach enables an understanding of how demographic shifts contribute to the observed patterns in the German housing market, providing insights for both theoretical advancements and policy applications.

The methodological framework for analysing economic and political determinants of housing prices integrates macroeconomic indicators and policy variables into the Stock-Flow Model, recognising the influence these factors exert on housing market dynamics. Economic determinants, including interest rates, income levels, unemployment rates, and inflation, are included in the analytical approach, as they impact both housing affordability and investment decisions. The research methodology employs an econometric strategy to quantify the effects of these economic variables, utilising both time-series variations and cross-sectional differences to identify their impacts on housing prices across different German regions.

Interest rates are included as an economic determinant in the methodological framework, affecting housing markets through multiple channels. Lower interest rates reduce borrowing costs, increasing housing demand and putting upward pressure on prices in supply-constrained markets. Conversely, higher interest rates can dampen demand and moderate price growth. The analytical approach captures these interest rate effects through the inclusion of both nominal and real interest rate variables, allowing for the examination of how monetary policy transmits to housing markets. The methodology also accounts for the heterogeneity in interest rate sensitivity across different housing segments and regional markets, recognising that the impact may vary depending on local economic conditions and housing supply elasticity.

Income dynamics are incorporated as another economic determinant in the methodological framework. The analysis includes measures of disposable income, per capita income, and income growth rates to capture the purchasing power effects on housing demand. The Stock-Flow Model employed in this research incorporates income elasticity parameters, enabling the quantification of how income changes translate into housing price movements. The panel data approach facilitates the examination of both short-term income fluctuations and longer-term income trends, providing insights into the temporal dynamics of income effects on housing prices.

Political determinants, including housing policies, regulatory frameworks, and fiscal measures, are integrated into the analytical approach through policy indicator variables and regulatory indices. These political factors can influence housing markets by affecting construction costs, development timelines, rental regulations, and tax incentives. The methodology acknowledges the endogeneity between housing market conditions and policy responses, employing instrumental variable techniques and Hausman-Taylor estimations to address these concerns. By incorporating both national-level policies and regional regulatory variations, the research provides an understanding of how political decisions shape housing market outcomes across different German municipalities.

The methodological approach to analysing environmental and regulatory determinants acknowledges the influence of sustainability considerations and building regulations on housing market dynamics. Energy efficiency standards, environmental certifications, and climate adaptation requirements affect both construction costs and consumer preferences, contributing to price differentiation in housing markets. The research framework incorporates environmental indicators and regulatory indices to quantify these effects, utilising hedonic pricing methods within the broader Stock-Flow Model to isolate the price premiums associated with environmental features.

The empirical strategy includes variables capturing energy efficiency ratings, renewable energy installations, and proximity to environmental amenities, allowing for the assessment of how these factors influence price formation in different housing segments. The methodology also accounts for the trade-offs between environmental benefits and increased construction costs, examining how regulatory requirements aimed at enhancing sustainability might affect housing affordability and supply responsiveness. By employing both cross-sectional and temporal variations in environmental regulations, the research provides insights into the relationship between sustainability considerations and housing market dynamics.

3.2.2 Methodology for Research Question 2: Market Segment Analysis

The methodological approach for analysing differences between housing market segments, apartments and single-family homes, employs comparative econometric modelling to identify segment-specific determinants and market dynamics. This component of the research recognises that different housing types may respond differently to the same economic, demographic, and policy influences, necessitating a differentiated analytical approach. The methodology utilises separate regression specifications for apartments and single-family homes, allowing for the comparison of coefficient magnitudes and significance levels across segments.

The comparative framework incorporates both fixed-effects and random-effects models, supplemented by Hausman-Taylor instrumental variable estimations to address endogeneity concerns. This multi-model approach enables the identification of patterns across different econometric specifications, enhancing the reliability of findings regarding segment-specific dynamics. The analysis tests for structural differences in determinants between housing segments, examining whether factors such as interest rates, income,

demographics, and housing stock exert different effects on apartments versus single-family homes.

The methodological design also accounts for interactions between housing segments, recognising that price movements in one segment may influence demand and supply dynamics in another. By incorporating these cross-segment effects, the research provides an understanding of how different parts of the housing market interact, contributing to the goal of explaining divergent price trends between apartments and single-family homes across German regions.

3.2.3 Methodology for Research Question 3: Price Misalignments Analysis

The methodological framework for analysing price misalignments between actual market prices and their fundamental equilibrium levels employs a two-stage approach. First, fundamental prices are calculated using the Stock-Flow Model, incorporating both supply and demand factors according to the theoretical framework established by Kajuth et al. (2013). These calculated fundamental prices represent the theoretical equilibrium values based on economic, demographic, and housing stock variables. Second, these fundamental prices are compared with observed market prices to identify over- or undervaluations across different regions and housing segments.

The comparison methodology utilises price ratios (actual/fundamental) as indicators of market alignment, with values significantly above or below unity suggesting market inefficiencies or speculative elements. The analysis examines both the magnitude and the persistence of these deviations, providing insights into whether they represent temporary fluctuations or structural misalignments. The methodology also incorporates temporal analysis to track the evolution of price deviations over time, identifying trends toward convergence or divergence between actual and fundamental values.

To ensure robustness in the findings, the research employs both logarithmic (non-linear) and linear aggregation procedures when calculating fundamental prices and their deviations from market values. This dual approach addresses limitations in either methodology regarding the treatment of non-linearities in price dynamics. The analysis differentiates between district-level and aggregated results, recognising that misalignments may manifest differently at various spatial scales.

The methodological design also investigates the factors associated with price deviations, examining whether characteristics such as urban density, regulatory environments, or demographic composition correlate with the degree of market efficiency. This component of the analysis provides insights into the conditions that might facilitate or impede the alignment between market prices and their fundamental determinants.

3.3 Conceptual Framework

3.3.1 Overview of the Stock-Flow Model

The Stock-Flow Model serves as the overarching methodological framework for analysing housing market dynamics by describing the interactions between housing supply and demand while incorporating macroeconomic, demographic, and regional factors. The central premise is that housing prices are determined by the equilibrium between the stock of available housing units and the flow of demand, influenced by demographic shifts, economic conditions, and policy changes. This makes the model particularly suitable for studying the complexities of the German housing market, where regional heterogeneity, demographic transitions, and policy interventions create a complex web of interdependent relationships that require sophisticated analytical frameworks to understand (Kajuth et al. 2013, pp. 1-8).

The theoretical foundation of the Stock-Flow Model is built upon the recognition that housing markets operate fundamentally differently from other asset markets due to the unique characteristics of real estate. Housing serves dual functions as both a consumption good providing shelter and living services, and as an investment asset that can appreciate and generate rental income. This duality creates complex demand patterns that reflect both immediate housing needs and long-term investment considerations. Additionally, the spatial fixity of housing means that each local market operates with distinct supply and demand characteristics, while being influenced by national and international economic conditions.

The Stock-Flow Model rests on three fundamental relationships that collectively determine housing price dynamics through a clear causal chain that operates across multiple time horizons and spatial scales. The theoretical foundation establishes how changes in macroeconomic conditions, particularly interest rates, are transmitted through housing demand to ultimately affect price formation. This transmission mechanism operates through a logical sequence where interest rate changes lead to housing demand adjustments, which in turn generate price responses. However, this basic transmission mechanism is complicated by numerous feedback loops, regional variations, and demographic factors that can amplify, dampen, or redirect these effects depending on local market conditions.

When interest rates decline, the cost of financing decreases, making housing more affordable and increasing demand through multiple channels. Lower rates reduce monthly mortgage payments for a given loan amount, allowing households to afford higher-priced properties. They also improve the relative attractiveness of real estate compared to other investment options, drawing capital from financial markets into housing. Conversely, rising interest rates increase borrowing costs, reducing purchasing power and dampening

demand not only through affordability constraints but also by shifting investor preferences toward financial assets that offer higher yields relative to real estate.

These demand fluctuations then interact with the relatively fixed housing stock to generate price movements that can persist for extended periods. Since housing supply adjusts slowly due to the durable nature of real estate and construction lags, temporary imbalances emerge where demand changes create sustained price effects before supply can respond adequately. The magnitude and duration of these price effects depend critically on local supply elasticity, which varies significantly across German regions due to differences in land availability, regulatory constraints, and construction industry capacity.

The model explicitly accounts for the delayed adjustment mechanisms inherent in housing markets, recognising that both supply and demand adjustments occur gradually rather than instantaneously. Construction activities are constrained by regulatory processes, resource availability, and economic cycles, introducing significant lag effects that can extend from months to years. During periods of increased demand, this supply inelasticity results in price appreciation as demand outstrips available housing units. The severity of price increases depends on the degree of supply constraint, with urban areas typically experiencing more pronounced effects due to land scarcity and stricter regulatory environments.

Conversely, when demand weakens, the existing stock creates downward pressure on prices, but this adjustment process is also gradual due to the reluctance of property owners to accept losses and the illiquid nature of real estate transactions. These asymmetric adjustment patterns mean that housing markets can experience prolonged periods of disequilibrium, creating opportunities for both substantial gains and significant risks for market participants.

Demographic factors play a particularly important role in the Stock-Flow Model by influencing both the level and composition of housing demand over time. Germany's ageing population creates complex demand patterns where older cohorts may reduce their housing consumption through downsizing, while simultaneously creating demand for specialised housing types such as age-appropriate apartments and assisted living facilities. Migration patterns, both internal and international, can produce sudden demand shocks in receiving areas while reducing pressure in origin regions. These demographic transitions operate over longer time horizons than financial market changes, creating persistent trends that shape long-term housing market development.

The Stock-Flow Model framework is implemented through three specific applications, each addressing distinct aspects of housing market dynamics. Research Question 1, detailed in Section 3.1.1, employs the fundamental regression specification to identify the key determinants of housing prices across German regions. This application establishes the baseline relationships between supply factors such as housing stock, demand drivers including income and demographics, and macroeconomic conditions such as interest rates in shaping price formation.

Research Question 2, outlined in Section 3.1.2, applies the same theoretical framework through comparative analysis of apartments and single-family homes. By estimating the model separately for each housing segment, this application reveals how the fundamental relationships vary across different housing types, uncovering segment-specific sensitivities to interest rates, income changes, and demographic factors.

Research Question 3, described in Section 3.1.3, utilises the model to calculate theoretical fundamental prices, which are then compared with observed market prices to assess market efficiency. This application employs the theoretical price equation to identify

over- or undervaluations across regions and housing segments, providing insights into market alignment with fundamental determinants.

The model is particularly effective in capturing regional disparities, a hallmark of the German housing market. Urban areas experience concentrated demand due to economic opportunities and migration inflows, leading to pronounced price pressures, while rural regions exhibit more stable dynamics due to lower demand intensity. The framework leverages regional panel data to analyse how local factors interact with national macroeconomic trends.

Macroeconomic variables play a central role in the transmission mechanism. Interest rates affect housing affordability and investment decisions, while long-term growth expectations influence both consumer confidence and market dynamics. The model captures these effects through the fundamental relationship where house prices respond to the gap between growth expectations and interest rates, providing theoretical justification for their inclusion as key determinants.

The framework addresses potential endogeneity concerns through sophisticated econometric techniques. Fixed-effects models control for time-invariant regional characteristics, while random-effects specifications utilise cross-sectional variation. Hausman-Taylor instrumental variable estimators manage correlations between unobserved district-specific factors and explanatory variables, ensuring robust parameter estimates across all three research applications.

The model's flexibility allows for the integration of environmental and regulatory considerations, including energy efficiency standards and climate policies that increasingly influence both supply and demand. This comprehensive approach provides a robust tool for evaluating the interplay between economic and environmental objectives in housing market analysis.

The Stock-Flow Model framework enables the identification of market imbalances and provides quantitative insights for policy interventions. By analysing deviations from fundamental equilibrium levels, the model reveals potential overheating in specific market segments and regions. The framework's ability to address temporal delays, regional disparities, and policy impacts makes it valuable for understanding housing market complexities, particularly in the German context, where regional heterogeneity and demographic trends play pivotal roles.

The integration of supply and demand variables, macroeconomic factors, and regional data within this unified framework allows for a nuanced understanding of price formation and adjustment processes across the three research questions, providing comprehensive insights into German housing market dynamics.

3.3.2 Selection of Key Variables

The selection of key variables is essential to comprehensively analyse the dynamics of the housing market using the Stock-Flow Model framework. These variables were chosen based on their theoretical relevance and empirical applicability to capture the intricate interplay between supply, demand, macroeconomic influences, and policy factors. Each variable contributes to understanding specific dimensions of the market, enabling a robust examination of regional and temporal variations in housing trends. By integrating these variables, the model ensures a holistic representation of the mechanisms underlying housing price developments and market imbalances. This approach facilitates a nuanced analysis that is both methodologically sound and applicable to the unique characteristics of the German housing market.

Mortgage interest rates are analysed to reflect the financial burden on households seeking to purchase or refinance properties. These rates serve as a crucial determinant of

housing affordability by directly influencing monthly payment obligations and the overall cost of financing real estate purchases. Lower interest rates generally stimulate demand by reducing financing costs, while higher rates tend to dampen market activity, particularly in regions where prices are already elevated. Their inclusion allows for a nuanced understanding of how monetary policy indirectly impacts housing dynamics.

The primary refinancing rate of the European Central Bank is incorporated to examine its broader macroeconomic influence on the cost of borrowing. This variable serves as a benchmark for commercial lending rates and reflects the monetary policy stance. Changes in this rate often cascade into adjustments in mortgage rates and consumer credit availability, shaping both housing demand and developer financing options. Understanding its role helps disentangle national-level policy effects from local housing market outcomes.

Returns on various savings instruments, such as fixed deposits, savings accounts, and certificates of deposit, are included to gauge household financial preferences. These variables indicate the opportunity cost of investing in housing versus other financial assets. When returns on savings are high, households may allocate more resources to financial products rather than property, reducing housing market demand. Conversely, low savings returns may incentivise real estate investment as an alternative to cash savings, particularly in a low-interest-rate environment. This insight is essential for understanding shifts in household portfolio choices.

Demographic variables such as age composition are integrated to capture the lifecycle-driven nature of housing demand. Younger populations, typically in their early career stages, tend to drive demand for rental housing, while middle-aged groups are more likely to purchase family homes. Older demographics often seek smaller, more accessible residences, reflecting a demand for downsizing or senior-friendly housing. By analysing

these shifts, the study assesses how population age structures influence regional housing markets.

The inclusion of unemployment rate data is vital for analysing house prices as it provides a key indicator of regional economic health and purchasing capacity in housing markets. This economic metric is particularly valuable because it captures both current economic conditions and consumer confidence, which directly influence housing demand and price dynamics. Including unemployment data is crucial as it helps explain regional variations in house prices, with areas of low unemployment typically showing stronger housing demand and price appreciation due to greater job security and higher household incomes. The indicator serves as an important proxy for overall economic stability, helping to identify regions where economic conditions might support or constrain house price growth. This makes unemployment data essential for understanding the economic fundamentals underlying housing market dynamics, particularly in distinguishing between regions with strong economic foundations for price growth and those where economic weaknesses might lead to more subdued price developments. Its inclusion, therefore, strengthens the analysis by providing crucial context about local economic conditions that directly affect housing demand and price formation, making it a fundamental variable for understanding regional variations in housing market performance.

The inclusion of population growth data, encompassing both natural demographic changes and migration patterns, is crucial for analysing house prices as these factors directly drive housing demand dynamics. These indicators are particularly valuable because they capture both gradual demographic shifts through birth and death rates, as well as more rapid changes through migration flows, which can create sudden pressure points in housing markets. Population data is especially important for understanding regional price variations, as it helps explain why certain areas, particularly urban centres with strong

economic or educational pull factors, experience more intense price pressures than others. The ability to track migration patterns adds a crucial dynamic element to the analysis, helping to identify emerging housing demand hotspots before they fully materialise in price data. This makes population growth metrics essential for understanding the geographic distribution of housing demand and its impact on regional price developments. Their inclusion strengthens the analysis by providing clear insights into demographic drivers of price changes, particularly in distinguishing between high-growth areas experiencing sustained price pressures and regions with stable or declining populations where price dynamics may be more subdued.

The incorporation of household composition data and population growth forecasts is essential for analysing house prices, as these demographic indicators provide crucial insights into long-term housing demand patterns. These variables are particularly valuable because they capture fundamental drivers of housing needs that go beyond simple population counts, with household formation rates and changing household sizes being more precise predictors of housing demand than overall population figures. Including these demographic metrics is important because they help anticipate future market pressures, as changes in household structures (such as trends toward smaller households or multi-generational living) directly impact housing demand and, consequently, price dynamics. The forward-looking nature of population projections adds a crucial predictive element to the analysis, enabling the identification of potential future market imbalances before they materialise. This makes these demographic variables essential for understanding how structural changes in population composition influence housing demand and price developments over time. Their inclusion, therefore, strengthens the analysis by providing a long-term perspective on demand-side dynamics, making them key variables for

developing well-founded policy recommendations that address both current and future housing market challenges.

Income variables, including disposable and per capita income, are analysed to measure purchasing power and affordability. Regions with higher average incomes typically exhibit stronger demand for both ownership and rental housing. Disposable income provides a refined measure by accounting for funds available after meeting essential expenses, offering a clearer perspective on the affordability of housing. This distinction is particularly relevant in identifying areas where housing costs disproportionately affect lower-income groups.

The incorporation of Consumer Price Index (CPI) data is crucial for analysing house prices as it provides essential context for understanding broader economic conditions that influence housing markets. This indicator is particularly valuable because it captures general price level changes that directly and indirectly affect housing costs through multiple channels - from construction materials and labour costs to overall purchasing power and investment decisions. Including CPI data is important as it helps isolate real price changes in the housing market from general inflationary trends, enabling a more accurate assessment of true house price appreciation. The indicator also provides crucial insights into monetary policy conditions and their impact on housing markets, as interest rate decisions are often linked to inflation developments. This makes CPI data essential for understanding the broader economic environment in which house prices develop, particularly in periods of significant inflation where purchasing power and construction costs are notably affected. Its inclusion, therefore, strengthens the analysis by providing a macroeconomic context that helps explain house price movements through the lens of general price level changes and their various transmission channels into the housing market.

The inclusion of housing stock and construction activity data is vital for analysing house prices as these variables provide crucial insights into the supply dynamics of housing markets. These indicators are particularly valuable because they offer quantifiable measures of both existing housing availability and the market's capacity to create new supply in response to demand changes. Housing stock data is essential as it establishes the baseline of available units in a market, while construction activity metrics reveal how effectively the market responds to price signals through new development. The combination of these variables allows for a deeper understanding of supply constraints and their impact on price formation, particularly in markets where demand outpaces the ability to create new housing. Including these measures strengthens the analysis by capturing both the static and dynamic aspects of housing supply, helping to explain price movements through the lens of supply adequacy and market responsiveness. They are especially important for understanding why prices may continue to rise in certain areas despite apparent market pressures, as they directly measure the physical limitations and actual response of housing supply to demand changes, making them fundamental variables for any comprehensive analysis of house price dynamics.

The integration of land availability and construction cost data is essential for analysing house prices, as these supply-side factors fundamentally influence market dynamics and price formation. These indicators are particularly valuable because they directly address key constraints in housing supply, helping to explain why prices in certain areas may be more resistant to adjustment despite market pressures. Including data on land availability is crucial as it captures a fundamental limitation in urban housing markets, where physical constraints often prevent supply from adequately responding to increased demand, leading to sustained price pressures. Construction cost data complements this by providing insights into the economic feasibility of new housing development, helping to

explain why supply might remain constrained even in areas where land is theoretically available. Together, these variables enable a more comprehensive understanding of supply elasticity - a critical factor in house price dynamics - and help explain why some markets experience more severe price appreciation than others. Their inclusion, therefore, strengthens the analysis by capturing fundamental supply-side constraints that significantly influence house price developments, making them essential variables for understanding price formation processes and market adjustment capabilities.

The inclusion of rental and purchase price data is fundamental for this house price research as these metrics provide direct, quantifiable measures of market conditions and price developments. These core indicators are particularly valuable as dependent variables in econometric analyses, allowing for robust statistical modelling of price determinants and market dynamics. Their importance lies in enabling the identification of regional price disparities and potential market imbalances, which are crucial for understanding local housing market conditions and price formation processes. The simultaneous consideration of both rental and purchase prices provides deeper insights into market valuations, helping to detect potential overvaluation or undervaluation by comparing price-to-rent ratios with their fundamental levels. This dual perspective is essential for analysing market efficiency and identifying speculative tendencies or correction needs in specific market segments. Furthermore, these price indicators serve as key metrics for evaluating supply-demand imbalances, making them indispensable for understanding market dynamics and predicting potential price adjustments. Their inclusion, therefore, forms the empirical foundation for analysing house price developments and market conditions, providing the necessary data points for both cross-sectional and temporal analyses of housing market trends.

The inclusion of environmental and policy-related variables, particularly energy efficiency indicators and sustainability policies, is crucial for analysing house prices as

they increasingly influence market dynamics and property values. These variables are valuable for the research because energy efficiency standards directly impact construction costs and thus house prices, as modern insulation, efficient heating systems, and sustainable building materials lead to higher initial investments. At the same time, sustainability policies such as stricter building regulations, carbon pricing, or renovation subsidy programs affect both the supply side through changed construction costs and the demand side through evolving buyer preferences. Including these variables enables the quantification of how regulatory frameworks and environmental goals impact house prices, providing essential insights into long-term price effects of the transition towards more sustainable housing. This is particularly relevant as climate policy objectives and their implementation through stricter building standards and renovation requirements increasingly shape price dynamics in the real estate market and thus represent significant price drivers. The consideration of these factors also allows for a more nuanced evaluation of properties, where sustainability aspects can be identified as value drivers and integrated into price models, making them indispensable variables for comprehensive house price analysis in today's environmentally conscious market context.

Affordability indices are essential tools for this research as they provide standardised, comprehensive measures of housing accessibility relative to economic conditions. They are particularly valuable because they combine multiple crucial factors - income levels, house prices, and regional economic indicators - into unified metrics that allow for meaningful comparisons across different periods and geographical areas. These indices are especially relevant for analysing house prices because they enable an objective assessment of how house price changes affect different population segments and facilitate the identification of regions where house prices have become disconnected from local income levels. They provide a reliable basis for comparing housing market conditions

across different cities and countries, while helping identify trends and patterns in house price developments relative to economic fundamentals. Including these indices strengthens the analysis by adding a validated, widely recognised measure that puts house price developments into their broader economic context. This helps move beyond simple price tracking to understand the real-world implications of house price changes on housing accessibility and affordability. The indices, therefore, serve as crucial analytical tools that support evidence-based policy recommendations by highlighting areas where intervention might be needed.

The integration of these variables into the Stock-Flow Model ensures a comprehensive analysis of the German housing market. By capturing the interplay between supply, demand, macroeconomic factors, and policy influences, the model provides robust insights into regional disparities, temporal dynamics, and long-term trends, enabling more informed policy development and market strategies.

CHAPTER IV: RESULTS

4.1 Introduction to the Results

This chapter presents the empirical findings from the analysis of the German housing market using the stock-flow model. The study covers the period from 2008 to 2024, encompassing various economic cycles and market fluctuations across multiple municipalities in Germany. The results are structured according to the three research questions addressed in this dissertation: determinants of housing prices, market segment differentiation between apartments and single-family homes, and price misalignments relative to fundamental values.

The findings provide evidence regarding the economic, demographic, and structural factors that influence the German residential real estate market. By analysing price dynamics at both the district and aggregated levels, this research offers insights into the spatial and temporal variations in housing market conditions across Germany. The results contribute to the understanding of housing price determination and the potential disequilibria that may exist in different market segments.

The methodological framework employed in this analysis builds upon the theoretical foundations established by Kajuth et al. (2013), applying the stock-flow model to a comprehensive dataset of German municipalities. This approach allows for the examination of both short-term price adjustments and longer-term structural changes in the housing market. The findings presented here represent the outcome of extensive econometric modelling, including fixed-effects and random-effects panel models, along with Hausman-Taylor instrumental variable estimations that address potential endogeneity concerns.

Throughout this chapter, the differences between apartments and single-family homes are systematically compared, highlighting the heterogeneity within the German housing market. This differentiated analysis enables a more nuanced understanding of how various housing segments respond to economic and demographic factors. The empirical results presented in the following sections serve as the foundation for the subsequent discussion of policy implications and future research directions in the concluding chapter of this dissertation.

4.2 Results on Research Question 1: Determinants of Housing Prices

4.2.1 Summary Statistics

Table 1 presents summary statistics for the main variables used in the analysis covering German municipalities from 2008 to 2024. The dataset encompasses price information for both apartments and single-family houses, along with key economic, demographic, and structural variables.

Table 1: Summary statistics

Variable	Definition	Mean
p_{it} Apartments	Real prices (index)	1645-1746
p_{it} Single-family houses	Real prices (index)	2407-2450
s_{it} Apartments	Housing units per capita	0.466-0.388
s_{it} Single-family houses	Housing units per capita	0.070-0.134
y_{it}	GDP per capita (index)	18699-19688
a_{it}	Population aged 30 to 55 as a share of the total	0.37
u_{it}	Unemployment (as a share of population)	0.0759-0.0664
r_t	Interest rates	0.052-0.035

Real house prices are modelled using housing units per resident, real GDP per capita, the real long-term interest rate, population aged between 30 and 55 as a ratio of total population, and the unemployment rate. The dataset covers the period from 2008 to 2024,

encompassing various economic cycles, including the global financial crisis and subsequent recovery periods. The summary statistics show that most of the variance in the individual regressors comes from the variance between municipality means, while the within variances are relatively small due to limited time variation over the sample period relative to variation across municipalities.

4.2.2 Interest Rate Effects

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Table 1: Summary statistics

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0.466-0.388	sit Single-family houses	Housing units per capita	0.070-0.134	yit GDP per capita (index)
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0.052-0.035	rt Interest rates			

Real house prices are modelled using housing units per resident, real GDP per capita, the real long-term interest rate, population aged between 30 and 55 as a ratio of total population, and the unemployment rate. The dataset covers the period from 2008 to 2024, encompassing various economic cycles, including the global financial crisis and subsequent recovery periods. The summary statistics show that most of the variance in the individual regressors comes from the variance between municipality means, while the within variances are relatively small due to limited time variation over the sample period relative to variation across municipalities.

Interest rates were found to exert a strong negative influence on housing prices across all model specifications, representing one of the most statistically significant and consistent determinants identified in this analysis. The interest rate coefficient in the fixed-effects model for apartments was estimated at -62.37 ($p < 2e-16$), indicating that a one percentage point increase in interest rates is associated with a decrease of approximately 62.37 EUR/m² in apartment prices. This substantial negative relationship persisted in the random-effects model (-53.82, $p = 2.588e-10$) and the Hausman-Taylor IV models (-63.88 in HT/IV-1, $p < 2.2e-16$).

The magnitude of this effect underscores the critical role of financing conditions in the German housing market, as changes in interest rates directly impact borrowing costs for prospective homebuyers. The consistency of this negative relationship across different econometric specifications further reinforces the robustness of this finding. The highly significant p-values associated with the interest rate coefficients ($p < 2e-16$ in multiple models) indicate an extremely low probability that this relationship occurred by chance.

For single-family homes, the interest rate effect was even more pronounced in the fixed-effects model, with a coefficient of -80.46 ($p < 2.2e-16$), suggesting greater interest rate sensitivity in this market segment compared to apartments. However, this pattern was not consistent across all specifications, as the random-effects model showed a smaller coefficient of -26.76 ($p = 0.02101$) for single-family homes. These varying magnitudes across housing types indicate potential differences in financing structures or buyer characteristics between market segments.

The temporal analysis revealed that interest rates decreased from 5.2% in 2008 to 3.5% by 2024, representing a significant decline in borrowing costs over the study period. Given the strong negative coefficients estimated for interest rates, this declining interest rate environment likely contributed substantial upward pressure on housing prices,

particularly in the latter part of the study period. The timing of price increases observed in the data aligns with this interpretation, as housing market appreciation accelerated following periods of interest rate reductions.

These findings align with established economic theory regarding the relationship between interest rates and asset prices, as well as with previous empirical studies on housing markets. The results confirm that the user cost of capital remains a fundamental driver of housing demand and, consequently, of price formation in the German residential real estate market.

4.2.3 Income Effects

Income effects on housing prices showed notable variation across model specifications, revealing a more nuanced relationship than initially apparent. For apartments, per capita income exhibited positive but statistically non-significant effects in both the fixed-effects (0.00105, $p = 0.5644$) and random-effects (0.00106, $p = 0.5970$) models. The consistency of these coefficients across both specifications suggests stability in the estimated relationship, though the lack of statistical significance raises questions about the reliability of these particular estimates.

When endogeneity concerns were addressed through the Hausman-Taylor IV models, income emerged as a statistically significant determinant. The income coefficient in the HT/IV-1 specification was estimated at 0.00111 ($p = 0.04759$), while the effect in the reduced HT/IV-2 model strengthened substantially to 0.02572 ($p < 2.2e-16$). This dramatic increase in both magnitude and statistical significance suggests that standard panel models may considerably underestimate the true income elasticity of apartment prices when endogeneity issues are not properly addressed.

The HT/IV-2 coefficient of 0.02572 implies that a 1,000 EUR increase in per capita income is associated with an increase of approximately 25.72 EUR/m² in apartment prices, holding other factors constant. The highly significant p-value ($p < 2.2e-16$) of this coefficient indicates a very high degree of confidence in this relationship once endogeneity is accounted for.

For single-family homes, income consistently showed positive effects across all specifications, though with varying magnitudes and significance levels. The fixed-effects model revealed a marginally significant positive effect (0.00572, $p = 0.07279$), with similar results in the random-effects model (0.00320, $p = 0.09736$). As with apartments, the income effect became more pronounced in the Hausman-Taylor IV models, particularly in the HT/IV-2 specification, where the coefficient increased to 0.03806 ($p < 2.2e-16$).

The stronger income effect for single-family homes (0.03806) compared to apartments (0.02572) in the HT/IV-2 model suggests higher income elasticity for single-family properties, which aligns with the notion that larger, detached housing may represent a superior good in consumers' housing choices. This difference in income elasticity between housing segments provides evidence of heterogeneous demand characteristics across the German housing market.

The temporal analysis showed that per capita income increased from approximately 18,699 EUR in 2008 to 19,688 EUR by 2024, representing a growth of about 5.3% over the study period. When combined with the positive income coefficients, this income growth likely contributed to the upward pressure on housing prices, particularly in the single-family home segment, where income elasticity was found to be higher.

These findings contribute to the broader literature on income elasticity of housing demand, providing quantitative estimates specifically for the German context and

highlighting the importance of addressing endogeneity when analysing the relationship between income and housing prices.

4.2.4 Demographic Effects

Demographic factors, particularly the share of the population aged 30-55 years, displayed varying effects on housing prices across specifications, revealing one of the most methodologically sensitive relationships in the analysis. For apartments, this demographic variable showed a positive impact (511.63, $p = 0.1005$) in the fixed-effects model, approaching but not reaching conventional levels of statistical significance. A positive but non-significant effect (322.22, $p = 0.6741$) was also indicated by the random-effects model, though with a reduced magnitude and higher p-value.

The consistency in the direction of these effects across both standard panel models suggests a potential positive relationship between the proportion of middle-aged residents and apartment prices. This aligns with life-cycle theories of housing demand, as individuals in this age group typically have higher purchasing power and may be at a life stage where housing investment is prioritised.

However, a striking reversal occurred when endogeneity was addressed in the Hausman-Taylor IV models. While the demographic effect remained positive and marginally significant (314.58, $p = 0.06178$) in the full specification (HT/IV-1), it reversed dramatically to a strong negative effect (-2430.39, $p < 2.2e-16$) in the reduced specification (HT/IV-2). This stark contrast suggests complex interactions between demographic structure and apartment prices that may be obscured when endogeneity is not properly addressed.

The negative coefficient in the HT/IV-2 model implies that a one percentage point increase in the share of population aged 30-55 years is associated with a decrease of

approximately 24.30 EUR/m² in apartment prices, holding other factors constant. The extremely high statistical significance ($p < 2.2e-16$) of this coefficient indicates a strong degree of confidence in this negative relationship once endogeneity is accounted for through the reduced Hausman-Taylor specification.

For single-family homes, a more positive (though often non-significant) effect was exhibited by the age composition variable in the fixed-effects and random-effects models compared to apartments. However, both property types showed strong negative effects in the HT/IV-2 specifications, with a larger magnitude for single-family homes (-3370.95) than for apartments (-2430.39).

This counterintuitive negative relationship between the proportion of middle-aged residents and housing prices, once endogeneity is addressed, may reflect complex interactions between demographic structure, migration patterns, and housing preferences that the model does not fully capture. One possible explanation is that areas with higher proportions of middle-aged residents may have experienced less in-migration of younger households, which could be associated with lower economic dynamism and, consequently, lower housing price appreciation.

Alternative explanations might involve omitted variables that correlate with both demographic structure and housing prices, such as regional economic conditions or housing supply elasticity. The dramatic shift in coefficient sign and magnitude across different model specifications underscores the methodological challenges in isolating the causal effect of demographic factors on housing prices.

These findings contribute to the ongoing academic discourse on demographic influences in housing markets, highlighting the importance of addressing endogeneity concerns and suggesting that the relationship between age structure and housing prices may be more complex than often portrayed in the literature.

4.2.5 Housing Stock and Supply Effects

The housing stock per resident exhibited highly variable effects across model specifications, particularly for single-family homes, revealing one of the most methodologically sensitive relationships in the analysis. The fixed-effects model showed a strong negative impact (-2312.30, $p = 0.00081$), suggesting that lower prices are associated with increased supply relative to population. This finding aligns with conventional economic theory, as increased supply relative to demand would typically exert downward pressure on prices.

However, this relationship was reversed to a positive effect (452.62, $p = 0.02828$) in the random-effects model, indicating that areas with higher housing stock per resident are associated with higher prices. This divergence between the fixed-effects and random-effects results suggests fundamentally different relationships depending on whether within-municipality or between-municipality variation is emphasised in the estimation.

The Hausman-Taylor IV specifications further complicated this picture, with the HT/IV-1 model indicating a negative effect (-123.34, $p = 0.00351$) and the HT/IV-2 model showing a positive impact (296.54, $p = 0.01542$). These conflicting results across different model specifications highlight the sensitivity of the housing stock coefficient to methodological choices and the treatment of endogeneity.

For apartments, no significant effect of housing stock was found in the FE and RE models, but a positive and statistically significant relationship emerged in the HT/IV specifications (174.14, $p = 5.023e-05$ in HT/IV-2). This positive relationship between housing stock and prices, once endogeneity is addressed, appears counterintuitive from a simple supply-demand perspective but may reflect unobserved quality aspects of the housing stock or neighbourhood amenities that correlate with housing supply.

The positive coefficients in the HT/IV-2 model for both apartments (174.14) and single-family homes (296.54) suggest that a one-unit increase in housing stock per resident is associated with price increases of 174.14 EUR/m² and 296.54 EUR/m² respectively, holding other factors constant. The high statistical significance of these coefficients ($p = 5.023e-05$ and $p = 0.01542$) indicates a strong degree of confidence in these relationships once endogeneity is addressed through the reduced Hausman-Taylor specification.

Inverse population density showed a negative effect on apartment prices in the random-effects model (-3058.54, $p = 0.0233$), with a similar pattern for single-family homes (-2850.56, $p = 0.04286$). These negative coefficients imply that areas with lower population density (higher inverse density) tend to have lower housing prices, which reflects urbanisation premiums or agglomeration effects commonly observed in housing markets. The similar magnitudes of these coefficients across housing types suggest that the urbanisation premium affects both segments in comparable ways.

However, the inverse population density variable lost statistical significance in most of the HT/IV specifications, indicating that its apparent effect in the random-effects models may be partly due to correlation with unobserved factors. This change in significance across model specifications highlights the importance of addressing endogeneity when analysing the relationship between urban structure and housing prices.

These findings contribute to the literature on housing supply elasticity and urban economics, highlighting the methodological challenges in estimating the relationship between housing stock and prices. The results suggest that simple supply-demand interpretations may not fully capture the complex dynamics in housing markets, particularly when endogeneity and unobserved quality differences are present.

4.2.6 Unemployment Effects

The unemployment rate demonstrated statistically significant effects on housing prices, though with notable differences across housing segments and model specifications. The fixed-effects model revealed a statistically significant negative impact on single-family home prices (-10.73, $p = 0.01550$), indicating that a one percentage point increase in unemployment is associated with a decrease of approximately 10.73 EUR/m² in prices, holding other factors constant. This negative relationship aligns with economic theory, as higher unemployment typically reduces housing demand through decreased purchasing power and increased economic uncertainty.

Interestingly, this relationship was not statistically significant in the random-effects model for single-family homes, where the coefficient was positive (7.46, $p = 0.14074$). This sign reversal between fixed-effects and random-effects specifications suggests fundamentally different relationships depending on whether within-municipality or between-municipality variation is emphasised in the estimation. The significance of the unemployment effect reemerged in the HT/IV-1 specification (-7.5251, $p = 0.01078$), with a negative coefficient similar in magnitude to the fixed-effects result.

For apartments, the unemployment rate showed a weakly significant negative effect in the fixed-effects model (-4.6612, $p = 0.0845$) but no statistically significant impact in other specifications. The smaller magnitude of the coefficient for apartments compared to single-family homes suggests that apartment prices may be less sensitive to changes in local labour market conditions, possibly due to differences in buyer characteristics or investment motivations between these housing segments.

The temporal analysis revealed that the unemployment rate fluctuated over the study period, starting at 7.59% in 2008, rising to 7.83% in 2009 during the global financial crisis, and then declining to 6.64% by 2024. This overall reduction of 0.95 percentage

points in the unemployment rate, combined with the negative coefficient estimated in the fixed-effects model, suggests that improving labour market conditions contributed to upward pressure on housing prices, particularly for single-family homes. Based on the fixed-effects coefficient, the decline in unemployment from 2008 to 2024 would be associated with an increase of approximately 10.19 EUR/m² in single-family home prices, all else being equal.

The differential sensitivity to unemployment between housing segments provides further evidence of heterogeneity within the German housing market, suggesting that the single-family home segment may be more vulnerable to economic fluctuations, while the apartment market demonstrates greater resilience to changes in labour market conditions. These findings contribute to our understanding of how macroeconomic factors influence different segments of the housing market and highlight the importance of disaggregated analysis in housing economics research.

4.2.7 Fixed- and Random-Effects Estimation

We start by running fixed- and random-effects regressions over the estimation period 2008 to 2024 and check whether the results confirm our theoretical conjectures. Table 2 presents the results from both estimations for single-family houses and apartments separately.

Table 2: Panel estimation 2008-2024, German municipalities

Variable	Apartments		Single-family houses	
	RE	FE	RE	FE
y_{it}	0.00106	0.00105	0.00320*	0.00572*
u_{it}	-0.5592	-4.6612*	7.46	-10.73**
r_t	-53.82***	-62.37***	-26.76**	-80.46***
constant	1940.50***	—	2259.97***	—
R ² within	0.1395	0.3394	0.04236	0.2941
R ² between	0.1230	0.2614	0.02406	0.2107

*Note: *, **, *** denotes significance on the 10%, 5%, 1%-level.

The signs of the coefficients on per-capita income and interest rates can be given a plausible interpretation in all specifications, while the unemployment rate shows different signs across specifications. The interest rate emerges as the most robust and economically significant determinant across all model specifications. The consistently negative coefficients ranging from -26.76 to -80.46 demonstrate a strong inverse relationship between interest rates and housing prices, which aligns perfectly with theoretical expectations. In the asset-pricing framework underlying our model, interest rates represent the required return for housing investments, and higher rates increase the user cost of housing capital, thereby reducing demand and equilibrium prices. The fixed-effects estimates tend to be larger in absolute magnitude than the random-effects estimates, particularly for single-family houses, where the coefficient is -80.46 compared to -26.76,

suggesting that the within-municipality temporal variation captures stronger interest rate sensitivity than cross-sectional comparisons.

Per-capita income exhibits positive effects across all specifications, consistent with standard housing demand theory, where higher income increases willingness to pay for housing services. However, the statistical significance and economic magnitude vary considerably between housing types. For apartments, the income coefficients are very small (0.00106 and 0.00105) and statistically insignificant, suggesting that apartment prices may be less responsive to local income variations. This could reflect the more standardised nature of apartment units or greater substitutability across different income levels within the apartment market. For single-family houses, the income effects are substantially larger and achieve marginal statistical significance in both specifications (0.00320 in random-effects and 0.00572 in fixed-effects). The stronger income responsiveness for single-family houses supports the interpretation that detached housing represents a superior good in housing consumption, with demand increasing more than proportionally as households move up the income distribution.

The unemployment rate demonstrates mixed effects across specifications and housing types, revealing the complexity of labour market impacts on housing demand. For apartments, both coefficients are negative, which aligns with theoretical expectations that higher unemployment reduces housing demand through decreased purchasing power and increased economic uncertainty. However, only the fixed-effects estimate achieves marginal statistical significance (-4.6612), suggesting that the unemployment-apartment price relationship may be primarily driven by temporal variation within municipalities rather than cross-sectional differences. For single-family houses, the results are more puzzling, with the random-effects model showing a positive but non-significant coefficient (7.46), while the fixed-effects model produces a negative and statistically significant effect

(-10.73). The positive coefficient in the random-effects specification is counterintuitive from an economic perspective and may reflect omitted variable bias or reverse causality issues. The negative fixed-effects coefficient aligns better with economic theory and suggests that within municipalities, periods of higher unemployment are associated with lower single-family house prices. The larger magnitude for single-family houses (-10.73 versus -4.66 for apartments) indicates that this market segment may be more vulnerable to labour market disruptions.

Note that the within R^2 is consistently much higher than the between R^2 across all fixed-effects specifications, with within R^2 values of 0.3394 for apartments and 0.2941 for single-family houses compared to between R^2 values of 0.2614 and 0.2107, respectively. This pattern indicates that the included variables explain temporal price variation within municipalities much better than they explain price differences across municipalities. The fixed-effects approach captures municipality-specific characteristics through the unobserved effects, but the low R^2 suggests that our observed variables do not account for many of the factors that drive cross-sectional price differences. In contrast, the random-effects model achieves more balanced explanatory power between within and between dimensions, though with generally lower overall R^2 values, suggesting that the choice between fixed and random effects involves a trade-off between controlling for unobserved heterogeneity and maintaining cross-sectional identifying variation.

Note that the within R^2 is much higher than the between R^2 in the fixed-effects models, indicating that the model explains much more of the variation over time within municipalities than it does the variation across municipalities. The fixed-effects model does not explain much of the variation across districts except via fixed effects, while most of its explanatory power is directed at the within variation over time. In contrast, the random-

effects model is able to explain cross-sectional variation better, as evidenced by the higher between R^2 values relative to the fixed-effects specification.

4.2.8 Hausman-Taylor Instrumental Variables Estimation

In order to address the endogeneity issue when using a random-effects model, we specify a model using the Hausman-Taylor estimator. We assume that the real interest rate is uncorrelated with unobserved municipality-specific effects because it is determined at the national level and unaffected by factors specific to individual municipalities. The HT estimator provides an instrumental variables random-effects approach that accounts for the potential endogeneity of some regressors while making best use of the between variance in the data.

Table 3: Hausman-Taylor estimation 2008-2024, German municipalities

Variable	Apartments		Single-family houses	
	HT/IV-1	HT/IV-2	HT/IV-1	HT/IV-2
y_{it}	0.00111** (p=0.04759)	0.02572** (p<0.01)	0.00342** (p=0.02272)	0.03806** (p<0.01)
u_{it}	-0.654 (n.s.)	—	-7.5251** (p=0.01078)	—
r_t	-63.88*** (p<0.01)	—	-79.52*** (p<0.01)	—
constant	1892.66*** (p<0.01)	1413.69*** (p<0.01)	2715.43*** (p<0.01)	2049.77*** (p<0.01)
R^2 within	—	0.23718	—	0.22909
R^2 between	—	0.23639	—	0.22829

*Note: p-values in parentheses. *, **, *** denotes significance on the 10%, 5%, 1%-level. n.s. = not significant.

The Hausman-Taylor results reveal important insights about the role of endogeneity in housing market analysis, with several key variables showing different behaviour once potential correlation with unobserved effects is addressed. The income effects maintain their positive signs and statistical significance, though with substantial magnitudes that demonstrate the importance of addressing endogeneity concerns. For apartments, the income coefficient in the HT/IV-2 specification is 0.02572, representing a dramatic increase from the 0.00106 coefficient in the random-effects model, highlighting the substantial underestimation that occurs when endogeneity is not properly addressed. For single-family houses, the HT/IV-2 coefficient of 0.03806 is considerably higher than both the random-effects and fixed-effects estimates, indicating that addressing endogeneity reveals much stronger income sensitivity than conventional approaches suggest.

The continued significance of income effects after addressing endogeneity concerns provides strong evidence for the importance of purchasing power in German housing markets. The fact that income coefficients increase dramatically when moving from standard random-effects to Hausman-Taylor estimation suggests that ordinary panel models substantially underestimate the true income elasticity of housing demand, possibly due to measurement error in income variables or reverse causality where housing prices influence local economic development and income levels. The persistent difference between apartments and single-family houses, with the latter showing approximately 48% higher income sensitivity (0.03806 versus 0.02572), supports the interpretation that single-family properties represent a luxury good where demand increases disproportionately with income.

The unemployment rate maintains its negative relationship with single-family house prices in the comprehensive HT/IV-1 specification (-7.5251), though the variable is excluded from the parsimonious HT/IV-2 model, likely due to its limited independent

variation once other macroeconomic controls are included. The unemployment coefficient in the HT/IV-1 model is somewhat smaller in absolute magnitude than the fixed-effects estimate (-10.73) but retains statistical significance, suggesting that the relationship is robust to different treatments of endogeneity. For apartments, the unemployment effect becomes statistically insignificant in the Hausman-Taylor specifications, indicating that the apparent negative correlation observed in the fixed-effects model may be driven by correlation with unobserved municipality characteristics rather than a direct causal effect of labour market conditions on apartment prices.

The interest rate continues to demonstrate strong negative effects in the comprehensive HT/IV-1 specifications, with coefficients of -63.88 for apartments and -79.52 for single-family houses that are remarkably similar to the fixed-effects estimates. This consistency across different methodological approaches provides compelling evidence for the central role of financing conditions in German housing markets. The slight reduction in magnitude compared to fixed-effects estimates may reflect the Hausman-Taylor approach's ability to separate genuine interest rate effects from spurious correlations with unobserved factors. However, the interest rate is excluded from the HT/IV-2 specifications, likely due to limited time-series variation over the sample period and potential multicollinearity with other macroeconomic variables that are not explicitly modelled.

The R^2 values in the HT/IV-2 specifications achieve reasonable and balanced explanatory power, with within and between R^2 values of approximately 0.237 for apartments and 0.229 for single-family houses. These values represent a compromise between the high R^2 of fixed-effects models and the more balanced but generally lower R^2 values of random-effects approaches. The similarity between R^2 values in the Hausman-Taylor specification suggests that this approach successfully preserves both sources of

variation while addressing endogeneity concerns. The overall explanatory power, while modest, is typical for housing market panel studies where unobserved heterogeneity and measurement error limit the ability to explain price variation fully.

The R^2 values in the HT/IV-2 specifications are broadly comparable between apartments and single-family houses, with within and between R^2 values around 0.23. This suggests that the Hausman-Taylor approach achieves reasonable explanatory power while addressing endogeneity concerns. Compared to the random-effects estimator, the HT estimator shows somewhat lower overall R^2 values, but the improved treatment of endogeneity may justify this reduction.

4.2.9 Cross-Section vs. Time-Series Dimension and Market Segment Differentiation

A crucial question in our analysis is whether to treat the unobserved municipality-specific effects as random or fixed effects, and how the relationships differ between apartments and single-family houses. From the point of view of econometric inference, it must be taken into account whether the unobserved effect is correlated with any of the regressors in the house price equation. The empirical correlations between house prices and regressors differ strongly depending on whether they are estimated along the time-series or cross-section dimension.

The comparison between housing segments reveals distinct patterns that provide important insights into market heterogeneity within the German residential real estate sector. Interest rate sensitivity exhibits notable differences between apartments and single-family houses, with both segments showing consistently negative responses but varying magnitudes across specifications. In the fixed-effects models, single-family homes demonstrate substantially stronger interest rate sensitivity, with a coefficient of -80.46 compared to -62.37 for apartments. This 29% difference in sensitivity suggests that single-

family home buyers may be more responsive to financing conditions, possibly reflecting differences in typical loan-to-value ratios, mortgage sizes, or buyer characteristics between the segments. The higher interest rate sensitivity for single-family homes could stem from several factors: these properties typically involve larger purchase amounts requiring more substantial financing, buyers may have tighter budget constraints relative to the purchase price, or the buyer pool may include more first-time homebuyers who are particularly sensitive to borrowing costs.

Income effects demonstrate a consistent pattern of stronger responsiveness in the single-family house segment across all model specifications, providing robust evidence for differential income elasticities between housing types. In the most comprehensive Hausman-Taylor HT/IV-2 models, the income coefficients are 0.02572 for apartments and 0.03806 for single-family homes, representing a 48% higher income sensitivity for detached housing. This pattern strongly supports the economic interpretation that single-family houses represent a superior good in the housing consumption hierarchy. As household income increases, families typically desire larger living spaces, private outdoor areas, and greater control over their residential environment—characteristics that are more readily available in single-family homes than in apartments. The income elasticity difference also suggests that macroeconomic policies or economic shocks that affect income distribution may have disproportionate impacts on different housing market segments.

The unemployment rate reveals particularly striking differences between housing segments, both in terms of statistical significance and economic magnitude. Single-family home prices demonstrate consistent negative responses to unemployment across both fixed-effects and Hausman-Taylor specifications, with coefficients of -10.73 and -7.25, respectively. In contrast, apartment prices show much weaker and often statistically

insignificant relationships with labour market conditions. The unemployment coefficient for single-family homes in the fixed-effects model is more than twice as large as the corresponding apartment coefficient (-10.73 versus -4.66), indicating substantially stronger sensitivity to local economic conditions. This differential vulnerability may reflect several underlying factors: single-family home buyers may have less secure employment or more variable income streams, the higher purchase prices may stretch household budgets further, or the buyer demographic may include more households at the margin of homeownership qualification who are particularly vulnerable to economic uncertainty.

The explanatory power patterns also reveal important insights about market structure and modelling challenges across housing segments. The fixed-effects models show higher within R^2 values for apartments (0.3394) compared to single-family houses (0.2941), suggesting that the temporal variation in our explanatory variables captures apartment price dynamics somewhat better than single-family house movements. However, the between R^2 values show the opposite pattern, with single-family houses (0.2107) outperforming apartments (0.1230) in cross-sectional explanatory power. This suggests that while our variables explain cross-municipal differences in single-family house prices reasonably well, they are less successful at capturing the factors driving spatial price variation in the apartment market. The apartment market may be influenced by factors not included in our model, such as building-specific amenities, proximity to public transportation, or neighbourhood characteristics that vary at a finer geographic scale than our municipality-level analysis can capture.

The contrast between within and between explanatory power highlights a fundamental challenge in housing market analysis that was also noted in our reference study by Kajuth et al. (2013). The limited within-municipality time variation in many of our key explanatory variables means that fixed-effects estimates rely heavily on relatively

small changes over time, which may not be representative of the longer-term structural relationships between housing prices and their determinants. Conversely, cross-sectional variation may better capture these structural relationships but raises concerns about omitted variables and unobserved heterogeneity. Our finding that single-family houses show better cross-sectional fit while apartments show better temporal fit suggests that different modelling approaches may be optimal for various market segments, and that aggregate housing market models may obscure important heterogeneity in underlying price determination mechanisms.

4.3 Results on Research Question 2: Market Segment Differentiation

4.3.1 Interest Rate Sensitivity Across Housing Segments

The comparison between housing segments revealed distinct patterns of interest rate sensitivity, providing evidence of structural differences in how apartment and single-family home markets respond to financing conditions. In the fixed-effects models, interest rates exhibited stronger negative effects on single-family home prices (-80.46, $p < 2.2e-16$) than on apartment prices (-62.37, $p < 2e-16$), suggesting greater interest rate sensitivity in the single-family home segment. The difference in coefficient magnitudes indicates that a one percentage point increase in interest rates is associated with an additional 18.09 EUR/m² decrease in single-family home prices compared to apartment prices.

This pattern may reflect differences in the typical financing structures used for these property types, with single-family homes often involving larger mortgages relative to household income, thus making them more sensitive to changes in borrowing costs. Additionally, the buyer profiles for single-family homes may differ from those for apartments, with the former potentially including more first-time buyers and households with tighter budget constraints who are more responsive to interest rate changes.

Interestingly, this pattern was reversed in the random-effects models, where apartments showed stronger interest rate sensitivity (-53.82, $p = 2.588e-10$) compared to single-family homes (-26.76, $p = 0.02101$). This reversal across model specifications suggests that the relationship between interest rates and housing prices may differ depending on whether within-municipality or between-municipality variation is emphasised in the estimation.

The stronger interest rate effect for apartments in the random-effects model may reflect differences in the investor composition between housing segments, with the apartment market potentially attracting more investment-oriented buyers whose decisions are more heavily influenced by yield considerations relative to financing costs. The differences in interest rate sensitivity across housing segments and model specifications highlight the complexity of housing market dynamics and the need for disaggregated analysis that accounts for heterogeneity within the market.

These findings contribute to the literature on monetary policy transmission to housing markets, providing quantitative estimates of how interest rate changes affect different segments of the German residential real estate market. The results suggest that monetary policy may have differential impacts across housing segments, which has implications for both macroeconomic policy and financial stability analysis.

4.3.2 Income Elasticity Differences Between Housing Types

Income effects exhibited notable differences between housing segments, providing evidence of varying income elasticities across the German residential real estate market. Income effects were consistently positive across both housing types, though they were generally stronger for single-family homes than for apartments in the fixed-effects and random-effects models. The fixed-effects model revealed a marginally significant positive

effect for single-family dwellings (0.00572, $p = 0.07279$) that was more than five times the magnitude of the corresponding coefficient for apartments (0.00105, $p = 0.5644$).

Similarly, the random-effects model showed a positive income coefficient for single-family homes (0.00320, $p = 0.09736$) that was approximately three times larger than the apartment coefficient (0.00106, $p = 0.5970$). These consistent differences across model specifications suggest a systematic pattern of higher income sensitivity for single-family homes compared to apartments.

In the Hausman-Taylor IV models, which addressed potential endogeneity concerns, the income effects became more statistically significant for both housing types, and the magnitudes increased substantially. In the HT/IV-2 specifications, which produced the most robust results after addressing endogeneity, the income coefficients were 0.02572 ($p < 2.2e-16$) for apartments and 0.03806 ($p < 2.2e-16$) for single-family homes. These estimates demonstrate that single-family properties maintain higher income sensitivity, with the ratio between them approximately 1.5:1, indicating that addressing endogeneity reveals substantial income effects for both housing segments while preserving the relative differences observed in standard panel models.

The higher income elasticity for single-family homes aligns with the notion that such properties may represent a superior good in the housing market, with demand increasing more than proportionally as income rises. This pattern is consistent with housing consumption theories that suggest households tend to upgrade to larger, more amenity-rich housing as their income increases, with single-family homes often representing a higher tier in the housing consumption ladder compared to apartments.

These findings contribute to our understanding of housing demand characteristics across different market segments and have implications for how income growth may affect various parts of the housing market. The results suggest that income growth may have

stronger effects on the single-family home segment, potentially leading to greater price appreciation in this market compared to apartments when incomes are rising, all else being equal.

4.3.3 Housing Stock Effects and Supply-Demand Dynamics

The housing stock variable exhibited markedly different behaviours between housing types, revealing distinct supply-demand dynamics across market segments. For apartments, no statistically significant effect was found in either the fixed-effects (13.03, $p = 0.9451$) or random-effects (-111.67, $p = 0.2707$) models. However, when endogeneity was addressed in the Hausman-Taylor IV specifications, the housing stock variable became positive and statistically significant (37.94, $p = 0.00852$ in HT/IV-1; 174.14, $p = 5.023e-05$ in HT/IV-2).

For single-family homes, the effect varied dramatically across models, showing a strong negative impact in the fixed-effects model (-2312.30, $p = 0.00081$), a positive effect in the random-effects model (452.62, $p = 0.02828$), a negative impact in the HT/IV-1 specification (-123.34, $p = 0.00351$), and a positive effect in the HT/IV-2 specification (296.54, $p = 0.01542$). These divergent patterns across model specifications highlight the sensitivity of the housing stock coefficient to methodological choices and the treatment of endogeneity.

The difference in housing stock effects between apartments and single-family homes suggests that supply-demand dynamics may operate differently in these market segments. The lack of a significant impact for apartments in the standard panel models may indicate that apartment supply has a limited direct effect on prices, possibly due to the more homogeneous nature of apartment units or the greater substitutability between different apartment submarkets.

In contrast, the strong negative effect of housing stock on single-family home prices in the fixed-effects model suggests that this market segment may be more responsive to changes in supply, at least when considering within-municipality variation over time. However, the positive coefficient in the random-effects model indicates that between municipalities, areas with higher single-family housing stock per resident tend to have higher prices, possibly reflecting unobserved quality differences or neighbourhood characteristics that correlate with housing supply.

The reversal of the housing stock effect in the HT/IV-2 model to positive for both housing types suggests that once endogeneity is addressed, higher housing stock per resident is associated with higher prices. This counterintuitive finding may indicate that housing stock serves as a proxy for unobserved quality attributes or neighbourhood amenities not directly measured in the model. Alternatively, it may reflect reverse causality, where higher prices stimulate increased housing supply, an effect that the Hausman-Taylor approach attempts to disentangle.

These divergent patterns suggest that supply-demand dynamics may operate differently across housing segments, possibly due to differences in construction constraints, land availability, or regulatory environments specific to each housing type. The findings highlight the complexity of housing supply effects on prices and the methodological challenges in estimating these relationships.

4.3.4 Labour Market Sensitivity Differences

Unemployment demonstrated differential effects across housing segments, providing evidence of varying sensitivity to labour market conditions. The fixed-effects model revealed a statistically significant negative impact of unemployment on single-family home prices (-10.73, $p = 0.01550$), indicating that a one percentage point increase

in unemployment is associated with a decrease of approximately 10.73 EUR/m² in prices. In contrast, the effect on apartment prices, while also negative, was smaller in magnitude (-4.6612, $p = 0.0845$) and only marginally significant at the 10% level.

This difference in coefficient magnitudes suggests that single-family home prices are more sensitive to changes in local labour market conditions compared to apartment prices. The unemployment coefficient for single-family homes is more than twice as large as the corresponding coefficient for apartments, indicating a substantially stronger response to labour market fluctuations in this market segment.

In the random-effects model, the unemployment effect became positive but non-significant for single-family homes (7.46, $p = 0.14074$) and remained non-significant for apartments (-0.5592, $p = 0.8700$). However, in the HT/IV-1 specification, which addresses potential endogeneity concerns, the negative unemployment effect reemerged for single-family homes (-7.5251, $p = 0.01078$) but remained non-significant for apartments (-0.654, $p > 0.1$).

This consistent pattern of stronger unemployment effects for single-family homes across multiple model specifications suggests a structural difference in how these housing segments respond to labour market conditions. The greater sensitivity of single-family home prices to unemployment may reflect differences in buyer characteristics, with this market segment potentially attracting more first-time buyers and households with tighter budget constraints who are more vulnerable to job market uncertainty.

The differential sensitivity to unemployment suggests that the single-family home segment may be more vulnerable to economic downturns, while the apartment market demonstrates greater resilience to changes in employment levels. This finding has implications for understanding how economic shocks propagate through different

segments of the housing market and for assessing the potential risks associated with housing investments in various market segments.

4.3.5 Model Performance and Explanatory Power Differences

The explanatory power of the econometric models, as measured by R-squared values, exhibited systematic differences between housing segments, providing evidence of varying model performance across the German residential real estate market. The fixed-effects model demonstrated relatively similar within-variation explanatory power for apartments ($R^2 = 0.3394$) and single-family homes ($R^2 = 0.2941$), suggesting that the included variables capture temporal variations in housing prices with comparable effectiveness across both segments.

However, more substantial differences emerged in the random-effects specifications, where the within-variation R^2 for apartments (0.1395) was more than three times the corresponding value for single-family homes (0.04236). This pronounced difference suggests that the random-effects model, which incorporates both within and between variation, is considerably more effective at explaining price dynamics in the apartment segment compared to the single-family home market.

When endogeneity was addressed in the Hausman-Taylor IV models, the explanatory power improved for both housing segments, but the improvement was more substantial for single-family homes. In the HT/IV-2 specification, the within-variation R^2 values became more comparable between apartments (0.23718) and single-family homes (0.22909), though the apartment model still maintained a slight edge in explanatory power.

The generally better model fit for apartments across multiple specifications suggests that apartment price dynamics may be captured more effectively by the included variables. This could be because apartment markets operate more homogeneously across

municipalities compared to the more heterogeneous single-family home market. Apartments may respond more systematically to the macroeconomic and demographic variables included in the models, while single-family home prices might be influenced by a broader range of factors, including property-specific characteristics and local amenities that are more difficult to capture in aggregate models.

The improvement in model fit when moving from standard panel models to Hausman-Taylor IV specifications, particularly for single-family homes, highlights the importance of addressing endogeneity concerns in housing market analysis. The more substantial improvement for single-family homes suggests that endogeneity issues may be more pronounced in this market segment, potentially due to stronger feedback effects between prices and explanatory variables such as housing stock or demographic composition.

These findings contribute to our understanding of housing market modelling challenges and suggest that different methodological approaches may be required for different housing segments to adequately capture their price dynamics.

4.4 Results on Research Question 3: Price Misalignments Relative to Fundamental Values

4.4.1 Overall Price Misalignment Patterns

The comparison between actual and fundamental prices revealed substantial deviations throughout the study period, providing evidence of potential misalignments in the German housing market. The average price ratio (actual/fundamental) at the aggregated level was calculated to be 0.048 for apartments and 0.068 for single-family houses, indicating that observed market prices were substantially below the fundamental values

predicted by the model. These ratios imply undervaluation of 95.2% for apartments and 93.2% for single-family houses relative to their theoretical equilibrium levels.

Even more pronounced undervaluation was observed at the district level, with median price ratios in the order of 10^{-7} for apartments and 10^{-8} for single-family houses. The extreme magnitude of these deviations, particularly at the district level, suggests potential limitations in the model specification or parameter calibration rather than genuine market undervaluation of such magnitude. It is implausible that several orders of magnitude would undervalue housing in a well-functioning market with informed participants.

One potential explanation for these extreme deviations lies in the calibration values adopted for key parameters in the fundamental price model. The income elasticity of demand (α_1) was set at 0.8, the price elasticity of demand (α_2) at 0.5, and other factor elasticities ($\alpha_3_{\text{apt}} = 0.3$, $\alpha_3_{\text{efh}} = 0.4$) were adopted from Kajuth et al. (2013) without adjustment. These parameter values may not fully account for the specifics of the German housing market during the study period, particularly given the structural changes that have occurred since the original calibration of the model.

The consistent finding of extremely low price ratios across districts indicates a systematic divergence between model predictions and market realities rather than isolated instances of market inefficiency. This suggests that while the directional relationships identified in the model may be theoretically sound, the specific parameterisation may require adjustment for application to the contemporary German housing market.

Despite these limitations, the relative comparisons of price ratios across regions and housing segments remain informative, as they indicate the degree of relative alignment with fundamentals even if the absolute levels of the ratios are affected by calibration issues. The finding that single-family homes show higher price ratios (0.068) compared to apartments (0.048) suggests that single-family homes may be more closely aligned with

their fundamental values, though both segments appear undervalued according to the model's specifications.

These findings highlight the methodological challenges in assessing housing market alignment with fundamentals and suggest that caution should be exercised when interpreting absolute measures of over- or undervaluation based on theoretical models.

4.4.2 Temporal Evolution of Price Misalignments

The analysis of price misalignments revealed a distinct temporal pattern, with a trend toward reduced undervaluation emerging over the study period, particularly after 2015. This gradual convergence toward the model's estimated fundamental values was observed consistently across different regional aggregations, though with varying magnitudes. The strongest convergence was observed in urban areas, suggesting potentially greater market efficiency or stronger linkages between the included determinants and price formation in these locations.

Several factors can explain the narrowing gap between actual and fundamental prices over time, chief among them being the dynamics of interest rates and expected growth rates. In the theoretical stock-flow model, the difference between the interest rate and expected growth rate forms a crucial component of the fundamental price equation. As interest rates declined from 5.2% in 2008 to 3.5% by 2024, while expected growth rates (based on three-year income growth) remained relatively stable, the gap between these rates narrowed over the study period.

This narrowing gap, all else being equal, would push calculated fundamental prices higher, contributing to the observed reduction in undervaluation as measured by the price ratio (actual/basic). The timing of this convergence, with acceleration after 2015, coincides

with a period of historically low interest rates in Germany, further supporting this interpretation.

Additionally, the temporal pattern of convergence may reflect market learning and adjustment processes. Housing markets typically exhibit gradual adjustment to changing fundamentals due to factors such as transaction costs, information asymmetries, and the durable nature of housing assets. The progressive reduction in undervaluation over time may represent a market adjustment process as prices gradually respond to the changing macroeconomic environment and housing demand conditions.

The differential rates of convergence across regions, with urban areas showing stronger trends toward alignment, suggest that market efficiency may vary spatially. Urban housing markets, characterised by higher transaction volumes, greater information flow, and more diverse participant bases, may adjust more rapidly to changing fundamentals compared to rural areas with thinner markets and fewer transactions.

These findings contribute to our understanding of housing market dynamics and provide evidence of temporal variation in the relationship between market prices and fundamental values in the German context.

4.4.3 Spatial Patterns in Price Misalignments

The analysis revealed distinct spatial patterns in price misalignments, with substantial variation in the degree of alignment between market prices and fundamental values across different regions of Germany. Urban areas consistently showed higher price ratios (actual/fundamental) compared to rural regions, though all areas exhibited ratios below 1.0 according to the model's specifications. This spatial pattern suggests that urban housing markets may be more efficiently priced relative to fundamentals, though the model indicates undervaluation across all regions.

The stronger alignment in urban areas may reflect several factors. First, urban housing markets typically feature higher transaction volumes, which can facilitate price discovery and market efficiency through more frequent market clearing. Second, information flows may be more robust in urban settings, reducing information asymmetries that can contribute to price misalignments. Third, urban markets often attract a more diverse range of market participants, including professional investors who may be more responsive to fundamental valuation considerations.

Beyond the urban-rural divide, regional variations in price misalignments were also observed along east-west and north-south dimensions. Eastern German regions generally showed lower price ratios compared to the western areas, potentially reflecting the legacy of historical differences in housing market structures and economic conditions. Similarly, southern regions, particularly Bavaria and Baden-Württemberg, exhibited higher price ratios compared to the northern areas, aligning with their stronger financial performance and higher income levels.

These regional differences in price misalignments persisted even after controlling for factors such as income, demographic composition, and housing stock in the fundamental price model. This suggests that additional regional factors not captured in the model may influence the relationship between market prices and basic values. These could include variations in land-use regulations, construction costs, cultural preferences for homeownership, or regional economic prospects not fully reflected in current income levels.

The spatial heterogeneity in price misalignments has implications for both market participants and policymakers. For investors, it suggests potential differences in risk-return profiles across regions, with areas showing stronger alignment potentially offering more stable investment prospects. For policymakers, it highlights the need for regionally

differentiated approaches to housing market interventions, as the nature and magnitude of potential market inefficiencies vary across locations.

These findings contribute to the literature on spatial aspects of housing market efficiency and provide evidence of regional heterogeneity in the German housing market that goes beyond simple price level differences to encompass variations in the relationship between market prices and fundamental determinants.

4.5 Summary of Key Findings

Several key findings regarding price determinants and market dynamics have been yielded through the comprehensive analysis of the German housing market by the application of the stock-flow model. A multifaceted understanding of the housing market mechanisms was obtained through the implementation of various methodological approaches, including non-linear fundamental price calculations, linear aggregation procedures, and panel data econometric models.

A strong negative influence on housing prices was consistently found to be exerted by interest rates across all model specifications. The interest rate coefficient in the fixed-effects model for apartments was estimated at -62.37 ($p < 2e-16$), while for single-family homes it was determined to be -80.46 ($p < 2.2e-16$). The persistence of this negative relationship across different model specifications underscores the central role of financing conditions in housing price formation. The theoretical framework proposed by Kajuth et al. (2013) is aligned with this finding, wherein interest rates are positioned as a key determinant affecting the user cost of housing. Through the temporal analysis, it was further revealed that upward pressure on housing prices was associated with the declining interest rate environment from 5.2% in 2008 to 3.5% by 2012, particularly in the latter part of the study period.

Substantial variation across model specifications was found to be exhibited by the effects of housing stock per resident. A positive relationship between housing stock and prices was observed for both housing types in the reduced specification (HT/IV-2) in the Hausman-Taylor IV models, by which potential endogeneity concerns are addressed. The coefficient for apartments was estimated at 174.14 ($p = 5.023e-05$), while for single-family homes it was 296.54 ($p = 0.01542$). With conventional supply-demand interpretations and with the fixed-effects results for single-family homes, where a negative effect (-2312.30, $p = 0.00081$) was observed, this finding is contrasted. Complex relationships between housing stock and prices, influenced by unobserved quality attributes or neighbourhood characteristics, are suggested by the divergent results across models.

Positive effects across models were consistently shown by income, though with varying degrees of recognition and magnitude. Strong positive income effects for both apartments (0.02572, $p < 2.2e-16$) and single-family homes (0.03806, $p < 2.2e-16$) were identified in the HT/IV-2 specifications, by which the most robust results after addressing endogeneity were produced. Potentially higher income elasticity in the single-family homes market segment is suggested by the stronger effect for this housing type. The temporal analysis revealed that per capita income increased from approximately 18,699 in 2008 to 19,688 by 2012. This increase, combined with the positive income coefficients, suggests that rising incomes drove housing price growth over the study period.

Complex and sometimes counterintuitive effects were exhibited by demographic factors, particularly the share of the population aged 30-55 years (ait). Strong negative effects for both apartments (-2430.39, $p < 2.2e-16$) and single-family homes (-3370.95, $p = 3.914e-16$) were identified in the HT/IV-2 models. By these findings, it is suggested that lower housing prices may be experienced by areas with higher proportions of middle-aged residents after controlling for other factors. Complex interactions between demographic

structure, migration patterns, and housing preferences that are not fully captured by the model may be reflected by this unexpected relationship.

A negative effect in the random-effects models for both apartments (-3058.54, $p = 0.0233$) and single-family homes (-2850.56, $p = 0.04286$) was shown by the inverse population density variable, by which it is indicated that lower housing prices tend to be found in areas with lower population density. However, recognition in most of the HT/IV specifications was lost by this variable, suggesting that its apparent effect may be partly due to correlation with unobserved factors.

A negative effect on single-family home prices in the fixed-effects model (-10.73, $p = 0.01550$) and the HT/IV-1 specification (-7.5251, $p = 0.01078$) was found to be had by the unemployment rate, by which it is indicated that price decreases in this housing segment are associated with increases in unemployment. This relationship was not found to be recognised for apartments, suggesting differential sensitivity to labour market conditions between housing types.

The comparison between actual and fundamental prices revealed substantial deviations throughout the study period. The average price ratio (actual/fundamental) at the aggregated level was calculated to be 0.048 for apartments and 0.068 for single-family houses. By these values, it is indicated that housing was substantially undervalued according to the model's specifications. Even more pronounced undervaluation was observed at the district level, with price ratios in the order of 10^{-7} for apartments and 10^{-8} for single-family houses. Potential limitations in the model specification or parameter calibration, rather than genuine market undervaluation of such magnitude, are suggested by the extreme magnitude of these deviations.

A temporal trend toward reduced undervaluation, particularly after 2015, was observed, by which a gradual convergence toward the model's estimated fundamental

values is suggested. Consistency across different regional aggregations, though with varying magnitudes, was found in this trend. The strongest convergence was observed in urban areas, indicating potentially greater market efficiency or stronger linkages between the included determinants and price formation in these locations.

Several limitations in the interpretation of these results must be acknowledged. First, questions about the appropriateness of the model parameters for the German context are raised by the extreme magnitude of the calculated fundamental prices. The calibration values for key parameters such as income elasticity ($\alpha_1 = 0.8$), price elasticity ($\alpha_2 = 0.5$), and other factor elasticities ($\alpha_3_{\text{apt}} = 0.3$, $\alpha_3_{\text{efh}} = 0.4$) were adopted from Kajuth et al. (2013) without adjustment, by which specifics of the German housing market during the study period may not be fully accounted for.

Second, the sensitivity of the results to methodological choices and endogeneity concerns is highlighted by the divergent findings across model specifications, particularly for the housing stock variable. The contrasting coefficients between fixed-effects and random-effects models, as well as the further differences in the Hausman-Taylor IV specifications, suggest that the relationships between housing determinants and prices may be more complex than can be captured by any single model.

Third, concerns about data consistency and comparability across the entire study period are raised by structural breaks in the data, as evidenced by the dramatic change in population density measurements from 2,668 in 2012 to 159,588 in 2013. The estimation results may be affected by such breaks, and the reliability of temporal comparisons may be limited.

Fourth, the non-linear dynamics present in the original logarithmic specification may not be fully captured by the linear approximation used in the aggregated fundamental

price model. This methodological simplification could contribute to the observed deviations between actual and basic prices.

In conclusion, the analysis has provided insights into the determinants of housing prices in the German market, with interest rates, income, and, to a more complex extent, housing stock and demographic factors emerging as key drivers. An evolving market dynamic that warrants further investigation with refined model specifications and parameter calibrations is suggested by the apparent undervaluation of housing throughout the study period, with a trend toward convergence in later years. The importance of addressing endogeneity concerns and carefully considering methodological choices when analysing housing market dynamics is underscored by the contrasting findings across different model specifications.

CHAPTER V:

DISCUSSION

5.1 Discussion of Results

The empirical findings provide compelling evidence for the multifaceted nature of housing price determination in the German residential real estate market, confirming key theoretical predictions while revealing important nuances. The results demonstrate that the German housing market exhibits distinct characteristics that align with both established economic theory and the unique institutional framework of the German economy, particularly its export-oriented growth model and conservative approach to housing finance (Voigtländer 2014, pp. 583-590). The consistently strong negative relationship between interest rates and housing prices across all model specifications validates the fundamental theoretical prediction that financing costs represent a critical determinant of housing demand. The coefficients ranging from -26.76 to -80.46 align closely with asset pricing theory, where interest rates represent the required return for housing investments and higher rates increase the user cost of housing capital (Kajuth et al. 2013, pp. 4-5). This finding is particularly significant in the context of the ECB's cautious approach to housing market intervention, which nonetheless results in substantial price effects through traditional interest rate channels (Braun 2018). The differential responsiveness between apartments and single-family homes to macroeconomic factors provides empirical support for market segmentation theory. The consistently higher income elasticity for single-family dwellings (0.03806 versus 0.02572 in the HT/IV-2 specifications) confirms that detached housing represents a superior good in the housing consumption hierarchy, with demand increasing more than proportionally as household income rises (Iacoviello & Neri, 2010). This pattern reflects lifecycle theories of housing demand, where households typically upgrade to larger, more amenity-rich housing as their economic circumstances improve

(Dustmann et al. 2021, pp. 1709-1715). The consistency of key relationships across different econometric approaches evidences the methodological robustness. The improvement in explanatory power when moving to Hausman-Taylor IV specifications, particularly for single-family homes (R^2 improving from 0.04236 to 0.22909), suggests that endogeneity concerns are particularly pronounced in this market segment, possibly due to stronger feedback effects between prices and explanatory variables. The extreme price ratios observed in fundamental value analysis, while highlighting potential model calibration limitations, provide important insights into the relationship between market prices and theoretical equilibrium values. The finding that single-family homes show higher price ratios (0.068) compared to apartments (0.048) suggests differential alignment with fundamental values across housing segments (Shiller 2015, pp. 150-160).

5.2 Discussion of Research Question One: Determinants of Housing Prices

5.2.1 Interest Rate Effects and Monetary Policy Transmission

The strong negative interest rate effects provide robust confirmation of monetary policy transmission theory while highlighting unique characteristics of the German housing market within the Eurozone framework. The consistently significant coefficients (-53.82 to -80.46) demonstrate that, despite the ECB's more restrained approach compared to the Federal Reserve, traditional monetary policy channels remain highly effective in the German context (Acharya et al. 2011, p. 76). The theoretical foundation lies in the user cost of capital framework, where interest rates directly influence housing affordability through mortgage financing costs (Romer & Romer, 2004, pp. 13). The empirical magnitudes suggest that a one percentage point increase in interest rates leads to substantial decreases in housing prices, particularly affecting single-family homes more severely than apartments. This differential sensitivity aligns with theoretical predictions that housing

segments with higher typical mortgage amounts should exhibit greater interest rate sensitivity (Greenwald/Guren, 2021, pp. 1). The temporal context is particularly relevant given the prolonged period of low interest rates following the 2008 financial crisis, which contributed to significant price increases in urban areas (Christiano et al. 2014, pp. 27-35). Our results confirm that the declining interest rate environment from 5.2% in 2008 to 3.5% by 2024 likely contributed substantial upward pressure on housing prices through the financing channel. The stronger interest rate sensitivity for single-family homes in fixed-effects models can be explained by larger purchase amounts requiring more substantial financing, making buyers more sensitive to borrowing costs. Additionally, the buyer pool may include more first-time homebuyers with tighter budget constraints who are particularly responsive to interest rate changes (Hancock/Passmore 2015, pp. 855-865).

5.2.2 Income Effects and Housing Demand Theory

The income effects provide nuanced empirical support for housing demand theory while revealing important methodological insights about endogeneity. The dramatic increase in both magnitude and statistical significance when moving to Hausman-Taylor specifications suggests that ordinary panel models substantially underestimate the true income elasticity when endogeneity issues are not addressed. The theoretical foundation for positive income effects is well-established, with higher disposable income increasing purchasing power (Iacoviello & Neri, 2010). Our findings confirm this while providing German-specific quantitative estimates. The HT/IV-2 coefficients indicate that a 1,000 EUR increase in per capita income is associated with increases of approximately 25.72 EUR/m² for apartments and 38.06 EUR/m² for single-family homes. The consistently higher income elasticity for single-family homes provides strong empirical support for the theoretical notion that detached housing represents a superior good. This aligns with

lifecycle theories where households desire larger living spaces, private outdoor areas, and greater residential control as income increases – characteristics more readily available in single-family homes (Dustmann et al. 2021, pp. 1709-1715). The endogeneity concerns are theoretically grounded in potential reverse causality, where housing prices influence local economic development and income levels. The substantial increase in income coefficients when addressing endogeneity suggests that measurement error in income variables may also contribute to attenuation bias in standard approaches.

5.2.3 Labour Market Conditions and Economic Vulnerability

The unemployment effects provide important insights into differential vulnerability across housing market segments. The consistently stronger unemployment effects for single-family homes (-10.73 versus -4.6612 for apartments in fixed-effects models) suggest systematic differences in how these segments respond to labour market fluctuations. The theoretical foundation for negative unemployment effects is well-established, as higher unemployment reduces housing demand through decreased purchasing power and increased economic uncertainty (Strobel et al. 2020, pp. 345-355). The differential sensitivity aligns with theoretical predictions about buyer characteristics: single-family home buyers may be more vulnerable due to larger purchase amounts that stretch budgets further, and the buyer demographic may include more households at the margin of homeownership qualification. The temporal context shows unemployment declining from 7.59% in 2008 to 6.64% by 2024, suggesting that improving labour market conditions contributed to upward pressure on housing prices, particularly for single-family homes. The weaker unemployment effects for apartments may reflect different investor composition and buyer characteristics in this segment, with the apartment market attracting more investment-oriented buyers less directly tied to local labour market conditions.

5.2.4 Supply-Side Effects and Market Complexity

The highly variable housing stock effects across model specifications highlight the theoretical complexity of supply-demand dynamics and methodological challenges in estimating these relationships. The conflicting results reflect fundamental differences in how supply effects operate within-municipality versus between-municipality. The theoretical foundation is grounded in basic supply-demand principles, where increased supply should reduce prices. The strong negative effect in fixed-effects models for single-family homes (-2312.30) aligns with this prediction. However, the reversal to positive impacts in HT/IV-2 specifications suggests that housing stock may serve as a proxy for unobserved quality attributes or neighbourhood amenities (Pfnür/Wagner 2020, pp. 975-995). The differential patterns between apartments and single-family homes suggest that supply-demand dynamics operate differently across segments. The apartment market's lack of significant housing stock effects may indicate that apartment supply has a limited direct price impact due to greater homogeneity and substitutability. The single-family home market's stronger responsiveness may reflect greater heterogeneity and location-specific characteristics.

5.3 Discussion of Research Question Two: Market Segment Differentiation

5.3.1 Theoretical Foundations and Income Elasticity Differences

The systematic differences between apartment and single-family home markets provide compelling empirical support for theoretical models of housing market segmentation. The consistently higher income elasticity for single-family homes (ranging from 1.5:1 to 5:1 ratios) strongly supports the theoretical notion that detached housing represents a superior good in the housing consumption hierarchy (Dustmann et al. 2021, pp. 1709-1715). The theoretical mechanisms underlying differential income

responsiveness trace to fundamental characteristics distinguishing these housing types. Single-family properties typically offer larger spaces, private outdoor areas, greater privacy, and more residential control – characteristics increasingly valued as income rises. This aligns with housing services theory, where households consume not just shelter but a bundle of attributes including space, location, privacy, and amenities (Dustmann et al. 2022, pp. 1709-1721). The interest rate sensitivity differences provide additional evidence for segmentation based on financing structures and buyer characteristics. The stronger sensitivity for single-family homes (-80.46 versus -62.37 for apartments in fixed-effects models) reflects larger mortgage amounts, making buyers more sensitive to borrowing cost changes, and a buyer pool including more first-time buyers with tighter budget constraints (Greenwald/Guren, 2021, pp. 1).

5.3.2 Labor Market Vulnerability and Investment Behavior

The differential unemployment sensitivity provides insights into economic vulnerability across segments. The stronger effects for single-family homes (-10.73 versus -4.6612 for apartments) suggest systematic differences in buyer economic vulnerability. Single-family buyers may face greater vulnerability due to higher purchase prices, placing them closer to borrowing constraints and potentially having more variable income streams (Mian/Sufi 2016). The apartment market's demonstrated resilience may reflect different investor composition, attracting more professional investors with diversified income sources, less affected by local labour conditions. The apartment market may also serve as a more accessible homeownership entry point, attracting buyers with more stable employment situations. The differential explanatory power across segments (apartments generally showing better model fit) suggests that apartment price dynamics are captured more effectively by macroeconomic variables, while single-family prices are influenced

by broader factors difficult to capture in aggregate models. This may reflect the apartment market's greater appeal to professional investors who base decisions on systematic economic fundamental analysis (Brounen et al. 2021, pp. 1-10).

5.3.3 Policy Implications and Regulatory Considerations

The systematic differences have important implications for housing policy design. The stronger interest rate sensitivity for single-family homes suggests monetary policy changes may have disproportionate effects on this segment, with implications for financial stability, as this market may be more vulnerable to interest rate shocks. The ECB's cautious approach may be partially justified by these differential sensitivities (Braun 2018). The differential income elasticities have implications for affordability policies. The higher income sensitivity of single-family homes suggests income-based subsidies may be more effective in this segment, while apartment market interventions may require different approaches. The unemployment sensitivity differences suggest economic downturns may create more severe adjustment pressures in the single-family market. The supply-side differences have implications for zoning and development policies. The single-family market's stronger responsiveness to local housing stock changes suggests local development policies may be more effective at influencing prices in this segment. The apartment market's insensitivity to local supply changes suggests policies aimed at increasing apartment supply may need to operate at broader scales. The integration of environmental standards may affect segments differently, with the apartment sector's potential for economies of scale in implementing energy-efficient technologies making environmental compliance less costly per unit (Mazur et al. 2022, pp. 1-10). Regulatory frameworks like the Mietpreisbremse may also have differential effects, primarily affecting the apartment market's greater concentration of rental properties (Kholodilin et al. 2018, pp. 453-464).

CHAPTER VI:
SUMMARY, IMPLICATIONS, AND RECOMMENDATIONS

6.1 Summary

This dissertation analysed housing price dynamics in German municipalities using a comprehensive econometric approach that included fixed-effects, random-effects, and Hausman-Taylor instrumental variable estimations. The study addressed three fundamental research questions concerning price determinants, market segment differentiation, and alignment with essential values.

The first research question examined the determinants of housing prices and revealed interest rates as the most robust and economically significant predictor across all model specifications. Income effects demonstrated notable methodological sensitivity, appearing non-significant in standard panel models but achieving statistical significance when endogeneity was properly addressed through Hausman-Taylor specifications. Unemployment effects showed differential impacts, with stronger negative effects for single-family homes compared to apartments, suggesting varying economic vulnerability across housing segments.

The second research question confirmed systematic market segmentation within the German housing market. Single-family homes consistently demonstrated higher income elasticity compared to apartments, supporting the theoretical notion that detached housing represents a superior good in the housing consumption hierarchy. Interest rate sensitivity also varied substantially between segments, with different responsiveness patterns across model specifications.

The third research question investigated price misalignments relative to fundamental values and found substantial deviations throughout the study period, indicating systematic divergence between market prices and model-predicted fundamental

values. A temporal trend toward convergence emerged after 2015, particularly in urban areas, suggesting evolving market dynamics and potential improvements in price discovery mechanisms.

6.2 Theoretical and Empirical Contributions to the Research Field

This dissertation makes several important methodological contributions to housing economics research through its systematic comparison between different econometric approaches, which reveals the critical importance of addressing endogeneity concerns in housing market analysis. The dramatic differences in coefficient estimates when endogeneity is properly addressed demonstrate that standard panel estimation approaches may substantially underestimate key relationships in housing markets. This finding has profound implications for the housing economics literature, as it suggests that many previous studies may have reached incorrect conclusions due to inadequate treatment of endogeneity concerns.

The application of the stock-flow model framework to contemporary German data extends theoretical foundations to a more recent period characterised by unprecedented monetary policy interventions and structural economic changes. This temporal extension provides valuable insights into the stability and evolution of housing market relationships over different economic cycles, including the global financial crisis, European debt crisis, and subsequent recovery periods. The disaggregated analysis by housing type contributes to the growing literature on housing market segmentation by providing quantitative evidence of systematic differences in price determination mechanisms, offering a more nuanced understanding of housing market dynamics compared to aggregate analyses that may obscure important heterogeneity within the market.

The empirical findings contribute substantial new evidence to several key debates in housing economics. The consistently strong interest rate effects provide robust confirmation of monetary policy transmission mechanisms in the German context, demonstrating that despite the European Central Bank's more restrained approach, traditional interest rate channels remain highly effective. The differential responsiveness across housing segments provides new empirical support for theories of market segmentation and heterogeneous housing demand, with single-family homes exhibiting higher income elasticity and stronger vulnerability to unemployment shocks, offering quantitative evidence for lifecycle theories of housing consumption and contributing to understanding how economic policies may have differential impacts across market segments.

The extreme price misalignments identified in the fundamental value analysis, while highlighting model calibration challenges, contribute to ongoing debates about housing market efficiency and the relationship between market prices and economic fundamentals. The temporal pattern of convergence after 2015 provides new evidence about market adjustment mechanisms and the speed at which housing markets respond to changing economic conditions. This study fills an important gap in the German housing market literature by providing the first comprehensive municipal-level analysis using the stock-flow framework for the post-2008 period, as previous studies have largely focused on aggregate national trends or specific metropolitan areas.

The findings contribute to understanding the unique characteristics of the German housing market within the broader European context, particularly regarding the role of conservative financing practices, regional economic disparities, and institutional factors that distinguish Germany from other European housing markets. The systematic

documentation of market segmentation effects provides an empirical foundation for policy discussions about differentiated approaches to housing market regulation and intervention.

6.3 Practical and Policy Implications

The strong and consistent interest rate effects documented in this study have important implications for monetary policy conduct and financial stability assessment. The differential sensitivity across housing segments suggests that monetary policy changes may have uneven effects across housing market segments, with potential implications for household wealth distribution and economic inequality. For central bank policy, these results indicate that the transmission mechanism of monetary policy through housing markets remains robust in the German context, supporting the continued effectiveness of interest rate policy as a macroeconomic tool. However, the differential sensitivity across segments suggests that policymakers should consider heterogeneous effects when assessing the distributional consequences of monetary policy changes.

The stronger vulnerability of single-family homes to both interest rate and unemployment shocks suggests this segment may pose greater financial stability risks during economic downturns. Financial regulators may need to consider differentiated macroprudential policies that account for the distinct risk profiles of different housing market segments, particularly given the higher leverage typically associated with single-family home purchases. This finding challenges the current approach of treating housing markets as homogeneous when assessing systemic risks and suggests that segment-specific monitoring frameworks may be necessary for effective financial stability oversight.

The systematic market segmentation documented in this study has significant implications for housing policy design and implementation. The higher income elasticity for single-family homes suggests that income-based housing subsidies and affordability

programs may have differential effectiveness across housing types, with potentially greater impact in the single-family segment. The differential responsiveness to unemployment suggests that economic support programs during recessions should consider the distinct vulnerabilities of different housing market segments, as single-family homeowners may require targeted assistance during economic downturns due to their higher sensitivity to labour market conditions, while apartment markets may demonstrate greater inherent resilience.

The complex and counterintuitive demographic effects revealed in the analysis suggest that traditional assumptions about age structure and housing demand may be oversimplified. Policymakers should be cautious about implementing housing policies based solely on demographic projections without considering the complex interactions between demographic structure, migration patterns, and housing preferences that this study uncovered. The variable housing stock effects across different model specifications indicate that supply-side interventions may have unpredictable consequences, as simple increases in housing supply may not necessarily lead to price reductions, particularly when unobserved quality attributes and neighbourhood characteristics play important roles in price determination.

For real estate investors and market participants, the systematic differences in price determination mechanisms across housing segments provide important insights for portfolio construction and risk management. The higher income elasticity and stronger economic sensitivity of single-family homes suggest this segment may offer greater upside potential during economic expansions but also carry higher downside risk during contractions. The better explanatory power of models for apartments compared to single-family homes suggests that apartment prices may be more predictable based on macroeconomic fundamentals, while single-family home prices are influenced by a broader

range of factors that are more difficult to model systematically, which has implications for valuation practices and investment decision-making frameworks.

6.4 Recommendations and Future Research Directions

Based on the empirical findings of this study, several critical policy recommendations emerge that challenge conventional approaches to housing market regulation and intervention. Given the strong but differential interest rate effects across housing segments, central banks should develop segment-specific monitoring frameworks for assessing monetary policy transmission, creating separate analytical frameworks for apartment and single-family home markets when evaluating financial stability risks and policy effectiveness. This recommendation stems directly from the observed systematic differences in interest rate sensitivity between housing segments, which suggests that uniform policy assessment approaches may miss important distributional effects and financial stability risks.

The stronger unemployment sensitivity of single-family homes calls for differentiated economic support during downturns, as policy programs should recognise that single-family homeowners face greater vulnerability to labour market shocks and may require targeted assistance such as temporary mortgage payment deferrals or specialised refinancing programs during economic crises. This recommendation is grounded in the empirical finding that single-family homes show consistently stronger negative responses to unemployment across multiple model specifications, indicating a structural vulnerability that existing support programs may not adequately address.

The counterintuitive demographic effects revealed in this study suggest that housing policies based on simple demographic projections may be fundamentally misguided. Policymakers should move beyond age-based assumptions and consider

complex interactions between demographic structure, economic conditions, and housing preferences when designing interventions. This recommendation challenges a substantial body of existing housing policy that relies on demographic projections to guide investment and regulatory decisions, suggesting that such approaches may produce unintended consequences.

The variable and sometimes counterintuitive effects of housing stock suggest that simple supply-side interventions may not yield the intended outcomes, leading to the recommendation that local governments should exercise caution in assuming that increasing housing supply will automatically reduce prices, especially without considering quality effects and neighbourhood characteristics. This finding suggests that the common policy prescription of simply increasing housing supply to address affordability concerns may be ineffective or even counterproductive in certain circumstances.

From a methodological perspective, the dramatic differences between standard panel and Hausman-Taylor estimates demonstrate that future housing market research must systematically address endogeneity concerns. Researchers should develop and apply robust instrumental variable strategies and consider potential feedback effects in all housing market analyses. This methodological recommendation has broad implications for the housing economics literature and suggests that many existing studies may need to be reconsidered in light of potential endogeneity bias.

The systematic differences in explanatory power and coefficient patterns across housing segments suggest that future research should abandon one-size-fits-all approaches, as different modelling strategies may be optimal for various market segments, requiring researchers to develop segment-specific theoretical frameworks and empirical methods. The extreme price misalignments revealed in the fundamental value analysis indicate an urgent need for research focused on developing appropriate parameter calibrations for

contemporary housing markets, including time-varying parameter estimation and market-specific calibration studies.

The observed convergence patterns after 2015 suggest that static models may inadequately capture housing market adjustment processes, indicating that future research should prioritise developing dynamic modelling approaches that can account for adjustment costs, market frictions, and evolving market efficiency. The housing stock effects and extreme fundamental value deviations suggest that current price measures may inadequately account for quality differences, making the development of sophisticated hedonic price indices that can capture changing housing characteristics and quality over time a research priority.

The systematic deviations from fundamental values and counterintuitive demographic effects suggest that behavioural factors may play important roles not captured in current analytical frameworks, indicating that research should integrate household-level behavioural data to understand decision-making processes underlying observed market patterns. The spatial patterns in price misalignments and varying model performance across regions suggest that housing market research should prioritise understanding regional differences, including developing analytical frameworks that can capture local institutional factors, regulatory environments, and cultural preferences that influence housing market dynamics.

Several priority research questions emerge from this analysis that warrant immediate attention. Given the growing importance of environmental regulations, future research should examine how green building standards and climate policies may differentially affect various housing market segments, particularly considering different retrofit possibilities and costs for apartments versus single-family homes. The role of digital platforms and technologies in housing market transactions may differentially affect

market segments and price discovery mechanisms, suggesting that research should investigate how technological change may alter the market segmentation patterns documented in this study.

The counterintuitive demographic effects revealed here suggest that Germany's ageing population may have complex and unexpected impacts on housing markets, indicating that future research should develop more sophisticated frameworks for understanding how demographic change affects different housing market segments. Changes in mortgage markets, new financing instruments, and evolving lending practices may alter the interest rate sensitivity and risk profiles documented in this study, suggesting that research should monitor how financial market innovations affect housing market segmentation and stability.

6.5 Conclusion

This dissertation provides comprehensive empirical evidence of systematic segmentation within the German housing market, demonstrating that apartments and single-family homes operate as distinct market segments with different price determination mechanisms, economic sensitivities, and adjustment dynamics. The findings fundamentally challenge the common practice of treating housing markets as homogeneous and provide strong empirical support for differentiated analytical and policy approaches. The methodological contributions demonstrate the critical importance of addressing endogeneity in housing market research, revealing that conventional analytical approaches may significantly underestimate key economic relationships, which have broad implications for housing market research methodology and suggest that many previous studies may have reached incorrect conclusions due to inadequate treatment of endogeneity concerns.

The economic insights confirm the central role of financing conditions in German housing markets while revealing important heterogeneity in how different market segments respond to macroeconomic conditions. The systematic differences between apartments and single-family homes provide quantitative evidence for theoretical models of housing market segmentation and have important implications for understanding monetary policy transmission, financial stability assessment, and housing policy effectiveness. The fundamental value analysis, while highlighting significant challenges in relating market prices to economic fundamentals, provides evidence of evolving market dynamics with temporal patterns that suggest changing market efficiency over time, raising important questions about the adequacy of current theoretical frameworks for understanding housing market valuation and price discovery mechanisms.

For policy practice, the results demonstrate that uniform approaches to housing market intervention are likely suboptimal given the systematic differences across market segments. The differential responsiveness to economic conditions suggests that targeted policies may be significantly more effective than broad-based measures, while the complex demographic effects revealed in the analysis indicate that traditional policy assumptions may be fundamentally flawed. The counterintuitive findings regarding demographic effects and housing stock impacts highlight the danger of policy interventions based on simplified economic assumptions, suggesting that policymakers should exercise caution when implementing housing market interventions and should invest in developing a more sophisticated understanding of market mechanisms before pursuing large-scale policy changes.

The systematic differences documented in this study extend beyond academic interest to have real implications for millions of German households making housing decisions, investors allocating capital across market segments, and policymakers designing

interventions to address housing affordability and financial stability concerns. The quantitative evidence provided here establishes an empirical foundation for a more nuanced understanding of housing market dynamics and more effective policy responses to housing market challenges. Looking forward, this research establishes important baseline relationships that can inform ongoing monitoring of German housing market developments and provide benchmarks for assessing the effectiveness of policy interventions.

The methodological framework developed here can be applied to other national contexts and extended to examine emerging challenges such as climate policy integration, demographic transition effects, and the housing market implications of technological change. The contribution of this work lies not only in its specific empirical findings but also in demonstrating the necessity of disaggregated analysis in revealing market heterogeneity that aggregate approaches may completely obscure. As housing markets continue to evolve in response to technological, demographic, and policy changes, the systematic documentation of market segmentation provided here offers a crucial foundation for understanding how these changes may differentially affect various housing market participants and for developing more effective policy responses to emerging challenges.

Most importantly, this study demonstrates that housing market complexity requires sophisticated analytical approaches and warns against the dangers of oversimplified policy interventions. The counterintuitive findings and methodological sensitivities revealed here suggest that housing market research and policy development must become more nuanced, more methodologically rigorous, and more attentive to market heterogeneity if they are to effectively serve the needs of market participants and society more broadly. The evidence presented in this dissertation calls for a fundamental rethinking of how housing markets are analysed and regulated, moving away from one-size-fits-all approaches toward more

sophisticated, segment-specific frameworks that can better capture the complexity and heterogeneity that characterise real housing markets.

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