Institutions, Contracts, and Regulation of Housing Financing

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List of Abbreviations

ABM	Agent-based model
AI	Alternative Investment
BCBS	Basel Committee on Banking Supervision
BIS	Bank for International Settlements
BLs	Building and loan associations
CAR	Capital adequacy requirements
CBs	Conventional banks
CCyB	Countercyclical capital buffer
CET1	Common Equity Tier 1
CSH	Contractual saving for housing
CV	Collateral value
DAX	Deutscher Aktienindex (German stock index)
DSGE	Dynamic stochastic general equilibrium
e.g.	Exempli gratia
i. e.	Id est
LBS	Landesbausparkasse
LCR	Liquidity Coverage Ratio
LTV	Loan-to-value
Max	Maximum
Min	Minimum
No.	Number
OECD	Organization for Economic Co-operation and Development
OTC	Over the counter
ROA	Return on assets
RWA	Risk-weighted assets
Std	Standard deviation
UK	United Kingdom
U.S.	United States

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1. Introduction

The real estate market and, more specifically, the housing market is one of the most important markets of an economy. It is one of the few commodities that significantly affects both, social and economic concerns. It is an indicator of a nation's economic wealth, triggers others sectors' growth, impacts public health (Warnock, 2008), and even influences social connections and crime (Glaeser, 2000). The close interconnectedness between economic sectors creates mutual dependencies and spillover effects from one market to another. Due to this, a stable and resistant housing market is in common public, economic, and political interest. Governing the housing market and predicting the evolution of housing market cycles, however, is a major challenge. It displays several individual features that clearly differentiate it from other markets.

One is its high capital intensity. What drives housing investment is sustainable access to housing financing. As sufficient funding is a precondition for acquiring residential property, mortgage lending institutions play a decisive role in the housing market. They enable home seekers to become homeowners and, at the same time, decide by whom and when a residential property can be bought. Furthermore, they influence housing prices. By either granting loans or rejecting applicants and conducting other business, the demand for dwellings is influenced which affects prices. The huge amounts needed to become a homeowner also significantly affect an economy’s financial system. In Germany, housing loans account for approximately 70% of total adjusted bank lending (German Central Bank, 2020). In the European Union, real estate loans make up around 74% of total lending. This is equivalent to 40% of the euro area's GDP (Euro Area Statistics, 2020). These aspects highlight the close interrelationships and the mutual dependencies between the housing and the financial market.

The research that has been conducted to explain the strong nexus of the economy, the financial markets, and the housing market and to examine the drivers of their relationship is numerous and manifold. As early as 1969, Smith (1969)[1] created a model of the Canadian housing and mortgage market within a stock-flow context and stated that housing projects are strongly influenced by the cost and the availability of mortgage credit which, in turn, depend on the yields of alternative market securities and existing financial institutions. Igan et al. (2011) and Iacoviello and Pavan (2013) examine the characteristics and co-movements of housing, credit, and real activity business cycles. They reveal that, over the long term, house price cycles lead credit and real activity. Anundsen and Jansen (2013) figure out that house price appreciations lead to credit expansion which, in turn, augments prices. On top, they observe the financial accelerator mechanism which is reinforced by collateralizing practices in housing financing. Imposed procyclic credit constraints of lending institutions jeopardize market stability and increase the probability of extreme market collapses (Sommervoll, Borgersen, and Wennemo, 2010). Erlingsson et al. (2014) confirm these results and outline that banks also affect market stability through different creditworthiness conditions.

An aspect that the existing literature does not address so far is the second decisive feature of the housing market: its distinct heterogeneity. From various perspectives, housing is, above all, particularly individual. Dwellings must meet individual circumstances, habits, and preferences. Furthermore, they need to fit into geographical or political circumstances. To meet these individual needs, some financial systems mainly consist of privately organized institutions, focused on common banking business. Others are quite diverse, characterized by

[1] Note: The sources mentioned in the following are only examples of the literature existing on this topic.

different types of financial intermediaries such as public, cooperative, or specialized financial institutions that offer distinct products to finance a residential property. In the latter, lending activities, loan granting decisions, as well as terms and conditions are significantly aligned with the organizational form, the business model, and the strategic orientation of the financial institution. It seems reasonable to assume that these disparities affect housing markets differently. Though, existing literature does not account for different institutional frameworks. Instead of examining the impact of banks as a homogeneous group, we investigate the effects of particular institutional bank forms and contracts with respect to the housing market.

The latest evidence of the strong nexus of housing and financial markets and that financial markets affect real economies via the financial accelerator was provided in the latest financial crisis (Bernanke et al., 2007; Delli Gatti et al., 2010; Gilchrist and Zakrajšek, 2012). Housing financing practices, especially those of US-American banks, led to global financial and economic turbulences. Through lax lending, risky business practices, and excessive leverage, banks contributed significantly to the recession in the financial and real markets. These events led to a strong agreement in politics and business that banking regulation was not sufficient. As a result, Basel III was introduced. The new regulatory rules impose a diverse set of micro- and macroprudential measures that aim at strengthening the supervision and risk management of banks and providing a resilient banking system (BCBS, 2017a). Implied by the financial crisis, these newly designed standards even address the risk arising from the housing market by implementing individual risk weights for residential loans (BCBS, 2017b). What they do not address, however, is the heterogeneity persistent in the financial markets. The rules are imposed on every internationally active bank, neglecting the heterogeneity of banks' business practices and their individual regulatory frameworks. Existing research about Basel III also falls short in two respects: First, it neglects the importance of the housing market, mainly investigating producing economies. Second, it treats financial institutions as homogeneously acting agents (see e.g. Bookstaber, Paddrik, and Tivnan, 2018; Cinotti, Raberto, and Teglio, 2012; Lengwiler and Maringer, 2011; Popoyan, Napoletano, and Roventini, 2020). I aim to narrow this gap among regulators and in existing research by examining whether banking regulation is more effective and whether capital and housing markets are more resilient if specialized financial intermediaries have specialized regulatory requirements.

Although financial accelerator theories have long been indicating the close interconnectedness between financial and real markets, it has been overlooked in regulatory frameworks (Bernanke and Gertler, 1995; Bernanke et al., 1999; Kiyotaki and Moore, 1997; Hammersland and Jacobsen, 2008). The major contribution of the banking sector to the latest Great Recession led to the strong agreement in politics and business that current frameworks were not sufficient. Especially, the microprudential focus and procyclical measures were sharply criticized (Blundell-Wignall and Atkinson, 2010; Goodhart and Hofmann, 2007; Kowalik, 2011). One dedicated tool of the set of macroprudential policies of the Basel III Accords is the countercyclical capital buffer ($CCyB$). It aims at alleviating the procyclicality of persistent regulatory requirements and mitigating the magnitude of the financial accelerator. By now, however, its effectiveness remains unclear. One reason might be, that the $CCyBs$ implementation is up to national authorities (BCBS, 2019). Thus, there is no sound basis of countries that have already experienced its effects. As mortgage lending practices of conventional banks are proven to be procyclical, an effective macroprudential tool could help to stabilize the housing market and mitigate negative spillover effects on adjacent markets. As existing research provides no insights, this is tested in a dedicated study.

In this dissertation, I investigate the impact of different types of financial institutions, financial contracts, and financial regulation on the housing market. As the housing market is one of the most decisive markets of an economy, the scope is to provide new insights into the strong nexus between housing and financial markets and shed some light on key stability indicators. The following three chapters of this thesis reveal knowledge about the special relationship between both economic sectors incorporating two specific features of homeownership: its high capital intensity and its heterogeneity. In this context, the matter of diversity within financial systems is evaluated. According to this, I put special emphasis on three components of the financial market: financial institutions, financial contracts, and financial regulation. The three individual studies conducted for this thesis verify the benefits of heterogeneous financial markets and products concerning the solidity of the housing market. Furthermore, the results show that heterogeneous regulatory requirements may have positive effects on housing and financial market stability. At last, it tests one dedicated regulatory tool that is designed to mitigate a highly criticized feature of persistent regulations, their procyclicality. These studies provide new insights into the mortgage lending practices of banks. They provide economists, practitioners, and regulators with a better understanding of the effect of heterogeneity in the banking systems, and show how regulatory measures influence banks' lending behaviour and the quality of borrowers.

Chapters 2 to 4 coincide with the three papers written for this cumulative dissertation. The papers are formally revised for this thesis.

Chapter 2 of this thesis presents my paper "*The volatility of housing prices: Do different types of financial intermediaries affect housing market cycles differently?*".[2] It addresses the existence of heterogeneous financial institutions and financial contracts to finance housing property and their impact on the stability of the housing market. In detail, this chapter investigates whether various lending practices of different types of financial institutions affect housing market cycles differently. We develop a heterogeneous agent-based model that mimics a real-world housing market, consisting of potential home buyers and sellers who trade residential property. Financial intermediaries finance dwellings and, therefore, mainly determine whether housing investment can be realized. We create a heterogeneous financial market with special emphasis on two institutional bank types: conventional banks (CBs)[3] and building and loan associations (BLs). BLs are particular financial institutions specialized in satisfying any needs related to housing financing. Inspired by British Building Societies, they evolved as demand-driven financial innovations to overcome the lack of adequate financing. Due to World War I, Germany suffered a severe housing shortage and hyperinflation (Müller, 1999). Since existing institutions were unable to meet financial needs, BLs attracted home seekers through the idea of saving collectively in order to afford a residential property. This idea is incorporated into their core product, contractual saving for housing (CSH). Besides this, the specialty of BLs is reflected by their individual law. In addition to international and national regulations, they are subject to the Building Society Act (*Bausparkassengesetz*) and the Building Society Decree (*Bausparkassenverordnung*). These legislations align their business model to collect deposits and grant

[2] I am the main corresponding author of this paper. Co-authors are Hans-Peter Burghof, Julius Langer, and Dag Einar Sommervoll. My contribution to this paper was the initial research idea, the introduction of the formal model, and the setup of the computational experiments. Moreover, I was responsible for the research design, the interpretation of the results, and co-writing every chapter.

[3] The term *conventional banks* is used for bank types others than BLs that are mainly privately organized institutions and that are focused on common banking business. This includes a range of alternative investments, others than mortgage lending.

loans for purposes of building, buying or modernizing dwellings to those who are part of their enclosed system and restrict BLs in funding and investment opportunities. Especially in Germany and continental Europe, BLs constitute a peculiar but essential real estate financier. In our research, BLs represent an example of specialized financial intermediaries. Contrasting the mortgage granting decisions of the two bank types that arise out of varying business models and specialized institutional regulations, we find that CBs exercise procyclic mortgage lending that exacerbates prevailing up- or downturns in the housing market. Using BLs' core product, CSH, they put less emphasis on collateral values. Instead, they use information out of relationship lending which leads to less pronounced housing market cycles and more stable housing prices. Computational experiments reveal that a heterogeneous financial market, consisting of both CBs and BLs creates the most stable housing market and, at the same time, provides homeownership for a larger share of the economy.

As the results of Chapter 2 of this dissertation suggest a diversified financial market with differing institutional features and heterogeneous product landscapes to stabilize the housing market and diminish the risk of crises, **Chapter 3** extends the research scope to embrace regulatory environments. The paper "*Different Business, Same Regulation: Does Homogeneous Regulation Succeed in Taming Housing and Financial Market Instability*?"[4] assesses whether it is reasonable to impose homogenous regulatory requirements for heterogeneous financial institutions out of the perspective of housing, capital, and financial market stability. I introduce an extended heterogeneous agent-based model of a housing and a financial market that additionally incorporates a capital market. Besides to the real estate market, where potential buyers and sellers can trade dwellings, I model a capital market on which banks can trade a standardized share portfolio that depicts alternative investment opportunities for financial institutions. If banks engage in risky business which is either to finance housing investments or trading shares, Basel III requires them to hold a specified amount of equity. Banks' business activities are thus restricted by the prevailing capital adequacy requirements (CAR). Via computational experiments, I introduce a heterogeneous regulation in terms of different levels of CAR for a special type of financial intermediary that is proven to have a cushioning effect on housing market cycles, BLs (Braun et al., 2022). CAR for CBs are held fixed. The results provide evidence that imposing CAR on banks is effective in increasing market stability and the resilience of the banking sector. The obligation to meet CAR restricts risky business activities and increases banks' loss absorbency capacity. However, stability is not only a monotonic function of capital. Elevating CAR for BLs worsens stability measures and banking soundness. The study reveals that the institutional type of BLs and their special regulation imposes a risk-mitigating and stabilizing effect on the housing, the capital, and the financial market which can be intensified if CAR are aligned to their individual business model. These findings advocate in favor of heterogeneous CAR that shape market structures and create most stable market conditions.

Chapter 4 introduces the paper "*The Effect of the Countercyclical Capital Buffer on the Stability of the Housing Market*"[5]. Although a heterogeneously designed regulatory framework as suggested in Chapter 3 of this thesis, may contribute to a higher degree of resilience and solidity in the housing market and the banking sector, procyclic lending practices are still an inherent problem of the common banking business. They exacerbate prevailing market cycles and fuel the financial accelerator mechanisms. In mortgage lending, this effect is

[4] I am the single author of this paper.
[5] I am the main corresponding author of this paper. Co-authors are Dag Einar Sommervoll and Hans-Peter Burghof. I contributed to this paper by identifying the research gap, developing the initial research idea and the formal model, and setting up the computational experiments. Furthermore, I was responsible for the interpretation of the results and co-writing every chapter.

reinforced by collateralizing the financed dwellings (Anundsen and Jansen, 2013). As evidenced during the latest financial crisis, the banking regulation in force during this time failed to mitigate its scale. Instead, it further fueled the ongoing dynamics by procyclical regulatory requirements (Blundell-Wignall and Atkinson, 2010; Goodhart and Hofmann, 2007; Kowalik, 2011). As a result of these events, Basel III introduced the countercyclical capital buffer ($CCyB$). This macroprudential tool strives to counteract the issue of procyclicality of the previous regulatory rules. The paper presented in Chapter 4 investigates whether these regulatory aims can be achieved and thus stresses the importance of adequate banking regulation to contribute to housing and financial market stability. Conducting computational experiments in an artificial market setting, we examine the macroeconomic performance of the $CCyB$ by evaluating the dynamics of key stability indicators of the housing and the financial market. Under four different scenarios, an undisturbed market, a financial shock scenario, a positive housing demand shock scenario, and in times of a housing bubble, we test whether the macroprudential tool meets its regulatory goals. Doing this, we find that, in general, the $CCyB$ performs well in stabilizing the housing and the financial market in all of the tested market settings. It is not able, however, to prevent any of the simulated crises to occur. Furthermore, its effectiveness depends on the magnitude of the shock and on how much buffer has been built up by banks in the previous periods. A $CCyB$ introduced at the wrong time might even affect market conditions procyclically.

Chapter 5 of this thesis summarizes the main findings of the chapters presented before and concludes. I outline their contribution to the overall topic of this dissertation and provide some scope for further research.

1.1. Bibliography Chapter 1

Anundsen, A. K. and Jansen, E. S. (2013). Self-reinforcing effects between housing prices and credit, Journal of Housing Economics 22(3): 192–212.

BCBS (2017a). High level summary of Basel III reforms, *Bank for International Settlements.* URL *https://www.bis.org/bcbs/publ/d424_hlsummary.pdf*.

BCBS (2017b). Basel III. Finalising post-crisis reforms, *Bank for International Settlements.* URL *https://www.bis.org/bcbs/publ/d424.htm*.

BCBS (2019). Risk-based Capital requirements – Buffers above the regulatory minimum. *Bank for International Settlements.* URL *https://www.bis.org/basel_framework/chapter/RBC/30.htm?inforce=20191215&published=20191215*.

Bernanke, B. S. and Gertler. M. (1995). Inside the black box: the credit channel of monetary policy transmission. *Journal of Economic Perspectives*. 9(4): 27-48.

Bernanke, B. S., Gertler. M.. and Gilchrist. S. (1999). The financial accelerator in a quantitative business cycle framework. In: Taylor. J.B.. Woodford. M.(Eds.). *Handbook of Macroeconomics*. vol. 1.

Bernanke, B. S. et al. (2007). The financial accelerator and the credit channel, *Technical Report*.

Blundell-Wignall, A. and Atkinson, P. (2010). Thinking beyond Basel III: Necessary solutions for capital and liquidity, *OECD Journal: Financial Market Trends*, 2010(1): 9-33.

Bookstaber, R., Paddrik, M., and Tivnan, B. (2018). An agent-based model for financial vulnerability. *Journal of Economic Interaction and Coordination*. 13(2): 433-466.

Braun. J., Burghof. H. P.. Langer. J.. and Einar Sommervoll. D. (2022). The Volatility of Housing Prices: Do Different Types of Financial Intermediaries Affect Housing Market Cycles Differently? *The Journal of Real Estate Finance and Economics*: 1-32. https://doi.org/10.1007/s11146-022-09907-y.

Cincotti, S., Raberto, M., and Teglio, A. (2012). Macroprudential policies in an agent-based artificial economy, *Revue de l'OFCE*, (5): 205-234.

Erlingsson, E. J., Teglio, A., Cincotti, S., Stefansson, H., Sturlusson, J. T., and Raberto, M. (2014). Housing market bubbles and business cycles in an agent-based credit economy. *Economics: The Open-Access, Open-Assessment E-Journal*, 8 (2014-8): 1-42.

Euro Area Statistics (2020). Growth rates in housing loans are steadily increasing in the euro area. URL https://www.euro-area-statistics.org/statistics-insights/growth-rates-in-housing-loans-are-steadily-increasing-in-the-euro-area?cr=eur&lg=en&page=0.

Delli Gatti, D., M. Gallegati, B. Greenwald, A. Russo and J. E. Stiglitz (2010). The financial accelerator in an evolving credit network, *Journal of Economic Dynamics and Control*, 34: 1627–1650.

German Central Bank (2020). Banking Supervision and Real Estate Financing: The Risks at a Glance. URL https://www.bundesbank.de/de/presse/gastbeitraege/bankenaufsicht-und-immobilienfinanzierung-die-risiken-im-blick-836218.

Gilchrist, S. and Zakrajšek, E. (2012). Credit supply shocks and economic activity in a financial accelerator model. *Rethinking the Financial Crisis*, 1: 37-72.

Glaeser, E. L. and Sacerdote, B. (2009). The Social Consequences of Housing, Journal of Housing Economics 9(1-2): 1-23.

Goodhart, C. and Hofmann, B. (2007). House Prices and the Macroeconomy – Implications for Banking and Price Stability, *Oxford University Press*.

Hammersland, R. and Jacobsen. D. H. (2008). The financial accelerator: Evidence using a procedure of structural model design (No. 569). Discussion Papers.

Igan, D., Kabundi, A., De Simone, F. N., Pinheiro, M., and Tamirisa, N. (2011). Housing, credit, and real activity cycles: Characteristics and comovement, *Journal of Housing Economics* 20(3): 210-231.

Iacoviello, M. and Pavan, M. (2013). Housing and debt over the life cycle and over the business cycle, Journal of Monetary Economics 60(2): 221–238.

Kiyotaki, N. and Moore. J. (1997). Credit cycles. *Journal of political economy*. 105(2): 211-248.

Kowalik, M. (2011). Countercyclical capital regulation: should bank regulators use rules or discretion?, *Economic Review*, Federal Reserve Bank of Kansas City, 63.

Lengwiler, Y. and Maringer, D. (2011). Autonomously Interacting Banks (No. 2011/07). WWZ Discussion Paper.

Müller, M. L. (1999). Bausparen in Deutschland zwischen Inflation und Währungsreform 1924-1948, C. H. Beck, München. http://dx.doi.org/10.2139/ssrn.2873919.

Popoyan, L., Napoletano, M., and Roventini, A. (2020). Winter is possibly not coming: Mitigating financial instability in an agent-based model with interbank market, *Journal of Economic Dynamics and Control*, *117*, 103937.

Smith, L. B. (1969). A model of the Canadian housing and mortgage markets, *Journal of Political Economy* 77(5): 795–816.

Sommervoll, D. E., Borgersen, T.-A. and Wennemo, T. (2010). Endogenous housing market cycles, *Journal of Banking & Finance* 34(3): 557-567.

Warnock, V. C. and Warnock, F. E. (2008). Markets and housing finance, *Journal of Housing Economics 17 (3):* 239-251.

The Volatility of Housing Prices: Do Different Types of Financial Intermediaries Affect Housing Market Cycles Differently?

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Abstract

Housing markets display several correlations to multiple economic sectors of an economy. Their enormous impact on economies' health, wealth, and stability is uncontroversial. Interestingly, the forms of financing residential property vary widely between the different countries in terms of both, the available product types and the institutions offering them. This research examines the implications of different financial intermediaries on housing market cycles with special emphasis on two institutional types, conventional banks and building and loan associations. Introducing a heterogeneous agent-based model, the interactions of buyers, sellers, and the two types of credit institutions are assessed. Heterogeneous economic principles and expectations of agents create endogenous market conditions which are strongly influenced by the lending practices of financial intermediaries.

Focusing primarily on collateral values to decide about lending, conventional banks may contribute to volatile housing markets which are prone to recessions. Building and loan associations, on the other hand, rely to a greater extent on endogenously created borrower information. Thus, they are able to cushion the volatility of house prices caused by procyclical mortgage lending of conventional banks and increase the stability of the housing market. Simulations show that the most stable market conditions are attained if both types of financial intermediaries serve the mortgage lending market jointly. Furthermore, transaction and homeownership rates are the highest in this market setting. These findings advocate in favor of diversified financial markets.

Keywords: Housing financing, housing market cycles, housing market stability, agent-based model, heterogeneous agents, building and loan associations

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2. The Volatility of Housing Prices: Do Different Types of Financial Intermediaries Affect Housing Market Cycles Differently?

2.1. Introduction

Housing is one of the few commodities that significantly affects both, social and economic concerns. The functionality of the real estate market and the prediction of housing market cycles, therefore, are of tremendous importance. This, however, is highly challenging since housing is, above all, particularly individual. Dwellings must be fitted to external factors as geographical or political conditions. On top, they are strongly determined by individual circumstances, habits, and preferences. To meet all these individual needs, it is not surprising that different financial institutions exist that offer real estate financing. Some financial systems mainly consist of privately organized establishments, focused on common banking business. Others are rather diverse, characterized by public, cooperative, or specialized financial intermediaries. Lending activities, loan granting decisions, as well as terms and conditions are significantly aligned to the organizational form, the business model, and the strategic orientation of financial institutions. It seems reasonable to assume that these disparities affect housing markets differently. Therefore, it is important to examine the effects of particular institutional forms. Though, we find no studies that assess the impact of different institutional frameworks with respect to housing finance

Our study examines the effect of different financial intermediaries on housing market cycles. We construct a housing market model with heterogeneous buyers, sellers, and two institutional bank types, i.e., conventional banks and building and loan associations. Buyers are characterized by heterogeneous preferences of consumption and housing investment. According to their individual utilities and income constraints, they enter the market, state their reservation prices, and place bids. Sellers perceive current market conditions and form expectations about future housing prices based on the recent price history. They decide whether to offer their property in the current period or to keep it in the expectation of subsequent house price appreciations. Credit institutions finance residential property and, thus, mainly determine whether transactions take place. In order to minimize default risk, they restrict lending on credit constraints that are aligned to institutional specifications and business orientation.

The computational experiments show that conventional banks exercise procyclic lending practices. They base their mortgage granting decision on recent price trends thus exacerbating prevailing price movements to high peaks or low troughs. As a result, housing prices are unstable and volatile and face endogenously created outbreaks. If, in addition to conventional banks, building and loan associations offer mortgage financing, housing market cycles are smoothened. Excessive price booms are prevented and sharp declines are dampened. Building and loan associations align their lending practices on their special business model of serving any demand of housing financing, need to comply with the institution-specific regulations, and highly consider endogenously created customer information out of relationship lending to decide about mortgage financing. These features have stabilizing effects on housing prices, mitigate volatility and positively impact transactions and homeownership.

By elaborating the implications of varying loan granting policies of financial institutions on the housing market, our study contributes to the question of a favorable composition of the mortgage financing market with respect to stability concerns of the housing market. The model gives an implication which financial institutions should finance housing investment in order to create stable and at the same time efficient and competitive financial markets. In this context, the matter of diversity within financial systems is evaluated. We also contribute to the European Union's consideration of creating a single European market for housing finance.[10]

The paper is organized as follows. In section 2.2, we introduce the specialized institutions of building and loan associations. The model setup and the features of the interacting economic agents are described in section 2.3. Section 2.4 presents the results of the model. On top, the basic model is extended by introducing an equity requirement. Section 2.5 concludes.

2.2. Building and Loan Associations

Building and loan associations (BLs) are financial institutions specialized in satisfying any needs related to real estate financing. Driven by the overarching aim to overcome capital-market imperfections and loosen credit rationing, they are comparable to rotating savings and credit associations (Scholten, 2000) and share similarities to co-operative banks, with respect to the idea of collecting deposits from savers and lending them to borrowers. Their emergence dates back to the foundation of Ketley's Building Society in 1775 in Birmingham, United Kingdom. Members were attracted by the idea of saving collectively in order to afford residential property. Although the former business model was unviable, the British innovation inspired the development of enduring, competitive institutions in several countries (Proettel, 2017). This also holds for Germany, where BLs evolved in the 1920s as a response to a housing shortage and hyperinflation due to World War I (Müller, 1999). Since existing institutions were unable to meet financial needs, BLs arose as demand-driven financial innovations to overcome loan-shortage. After the establishment of the first BLs in 1924[11], the new financial intermediaries flourished over the centuries and established themselves as an integral part of the German financial market.[12]

Similar to conventional banks, BLs are usually organized as public[13] or private institutions, hold by banks or insurance companies. They are regulated by the German Banking Act and overseen by the Federal Financial Supervisory Authority. Their specificity is revealed, among others, by the separate law, they are additionally subject to. The Building Society Act (*Bausparkassengesetz*) and the Building Society Decree (*Bausparkassenverordnung*) align their business model to collect deposits and grant loans for purposes of building, buying, or modernizing residential property to those who are part of their enclosed system (sect. 1 (1) to (3) BauSparkG). To ensure this business approach and to protect customers from potential misuse of deposits (Müller, 1990), BLs are restricted in funding and investment opportunities (sect. 4 and sect. 6 BauSparkG). By allowing collateral values without risk discount in case of financing owner-occupied property, national law encourages lending and relaxes credit rationing which is further promoted by BLs, that subordinate granted mortgages (sect. 7 (1) BauSparkG, Diamond and Lea, 1992).

BLs are further characterized by their core product, contractual saving for housing (CSH) (*Bausparvertrag*), which establishes the underlying idea of saving unitedly to enable access to mortgages and shorten the waiting

[10] In order to complete the European Single Market, the European Commission arguments in favor of cross-border housing financing. This is intended to decrease financing costs, facilitate access to differing financial products, and intensify competition. However, due to huge differences within the member states according to conditions and products, harmonization has not yet been achieved. For more information see Voigtländer et al. (2010).
[11] The first BL, *Gemeinschaft der Freunde* (Society of Friends), was founded by Georg Kropp in Wüstenrot.
[12] For a detailed description of the history of German BLs, see for instance Lehmann (1983) and Müller (1999).
[13] Public building societies, called *Landesbausparkassen (LBS),* are part of the German Savings Banks Association (*Deutscher Sparkassen- und Giroverband*) and are limited in competition by regional segregation according to the federal states in which they operate.

period until investment. This enables participants to achieve Pareto-improvement and satisfy their positive time preference for homeownership. The concept is based on an overlapping generation model which consists out of savers and borrowers who build a self-enclosed, collective system (Scholten, 2000). To get a part of this system, a saver contractually obliges to save a specified amount for a certain period of time and, simultaneously, receives a commitment to be granted a residential loan at a later date. During the savings period, the customer earns an interest that is lower than prevailing market interest rates. The resulting opportunity costs shall be offset by a loan interest rate which is also below market conditions. Since both, savings and debt interest rates, are locked in for the whole contract period, the customer is protected from unfavorable market developments, which is especially attractive for risk-averse borrowers. Debts are granted from the pool of savings done by all customers collectively during different generations. The length of the qualifying savings period, therefore, depends on the customer's individual savings effort and the total volume of collected deposits. As soon as both criteria are fulfilled, the customer obtains the legal right of loan disbursement, which, according to his individual request, can be exercised immediately or at a later stage. This option grants the customer additional flexibility. At the time he decides to draw on the loan, his position changes from being a creditor to being a debtor. Instead of saving regularly, he is now required to service his loan. Following this concept, the BLs' lending business is endogenously driven and independent from capital markets.

BLs' business practices, as well as its core product, characterize BLs as special-purpose savings companies. In many legislations, financial intermediaries that accept deposits and in return commit to grant loans for specific purposes are prohibited in order to protect depositors. BLs, however, are explicitly exempt from this prohibition.[14] They promote residential property and thus contribute to overall economic prosperity. Following the underlying idea of saving collectively to realize housing investment and at the same time, being an economic institution that aims at profit maximization are, however, somewhat contradictory principles. In order to achieve positive effects on the real estate market and simultaneously protect customers, the regulator set up a particular framework to regulate the specialized financial institutions. This framework clearly defines their business model, their business operations as well as their organizational form. In return for the regulatory restrictions, the CSH business is reserved for BLs only.[15] This exclusivity generates a good reputation and creates customer confidence.

Although the regulatory framework significantly restricts the flexibility and the business activities of BLs, the special regulations seem to be a precondition for BLs to exist. Examples from the past have shown that financial liberalization and deregulation abandoned institutions from the market that were founded on the principles of BLs. When building societies in the U.K. and savings and loan institutions in the U.S. started to refinance loans on the capital market, their market share in housing finance significantly decreased and finally, they were forced out of the market (Diamond and Lea, 1992; Scholten, 2000). This indicates that deregulation increases the incentives for specialized financial institutions to expand business activities, resulting in a convergence of specialized institutions with conventional banks. In both nations, the elasticity of the supply of funds for housing increased, thus, the amplitude of housing cycles rose and the housing market got more volatile as a result of deregulated market environments and the disappearance of BLs (Scholten, 2000). For reasons such as different legal systems,

[14] For more information see for instance Boos, Fischer, Schulte-Mattler, and Schäfer KWG § 3 Rn. 14-18; Drescher, Fleischer, and Schmidt KWG § 3 Rn. 168-179; Erbs, Kohlhaas, and Häberle KWG § 3 Rn. 8.

[15] For more information about the development of the German regulatory requirements of BLs see Schäfer, Cirpka., and Zehnder, 1999.

deregulation had another scale in European countries. In Germany and Austria, for example, BLs experienced market declines but successfully defended their raison d'être. At the time of its development, CSH and the innovative financial intermediaries distributing it were important to support housing investment. Just as then, the housing and the mortgage lending market are of high economic relevance and among the most important markets in Europe. In the EU, real estate loans account for about 74% of total adjusted bank lending which is equivalent to 40% of the euro area's GDP (Euro Area Statistics, 2020). German conditions are quite similar where housing finance makes up around 70% of total lending (German Central Bank, 2020). Nowadays, however, financing conditions have changed. Especially in developed countries with highly competitive and easily accessible financial markets, plenty of products and financial institutions are available to finance residential property. This might be one reason for BLs to loosen their focus from their former main product and expand their product range to further real estate financing products (Burghof and Gehrung, 2019), which is apparently successful. In Germany, BLs account for approximately 14.2% of today's total financing volume for housing and, therefore, constitute an essential real estate financier. Since BLs serve any demand of housing financing, which, in addition to housing purchase also includes renovation, modernization or investments in sustainable housing, BLs are involved in one out of three private housing financings. The market penetration of CSH in Germany reaches 30% and almost every second household is CSH customer. Similar or even higher market penetration rates can be observed in other European countries. Austria records the highest market penetration of 43%. This means that almost every second citizen uses CSH. The market penetration of the Czech Republic reaches 33%, Slovakia 16%, and Hungary 8%. Smaller but stable rates can be observed in Hungary and Romania.[16] The high popularity the special institutions enjoy in these countries is also evident in Luxembourg. German BLs even service customers in China and India (Kirsch and Burghof, 2018). Similar concepts of BLs exist in UK and Ireland and even in Australia and New Zealand.[17] The continued successful existence on financial markets indicates that BLs serve a purpose beyond the distribution of CSH contracts. This purpose is to be explored within this research.

2.3. The Model

2.3.1. Overall Model Structure

As stated previously, housing and real estate financing markets are strongly characterized by heterogeneity. For this reason, a generally applicable, globally transferable market setting must be examined, to address the research question. In the following, a heterogeneous agent-based model is developed in which agents with deviating beliefs about future housing prices interact with each other and thus create endogenous housing market cycles. The model incorporates four types of agents: buyers, sellers, and two types of credit institutions. Buyers determine whether to buy a dwelling and therefore, state the demand in the housing market. Sellers, in contrast, provide housing units on the market. Credit institutions grant mortgages to buyers who decided to invest in housing. Those are differentiated by two types of financial institutions. On the one hand, a conventional mortgage can be granted by a conventional bank.[18] On the other hand, housing investment can be financed by a BL, using CSH. By

[16] Data is available from the Verband der deutschen Bausparkassen, EFBS and Eurostat.

[17] For more information, see: https://www.rba.gov.au/publications/fsr/2006/mar/struct-aus-fin-sys.html, https://www.companiesoffice.govt.nz/all-registers/building-societies/about-building-societies/.

[18] The terms *conventional mortgage* and *conventional bank* are used for standardized mortgages, granted by financial institutions, others than BLs, at the time of request, characterized by a fixed term and a fixed interest rate.

distinguishing loan granting financial intermediaries, the model reveals the effects of different product types and institutions on the housing market.

The model incorporates the important feature of heterogeneity persistent in the housing market by considering the individual penchants of households according to consumption and housing investment. Furthermore, all agents align their actions to individual expectations about future housing prices. Since the model is set up in a multi-period framework, not only market interactions, but also the feedbacks of those are displayed.

2.3.2. Types and Characteristics of Economic Agents

2.3.2.1. Buyers

Buyers are assumed to be households and represent potential customers of residential property. They can enter the housing market at the beginning of each period and are restricted to buy one unit of housing each. Their individual demand is formed out of the utility they receive from owning one housing unit h and from consuming any other consumption goods c. The investment choice of a buyer b is based on his preferences expressed in the form of a Cobb-Douglas utility function. Every agent has a disposal period income Y_t which is fully spent in each period. Investment choices are therefore constrained by $Y_t = P_{ct}c + P_t h$.

Utilizing Lagrangian function and solving for P_t gives the highest possible periodical expenditure for housing purposes a buyer can afford under his given budget constraint. This price can be stated to be the reservation price $P_{res,b,t}$ of a buyer b who maximizes the utility of his preferences. $P_{res,b,t}$ is:

$$P_{res,b,t} = \left(\frac{Y_t}{\left(\frac{\alpha}{\beta}+1\right)}\right) - (rP_t). \tag{1}$$

It is assumed, that an investment in residential property is fully mortgage financed. Housing expenditure, therefore, includes interest cost r_t on the mortgage volume (P_t) as well as a redemption on the principal r_p. The sum of interest cost and redemption $r = r_t + r_p$[19] lowers the highest possible purchase price. This assumption creates a base scenario that serves as a benchmark. In chapter 4.3, the assumption of a fully mortgage financed dwelling is relaxed by introducing an equity constraint. As financiers usually demand a minimum level of equity to finance residential property, this scenario mimics reality.

Formulating a reservation price as stated in (1) follows an equilibrium approach in which all agents make optimal decisions and the market clears up completely. However, markets are dynamic systems following the interactions of market participants. The equilibrium approach serves as a good starting point for the model. To display market dynamics and set up realistic market conditions, further periods follow a disequilibrium approach.

A disequilibrium approach as formulated by Filatova, Parker and van der Veen (2007) assumes that prices for residential properties are built by bilateral bidding. This model applies a price formation that evolves out of bilateral transaction. The reservation price in (1) represents a threshold above which a household is not able to buy a dwelling. This price level, however, must not equal the price a buyer is willing to bid when entering the market. The bid price is specified by taking current and expectations about future market conditions into account. The expected market price of an upcoming period is based on the available price information and an individual market assessment and is formed as:

[19] If a redemption period of 10 is considered and 10 payments on the principal are made, $r_p = 0.1$.

$$P_{expected,b,t} = (1 + e_b) * (P_{t-1} + \Delta P_{t-1}), \quad (2)$$

where e_b indicates an agent's belief of future market performance, P_{t-1}indicates the price level of the previous period, and ΔP_{t-1} the change of the price level which has happened during this period. By considering recent price changes when determining future prices, the prevailing market condition is included. A buyer's demand consequently depends on both, $P_{res,b,t}$ and $P_{expected,t}$, whereas he only places a bid, if

$$P_{expected,b,t} \leq P_{res,b,t}. \quad (3)$$

If (3) holds, the price a buyer bids is:

$$Bid_b = min(P_{expected,b,t}, P_{res,b,t}). \quad (4)$$

2.3.2.2. Sellers

Whereas buyers are assumed to be households, sellers can either be households, too, or they are residential developing firms. In the following, the term 'seller' designates households who sell already established properties, whereas 'residential property firms' produce and sell new dwellings. In both cases, they aim at profit maximization. At the beginning of each period, a potential seller decides whether to keep a house or to sell it. This decision is based on the expected profit out of the given options. By keeping a property, the earliest possible profit Z can be achieved in period t_{+1}, which would be the observed price level of t. The price a seller expects in period t is $P_{expected,s,t}$ and follows those of buyers (see (2)). The expected profit in period t out of keeping a dwelling consequently is:

$$Z_{keep,t} = \frac{(1+e_s)*(P_{t-1}+\Delta P_{t-1})}{(1+r_f)}. \quad (5)$$ [20]

It is assumed that a seller leaves the housing market as soon as a sale has been conducted and the quantity of sales is restricted to 1. Furthermore, a seller cannot be a buyer in the same period, whereas a former seller can become a buyer in subsequent periods. Freed up liquidity out of a sale is entirely invested in an alternative investment which bears interest at the risk-free interest rate r_f. A seller would only offer his property for sale if $Z_{sell,t} \geq Z_{keep,t}$, respectively, if $Z_{sell,t} - Z_{keep,t} \geq 0$. The expected profit out of selling a property equals the sum of the observed price level in the previous period, P_{t-1}, and the return of the alternative investment:

$$Z_{sell,t} = P_{t-1} + \frac{(r_f AI)}{(1+r_f)}. \quad (6)$$ [21]

Since a seller uses the previously observed price level in order to decide between keeping and selling, P_{t-1} determines the seller's reservation price:

$$P_{res,s,t} = P_{t-1}. \quad (7)$$

[20] Since a cash flow would not occur until period t_{+1}, it is discounted with the risk-free interest rate r_f.
[21] Note: Because of great variations in transaction costs, they are not considered in the model.

However, a seller can be optimistic to achieve more than his reservation price and mark it up by φ. To determine a markup ratio, the agent consults the previous ratio of buyers and sellers in the housing market. For this purpose, he calculates:

$$\varphi = \frac{(NB-NS)}{(NB+NS)}, \tag{8}$$

where NB means the number of buyers and NS means the number of sellers. By doing this, he figures out whether a buyer or a seller market exists. For $\varphi > 0$, the price is adjusted upwards while for $\varphi < 0$, $P_{offer,t} = P_{res,s,t}$ since $P_{res,s,t}$.is the lower limit of $P_{offer,t}$ Accordingly, the offered market price is:

$$P_{offer,t} = \begin{cases} P_{t-1}(1+\varphi) & for\ \varphi_t > 0 \\ P_{t-1} & for\ \varphi_t < 0 \end{cases}. \tag{9}$$

If a property is not sold during t, it remains on the market and can be bought in t_{+1}. In this case, the seller must admit that his price offer was not in line with the market and thus, he reduces it by a markdown ratio of σ. For σ, $0 < \sigma < 1$ applies. In the case that the dwelling is not sold in t_{+1}, despite the granted markdown, it remains on the market to be bought in t_{+2}. This approach applies for all further periods until the dwelling is sold. A seller's reservation price of a housing unit available for sale thus is:

$$P_{res,s,n} = \begin{cases} \left(P_{t-1}(1+\varphi)\right)\sigma^n & for\ \varphi_t > 0 \\ P_{t-1}\sigma^n & for\ \varphi_t < 0 \end{cases}, \tag{10}$$

where n denotes the number of periods a house remains on the market. This implies that an agent only accepts bids from potential buyers equal to or above his prevailing reservation price. Since the bid price formation of buyers is not directly dependent on sellers' behavior, bids may exceed a reservation price.

2.3.2.3. Housing Price

After evaluating the market situation and considering individual conditions, agents place their bids and offers at the market. As soon as a bid equals or exceeds a potential seller's reservation price, a sale takes place. Prices of conducted transactions are thus formed by agents' valuation and interaction. The transaction price is registered as the actual price of the traded property. For building the price level of one period, we follow the approach of Sommervoll, Borgersen and Wennemo (2009) and calculate the mean of all transaction prices during this period. The price level as well as its change are observable for every market participant and serve as reference points for expectations about price developments. The price index is:

$$P_t = \left(\frac{1}{N_{transactions}}\right)\sum_{h=1}^{N} P_i, \tag{11}$$

where $N_{transactions}$ represents the number of all transactions in one period, and P_i represents the price of the sold unit i. The market closes when demand is satisfied, supply is exhausted, or when remaining bids and offers cannot be matched. After that, a new price index is calculated. Correspondingly, actual transaction prices affect agents' future bids and offers.

2.3.2.4. Number of Properties

The housing stock available for sale is composed of offers from sellers and those from residential property firms.[22] In each period, potential sellers decide anew whether to keep or to sell their dwelling out of which the number of first-time sales, $N_{new\ sellings}$, is made up of. In addition, not sold offers of the previous period, $N_{left\ over}$, may remain on the market. On top, at the beginning of each period, construction firms decide whether, and if yes, how many houses to construct. This is done by consulting φ and, thus, by considering whether the market lacks or exceeds supply. Since residential property firms are assumed to maximize profit, the construction volume also depends on recent price developments. Accordingly, a volume of newly constructed houses, $N_{constructions}$, enter the market in the course of:

$$N_{constructions,t} = N_{remaining\ buyers,t-2} * \varphi_{t-2} * \rho_{t-2}, \tag{12}$$

where $N_{remaining\ buyers,t-2}$ is the number of buyers who were not satisfied two periods before, φ_{t-2} is the ratio of buyers and sellers at the market in the period t_{-2}, and $\rho_{t-2}$is the change rate of the price level in the same period and is calculated by: $\rho_{t-2} = \left(\frac{P_{t-2}+\Delta P_{t-2}}{P_{t-2}}\right)$.

The construction time for new houses is assumed to be one period. Newly constructed houses available on the market in t are based on the number of houses, and the market and price situation two periods ago, since the decision how many houses to build, must be made at the beginning of t_{-1}. At this time, however, the most recent data available is this of the period t_{-2}. Construction starts at the beginning of t_{-1} and is finished in t. By following this approach, supply is adjusted to market conditions, and the delay of supply, resulting out of the long construction period of residential property, is considered. To determine the number of constructions, $N_{constructions,t} \geq 0$ holds. The total number of houses available for sale in a prevailing period consequently is:

$$N_{h,t} = N_{new\ sellings,t} + N_{left\ over} + N_{constructions,t}. \tag{13}$$

The prices for which residential construction firms offer their houses at the market follow the equations (7), (9), and (10).

2.3.2.5. Credit Institutions

Unlike other markets, the real estate market is strongly influenced by financial institutions. By approving or rejecting mortgages, they affect whether and to whom properties are sold. This model lays focus on two types of credit institutions. Type one represents a bank, herein referred to as conventional bank (CB), granting a mortgage after evaluating the financial circumstances of a potential borrower, with a fixed term and a fixed interest rate. Type two is a building and loan association (BL) as introduced in chapter two. Given their displayed specialties, the loan granting behavior of BLs differs from that of CBs.

As banks are economic enterprises, the maxim of profit maximization applies to both types of credit institutions. Since borrowing applicants are budget constraint, a bank limits a potential borrower's mortgage

[22] Note: Residential property firms are not further divided into individual companies. Instead, the entire industry is represented.

volume to the amount of his highest possible expenditure for housing purposes, which is $\frac{Y}{\left(\frac{\alpha}{\beta}+1\right)}$ (equation (3)), and can be stated as a first mortgage constraint for borrowers:

$$C1: M_{max,i,1} = \frac{Y}{\left(\frac{\alpha}{\beta}+1\right)}. \tag{14}$$

Following the lines of Heuson et al. (2001), credit institutions are assumed to be risk-neutral and only approve a mortgage if the expected profit $Z_{mortgage,t}$ exceeds this of investing the same amount in an alternative investment, which bears interest of r_{AI}. The decision of mortgage granting, therefore, involves determining:

$$Z_{mortgage,t} = (qr_t + (1-q)r_d)M, \tag{15}$$

where q indicates a potential borrower's probability of not defaulting, $r_t$indicates the mortgage interest rate, r_d indicates the rate of return if the borrower defaults and M indicates the mortgage sum and determining:

$$Z_{no\ mortgage,t} = r_{AI}M. \tag{16}$$

A bank only grants a mortgage if $Z_{mortgage,t} \geq Z_{no\ mortgage,t}$, which means:

$$\mathrm{q}r_t + (1-q)r_d \geq r_{AI}. \tag{17}$$

Whereas Heuson et al. (2001) assume $r_{AI} > r_d$, to restrict lenders from benefiting from mortgage default, we follow the approach of Sommervoll, Borgersen and Wennemo (2009), who allow for $r_{AI} = r_d$. If this sets in, the potential lender can consider other information, too, when deciding about lending, as expected house prices or the composition of its individual investment portfolio. Solving (17) for r_t, the lowest mortgage interest rate a lender would accept as a function of a potential borrower's probability of not defaulting is obtained. Those indifference rates are unequal for CBs and BLs. BLs are by law quantitatively restricted in investment opportunities. The return out of their alternative investment shall therefore be calculated as a discrete one in the sense of:

$$r_{AI,BL} = \left(wr_f\right) + ((1-w)r_M), \tag{18}$$

where w states the investment volume in percent of the respective investment, r_f states the risk-free interest rate, and r_M the capital market return. CBs, however, are not governed by any restrictions. Considering capital market theory, $r_{AI,CB}$ can be stated to be r_M. The indifference rates for mortgage granting of CBs and BLs accordingly are:

$$CB: r_{min,CB} = r_d + \left(\frac{r_M - r_d}{q}\right) \tag{19}$$

$$BL: r_{min,BL} = r_d + \left(\frac{\left(wr_f\right)+((1-w)r_M)-r_d}{q}\right). \tag{20}$$

Solving (17) for q reveals the lowest probability of not defaulting of potential lenders the respective bank would accept for a given r_t:

$$CB: q_{min,CB} = \left(\frac{r_M - r_d}{r_t - r_d}\right) \tag{21}$$

$$BL: q_{min,BL} = \left(\frac{\left(wr_f\right)+((1-w)r_M)-r_d}{r_t - r_d}\right). \tag{22}$$

The lower the value of q, the higher the return of lending must be in order to be advantageous for the bank. Since $r_{min,CB} > r_{min,BL}$, the customers with lower probabilities of not defaulting will be those of BLs. Consequently, for a given r_t borrowers can be assigned to the two institutional types according to their values of q. All customers with q in the interval $[0, q_{min,BL}]$ are rejected by both banks. Those in the range of $[q_{min,BL}, q_{min,CB}]$ are only granted a mortgage by BLs. For $[q_{min,CB}, 1]$, however, both banks are willing to lend. Borrowers are assumed to have a positive time preference for housing investment. Therefore, every borrower with a value of $q \in [q_{min,CB}, 1]$ who can afford the comparatively high interest rate of CBs, will decide in favor of CBs. Accordingly, customers will borrow from CBs if their disposable income equals or exceeds debt service, which is the annuity $A_{m,CB} = \frac{(1+r_{min,CB})^n r_{min,CB}}{(1+r_{min,CB})^n - 1} M$. Customers of BLs with $q \in [q_{min,CB}, 1]$ can thus be referred to as those, for which $\frac{Y}{\left(\frac{\alpha}{\beta}+1\right)} < A_{m,CB}$ holds.

In our model, banks operate in a competitive financial market. Their expected profit is zero and no single institution has market power. Both institutional types are able to accurately risk price borrowers, thus, no market failure exists. In reality, however, an additional dimension of imperfect information may exist. This is where problems of adverse selection set in and a competitive market may turn out to be inefficient. In a market setting in which different financial intermediaries offer different kinds of lending contracts, agents may self-select choosing their contract (Rothschild and Stiglitz, 1976). Thus, there is some risk that unsuccessful mortgage seekers of CBs turn to BLs and hence, BLs cater to less attractive mortgagors. To counteract adverse selection, BLs would have to price mortgages higher. Instead, they provide mortgages at a lower interest rate which is induced by regulatory requirements. In our model, we comply with this fact, calculating their alternative investment return as a discrete one (18). Assumed adverse effects, however, are not dominant. Instead, it is evidenced empirically that BLs experience lower mortgage defaults than CBs (Burghof and Schairer, 2017). This may have different reasons. One might be the inherent borrower information out of relationship lending. According to these findings, the model assumption of a competitive market neglecting adverse selection seems reasonable.

Further following the approach of Sommervoll, Borgersen and Wennemo (2009), it is assumed that the probability of not defaulting is oppositely associated with an applicant's mortgage-to-income ratio, which is $\gamma = \left(\frac{M}{Y}\right)$. The smaller the mortgage-to-income ratio, the higher the no-default probability q, what leads to the expression of q as a decreasing function of γ, $q = q(\gamma)$. Resulting from this, the mortgage a lender would grant to an applicant i must not be higher than the opposite of his mortgage-to-income ratio times i's income, given his probability of not defaulting:

$$C2\colon M_{max,i,2} = (1 - \gamma_i)Y_i. \tag{23}$$

The mortgage-to-income ratio serves as a good proxy to estimate borrower default since higher borrower income is associated with a lower probability of default (Yang, Buist, and Megbolugbe, 1998; Hakim and Haddad, 1999; Ambrose and Capone, 2000). We restrain from modeling strategic default decisions of borrowers since, via the individual utility functions of potential borrowers, only those agents enter the housing market who positively assess owning residential property. Strategic default in contrast is a decision to abandon homeownership and its benefits.[23] Homeowners may try to avoid default as they attach a non-financial value to their homes. This point is evidenced by the fact that default among homeowners is relatively raw even if households suffer severe financial difficulties (Bhutta, Dokko, and Shan, 2017; Foote and Willen, 2017).

Existing literature identifies further default decisions arising from external factors such as falling house prices or income shocks. Negative home equity due to house price depreciation is positively correlated with borrower default (Deng, 1997; Ambrose and Capone, 2000; Ambrose, Capone, and Deng, 2001). It is the necessary condition for failing to repay debts, however not the sufficient one (Foote, Gerardi, and Willen, 2008). Borrower default usually arises from two triggers that combine negative equity with adverse life effects such as loss of employment or divorce (Deng, 1997; Ambrose and Capone, 2000; Foote, Gerardi, and Willen, 2008; Campbell and Cocco, 2015). External triggers from housing or macroeconomic conditions are volatile house prices and interest rates (Schwartz and Torous, 1993; Ambrose, Capone, and Deng, 2001). We refrain from modeling such default decisions, too, since those would affect the two investigated financial intermediaries equally and, thus, the result would be unaffected. Instead, we use the mortgage-to-income ratio to select borrowers. It reduces mortgage affordability, making borrowing constraints more likely to bind and, thus, considers borrower default.

Collateralizing the financed dwelling is common business practice in housing financing in order to lower financiers' risk (Bester, 1985). Pledged collateral reduces the risk of moral hazard and strategic borrower default and protects creditors (Aghion and Bolton, 1992; Hart, 1995). Screening customers and creating endogenous or acquiring external customer information is costly. Collateralizing the financed dwelling is comparably cheap and a reliable way to prevent losses. This induces CBs to omit screening and to primarily focus on collateral values to decide about lending (Manove, Padilla, and Pagano, 2001).[24] In this model environment, it is assumed that the whole stock of debt shall be collateralized what constrains the mortgage sum to the amount of collateral. To determine the collateral value, CBs rely on recent market information and adapt expectations. Furthermore, mortgage lending is part of strategic portfolio selection and shall always be considered for diversification reasons.

In times of favorable market conditions, CBs imply further house price appreciation. In times of previous depreciation, they determine a threshold up to which mortgage lending is advantageous because of diversification reasons. If price declines exceed this threshold, CBs imply the same decrease for future periods. If price declines are below this threshold, mortgage granting of CBs is more permissive in order to benefit from positive diversification outcomes. In this case, they do not only account for market information and collateral values, but also for a potential buyer's affordability of housing investment. On top, they lower the collateral value by applying a risk discount. The mortgage constraints for the different scenarios are:

$$C3_{CB}: M_{max,i,3} = CV_{k,i} = \begin{cases} (1+\rho)^2 P_{t-1} & for\ \rho^+ \\ \chi\,(1+\rho) P_{t-1} & for\ \rho^- > \psi \\ \chi\,(1+\rho)\frac{Y}{\left(\frac{\alpha}{\beta}+1\right)} & for\ \rho^- < \psi \end{cases} \quad , \tag{24}$$

[23] Benefits of homeownership and reasons to deter default are e.g. the ability to hedge fluctuations in housing costs (Sinai and Souleles, 2005) or the tax deductibility of mortgage interest (Glaeser and Shapiro, 2003; Poterba and Sinai, 2011).
[24] Empirical evidence confirms that conventional banks base their lending decisions on collateral. See e.g. Collyns and Senhadji (2005), Freund et al. (1998), Herring and Wachter (1999), Hilbers, Lei and Zacho (2001), Niinimäki (2009).

where ρ^+represents a positive relative price change, ρ^-a negative relative price change, χ a risk discount, and ψ the threshold until which mortgage lending is advantageous out of diversification reasons although prices fell in previous periods. Given (14), (23) and (24), a CB approves a mortgage to applicant i in the volume of:

$$M_{CB,i} = \min(C1, C2, C3_{CB}). \tag{25}$$

According to the ruling law of BLs, owner-occupied dwellings are allowed to be fully collateralized. Opposite to CBs, BLs do not primarily refer to the collateral value to determine the maximum amount of debt, since they subordinate granted mortgages. Instead, they depend the volume on information gathered during the qualifying period of the CSH. During this time, a potential borrower is contractually obliged to save regularly a specified amount of money. If the customer fulfills this obligation, he can be referred to be a good customer, represented by the proportion μ. The mortgage amount disbursed is not further limited.[25] If the customer violates his contractual obligation during the qualifying period, he reveals himself as a bad customer with the proportion $(1-\mu)$. The bad personal traits disclosed before indicate additional breaches of contract during the credit period. Therefore, the mortgage is not disbursed. This kind of endogenously created information about borrower behavior during a long-term savings contract has a high value content and is the most reliable information they can obtain. Borrower's long-term neglect of consumption reveals reliability and creditworthiness. A third mortgage constraint holds which is $C3_{BL}: M_{max,i,3} = 0$. The disbursed mortgage volume of a BL which accounts for having two customer types is:

$$M_{BL,i} = \begin{cases} \min(C1, C2) & for\ \mu \\ \min(C1, C2, C3_{BL}) & for\ (1-\mu) \end{cases}. \tag{26}$$

Since this mortgage granting behavior does not account for collateral values, it is independent of expectations of future house prices. On top, it incorporates the monetary credit capacity of applicants as well as their personal creditworthiness. By following this approach, the credit approval procedure is less dependent on prevailing market conditions.[26]

2.4. Results

2.4.1. Calibration of the Simulation Setting

A set of computational experiments of the model presented in the previous sector has been carried out. Based on numerical simulations, it shall be evaluated whether varying lending practices of financial intermediaries affect housing market cycles differently. To start the simulation, initial parameter values are defined to set a model frame that mirrors a real housing market with respect to relations and conditions. To initialize the market, 60 potential buyers and 30 potential sellers are put on the market who observe an initial market price of one unit of housing of $P_t = 2500$. To let agents follow their decision-making process right from the beginning, $\Delta P_{t-1} = 50$ and $\Delta P_{t-2} = 50$. The heterogeneity of potential buyers and sellers is set by various parameters. Buyers' preference for consumption is uniformly distributed between $[0, 1]$. Their income ranges from $[100, 1000]$ and the individual

[25] Note: Mortgage disbursement is not only contingent on the individual savings effort. Instead, a minimum duration of the savings period must be fulfilled as well as a fixed threshold level that depends on the collective savings volume of the whole group of customers.

[26] CBs may assess for personal credit worthiness of debt applicants as well. However, these information are exogenously, disclosed by the applicant himself and, therefore, less reliable than information created endogenously by relationship lending.

expectations of future market conditions are drawn from a uniform distribution, therefore allowing a deviation up to 10% around the price index expectation. Buyers' initial burden rate for housing investment equals $r = 0.13$ which is composed of a fixed redemption rate of $r_p = 0.1$[27] per period and a mortgage interest rate of $r_t = 0.03$. In subsequent periods, buyers use the average mortgage interest rate of the previous period to calculate their reservation price. If a buyer is unsuccessful for the repayment period of 10, he is assumed to be too old to buy a dwelling and stays a tenant.

As sellers are assumed to be households, too, having the same information available, their market expectation is determined as those of buyers. If a house is not sold, a seller reduces his offer price by 5% each period up to a maximum of 30 periods. If a dwelling stays unsold during this time, it is assumed to be depreciated and, therefore, removed from the market. In each subsequent period, a random number of potential buyers in a range of $[30, 36]$ and potential sellers in a range of $[10, 12]$ attend the market setting.

After evaluating market conditions and determining their reservation prices, potential buyers and potential sellers enter the market. Sales are conducted following a first-price-sealed-bid auction. All bidders submit their bids which are assigned to sellers' offers in descending order. Although the model does not account for different housing features, this auction process implicitly measures quality differences. It can be assumed that more expensive houses have a higher quality standard and buyers with a higher disposable income value this by placing higher bids. The transaction price equals the mean of matched bid and offer. This incorporates a realistic negotiation range in real estate transactions and allows the seller to make an additional profit if the bid exceeds the offer.

Credit institutions are assumed to have a r_d of 0.001 in all simulations. To determine the collateral value of a dwelling, a risk discount of 0.2 ($\chi = 0.8$)[28] is applied. The price decline until which mortgage lending is advantageous for CBs out of diversification reasons is $\psi = 0.03$. BLs recognize a ratio of good customers in the market of $\mu = 0.8$ and they are restricted by national law to invest not more than 5% in assets on the financial market other than the risk-free interest rate (sect. 4 and sect. 6 BauSparkG).[29] Financial markets display a risk-free interest rate of 0.01 and a market return of 0.02. The initial simulation parameters are displayed in Table 2.1.

[27] This corresponds to a repayment period of 10.

[28] Loan-to-value ratios vary internationally. Conventional German banks are quite restrictive, only funding 60% of the market value when a senior loan is granted. The LTV of junior loans reaches 80% (Bienert and Brunauer, 2006). BLs, in contrast, are legally permitted to finance 100% of owner-occupied residential property by their national law. In Denmark, the LTV-level reaches 80% (Jensen, Petersen and Landa, 2015). The same holds for Russia (Zubov, 2011) whereas in Ireland a maximum LTV of 90% is permitted (Corrigan, O'Toole and Slaymaker, 2020).

[29] The Bausparkassengesetz, respectively, the Building Society Act, is the national law, BLs are subject to.

Table 2.1: Initial simulation parameters

Parameter	Description	Value
Buyers		
α	Preference for consumption	[0, 1]
Y	Income	[100, 1000]
e_b	Individual market expectation	[-0.1, 0.1]
Sellers		
e_s	Individual market expectation	[-0.1, 0.1]
σ	Markdown ratio	0.95
Financial Market		
r_f	Risk-free interest rate	0.01
r_M	Market return	0.02
r_p	Redemption rate	0.1
r_t	Mortgage interest rate	0.03
Housing Market		
P_t	Price Index	2500
ΔP_{t-1}	Price Change in t-1	50
ΔP_{t-2}	Price Change in t-2	50
N_{Buyers}	Number of buyers	60
$N_{Sellers}$	Number of sellers	30
Credit Institutions		
r_d	Default rate of return	0.001
χ	Loan-to-value	0.8
Ψ	Threshold of price decline	0.03
μ	Ratio of good customers	0.8

2.4.2. Analysis of Agent Interactions

To assess the effect of different financial intermediaries on housing market cycles, multiple computational simulations of the model presented in section 2.3 have been carried out. Each model run develops three scenarios that are investigated individually and compared to each other: a first, in which only CBs operate, a second, in which only BLs grant mortgages, and a third, in which CBs and BLs finance residential property. In each scenario, the banks operate on a competitive financial market and no single institution has market power. For each scenario, 100 periods are simulated.

Figure 2.1 displays the house price dynamics which arise in the different simulation scenarios. Each of the scenarios reveals that the housing market, based on the interactions of heterogeneous agents, proceeds in cycles. As potential buyers and sellers follow their decision-making process, they perceive market conditions and make backward-looking expectations about future development. House price appreciations of previous periods spur investment motives of potential buyers. As a result, prices increase. The affordability of residential property for buyers gets more severe, while, recognizing steady positive price developments, potential sellers decide to keep their houses to generate higher profits out of future sales. The combination of a higher price level and reduced supply mitigates positive price developments, until, after reaching a peak, prices start to fall. The depreciation depresses future market expectations what pushes the market downwards until a recession sets in. Buyers recognize the decreased price level, align their actions to the new market conditions, and the fall bottoms out when bids start to pick up again. As a response to higher demand, house prices appreciate. As housing investment is fully mortgage financed in this model environment, the arising market dynamics are strongly affected by the lending policies of the loan granting financial intermediaries. Since they constrain lending on different conditions, they determine whether and in what amount residential property can be acquired and, therefore, directly influence market dynamics.

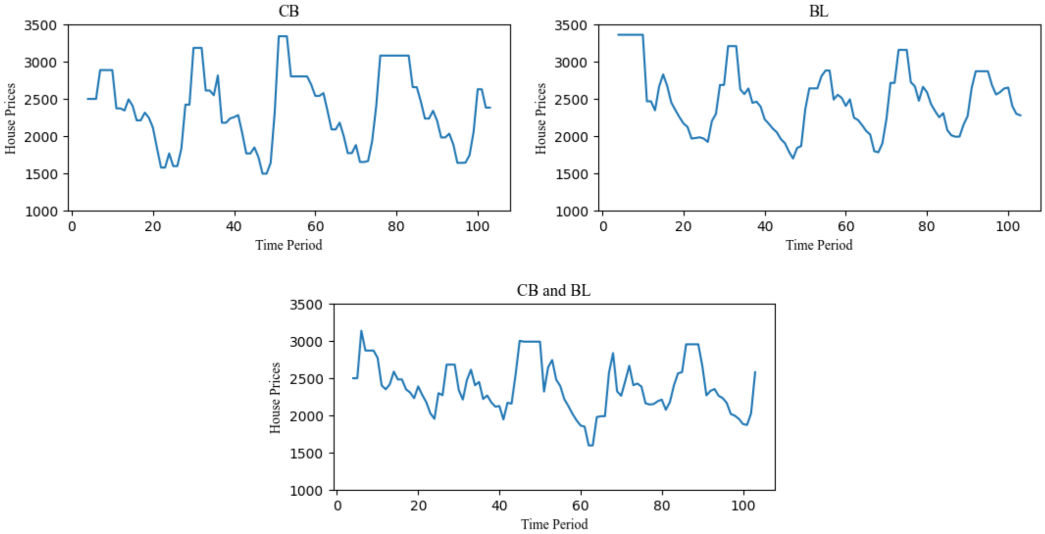

Figure 2.1: House price dynamics in simulation scenarios[30]

The first simulation scenario, in which only CBs finance residential property, reveals recurring upturn and downturn phases which are distinct and strongly defined. The market cycles feature high peaks and strongly pronounced troughs. Previous house price appreciations do no not only spur demand of potential buyers but also lending of CBs. Their lending decision is strongly determined by the collateral value of the financed dwelling. In times of positive market conditions, house prices are expected to continue to increase in future periods. Therefore, CBs are lending generously, further driving prices upwards. If prices declined in previous periods, CBs evaluate whether or not it is advantageous out of portfolio diversification reasons to finance residential property. If the price decline is too sharp, they refuse lending This strategic lending decision reinforces a prevailing downswing, pushing the house price into a deep low.

Table 2.2 provides some summary statistics of all simulation scenarios. The market in which solely CBs interact as financial intermediaries displays the lowest minimum price for residential property as well as the largest price drops in times of recessions. The difference between the minimum and maximum price exceeds those of the other simulation scenarios. Due to the sharp declines in recessions, the mean price for dwellings settles at a low level. A low transaction rate[31] indicates sluggish market conditions and leads to a comparably low homeownership rate. The construction rate, in contrast, reaches a moderate level. Due to attractive alternative investment opportunities, the mortgage interest rates charged by CBs for housing investment exceed those of the other scenarios.

Table 2.2 also shows the standard deviation of the respective mean values (written in brackets). The standard deviation of the house prices of the CB scenario affirms what is visible in Figure 2.1. House prices oscillate sharply

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[30] Note: The figure reflects trend-adjusted housing market cycles. Exogenous factors as inflation or changes in market interest rates are not considered.

[31] Transaction, homeownership, and construction rate are calculated in every simulation period as:

$$Transaction\ Rate = \frac{N_{transactions,t}}{\min(N_{buyers,t}, N_{sellers,t})},\ Homeownership\ Rate = \frac{N_{transactions,t}}{N_{potential\ buyers,t}},$$

$$\text{Construction Rate} = \frac{N_{constructions,t}}{(N_{new\ sellings,t} + N_{left\ over})}.$$

and market dynamics are unsettled and noisy if only CBs operate as financial institutions. The imposed credit constraints lead to an overvaluation of past market periods and procyclic mortgage granting. The permissive lending in times of appreciation pushes prices upwards while in times of depreciation, decreasing house prices are further exacerbated by the restrictive lending decisions.

Table 2.2: Summary statistics of the simulation scenarios

	Scenario								
	CBs			BLs			CBs & BLs		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
House Prices	1496.31	3341.41	2340.65	1699.97	3361.03	2482.30	1598.29	3138.35	2380.42
			(499.66)			(428.12)			(339.03)
Transaction	0.000	1.000	0.294	0.000	1.000	0.332	0.000	1.000	0.359
Rate			(0.351)			(0.309)			(0.286)
Homeownership	0.000	1.000	0.179	0.000	0.500	0.185	0.000	1.000	0.255
Rate			(0.230)			(0.135)			(0.187)
Construction	0.000	0.500	0.045	0.000	3.000	0.046	0.000	1.000	0.048
Rate			(0.051)			(0.307)			(0.162)
Mortgage Interest	0.024	0.030	0.027	0.013	0.015	0.014	0.014	0.030	0.024
Rate			(0.001)			(0.001)			(0.005)

The second simulation scenario investigates house price dynamics in which only BLs operate to finance housing investment. Those are also shown in Figure 2.1. As for the CB scenario outlined previously, cyclical market behavior is also clearly observable in the BL scenario. The market cycles, however, are less pronounced. Prevailing market phases turn earlier, troughs are not as low and the difference between the minimum and maximum price is lower than in the CB scenario. This can be seen in Table 2.2. The mean of the house price in the BL scenario settles at a higher level than in the case of CBs. On the one hand, this corresponds with less pronounced lows. On the other hand, this is due to the smaller mortgage interest rates imposed by BLs. Cheaper mortgage terms allow more of the disposable income to be invested in homeownership. The standard deviation of the price oscillations falls below that of the CB scenario. By putting less emphasis on previous market developments, and focusing on information out of relationship lending, BLs create a housing market which is less volatile.

The transaction, as well as the homeownership rate, exceed those of the CB scenario. Therefore, BLs enhance market transactions and promote homeownership. As mortgage interest rates are below those of CBs, BLs enable access to real estate financing for a broader share of the population. This, in turn, pushes the house prices to the highest level of all of the three scenarios.

The third simulation scenario combines CBs and BLs and creates a market setting in which both financial institutions operate on the market and grant mortgages according to their lending strategies. The effects on house price dynamics can also be seen in Figure 2.1. The interactions of real estate buyers, sellers, CBs, and BLs create market cycles with the lowest peaks and higher troughs.

Figure 2.2 displays how the different lending practices of the CBs and BLs play out over the market cycles. In times of sharp downturns, CBs restrict lending, and, thereby, push the market further downwards. BLs, in contrast, concentrate on customer information. The mortgage lending decision, based on endogenously created information about creditworthiness and credit eligibility stops the downturn and induces a turnaround. Recognizing house price appreciation, CBs lend more generously. As CBs view mortgages as secure because of expected increases of collateral values, they reinforce the induced upswing by BLs. BLs, in contrast, still focus on borrower information and reject mortgages in case of previous breaches of contract and thereby prevent the market from enormous price increases and exorbitant peaks. Since borrowers do have a positive time preference for housing investment, they decide in favor of CBs if both institutions are willing to finance their desired dwelling. For this reason, CBs dominate the market after a previous upswing. In times of previous downturns, however, BLs grant the majority of mortgages and, thereby, push prices up again.

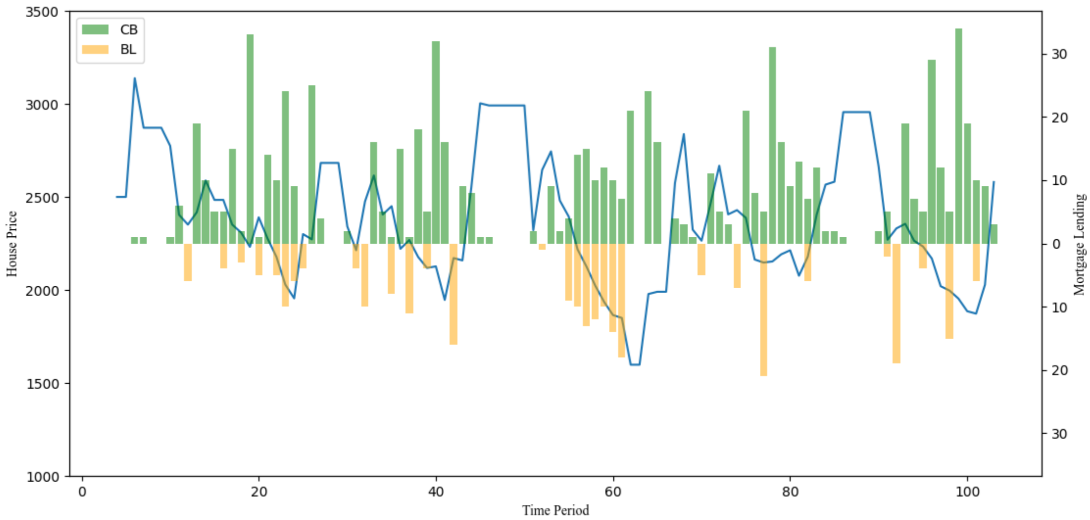

Figure 2.2: Lending strategies of CBs and BLs

The lending strategies of CBs and BLs create a house price level which is between the first two scenarios (Table 2.2). This is the reasonable result out of the higher average mortgage interest rate when both institutions grant mortgages. The standard deviation of the mean price, stated in Table 2.2, reveals that a housing market in which CBs and BLs interact with potential buyers is the most stable one. On top, transaction and homeownership rate reach the highest level compared to the scenarios with a single interacting financial institution.

Table 2.3 summarizes some further cycle characteristics of the simulation scenarios. The average cycle length of the isolated CB scenario exceeds this of the combined scenario. Accordingly, more cycles occur in the CB and BL case. These results reveal that the market is stuck in a cycle longer if only CBs grant mortgages. Due to the large outbreaks up and down, it takes more time for the market to stabilize again. If both, CBs and BLs grant mortgages, cycles are less severe. Therefore, agents approach their personal threshold for housing investment earlier. As a result, market entry barriers are reduced. This, in turn, corresponds with the higher transaction and homeownership rates observed in the combined scenario (Table 2.2). On top, the combined scenario reveals the lowest number of outbreaks[32] which confirms the lowest market volatility in this setup. Furthermore, Table 2.3 discloses the number of mortgages granted by the different financial intermediaries in the respective scenario. The fact that CBs dominate the mortgage market in the combined case underlines the positive time preference of borrowers if they fulfill the credit constraints imposed by CBs.

[32] An outbreak is defined as a price movement up or below the mean, +/- the lowest standard deviation of the three simulation scenarios.

Table 2.3: Cycle statistics of the simulation scenarios

	Scenario		
	CBs	BLs	CBs & BLs
Average Cycle Length	24	13	9
No. of Cycles	3	7	9
No. of Outbreaks	53	43	35
No. of Accepted Mortgages	976	908	1042
out of which CBs			774
out of which BLs			268

The simulation experiments show that CBs exercise procyclic lending practices which intensify housing market cycles and prevent a stable housing market. The mortgage granting strategy of BLs, in contrast, generates cyclic market activities which are more stable and predictable. The third scenario, in which CBs and BLs operate jointly on the housing market, dominates the other settings. CBs spur the market in the prevailing market period while BLs, although they are less strongly represented on the market, counteract downturns and reduce housing market cycles. The combined result of the different lending strategies of the financial institutions studied reduces price volatility, maximizes transaction and homeownership (Table 2.2), and minimizes price outbreaks (Table 2.3).

Due to the heterogeneity of the interacting agents, the simulations performed rely to some extent on random variation. To ensure that the simulation runs are representative and the presented model is structurally coherent and consistent, a robustness check has been performed which is provided in the Appendix.

2.4.3. Model Extension

The base model presented above assumes that the desired house is fully mortgage financed. In reality, however, financiers usually demand a minimum level of equity to finance residential property. To allow for this contingency, the model is extended by an equity condition. The equity ratio demanded by a financier constitutes a fixed share of the price of the desired dwelling in the means of $\varepsilon = \frac{E}{P_i}$. Based on this equity requirement, CBs impose a fourth credit constraint on their potential customers which is:

$$C4_{CB}: \frac{E}{P_i} \geq \varepsilon, \tag{27}$$

where E is the total equity of the potential buyer, P_i the price of a housing unit an individual buyer desires to buy and ε the required equity ratio. Available equity lowers the mortgage-to-income ratio in the sense of $\gamma = \left(\frac{M-E}{Y}\right)$. The size of the equity of potential buyers is drawn from a uniform distribution on $[0,0.35]$. As conventional banks do not have reliable customer information, they cannot infer the equity ratios of potential borrowers. Instead, they need to rely on imposed self-disclosures. The mortgage amount granted by a CB now is $M_{CB} = \min(C1, C2, C3_{CB})$ while $C4_{CB}$ holds.

A main feature of CSH is the savings period which precedes the loan. These accumulated savings serve as equity available for housing financing.[33] Since BLs can directly observe the individual savings performance of

[33] The amount of regularly savings as well as the length of the savings period are determined by a BL at the beginning of the savings phase. Therefore, a BL and it's customer know the amount of equity that will be available at the beginning of the credit phase if all savings are done properly.

their customers, they do not further constrain mortgage granting according to equity requirements, while still accounting for μ, the proportion of good customers. As a result, lending practices of BLs are independent of pre-existing wealth. Instead, their mortgage granting decision is based on the endogenously created information out of relationship lending.

Figure 2.3 displays housing market dynamics of the CB, the BL, and the CB & BL scenario with the additionally imposed equity requirement which is set to $\varepsilon = 0.2$.[34] As in the simulation scenarios presented previously, the interaction of buyers, sellers, and financial institutions leads to a housing market which moves in cycles and in which house prices oscillate around its mean. In comparison to the CB scenario without equity constraint, however, the amplitudes of the house price cycles are less severe. By additionally constraining mortgages to available equity, CBs only grant loans to potential customers who have lower mortgage-to-income ratios, since $\gamma = \left(\frac{M-E}{Y}\right)$. Applicants who do not fulfill the equity requirement, and, therefore, feature a higher probability of default, are rejected. As a result, these customers cannot enter the housing market. These findings are in line with existing literature which provides evidence that markets are more stable and the borrower risk of default is lower if lenders require an initial down payment for mortgages (Danis and Pennington-Cross, 2008; Demyanyk, 2009; Sommervoll, Borgersen and Wennemo, 2010).

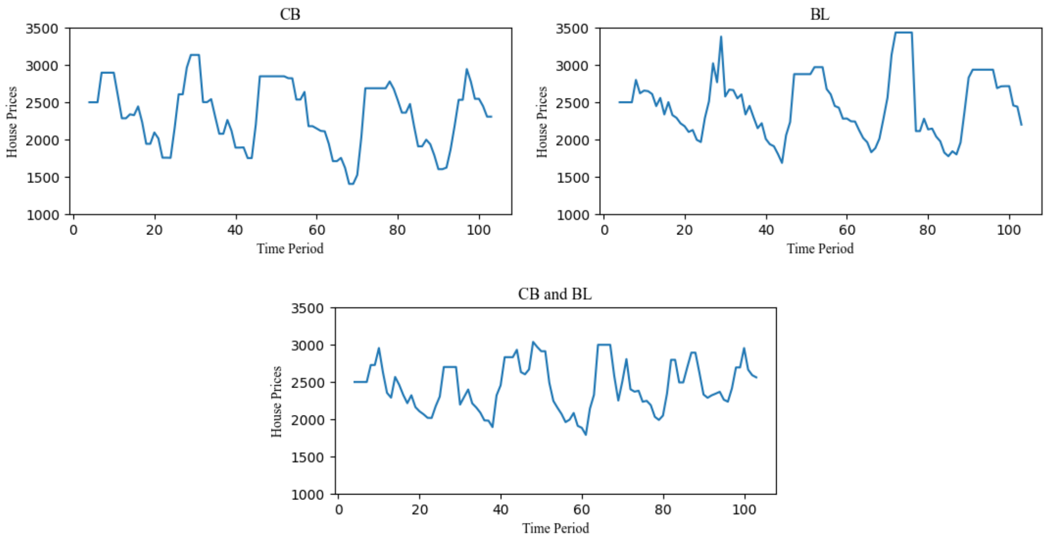

Figure 2.3: House price dynamics with equity constraint

As BLs base their lending decision on endogenously created customer information and do not constrain lending on an additionally imposed equity requirement, the house price cycles of the BL scenario are similar to those of the base model. The house price dynamics of the two bank scenario, however, is affected by the extended lending strategy of CBs. As in the base model, market cycles show the most stable movements and less outbreaks if both banks act on the market. The equity requirement of CBs has a smoothening effect on the market. However, the procyclical mortgage lending of CBs cannot completely be compensated by requiring initial wealth for housing

[34] Equity requirements vary internationally. However, an equity requirement of 20% is in line with those of several countries. In Germany, Denmark, and Russia 20% of equity are necessary to get a mortgage loan (Chiuri, Jappelli, 2003; Jensen, Petersen and Landa, 2015; Zubov, 2011). In Ireland, borrowers are required to make a down payment of at least 10% (Corrigan, O'Toole and Slaymaker, 2020). UK and US, in contrast, require comparatively low down payment rates of 5% (UK) and 11% (US) (Chiuri, Jappelli, 2003).

financing.[35] The lending strategy of BLs again counteracts the procyclical mortgage lending of CBs, and, as. a result, the volatility of house prices of the combined credit scenario with equity requirement of CBs is even lower than this of the combined base scenario.

These results are exemplified in Table 2.4, which provides the summary statistics for the model extension. As already revealed by Figure 2.3, the equity requirement of CBs dampens the volatility of house prices. This also has a positive effect on the cycle volatility of the combined bank scenario. As BLs do not constrain for available equity, the market of this scenario stays unaffected.[36]

Table 2.4: Summary statistics of the model extension

	Scenario								
	CBs			BLs			CBs & BLs		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
House Prices	1405.72	3134.58	2323.48	1687.40	3435.18	2468.08	1791.29	3037.67	2442.85
			(432.662)			(426.714)			(318.534)
Transaction Rate	0.000	1.000	0.204	0.000	1.000	0.335	0.000	1.000	0.315
			(0.356)			(0.326)			(0.295)
Homeownership Rate	0.000	1.000	0.160	0.000	1.000	0.193	0.000	0.628	0.205
			(0.234)			(0.182)			(0.169)
Construction Rate	0.000	0.130	0.002	0.000	2.000	0.045	0.000	5.000	0.074
			(0.014)			(0.232)			(0.505)
Mortgage Interest Rate	0.024	0.029	0.027	0.013	0.015	0.014	0.014	0.030	0.025
			(0.001)			(0.001)			(0.005)

The smoothening effect of equity is also reflected in the cycle characteristics of the market scenarios which are stated in Table 2.5. The average cycle length of the CB scenario shortens when CBs demand for equity. Therefore, more cycles occur. As market cycles are less severe, those applicants who fulfill all credit constraints approach their threshold for housing investment faster and can enter the market earlier. The number of market outbreaks is reduced.

Table 2.5: Cycle statistics of the model extension

	Scenario		
	CBs	BLs	CBs & BLs
Average Cycle Length	18	15	13
No. of Cycles	5	6	6
No. of Outbreaks	50	45	34
No. of Accepted Mortgages	913	891	924
out of which CBs			627
out of which BLs			297

This favorable circumstance coincides, however, with limited access to housing financing for those potential customers who do not fulfill the imposed equity constraint. By conditioning lending on preexisting equity, housing investment is denied to those applicants with no or too little initial wealth. Accordingly, CBs reduce lending

[35] Note: In this model extension, CBs only account for whether potential buyers meet the imposed equity requirement or not. Impacts of a higher available equity i.e. on the mortgage interest rate are not considered.
[36] Note: The minor variations of the parameters are due to the individuality of each simulation run.

(Table 2.5) and less agents can enter the market, which dampens transaction and homeownership rate in comparison to the CB base scenario (Table 2.4). With regard to this aspect, BLs fulfill an additional stabilizing function on the housing market as they grant mortgages independent of prior equity.

Due to the extended credit constraint of CBs, potential home buyers reallocate between the two financial institutions. Applicants, who would have been accepted by CBs in the base model, are rejected in the model extension due to lack of equity. These apply for mortgages at BLs. Since BLs do not demand for equity a priori, BLs accept the applicant if he reveals himself as a good customer. Accordingly, a customer shift sets in. The customers of BLs are those with $\frac{E}{P_i} \in [0, \varepsilon]$. Those represent this part of potential buyers who do not meet the equity requirements set by CBs. Since clients are assumed to have a positive time preference for housing investment, wealthier clients, in the means of an equity ratio in the range of $[\varepsilon, 1]$ are those of CBs. Evidence of the reallocation of customers is provided in Table 2.5. In comparison to the base model, BLs grant more credit, whereas CBs lose market shares. Furthermore, the extended lending by BLs cushions transaction, homeownership, and construction rate and ensures reasonable levels in comparison to the base model.

This observation strengthens the result that BLs expand accessibility to real estate financing within the population and serve as stabilizers for the housing market. They incorporate the smoothening nature of an equity requirement in its CSH which must be fulfilled during the savings phase in order to get a mortgage while not limiting the access to housing financing for households with little or no initial equity.

2.5. Conclusions

In a computational simulation experiment, this paper investigates whether various lending strategies of financial intermediaries affect the housing market differently. We develop a heterogeneous agent-based model in which buyers, sellers, and two types of financial intermediaries, conventional banks and building and loan associations, interact on the market. Buyers and sellers use recent price information to form expectations about future market conditions and are restricted by individual income levels. Financial intermediaries finance residential property and, therefore, mainly determine whether housing investment can be realized. CBs mainly base their lending decision on backward-looking, expectation-driven collateral values. BLs, in contrast, focus on endogenously created customer information out of relationship lending. Endogenous housing market cycles are created by the decisions and interactions of agents.

Three simulation scenarios are examined individually and compared to each other: one in which only CBs operate, a second, in which only BLs grant mortgages, and a third, in which CBs and BLs serve the mortgage market jointly. The simulations show that a residential property market in which solely CBs act as financial intermediaries tends to be the most volatile. As they focus on collateral values, they grant mortgages generously in times of previous house price appreciations, further cheering prevailing upturns. In times of downturns, applicants are rejected. This procyclic lending strategy leads to sharp oscillations of house prices, restricts transactions and homeownership, and creates a housing market, prone to recessions. As the housing market is closely correlated with other economic sectors as production, social health, and welfare, the lending practices of CBs may pose risks for an entire economy and the society at large.

A housing market, in which only BLs grant mortgages shows milder price level fluctuations and less outbreaks. BLs put less emphasis on collateral values and use information out of relationship lending what leads to less pronounced market cycles, a higher rate of property transactions, and promotes homeownership. Due to low mortgage interest rates, BLs enable lower-income households to invest in residential property, thus adding potential buyers to the real estate market.

A mortgage market that consists of both, CBs and BLs, shows less market volatility than a market with a single financial institution. BLs mitigate the procyclic lending activities of CBs and create smoothened housing market cycles. The simulations show that BLs act as stabilizers of the housing market which is consistent with empirical evidence (Molterer, Amon and Tyrell, 2017). Transactions and homeownership reach the highest level if both financial intermediaries act on the market. Less market volatility can also be achieved by constraining mortgage lending on an equity requirement. This, however, dampens transaction and homeownership rates and makes the market shrink. BLs cushion these negative effects as they do not constrain mortgage lending to equity conditions and also lend to those who do not fulfill the equity requirements if they revealed themselves as good customers. Therefore, a diversified market in which financial intermediaries with differing lending strategies, especially ones that detach lending decisions from previous market developments, finance residential property appear to have a positive effect on market stability, and, at the same time provide homeownership for a larger share of households. This market composition contributes to economic and social prosperity while at the same time preventing the housing market from crashes.

Our model assumes that CBs primarily focus on collateral values to decide about mortgage lending. This, in turn, does not imply that BLs have a monopoly on information. CBs may also create endogenous information about borrowers or acquire it from external sources. As evidenced in existing literature, however, CBs mainly use collaterals as their primary source of information to save screening costs and to prevent losses out of default. If external borrower information would be as cheap and as loss-preventing as pledged collateral, CBs may use other information, too. This might have stabilizing effects on the housing market if the information is as valuable as this generated by BLs. During the savings phase of a CSH, customers reveal their ability and willingness to steadily forgo consumption in order to acquire residential property at a later date. With regard to a long-term real estate mortgage, this information is more valuable than credit card or one-time consumer debt information from 3rd-party credit reports.[37] Non-reliable or unsuitable information, in turn, would counteract a possible stabilizing effect.

Even if CBs would also take customer information into account for some extent, BLs would still act as market stabilizers. This becomes apparent in the model extension. Their cooperative idea to bring people together to save jointly and to make housing purchase affordable grants access to the housing market to a broader share of the population. Thus, the advantageous effects of BLs are not only linked to asymmetric information regarding creditworthiness. They serve a value beyond that by not solely maximizing profits but by following their cooperative idea. This, in turn, benefits households and enhances the total public welfare.

Past experiences have shown from different perspectives that the homogenization of financial markets entails a diverse set of risks. In the 1980s, deregulation caused building societies and savings and loan institutions to disappear from the market in the U.K. and the U.S. which, as a result, led to increased housing market volatility. High volatilities, in turn, induce rising defaults (Yang, Buist, and Megbolugbe, 1998; Ambrose, Capone, and Deng, 2001). In addition, both countries suffered severe consequences from the latest financial crisis of 2008 while

[37] This is pointed out by Vercammen (1995) and, in a comparable setting, Holström (1982) who state that disciplinary reputation effects of sharing default information about borrowers can only be maintained in a two-period model framework. In a multi-period framework, reputation effects diminish.

countries with BLs experienced milder downturns and thus proved to be more resilient to crises. A possible explanation of this phenomenon is the finding of Ambrose, Capone and Deng (2001) who evidenced that the probability of borrower default is lower in areas in which the market interest rates exceed mortgage contract rates. This condition is integral to the business model of BLs.

Given the negative consequences of volatile housing markets, the findings of our study have important political implications and should be taken into account when making policy decisions concerning the composition and the regulation of the mortgage market. Our results can be taken as support for the presence of BLs in housing markets as they are able to dampen market oscillations. As such, this study may serve as a reference for policy implications to consider (re)introducing BLs in markets with historically high volatility, being aware that an appropriate regulatory framework is necessary to successfully establish the system.

2.6. Appendix Chapter 2

The appendix provides a robustness check to ensure that the simulation results shown above are representative and the presented model is structurally coherent and consistent. Table 2.6 provides the average values and their standard deviations of the house price, the transaction rate, the homeownership rate, the construction rate, and the mortgage interest rate of 100 simulation runs, each of 100 simulation periods for the three different simulation scenarios. Table 2.7 contains the mean values of the corresponding cycle characteristics. The outcomes of the robustness check confirm the specific analysis results of the simulation run presented in section 2.4.2.

Table 2.6: Summary statistics of the robustness check

	Scenario								
	CBs			BLs			CBs & BLs		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
House Prices	1461.24	3231.06	2381.24	1684.21	3325.80	2460.42	1677.95	3242.42	2460.92
	(170.76)	(185.87)	(128.99)	(193.08)	(185.87)	(43.86)	(204.53)	(192.13)	(89.90)
Transaction Rate	0.000	1.000	0.285	0.000	1.000	0.333	0.000	1.000	0.337
	(0.000)	(0.000)	(0.037)	(0.000)	(0.004)	(0.028)	(0.000)	(0.004)	(0.034)
Homeownership Rate	0.000	0.899	0.185	0.000	0.686	0.191	0.000	0.872	0.227
	(0.000)	(0.140)	(0.022)	(0.000)	(0.214)	(0.012)	(0.000)	(0.161)	(0.025)
Construction Rate	0.000	2.141	0.045	0.000	1.391	0.040	0.000	1.517	0.042
	(0.000)	(2.282)	(0.039)	(0.000)	(0.963)	(0.021)	(0.000)	(1.330)	(0.027)
Mortgage Interest Rate	0.024	0.030	0.027	0.013	0.016	0.014	0.013	0.030	0.025
	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)

Table 2.7: Cycle statistics of the robustness check

	Scenario		
	CBs	BLs	CBs & BLs
Average Cycle Length	16	13	12
No. of Cycles	5	7	8
No. of Outbreaks	55	42	41
No. of Accepted Mortgages	951	924	952
out of which CBs			716
out of which BLs			236

2.7. Bibliography Chapter 2

Ambrose, B. W. and Capone, C. A. (2000). The Hazard Rates of First and Second Defaults. *The Journal of Real Estate Finance and Economics* 20: 275-293. https://doi.org/10.1023/A:1007837225924.

Ambrose, B. W., Capone, C. A., and Deng, Y. (2001). Optimal put exercise: an empirical examination of conditions for mortgage foreclosure. *The Journal of Real Estate Finance and Economics*, 23(2): 213-234. https://doi.org/10.1023/A:1011110501074.

Aghion, P. and Bolton, P. (1992). An incomplete contracts approach to financial contracting. *The review of economic Studies* 59.3 (1992): 473-494. https://doi.org/10.2307/2297860.

Bester, H. (1985). Screening vs. rationing in credit markets with imperfect information. *The American economic review*, 75(4): 850-855.

Bhutta, N., Dokko, J., and Shan, H. (2017). Consumer ruthlessness and mortgage default during the 2007 to 2009 housing bust. *The Journal of Finance*, 72(6): 2433-2466. https://doi.org/10.1111/jofi.12523.

Bienert, S. and Brunauer, W. (2007). The mortgage lending value: prospects for development within Europe, *Journal of Property Investment & Finance*, 25(6): 542-578. https://doi.org/10.1108/14635780710829289.

Boos, K.-H.; Fischer, R.; Schulte-Mattler, H., and Schäfer, F. A. (2016). KWG § 3: Zwecksparunternehmen, *Kommentar zum KWG – CRR-VO* (5) Band 1: Rn. 14-18.

Burghof, H.-P. and Gehrung, M. (2019). Bausparen und die Kosten der privaten Immobilienfinanzierung, *Immobilien und Finanzierung* 4: 28-30.

Burghof, H.-P. and Schairer, M. (2017). Loan Performance of Contractual Savings for Housing. *Available at SSRN* 2925104. http://dx.doi.org/10.2139/ssrn.2925104.

Campbell, J. Y. and Cocco, J. F. (2015). A model of mortgage default. *The Journal of Finance*, 70(4): 1495-1554. https://doi.org/10.1111/jofi.12252.

Chiuri, M. C. and Jappelli, T. (2003). Financial market imperfections and home ownership: A comparative study, *European Economic Review* 47 (5): 857-875. https://doi.org/10.1016/S0014-2921(02)00273-8.

Collyns, C., and Senhadji, A. (2003). Lending booms, real estate bubbles, and the Asian crisis. *Asset price bubbles: the implication for monetary, regulatory and international policies, MIT Press*, Cambridge and London: 101-25.

Corrigan, E., O'Toole, C. and Slaymaker, R. (2020). Credit demand in the Irish mortgage market: What is the gap and could public lending help? (No. 671). ESRI Working Paper.

Danis, M. A. and Pennington-Cross, A. (2008). The delinquency of subprime mortgages, *Journal of Economics and Business* 60(1-2): 67-90. https://doi.org/10.1016/j.jeconbus.2007.08.005.

Demyanyk, Y. (2009). Quick exits of subprime mortgages, *Federal Reserve Bank of St. Louis Review*, 2: 79-93.

Deng, Y. (1997). Mortgage termination: An empirical hazard model with a stochastic term structure. *The Journal of Real Estate Finance and Economics*, 14(3): 309-331. https://doi.org/10.1023/A:1007758412993.

Drescher, I., Fleischer, H., and Schmidt, K. (2019). Verbot von Zwecksparunternehmen. *Münchener Kommentar zum HGB* (4) Band 6: Rn. 168-179.

Diamond, D. B. and Lea, M. J. (1992). The decline of special circuits in developed country housing finance, *Housing Policy Debate, Informa UK Limited* 3: 747-777. https://doi.org/10.1080/10511482.1992.9521107.

Euro Area Statistics (2020): Growth rates in housing loans are steadily increasing in the euro area. URL https://www.euro-area-statistics.org/statistics-insights/growth-rates-in-housing-loans-are-steadily-increasing-in-the-euro-area?cr=eur&lg=en&page=0.

Erbs, G., Kohlhass, M., and Häberle, P. (2021). KWG § 3: Zwecksparunternehmen, *Beck'sche Kurzkommentare* Band 17: Rn. 8.

Filatova, T., Parker, D. C. and Van der Veen (2007). Agent-based land markets: heterogeneous agents, land prices and urban landuse change, *Proceedings of the 4th Conference of the European Social Simulation Association (ESSA'07)*.

Foote, C. L., Gerardi, K., and Willen, P. S. (2008). Negative equity and foreclosure: Theory and evidence. *Journal of urban economics*, 64(2): 234-245. https://doi.org/10.1016/j.jue.2008.07.006.

Foote, C. L. and Willen, P. (2017). Mortgage-default research and the recent foreclosure crisis. *Available at SSRN* 3082773.

Freund, J., Curry, T., Hirsch, P., and Kelly, T. (1998). Commercial real estate and the banking crises of the 1980s and early 1990s. *History of the eighties: Lessons for the future (an examination of the banking crises of the 1980s and early 1990s)* 1: 137-165.

German Central Bank (2020): Banking Supervision and Real Estate Financing: The Risks at a Glance. URL https://www.bundesbank.de/de/presse/gastbeitraege/bankenaufsicht-und-immobilienfinanzierung-die-risiken-im-blick-836218.

Glaeser, E. L. and Shapiro, J. M. (2003). The benefits of the home mortgage interest deduction. *Tax policy and the economy* 17: 37-82. https://doi.org/10.1086/tpe.17.20140504.

Hakim, S. R. and Haddad, M. (1999). Borrower attributes and the risk of default of conventional mortgages. *Atlantic Economic Journal* 27.2: 210-220. https://doi.org/10.1007/BF02300240.

Hart, O. (1995). Firms, contracts, and financial structure. *Clarendon press*.

Herring, R. J. and Wachter, S. M. (1999). Real estate booms and banking busts: An international perspective. *Wharton School Center for Financial Institutions,* Working Paper 99-27.

Heuson, A., Passmore, W., and Sparks, R. (2001). Credit Scoring and Mortgage Securitization: Implications for Mortgage Rates and Credit Availability, *Journal of Real Estate Finance and Economics* 23(3): 337-363. https://doi.org/10.1023/A:1017952120081.

Hilbers, P., Lei, Q., and Zacho, L. (2001). Real estate market developments and financial sector soundness. Working paper 01/129, IMF. http://dx.doi.org/10.2139/ssrn.879898.

Holmström, B. (1982). Managerial incentive problems - a dynamic perspective, *Essays in Economics and Management in Honour of Lars Wahlbeck*, Svenska Handelshogskolan, Helsinki. Reprinted 1999 in Review of Economic Studies 66(1): 169–182.

Jensen, T. L., Leth-Petersen, S., and Nanda, R. (2015). Home equity finance and entrepreneurial performance: Evidence from a mortgage reform. No. 15-020. *Harvard Business School.*

Kirsch, S. and Burghof, H.-P. (2018). The efficiency of savings-linked relationship lending for housing finance, *Journal of Housing Economics* 42: 55–68.

Lehmann, W. (1983). *Abriß der Geschichte des deutschen Bausparwesens*, Domus Verlag, Bonn.

Manove, M., Padilla, A. J., and Pagano, M. (2001). Collateral versus project screening: A model of lazy banks. *Rand Journal of Economics* (2001): 726-744. https://doi.org/10.2307/2696390.

Molterer, M., Amon, J., and Tyrell, M. (2017). Specialized Financial Intermediaries and the Impact of Savings and Loan Contracts on Real Estate Finance. *Available at SSRN 2873919.*

Müller, M. L. (1999). Bausparen in Deutschland zwischen Inflation und Währungsreform 1924-1948, C. H. Beck, München. http://dx.doi.org/10.2139/ssrn.2873919.

Niinimäki, J. P. (2009). Does collateral fuel moral hazard in banking? *Journal of Banking & Finance*, 33(3): 514-521. https://doi.org/10.1016/j.jbankfin.2008.09.008.

Poterba, J. M. and Sinai, T. (2011). Revenue costs and incentive effects of the mortgage interest deduction for owner-occupied housing. *National Tax Journal* 64(2): 531-564. https://doi.org/10.17310/ntj.2011.2S.05.

Proettel, T. (2017). Path dependencies in European savings banks: the impact of the fundamental decisions from the beginning of the 19th century, *Vierteljahrsschrift für Sozial- und Wirtschaftsgeschichte* 104(2): 177-202.

Rothschild, M. and Stiglitz, J. (1978). Equilibrium in Competitive Insurance Markets: An Essay on the Economics of Imperfect Information. *Quarterly Journal of Economics*, 90: 626-649.

Schäfer, O., Cirpka, E., and Zehnder, A. J. (1999). Bausparkassengesetz und Bausparkassenverordnung: Kommentar. Domus-Verlag.

Scholten, U. (2000). Rotating Savings and Credit Associations in Developed Countries: The German-Austrian Bausparkassen, *Journal of Comparative Economics* 28(2): 340-363. https://doi.org/10.1006/jcec.2000.1657.

Schwartz, E. S. and Torous, W. N. (1993). Mortgage prepayment and default decisions: A Poisson regression approach. *Real Estate Economics*, 21(4): 431-449. https://doi.org/10.1111/1540-6229.00619.

Sinai, T. and Souleles, N. S. (2005). Owner-occupied housing as a hedge against rent risk. *The Quarterly Journal of Economics* 120.2: 763-789. https://doi.org/10.1093/qje/120.2.763.

Sommervoll, D. E., Borgersen, T.-A., and Wennemo, T. (2010). Endogenous housing market cycles, *Journal of Banking & Finance* 34(3): 557-567. https://doi.org/10.1016/j.jbankfin.2009.08.021.

Vercammen, J. A. (1995). Credit bureau policy and sustainable reputation effects in credit markets, *Economica* 62(248): 461–478. https://doi.org/10.2307/2554671.

Voigtländer, M. and Institut der Deutschen Wirtschaft Köln. (2010). Ein europäischer Binnenmarkt für die Wohnungsbaufinanzierung: Studie des Instituts der Deutschen Wirtschaft Köln (IW) in Zusammenarbeit mit dem Zentrum für Europäische Wirtschaftsforschung Mannheim (ZEW) und Prof. Dr. Johannes Köndgen, Universität Bonn. Schriftenreihe des Instituts für Städtebau, Wohnungswirtschaft und Bausparwesen e.V. 73. Domus Verlag-und Servicegessellschaft mbH, Berlin.

Yang, T. T., Buist, H., and Megbolugbe, I. F (1998). An analysis of the ex ante probabilities of mortgage prepayment and default. *Real Estate Economics* 26.4: 651-676. https://doi.org/10.1111/1540-6229.00760.

Zubov, S. (2020). Mortgage Lending in January-September 2020. Monitoring of Russia's Economic Outlook. Trends and Challenges of Scoio-Economic Development. Moscow. *IEP*. No. 20: 11-13.

Different Business, Same Regulation: Does Homogenous Regulation Succeed in Taming Housing and Financial Market Instability?

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Abstract

The housing and the mortgage lending market are of particular interest to regulators for two reasons. First, housing markets mostly generate a large part of an economy's GDP. Second, the loans granted to finance residential property account for a major share of an economy's total bank lending. As a response to the latest financial crisis, the Basel Committee published the Basel III accords which intensify micro- and introduce macroprudential instruments to enhance the resilience of the financial market. One crucial aspect that the regulatory reforms do not address is the diversity of the banking sector. We introduce a heterogeneous agent-based model that develops a housing and a capital market to assess the ability of Basel III rules to mitigate mutual feedback effects and dampen instability. Computational experiments reveal that the most stable markets are achieved if the financial market is diversified and consists of different types of financial intermediaries that need to comply with type-specific capital adequacy requirements. The results point out that capital adequacy requirements are, in principle, effective in stabilizing the banking sector. However, the stability of housing and share prices and the solidity of the banking sector can be increased if capital adequacy requirements are aligned to the individual business models of financial intermediaries and their institutional frameworks. These findings advocate in favor of a diversified banking sector and heterogeneous capital adequacy requirements and thus provide important policy implications.

Keywords: Financial stability, housing market stability, bank regulation, Basel III, agent-based model, computational economics, building and loan associations

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3. Different Business, Same Regulation: Does Homogenous Regulation Succeed in Taming Housing and Financial Market Instability?

3.1. Introduction

The events of the latest financial crisis led to a strong agreement in politics and business that banking regulation was not sufficient. Through lax lending, risky business practices, and excessive leverage, banks contributed significantly to the recession in the financial and the real market. The great turmoil caused by the banking sector is the latest evidence that financial markets affect real economies via the financial accelerator (Bernanke et al., 2007; Delli Gatti et al., 2010; Gilchrist and Zakrajšek, 2012) and amplify real economy cycles. The banking regulations in force during the time of the crisis have obviously failed to mitigate its scale. Instead, it further exacerbated the collapse by procyclical regulatory requirements (Blundell-Wignall and Atkinson, 2010; Goodhart and Hofmann, 2007; Kowalik, 2011).

As a response, Basel III was introduced. These standards, developed by the Basel Committee on Banking Supervision (BCBS) shall be applied by all internationally active banks to provide a resilient banking system (BCBS, 2017a). They aim to strengthen the regulation, supervision, and risk management of banks by introducing a diverse set of micro- and macroprudential measures. What they do not address, however, is the heterogeneity of banks' business practices and their individual regulatory frameworks. The global banking systems consist of diverse financial institutions, characterized by different organizational forms, individual strategic orientations, and business models. These diversified financial markets have proven to be superior compared to unilateral systems for both, the economy and the financial market itself (Braun et al., 2022).

In this paper, we develop a heterogeneous agent-based model (ABM) to assess whether homogeneous capital adequacy requirements (CAR) for heterogeneous financial institutions are successful to tame housing and capital market instability and to create a resilient banking market. To measure valid outcomes of bank-regulatory reforms, a suitable model must be introduced that includes both, the behavioral aspects of individual economic units that serve as a micro foundation as well as a macro level system that focuses on macroeconomic performance resulting from the micro level (Bezemer, 2012). Furthermore, it should allow for cross-sectional effects that lie at the heart of business fluctuations and financial instability and it should present the dynamic processes out of equilibrium which makes it necessary to introduce heterogeneity and inconsistent expectation at the individual agent level (Arnold et al., 2012; Borio, 2011). These necessities contradict the use of a dynamic stochastic general equilibrium (DSGE) model. DSGEs assume one representative agent with perfect foresight and an equivalence between the micro and macro level (Ackerman, 2002; Gaffeo et al., 2008). On top, they do not model economic cycles and only analyze deviations from steady states that are independent of financial regulation (Bean, 2010; Gatti et al., 2010; Tovar, 2009).

ABMs address these shortcomings of DSGEs. In an agent-based approach, an economy is modeled as a complex adaptive system in which aggregate dynamics arise out of interactions between heterogeneous agents that may change their behavior in order to adapt to changing economic environments (Farmer and Foley, 2009; Dosi, 2012; Kirman, 2016). It allows studying credit and liquidity market dynamics where heterogeneous agent-specific solvency and liquidity risks affect their behavior and interactions. In that, an ABM is a particularly suitable approach for policy analysis.

The model introduces a housing market and a capital market. The housing market consists of potential home buyers and sellers that behave individually according to their capabilities and market expectations. Financial institutions either finance housing investment or trade a standardized share portfolio in the capital market. We incorporate two institutional bank types: conventional banks (CBs) and building and loan associations (BLs) to create a diversified financial market. According to Basel III, both bank types need to comply with the prevailing CAR including a countercyclical capital buffer (CCyB) similarly although their business practices and other underlying regulation vary widely.

The interaction of potential home buyers, sellers, and financial institutions creates endogenous market conditions of a housing and a capital market that allows to investigate the stability of both and their mutual feedback effects, as well as for the resilience of the banking sector. By creating different simulation scenarios, we evaluate whether it is reasonable to subject different institutional financial intermediaries to the same regulatory requirements. Furthermore, we study the effect of customized regulatory frameworks for specialized financial institutions, namely BLs. The aim of this paper is to examine whether banking regulation is more effective and whether capital and housing markets are more resilient if specialized financial intermediaries have specialized regulatory requirements.

The computational experiments show that varying lending practices of different financial institutions mitigate housing and capital market cycle fluctuations and affect banking stability positively. This advocates in favor of a diversified financial market, consisting of different types of financial intermediaries. Introducing a heterogeneous regulation in terms of different CAR levels for BLs including a CCyB while still subjecting them to their specific laws reveals different insights. First of all, the results provide evidence that imposing CAR on banks is effective in increasing market stability and the resilience of the banking sector as it increases banks' loss absorbency capacity. Second, the experiments reveal that stability is not only a monotonic function of capital. If BLs need to comply to a lower level of CAR than CBs, market conditions of all investigated markets improve. Fluctuations of house and share prices decrease and the solidity of the banking sector enhances. Stability measures and banking soundness worsen with rising CAR levels for BLs. Imposing very high CAR on BLs obliges them to reduce business activities drastically and they are forced to adjust their business model to this of CBs. This leads to a homogenization of banking behavior which reinforces herding activity and induces strong house price oscillations.

On the occasion of the crisis and the herewith related criticism of the banking regulation, the regulatory rules gained emphasis in economics and research. As a consequence, several studies have been conducted that examine the impact and the effectiveness of the new Basel III rules. Most of the models in the existing literature that address the effects of regulation using agent-based models either set up a two-asset market and differentiate between one risk-free and one risky asset (Bookstaber, Paddrik, and Tivnan, 2018; Lengwiler and Maringer, 2011) or investigate producing economies (Cinotti, Raberto, and Teglio, 2012; Popoyan, Napoletano, and Roventini, 2020). This disregards one of the most important markets of an economy: the housing market. In the European Union, housing loans account for approximately 74% of total adjusted bank lending. This is equivalent to 40% of the euro area's GDP (Euro Area Statistics, 2020).[39] And though, to the best of our knowledge, none of the existing studies investigates the impact of Basel III accords on the housing and the mortgage market.

[39] This reflects German conditions quite well, where real estate loans make up around 70% of total lending (German Central Bank, 2020).

The model contributes to the existing research as we model the financial intermediaries' portfolio optimization problem under CAR including a CCyB introducing a three-asset model that considers two different types of financial institutions: CBs and BLs. Thus, we create a diversified banking market that connects two market settings: the housing and the financial market. This allows for investigating the mutual impacts and the contagion between both of them when heterogeneous institutional bank types are regulated heterogeneously. As a result, the model displays whether uniform or individual capital requirements are superior and how specialized institutional laws impact the stability and resilience of market conditions.

The remainder of this paper is organized as follows. Section 3.2 introduces the specialized institutions of building and loan associations. Section 3.3 provides a detailed description the model features and the behavioral rules of the interacting economic agents as well the regulatory requirements. The results of the computational experiments are presented in section 3.4 after which section 3.5 concludes.

3.2. Building and Loan Associations

Building and loan associations (BLs) are a particular institutional form of financial intermediaries that are specialized in serving any demand in housing financing. Unlike capital market-based conventional banks, their funding system is based on a collective principle. They pool deposits from savers and allocate them to borrowers, thus forming an enclosed system for potential real estate buyers. Based on these activities, they share similarities with credit unions and are comparable to rotating savings and credit associations (Scholten, 2000).

An earlier form of BLs first emerged in the United Kingdom in the 18th century. The British building societies were founded as a solution to the lack of capital for housing investment. Inspired by this new institutional form of financial intermediation, savings and loan associations were founded at the beginning of the 19th century in the United States. Almost simultaneously, BLs evolved in Germany in the 1920s. Due to World War I, there was a severe housing shortage. Furthermore, prevailing hyperinflation led to a breakdown of the capital market, savings banks were unable to grant loans due to depreciated deposits, and mortgage bonds disappeared (Müller, 1999). As existing institutions were unable to meet the increased demand for housing financing, BLs arose as demand-driven financial innovations that attracted members to step together and save collectively to afford residential property.[40]

In the U.K. and in the U.S., building societies and savings and loan associations ran into difficulties when the average length of the savings period became too long. To solve refinancing problems, both institutional types skipped their collective idea and started to refinance lendings on the capital market. As a result, they were forced out of the market (Diamond and Lea, 1992; Scholten, 2000). In Germany, in contrast, the new form of financial institutions flourished and became a viable and substantial form of financing residential property. Nowadays, BLs account for approximately 14.2% of today's total financing volume for housing. They are involved in one out of three private housing financings, which, in addition to housing purchases also include renovation, modernization, or investments in sustainable housing. The market penetration of their core product, contractual saving for housing (CSH), reaches 30% in Germany and almost every second household is a CSH customer. But BLs also constitute an essential real estate financier in other European countries. In Austria, almost every second citizen uses CSH which equals a market penetration of 43%. The Czech Republic records a market penetration of 33%, Slovakia

[40] For a detailed description of the history of German BLs, see for instance Lehmann (1983) and Müller (1999).

16%, and Hungary 8%. Smaller but stable rates can be observed in Croatia and Romania.[41] Also in Luxembourg, BLs enjoy high popularity. Similar concepts of BLs exist in UK and Ireland and even in Australia and New Zealand.[42]

The idea of saving unitedly and enabling those savers access to mortgages is inherited in BLs core product, CSH (*Bausparvertrag*). CSH customers contractually commit to regularly save a specified amount for a certain period of time and in return qualify to receive a residential loan entitlement at a later date. During the savings period, the customers earn an interest on their deposits that is lower than prevailing market interest rates. The opportunity costs out of forgone higher interest shall be offset by a loan interest rate that is also below market conditions. Both interest rates are locked-in at the time of contract conclusion. Debts are granted from the pool of deposits saved by all customers collectively. Loan disbursement is contingent on the savings effort of the individual customer as well as on the total volume of collected deposits. The concept of CSH is thus based on an overlapping generation model (Scholten, 2000) which grants access to mortgages and shortens the waiting period for housing investment. If both criteria are fulfilled, the customer becomes eligible for loan disbursement. According to his individual requests, he can draw on his legal right immediately or at a later stage. As soon as he decides to exercise the loan option, he changes from being a creditor to being a debtor. Former savings during the qualifying period are now converted into loan repayments. Following these principles of lending, BLs and their customers build an enclosed system that is endogenously driven and independent from capital markets. By saving unitedly, all participants achieve Pareto-improvement and satisfy their positive time preference for homeownership.

The specialized institutional form of BLs and their core product, CSH, characterize these types of financial intermediaries as special-purpose savings companies. In many legislations, financial intermediaries that accept deposits and in return commit to grant loans for specific purposes, are prohibited in order to protect depositors (Müller, 1999). In Germany and other countries, in which BLs are an integral part of the financial markets, BLs are explicitly exempt from this prohibition.[43] In order to nevertheless ensure a sufficient degree of customer protection, BLs are subject to specialized legal requirements: the Building Society Act (*Bausparkassengesetz*) and the Building Society Decree (*Bausparkassenverordnung*).[44] The detailed legal regulation of BLs was, however, not only set up due to customer protection but also to ensure that these institutions are able to fulfill their specialized business purpose of granting residential loans and achieving positive effects on the real estate market. As already established financial intermediaries were incapable to allocate sufficient funds to meet the demand for housing financing, policy promoted the new institutional types in order to promote residential property and thus contribute to overall economic prosperity (Diamond and Lea, 1992). That these reasons still apply today is reflected by the fact that many governments subsidize CSH contracts.[45]

[41] Data is available from the Verband der deutschen Bausparkassen, EFBS and Eurostat.
[42] For more information see: https://www.rba.gov.au/publications/fsr/2006/mar/struct-aus-fin-sys.html, https://www.companiesoffice.govt.nz/all-registers/building-societies/about-building-societies/.
[43] For more information see for instance Erbs, Kohlhaas, and Häberle KWG § 3 Rn. 8, Boos, Fischer, Schulte-Mattler, and Schäfer KWG § 3 Rn. 14-18, Drescher, Fleischer, and Schmidt KWG § 3 Rn. 168-179.
[44] A detailed description of the evolution of the German regulatory requirements of BLs is provided by Schäfer, Cirpka, and Zehnder, 1999.
[45] The type and the amount of state subsidies for CSH varies between different countries.

Similar to conventional banks, BLs are usually publicly[46] or privately organized institutions. BLs' specialized regulations clearly define their business model. They align BLs' business operations to collect deposits and grant loans for purposes of building, buying, or modernizing residential property to those who are part of their enclosed system (sect. 1 (1) to (3) BauSparkG). To ensure this business approach and to protect customers from potential misuse of deposits (Müller, 1990), BLs are restricted in funding and investment opportunities (sect. 4 and sect. 6 BauSparkG). By allowing collateral values without risk discount in case of financing owner-occupied property, national law encourages lending and relaxes credit rationing which is further promoted by BLs, that subordinate granted mortgages (sect. 7 (1) BauSparkG; Diamond and Lea, 1992). As compensation for the regulatory restrictions, the CSH business is exclusively reserved for BLs.

Although the regulatory framework significantly restricts the flexibility and the business activities of BLs, the German regulatory authorities viewed these restrictions to be necessary to balance the fund provision for business and homeownership after World War II (Diamond and Lea, 1992). Examples of the U.K. and the U.S. provide evidence that the specialized regulations seem to be a precondition for BLs to exist. When building societies and savings and loan institutions started to refinance loans on the capital market, they could not stand the competition and disappeared from the market (Diamond and Lea, 1992; Scholten, 2000). This indicates that deregulation increases the incentives for specialized financial institutions to expand business activities and converge with conventional banks. Subjecting BLs to both legislations, the Banking Act and their individual regulatory regulations, however, bears the risk of over-regulation and damming positive effects of high homeownership rates. This as well as the effects of their specialized institutional laws are to be explored within this research.

3.3. The Model

3.3.1. Model Structure

Real-world economies are complex adaptive systems in which agents with deviating beliefs interact with each other. These agents are heterogeneous in terms of their characteristics, their expectations about future market conditions, and they are adaptive to changing environments. Through interaction, they create endogenous business cycles and feedback loops on adjacent markets and market participants. An agent-based model incorporates these characteristics and develops an artificial market environment that allows to investigate endogenously created market conditions.

Due to the close interconnectedness of the housing and the mortgage market, changes in market conditions in one market may lead to mutual feedback effects. The stability of both markets can thus be affected by both, exogenous factors as well as their endogenous constitution. The following model displays an economy that consists of a housing market and a financial market. In each market, agents interact with each other and create endogenous market structures. An agent-based model is an auspicious tool that allows assessing the impact on the resilience of the individual markets.

[46] Public building societies, called Landesbausparkassen (LBS), are part of the German Savings Banks Association (Deutscher Sparkassen- und Giroverband) and are limited in competition by regional segregation according to the federal states in which they operate.

3.3.2. The Housing Market

The housing market builds on Braun et al. (2022) and is populated by two types of agents: buyers and sellers. Buyers form the demand in the real estate market while sellers decide whether to provide housing units. They interact on the market and form an endogenous market setting, driven by individual considerations.

3.3.2.1. Buyers

Buyers are assumed to be households demanding for residential property. They are characterized by a Cobb-Douglas utility function in the form of $U_b = c^\alpha * h^\beta$ where h^β indicates the utility of owning one unit of housing and c^α the utility of any other consumption goods with $\alpha + \beta = 1$ and $\alpha \sim N(0,1)$ while the expected value of α is 0.5 and its standard deviation 0.05. Potential buyers have a disposal period income of Y_t which is fully spent in each period. Based on their individual perceptions of consuming and owning residential property, they either enter the housing market or stay a tenant. Via the individual parameters of α and β, each potential buyer assesses the positive and negative externalities of homeownership individually.[47] Following the approach that only those agents enter the housing market who positively assess owning residential property, we implicitly account for both, positive and negative implications of homeownership and only consider buyers in the housing market that affect house prices via housing transactions.

A potential buyer's budget constraint is given by $Y_t = P_{ct}c + P_t h$. Using the method of Lagrange multipliers and solving for P_t while $h = 1$ gives the maximum affordable periodical expenditure for housing investment which can be stated to be a potential buyer's b reservation price:

$$P_{res,b,t} = \left(\frac{Y}{\left(\frac{\alpha}{\beta}+1\right)}\right) - (r(P_t - E). \tag{1}$$

Buyers are assumed to have a fixed amount of equity E which is drawn from a uniform distribution on $E \sim U(0, 0.35)$[48] and fully spent for housing investment. The outstanding amount is mortgage financed which bears interest cost r_t on the mortgage volume $(P_t - E)$ as well as a redemption on the principal r_p.[49]

However, the reservation price must not equal the price a potential buyer is willing to bid. Instead, he forms an individual price expectation based on past price information. The expected market price of a potential buyer b is:

$$P_{expected,b,t} = (1 + e_b) * (P_{t-1} + \Delta P_{t-1}), \tag{2}$$

where e_b indicates the buyer's expectation about future market developments and $e_b \sim U(-0.1,0.1)$. P_{t-1} indicates the price level of the previous period and ΔP_{t-1} the price change of the previous period. Since the reservation price

[47] Existing literature debates about the positive and negative effects of homeownership. Benefits are e.g., the ability to hedge fluctuations in housing costs (Sinai and Souleles, 2005) or the tax deductibility of mortgage interest (Glaeser and Shapiro, 2003; Poterba and Sinai, 2011). Furthermore, homeowners attach a non-financial value to their homes. Negative externalities are lower labor mobility (Blanchflower and Oswald, 2013; Oswald, 1996) or the limited positive neighborhood externalities (Rohe et al., 2013).

[48] The equity distribution is obtained from the German Federal Statistical Office from the year 2021 and thus reflects the distribution of German households.

[49] In the simulation, a redemption period of 10 is assumed. Thus,10 payments on the principal are made so that $r_p = 0.1$. Interest and redemption sum up to $r = r_t + r_p$.

of a potential buyer is the upper threshold for housing investment, he only places a bid if $P_{expected,b,t} \leq P_{res,b,t}$ which leads to a bid price of: $Bid_b = min(P_{expected,b,t}, P_{res,b,t})$.

3.3.2.2. Sellers

Sellers offer residential property and can either be households, too, who sell already existing dwellings, or residential property firms, that build and sell new ones. Both aim at profit maximization and decide every period anew, whether to sell or keep their houses. Just as buyers, sellers are agents with heterogeneous attitudes towards market developments. They form expectations about future market prices and only offer their property for sale if selling is advantageous compared to keeping and selling in a subsequent period. Thus, they evaluate whether the profit out of selling and investing freed up liquidity in an alternative investment AI that bears interest at the risk-free interest rate r_f is higher than keeping for now and selling later, which is:

$$P_{t-1} + \frac{(r_f AI)}{(1 + r_f)} \geq \frac{(1 + e_s) * (P_{t-1} + \Delta P_{t-1})}{(1 + r_f)}. \qquad (3)$$

[50]

If (3) holds, the seller places an offer at the market which equals at least the price of the previous period which is P_{t-1} that, thus, states the seller's reservation price. To adjust his ask price to current market conditions, a seller evaluates whether a buyer or a seller market exists by computing $\varphi = \frac{(NB-NS)}{(NB+NS)}$, where NB is the number of buyers and NS is the number of sellers interacting in the previous period. If buyers exceed sellers, which means $\varphi_t > 0$, the price is adjusted upwards. If $\varphi_t < 0$, P_{t-1} states the lower limit of the ask price.

If a house is not sold in t, it remains on the market to be bought in t_{+1}. To increase the probability of sale, the seller lowers the price by ς for which $0 < \varsigma < 1$ holds which mimics sellers' real market behavior (De Wit, 2013). The reduced price states the new reservation price of the seller. This price formation applies for all subsequent periods until the house is sold and can be stated as:

$$P_{ask,s,n} = \begin{cases} \left(P_{t-1}(1 + \varphi)\right) \varsigma^n & for\ \varphi_t > 0 \\ P_{t-1}\varsigma^n & for\ \varphi_t < 0 \end{cases}, \qquad (4)$$

where n states the number of periods a housing unit is available for sale. If a residential property stays unsold for 30 periods, it is assumed to be depreciated and removed from the market. On top, a seller cannot be a buyer in the same period, whereas a former seller can become a buyer in subsequent periods.[51]

3.3.2.3. Housing Price

A sale takes place if a buyer's bid equals or exceeds a seller's reservation price. The auction is modeled as a first-price-sealed-bid auction. All potential buyers place their bids on the market which are assigned to sellers' offers in descending order. Following this auction process, we implicitly account for quality differences of real estate objects, since it can be assumed that more expensive dwellings have a higher standard which is valued by buyers

[50] The interest of the alternative investment is paid out at the end of a period.

[51] Depending on risk-aversions and market conditions it may be that, in reality, a potential seller is a potential buyer simultaneously. This, however, bears different risks for the seller, such as, not being offered a loan for the new dwelling if the old one is not sold yet, excess debt, or forgoing a cheap mortgage rate. Furthermore, extensive acquisition periods for real estate transactions reduce the probability of being both at the same time. Referring to this, the assumption to be either a buyer or a seller in one period seems suitable.

by placing higher bids. As real estate prices are built by bilateral bidding (Filatova, Parker and van der Veen, 2007), the transaction price is calculated as the mean of the respective bid and ask price of the agents.

The price index of one period is the mean of all transaction prices during this time:

$$p_t^h = \left(\frac{1}{N_{transactions}}\right)\sum_{h=1}^{N} P_i, \tag{5}$$

where $N_{transactions}$ is the number of transactions in one period and P_i is the price of the sold house i. The price index is observable for all agents and serves, in combination with its change, as the basic reference for agents to evaluate current market conditions and make expectations about future developments.

3.3.2.4. Number of Properties

The number of housing units available for sale includes those of sellers who sell already existing property and those of residential property firms. Offers from sellers are either first-time sales, $N_{new\ sellings}$, or unsold houses from previous periods, $N_{left\ over}$. Residential property firms decide whether or not to build new houses following the maxim of profit maximization. They evaluate the market composition of buyers and sellers by consulting $\varphi_{t_{-2}}$, the number of buyers who did not succeed in acquiring property two periods ago, $N_{remaining\ buyers,t-2}$, and the price changes of previous periods by calculating $\rho_{t-2} = \left(\frac{P_{t-2}+\Delta P_{t-2}}{P_{t-2}}\right)$.[52] The number of newly constructed houses accordingly is:

$$N_{constructions,t} = N_{remaining\ buyers,t-2} * \varphi_{t-2} * \rho_{t-2}, \tag{6}$$

for which $N_{constructions,t} \geq 0$ holds. The total stock of dwellings for sale is the sum of these components, i.e., $N_{h,t} = N_{new\ sellings,t} + N_{left\ over} + N_{constructions,t}$. The ask price formation of residential property firms follows this of sellers, stated in equation (4).

3.3.3. The Financial Market

The financial market consists of two types of financial institutions, conventional banks (CBs) and building and loan associations (BLs) as introduced in section 3.2. Both aim at profit maximization and follow individual investment strategies. The model setting offers three investment options for financial institutions: they either hold cash, grant mortgages to potential real estate buyers, or invest in another risky asset which is supposed to be a diversified market portfolio of financial assets and represents alternative investment opportunities. Cash earns no interest and is supposed to be risk-free. Mortgages and the market portfolio generate profit but also bear risk which is either default or price risk. Financial institutions are investment constraint by the regulation of Basel III. In detail, when acting on the market, the financial agents must comply with Basel III capital requirements, including a countercyclical capital buffer.

Every bank is characterized by its individual simplified balance sheet which is initially calibrated to BankFocus data. Their balance sheet structure is displayed in Table 3.1. All investments or disinvestments are accounted for in the respective balance sheet variables. They vary every period and are the result of individual

[52] The construction time of residential property is assumed to be one period. The appropriate information to determine the number of houses to be built at the beginning of t_{-1} therefore is the information out of t_{-2}.

expectations and agent interaction.[53] As BLs must meet their special business purpose, they are restricted in investment opportunities. CBs in contrast chose freely between mortgage lending and investing in the market portfolio. The financial market is populated by m banks of each branch.

Table 3.1: Balance sheet structure of banks

Assets		**Liabilities**	
Cash (C)		Debt (D)	
Risky Assets		Equity *(E)*	
	Mortgages (T)		Free equity
	Alternative Investment (AI)		Regulatory equity for T
			Regulatory equity for AI

Notes: Table 3.1 displays the balance sheet structure of banks in the model. The simplified balance sheets are initially calibrated to data from German banks in the period from 2012-2021 which is obtained from BankFocus.

3.3.3.1. Regulatory Requirements

The regulatory framework of the model is designed according to the rules of Basel III, the most recent version of the Basel international standards for bank regulation, introduced by the Basel Committee on Banking Supervision (BCBS). It aims at providing a regulatory foundation for a resilient banking system that supports the real economy (BCBS, 2017a).[54] As a response to the global financial crisis, the Basel III reforms tighten the microprudential regulation of the banking sector and add macroprudential elements.

The microprudential regulation addresses the safety and stability of individual financial institutions. To mitigate the effects of loan defaults and other depreciation, banks are required to hold a minimum amount of equity to absorb potential losses. Compared to its predecessor, Basel III introduces higher quality standards of loss-absorbing capital and increases the level of minimum risk-based capital adequacy requirements (CAR). The CAR are defined as the ratio of a bank's Common Equity Tier 1 capital ($CET1$) and its total risk-weighted assets (RWA), where RWA, in turn, represent a bank's assets adjusted each with their corresponding risk weight according to the guidelines of the BCBS (BCBS, 2019a).[55] The framework requests a static minimum level of CAR which is:

$$CAR = \frac{CET1}{RWA} = \frac{CET1}{(rw_T * T) + (rw_{AI} * AI)} \geq \bar{\epsilon_3} \text{ with } \bar{\epsilon_3} = 4.5\%. \quad (7)$$

[53] Funding opportunities are not specifically modelled. Instead, the amount of debt is calculated as the difference of total assets and equity and develops passively.
[54] For more information and details on Basel III and it's regulatory requirements, visit the website of the Bank for International Settlements (BIS) at: https://www.bis.org/bcbs/basel3.htm?m=3_14_572.
[55] According to the regulatory setup, cash is risk-free. Equity instruments, in contrast, are assigned a risk weight of 100% and the risk weight of mortgage loans depends on the custom LTV. According to the BCBS, the LTV is defined as the mortgage amount divided by the value of the property. This implies a LTV ratio for the model of: $LTV = \frac{(T-E)}{P_i}$. The risk weights of the respective LTVs are summarized in Table 3.7 in the appendix. For detailed information see BCBS, 2017b.

The banks' RWA of this model are either mortgage loans or a risky market portfolio of financial assets.[56] The initial balance sheets of the banks are calibrated to BankFocus data from 2012 to 2021. This ensures a distribution of RWA which is sufficiently close to reality.

The second measure that focuses on the microprudential level of bank regulation is the Liquidity Coverage Ratio (LCR). In contrast to the CAR, the LCR promotes the short-term resilience of banks' liquidity risk profile. The regulator requires banks to hold a stock of high-quality liquid assets that can be converted into cash to survive a distinct period of stress lasting 30 calendar days (BCBS, 2019b) and to avoid fire sales (Balasubramanyan and VanHoose, 2013). The LCR relates a banks' stock of unencumbered high-quality liquid assets to its total net cash outflows over the next 30 calendar days. The ratio must never be lower than 100%. This model indirectly accounts for the LCR, calibrating the banks' cash positions according to BankFocus data, assuming that all banks meet the LCR and holding these liquidity ratios fixed during the simulation. Accordingly, banks only decide to hold cash, if the initial liquidity ratio is undercut or not enough free equity is available to buy shares without violating the CAR. Banks prefer investing in risky assets instead of holding cash since banks focus on profit maximization and liquidity earns no profit. Following this approach, we ensure that the requirements on liquidity are met during the simulations and, on top, we consider the individual risk aversions of the single institutions.

The newly introduced macroprudential tools of Basel III focus on the systemic dimensions of risk arising from banks. They are designed to minimize spillover effects to the real economy sector and to foster and improve macroeconomic stability. To achieve these purposes, the regulator introduced a countercyclical capital buffer to mitigate procyclical behavior and to smooth financial cycles (BCBS, 2017a).

Banking crises often appear after periods of extensive credit growth (Schularick and Taylor, 2012; Gourinchas and Obstfeld, 2012). The countercyclical capital buffer ($CCyB$) extends the established regulations of CAR (BCBS, 2019c). It allows national authorities to impose further capital requirements on banks to prevent excessive credit growth in favorable economic periods. If credit growth is judged to be associated with a build-up of system-wide risk, financial institutions shall build a precautionary capital buffer during upswings that protect against future potential losses. These restrictions are released in times of downswings to counteract credit constraints and to ensure a sufficient supply of capital. To model this type of macroprudential regulation, previous credit growth is used as an indicator to account for economic and financial cycles, respectively. Mortgages indicate the approved credit volume and link both markets, the financial and the housing market. Thus, the aggregate loan portfolio of banks represents the conditioning variable to identify economic conditions.[57] The $CCyB$, denoted by κ_t^m, varies between $0 \leq \kappa_t^m \leq 2.5\%$ and is calculated as:

$$\kappa_t^m = \begin{cases} \kappa_{min} & for\ \frac{\Delta M}{M} \leq 0 \\ \kappa_{max} * \frac{\Delta M}{\Theta M} & for\ 0 < \frac{\Delta M}{M} < \Theta \\ \kappa_{max} & for\ \frac{\Delta M}{M} \geq \Theta \end{cases} , \tag{8}$$

[56] The market portfolio is assumed to consist out of shares. Therefore, the BCBS risk weight of 100% is assigned.
[57] This is reasonable since credit growth has been a good predictor of financial crises in the past (Goodhart and Hofmann, 2007).

where $\frac{\Delta M}{M}$ means the percentage change of aggregate mortgages from the previous to the current period and Θ means the threshold of mortgage growth above which κ_t^m is set at its maximum.[58] The $CCyB$ must also be built in relation to RWA and extends the CAR so that according to prevailing market conditions the minimum requirement of capital for banks is $CAR = \frac{CET1}{(rw_T * M)+(rw_{AI} * AI)} \geq \bar{\epsilon_3} + \kappa_t^m$ where $4.5\% \leq \bar{\epsilon_3} + \kappa_t^m \leq 7.0\%$.

3.3.3.2. Mortgage Supply

The principles of mortgage supply also build on Braun et al. (2022). Except for available equity, housing investment is mortgage financed. Banks allocate capital to potential real estate buyers and thus have a direct impact on the real estate market. At the beginning of each period, CBs and BLs decide between loan granting and investing in the alternative risky investment (AI). Financial institutions are assumed to be risk-neutral and profit-maximizing. Therefore, they only grant a mortgage if the expected profit exceeds this of AI, formally if:

$$(\mathrm{q}r_t + (1-q)r_d) - c_t \;\geq\; r_{AI}. \tag{9}$$

where q indicates a potential borrower's probability of not defaulting, r_t the mortgage interest rate, r_d the rate of return in case of default,[59] c_t the opportunity costs of lending due to the capital requirements of Basel III, and r_{AI} the expected return of AI.

Solving (9) for r_t gives the indifference rate of potential lenders which is the lowest mortgage rate a lender would accept as a function of a potential buyer's no-default probability. We assume that the financial market is highly competitive and no single institution has market power. Accordingly, $r_t = r_{min}$ which is:

$$r_{min} = r_d + \left(\frac{r_{AI}-r_d}{q}\right) + c_t \tag{10}$$

Both bank types risk-price mortgages according to potential borrowers' probability of not-defaulting. Solving (9) for q indicates the lowest value of q and thus the highest risk a lender would accept for a given r_{min} which is $q_{min} = \left(\frac{r_{AI}-r_d}{r_{min}-r_d}\right) + c_t$. Since r_{min} and q_{min} are oppositely linked to each other, the higher the return of lending must be in order to be advantageous for the bank the lower the value of q_{min}. Due to investment restrictions of BLs according to their special law, $r_{min,CB} > r_{min,BL}$ holds. Thus, for a given r_{min} borrowers can be assigned to the bank types according to their values of q. Potential borrowers with a probability of not defaulting for which $[0, q_{min,BL}]$ holds are not offered a loan by any bank. Those having a q in the interval of $[q_{min,BL}, q_{min,CB}]$ only get a mortgage by BLs. For potential borrowers with a value of $q \in [q_{min,CB}, 1]$, CBs and BLs are willing to lend. As potential house buyers assess homeownership positively, we assume a positive time preference for housing investment. Accordingly, every borrower with a value of q in the range of $[q_{min,CB}, 1]$ who can afford the comparatively high interest rate of CBs, will decide in favor of CBs. As a result, borrowers whose disposable

[58] In the simulation results presented below, $\Theta = 5\%$. This represents the average long-time increase of mortgage loans in Germany (German Central Bank, 2019).

[59] We follow Sommervoll, Borgersen and Wennemo (2009) and allow for $r_{AI} = r_d$. This is reasonable for two reasons: first, the banks' portfolio composition is a strategic consideration. Second, they make individual expectations about future market settings. If $r_{AI} = r_d$, a potential lender decides between borrowing and investing according to its individual balance sheet structure and market expectations.

income equals or exceeds CBs debt service which is the annuity $A_{m,CB} = \frac{(1+r_{min,CB})^n r_{min,CB}}{(1+r_{min,CB})^n - 1} M$ will decide in favor for CBs. Borrowers with $q \in [q_{min,CB}, 1]$ for which $\frac{Y}{\left(\frac{\alpha}{\beta}+1\right)} < A_{m,CB}$ holds will borrow from BLs.

If banks engage in risky business, Basel III requires them to hold a specified amount of equity (see section 3.3.3.1). The retained equity cannot be invested alternatively, and, thus, causes opportunity costs.[60] These costs are given by:

$$c_t = r_{wT} * \left(\frac{\emptyset r_t + \emptyset r_{AI}}{2}\right), \tag{11}$$

where r_{wT} states the risk weight of the custom mortgage, $\emptyset r_t$ the average of past mortgage returns, and $\emptyset r_{AI}$ the average of past returns of AI.[61] The opportunity costs lower the return out of mortgage lending. The effective mortgage return r_{eff} of a mortgage T is:

$$r_{T,eff} = \left(r_d + \left(\frac{r_{AI} - r_d}{q}\right)\right) - \left(r_{wT} * \left(\frac{\emptyset r_t + \emptyset r_{AI}}{2}\right)\right).^{62} \tag{12}$$

To lower the risk of mortgage lending, banks follow a credit allocation process and constrain lending. To account for potential borrowers' budget constraints, they limit the mortgage volume to the applicant's i highest possible expenditure for housing investment in terms of:

$$C1: T_{max,i,1} = \frac{Y}{\left(\frac{\alpha}{\beta}+1\right)}. \tag{13}$$

Furthermore, lenders determine a potential buyer's mortgage-to-income ratio as $\gamma = \left(\frac{T-E}{Y}\right)$ which is assumed to be oppositely associated with his no-default probability. As q being a decreasing function of γ, $q = q(\gamma)$, banks limit the mortgage volume of i, given his no-default probability to:

$$C2: T_{max,i,2} = (1 - \gamma_i)Y_i. \tag{14}$$

The mortgage-to-income ratio serves as a measure for lenders to select borrowers according to their riskiness. Since a higher income of borrowers is associated with a lower probability of default, it serves as a good proxy to estimate borrower default (Yang, Buist, and Megbolugbe, 1998; Hakim and Haddad, 1999; Ambrose and Capone, 2000). We restrain from modeling strategic default. Instead, the utility function of potential buyers indicates their assessment of homeownership via which only those with positive attitudes toward housing investment enter the housing market (see section 3.3.2.1.). Default among homeowners is relatively raw even if households suffer severe financial difficulties (Bhutta, Dokko, and Shan, 2017; Foote and Willen, 2017). This indicates that homeowners attach a non-financial value to their homes and try to avert default as far as possible. Strategic default, in contrast, reflects the conscious decision to abandon homeownership and being a tenant. We refrain from modeling other default decisions arising from external factors such as falling house prices or income shocks, too, as they would affect both types of financial institutions similarly and, thus, would leave the results unaffected.

[60] Operating costs of mortgage lending are not considered.

[61] To determine forgone returns, we use the mean of past average returns of both, T and AI, since the potentially invested asset as well as its return is unknown.

[62] Note: $r_{T,eff,CB}$ and $r_{T,eff,BL}$ differ since CBs and BLs have different return rates of AI ($r_{AI,CB} \neq r_{AI,BL}$). For detailed explanation, see section 3.3.3.3.

A third credit constraint is assessed according to the collateral value of the housing unit. To lower credit risk, conventional banks collateralize the financed dwelling (Bester, 1985) and base their lending decision on it.[63] To determine the collateral value, CBs use recent price information and have adaptive as well as individual expectations. According to previous price trends, they constrain the mortgage amount to:

$$C3_{CB}: T_{max,i,3} = CV_{k,i} = \begin{cases} (1 + e_{CB,h})(1+\rho)^2 P_{t-1} & for\ \rho^+ \\ \chi\,(1 + e_{CB,h})(1+\rho) P_{t-1} & for\ \rho^- > \psi\ , \\ \chi\,(1 + e_{CB,h})(1+\rho) \dfrac{Y}{\left(\dfrac{\alpha}{\beta}+1\right)} & for\ \rho^- < \psi \end{cases} \tag{15}$$

where $e_{CB,h}$ states the individual CB's expectation about future house prices and $e_{CB,h} \sim U(-0.1, 0.1)$, ρ^+ states a positive and ρ^- a negative relative price change, χ a risk discount, and ψ a threshold until which mortgage lending is advantageous out of diversification reasons although prices fell in previous periods. Considering (13), (14), and (15), the mortgage volume granted by a CB to applicant i is $T_{CB,i} = \min(C1, C2, C3_{CB})$.

According to their ruling law, BLs are allowed to fully collateralize owner-occupied dwellings. Opposite to CBs, they do not primarily focus on the collateral value to determine the approvable mortgage sum. Instead, they also use endogenous customer information gathered during the qualifying period of a CSH. If a customer fulfills his obligation to save regularly, he is classified as a reliable customer with the proportion of τ. In this case, the amount of debt is not further limited. If an applicant violates his contractual obligations, he is assumed to be an unreliable customer, represented by the proportion $(1-\tau)$. This type of applicant is rejected, so that $C3_{BL}: T_{max,i,3} = 0$ holds. The approved mortgage volume of a BL accordingly is:

$$T_{BL,i} = \begin{cases} min(C1, C2) & for\ \tau \\ min(C1, C2, C3_{BL}) & for\ (1-\tau) \end{cases}. \tag{16}$$

3.3.3.3. Share Price Formation

The price formation of the second risky investment option, AI, follows a continuous time stochastic process in which the logarithm of a random variable follows a Brownian motion. This process is called geometric Brownian motion and is used to model price paths (Klebaner et al., 1999; Sheldon, 1999). The fundamental value of AI is calculated on the basis of its previous value which is normally distributed with a constant mean change and a drift:

$$f_t^V = f_{t-1}^V + \mu - \frac{\sigma^2}{2} + \eta_{t-1}. \tag{17}$$

f_{t-1}^V denotes the previous log fundamental value of AI, μ its long-term expected drift, σ its standard deviation and η_{t-1} a random walk for which $\eta_{t-1} \sim N(0, \sigma_\eta^2)$ holds. The annual volatility of f_t^V is set to 19.2% and its drift to 12.5%.[64]

The market price p_M is the log price at which transaction occurs on the market. This may differ from the $AI's$ fundamental value as p_M is the result of agents' interaction. The market price level is calculated at the end of each

[63] For empirical evidence, see i.e. Collyns and Senhadji (2005), Freund et al. (1998), Herring and Wachter (1999), Hilbers, Lei and Zacho (2001), Niinimäki (2009).

[64] These values are calibrated to the volatility and the drift of the German stock index (DAX) on a daily basis in the period from 2012 to 2021.

period as the mean of all transactions during one period $p_{M,t} = \left(\frac{1}{N_{transactions,AI}}\right) \sum_{p=1}^{N} P_{bid}, P_{ask}$. Agents observe the market price and the fundamental value at the end of the period and form expectations about the prospective price development. Doing some research at the beginning of each period, agents derive a private noisy signal s about the future fundamental value of AI. This signal is modeled as a comparison of the previous fundamental value and the market price plus an agent-specific term $e_{CB/BL}$ that considers the variability in the perception of the fundamental value where $e_{CB,AI/BL,AI} \sim N\left(0, \sigma^2_{e_{CB,AI/BL,AI}}\right)$:

$$s_{m,t} = (f^V_{t-1} - p_{M,t-1}) + e_{CB,AI/BL,AI}\,. \tag{18}$$

The expected fundamental value of an agent m is:

$$f^V_{exp,m} = f^V_{t-1} + \mu + s_{m,t}. \tag{19}$$

As for mortgage lending, Basel III rules require banks to hold equity when investing in the risky market portfolio. The tied-up equity causes opportunity costs that must be considered to determine the effective return out of AI which, in turn, is crucial for banks to decide between lending for real estate purposes and investing in the capital market. The two different bank types predict effective returns calculating:

$$r_{AI,eff,CB} = \left(\frac{(f^V_{exp} - p_{M,t-1})}{p_{M,t-1}}\right) - \left(r_{wAI} * \left(\frac{\emptyset r_t + \emptyset r_{AI}}{2}\right)\right), \tag{20}$$

$$r_{AI,eff,BL} = \left((wr_f) + (1-w)\left(\frac{(f^V_{exp} - p_{M,t-1})}{p_{M,t-1}}\right)\right) - \left(r_{wAI} * \left(\frac{\emptyset r_t + \emptyset r_{AI}}{2}\right)\right), \tag{21}$$

where the first part of the equation in each case represents the predicted return of AI, r_{AI}, and the second part represents the opportunity costs for investing in AI. Because of the legally restricted investment policy of BLs, their predicted return of AI is calculated as a discrete one.

To decide between mortgage lending and investing in AI, the financial institutions compare the effective rates of return of the risky assets and only grant a mortgage if $r_{T,eff,CB} \geq r_{AI,eff,CB}$ resp. $r_{T,eff,BL} \geq r_{AI,eff,BL}$. If one decides in favor of AI, it places an order at the capital market. Each bank can be a buyer or a seller for which we distinguish two types of trading: voluntary and forced trading, doing fire sales. To decide whether to buy or sell shares, an agent compares his expected fundamental value with the previous market price. If $f^V_{exp,m} > p_{M,t-1}$, the market portfolio is undervalued and the agent decides to buy. If the opposite is the case and $f^V_{exp,m} < p_{M,t-1}$, the portfolio is overvalued; the agent decides to sell. Buy and sell orders are placed indicating the agents' bid/ask price. Orders of an agent m are placed at:

$$\begin{aligned} &\text{Buy order: } P_{bid,m} = f^V_{exp,m} + spread \\ &\text{Sell order: } P_{ask,m} = f^V_{exp,m} \\ &\text{Fire sale: } P_{ask,FS,m} = f^V_{exp,m} - spread. \end{aligned} \tag{22}$$

The desire to buy or sell shares also depends on the current state of the balance sheet and the free equity available to fulfill the regulatory requirements of each individual bank. If a bank meets the CAR and has enough free equity, it decides between mortgage lending and share trading according to the respective returns. If CAR are violated, banks may be forced to sell shares to meet the regulations again.

All agents interact indirectly via one central order book. Direct OTC trading is not possible. Bids and asks are collected in the order book and matched oppositely using price priority. When agents state their bid/ask price, they do not know the orders of other agents. Therefore, an agent is unsure whether and how much of his order will be realized. It might occur that some orders are unmatched and stay unsatisfied. Thus, it is possible that an agent must place orders in several successive periods to achieve a certain balance sheet structure.

At the end of each period, the financial institutions recalculate their balance sheet variables. The cash position is used to buy shares. This decreases the cash balance whereas share sales increase it. The mortgage loan portfolio expands if new loans are approved. Repayments and defaults have an offsetting effect.[65] Realized losses out of mortgage default are absorbed in the equity position. The same holds for gains and losses out of stock trading. Depending on the market price development, agents may face gains or losses from one period to the next. These are directly translated into changes in equity. The amount of debt is the difference between total assets and equity. It increases when mortgages are granted and decreases when loans are repaid or defaulted.[66]

According to the amount of equity available at the end of each period, the financial situation of every financial institution can be evaluated and grouped in one of four categories. If a bank has positive equity and fulfills all of the regulatory requirements, it is a perfectly healthy bank which can trade shares and grant mortgages freely (*State A*). A financial institution that has positive equity but violates regulatory rules is restricted in actions. Its primary goal is to meet the regulation again (*State B*). A bank is in trouble as soon as its equity position becomes negative. If such an institution has assets which can be sold, he is forced to do fire sales (*State C*). If no saleable assets are left, the bank can neither seller nor buy share, nor grant mortgages. It is declared to be bankrupt (*State D*).[67]

3.4. Computational Experiments

The model presented in the previous sections is analyzed by conducting a set of computational experiments. To assess the effectiveness of current capital adequacy requirements according to Basel III, we create differential scenarios which are investigated individually and compared to each other. For every scenario, we evaluate stability measures of the housing market, the capital market, and the banking sector. Building on the real-world indicators used by regulators and existing research (BCBS, 2017b; Dyrberg, 2001; Sundararajan et al., 2002), we account for the intensity of price movements in terms of the standard deviation of house and share prices, mortgage, and share interest rates to measure market (in-)stability. Furthermore, we address the market penetration of both types of financial institutions as well as the number of granted mortgages and the number of trades in each scenario. As for regulatory purposes, those indicators are used to indicate excess market behavior and excess credit growth (BCBS, 2019c). Reporting those measures addresses both aims of the regulation which are to mitigate fluctuations in house prices and to reduce systemic risk by stabilizing fluctuations in credit. To assess the fragility of the banking sector, we account for the Z-Score. The Z-score is an indicator of bank soundness and measures their distance from insolvency (Roy, 1952). It is a key figure to measure bank stability (Boyd and Runkle, 1993; Lepetit and Strobel,

[65] An individual default rate for mortgage loans granted by CBs/BLs is considered which is calibrated to empirical data of the statistical data warehouse of the ECB from the periods 2015–2021.

[66] A redemption period of 10 is assumed. In each period, a respective fraction is repaid which decreases the mortgage and the debt position.

[67] In reality, banks have different possibilities to prevent bankruptcy. For example, they retain earnings or issue new equity to meet the regulatory requirements again. As the liability side develops passively, strategic actions like this are not considered.

2015) and is calculated as $Z_{i,t} = \frac{ROA_{i,t}+(\frac{E}{A})}{\sigma(ROA_{i,t})}$.[68] In each scenario, the operating banks act in a competitive market and no single institution has market power. For each scenario, 100 periods are simulated.

3.4.1. Calibration of the Simulation Setting

The model setting is calibrated according to empirical evidence as well as assumed parameters consistent with a real economy in terms of relations and conditions in order to mimic the housing and the financial market as close as possible. Table 4.2 summarizes the model parameters to initialize the market setting.

Buyers and sellers constitute supply and demand on the housing market. Each of them is characterized by individual features which ensure a high level of heterogeneity. In the beginning, 60 buyers and 30 sellers act on the housing market. When a trade has been conducted, both counterparties leave the market. If a buyer is unsuccessful in buying a property for the repayment period of 10, he is assumed to be too old for housing investment and stays a tenant. Dwellings, which are unsold within 30 periods are assumed to be depreciated and removed from the market. In each period, a random number of potential buyers in a range of [30,36] and potential sellers in a range of [10,12] enter the housing market. Every newly added potential buyer is equipped with individual measures of utility for consumption and housing, income, and perceptions about market development. The same holds true for potential sellers that are put on the market. Every agent follows the model processes described in section 3.3.2.1. and 3.3.2.2. According to their characteristics and own perceptions of previous and future market developments, new potential buyers either aim at acquiring a dwelling, stating housing demand, or staying a tenant. Potential sellers either state housing supply or decide to keep their housing unit and hope for house price appreciations in the following period. Following this approach, the housing market is composed endogenously, based on internal factors.

The model consists of 79 loan lending and share investing financial intermediaries, out of which 53 are CBs and 26 are BLs. This composition is obtained from the BankFocus database and represents the German financial market.[69] The balance sheet structures of the individual banks are calibrated on BankFocus data as well. By doing this, we ensure a distribution of RWA which represents real market conditions. Both types of credit institutions are economic agents having custom beliefs about future market developments (e_h, e_{AI}) across and within branches and follow their individual strategic goals. To decide about loan granting, the loan-to-value of CBs is set to $\chi = 0.8$ which mimics German conditions (Bienert and Brunauer, 2006). BLs observe a ratio of good customers in the market of $\mu = 0.8$ and they are restricted by national law to invest a maximum of 5% in assets on the financial market other than the risk-free interest rate (sect. 4 BauSparkG). Loan default rates of the credit institutions are $D_{CB} = 0.01$ and $D_{BL} = 0.005$ in all simulations.[70]

The share market sets framework conditions that affect the real estate market. Furthermore, on the share market, banks place bids and offers in order to invest in the alternative investment portfolio AI. AI represents a

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[68] ROA is the return on assets and $(\frac{E}{A})$ denotes the equity to assets ratio. As Z-scores are highly skewed, we transform the values, using the natural logarithm and calculate $\ln(Z_{i,t}) = \ln(\frac{ROA_{i,t}+(\frac{E}{A})}{\sigma(ROA_{i,t})})$.

[69] The data set contains every CB and BL of the German financial market which are classified as credit institutions according to the national Banking Act (sect. 1 KWG), grant mortgage loans to households, and for which the respective balance sheet data was available. Group companies are only included once with the parent company.

[70] The loan default rates of both institutional types are obtained from the ECB Statistical Data Warehouse.

diversified market portfolio which has an initial rate of return of $r_{AI} = 0.084$, a past fundamental value of $f_{t-1}^{v} = 1008$, a drift of $\mu = 0.1215$ and a volatility of $\sigma = 0.192$. These parameters are calibrated on average data of the German stock index (DAX) of the last 10 years.[71]

Table 3.2: Initial simulation parameters

Parameter	**Description**	**Value**
	Buyers	
α	Preference for consumption	[0, 1]
Y	Income	[100, 1000]
e_b	Individual market expectation	[-0.1, 0.1]
E	Equity	[0, 0.35]
	Sellers	
e_s	Individual market expectation	[-0.1, 0.1]
ς	Markdown ratio	0.95
	Housing Market	
P_t	Price index	2500
ΔP_{t-1}	Price change in t-1	50
ΔP_{t-2}	Price change in t-2	50
N_{Buyers}	Number of buyers	60
$N_{Sellers}$	Number of sellers	30
r_p	Redemption rate	0.1
r_t	Loan interest rate	0.03
	Credit Institutions	
$e_{CB,h}$	Individual market expectation	[-0.1, 0.1]
$e_{CB,AI/BL,AI}$	Individual market expectation	[-0.192, 0.192]
r_d	Default rate of return	0.001
χ	Loan-to-value	0.8
Ψ	Threshold of price decline	0.03
μ	Ratio of good customers	0.8
D_{CB}	Default rate CB	0.01
D_{BL}	Default rate BL	0.005
	Financial Market	
r_f	Risk free interest rate	0.01
r_{AI}	Market return	0.084
f_{t-1}	Fundamental value of AI	1008
μ	Drift	0.1215
σ	Volatility	0.192
p_m	Market price of AI	1000
Θ	Threshold of mortgage growth	0.05

3.4.2. Simulation Results of an Undiversified and Regulated Market

The first simulation scenario assesses the market conditions of an undiversified banking market which is regulated according to the rules of Basel III (see section 3.3.3.1). In this market setting, either solely CBs or solely BLs grant mortgages and trade the share portfolio on the capital market. The first market constitution mimics banking systems in which mortgage originations are heavily concentrated and dominated by conventional banks. This holds true for e.g. the United Kingdom or Canada (Benetton, 2021). The second market constitution is a rather hypothetical one to capture market conditions and understand market mechanisms.

[71] The input parameters are calculated using the price history of the German stock index (DAX) on a daily basis for the time period from January 2012 to December 2021. The data is obtained from the Refinitiv Eikon database.

During the computational experiments, the operating banks decide every period anew whether to finance housing or to buy shares, steadily restricted in actions by the regulatory requirements. Their decision is influenced by exogenous conditions such as house prices, share prices, or borrower quality as well as endogenous parameters such as future market expectations or individual balance sheet compositions. Considering all these parameters, they interact with potential home buyers and create endogenous housing market cycles or with each other and create endogenous share market cycles. The deviation of the house prices and the share prices from their means are displayed in Figure 3.1. Figure 3.2 shows the fluctuations of the mortgage interest rates and the share interest rates that develop through interactions between participants for both market constitutions. Table 3.2 provides the statistical properties of the evaluated market settings. The values reported are those of single simulation runs.[72]

In the first market setting, in which only CBs act as financial institutions, both the graphical illustrations and the statistical measures reveal that the housing prices, as well as the share prices, fluctuate distinctively. Compared to the market setting in which BLs are the only interacting banks, the minimum values of house and share prices experience deep drops in times of depreciating market conditions. This leads to high standard deviations of prices in both markets. The strongly pronounced peaks and troughs of house prices are due to the procyclic mortgage lending practices of CBs. Existing literature reveals that the lending decision of CBs is strongly determined by the collateral values of the financed property (Braun et al., 2022; Collyns and Senhadji, 2005; Freund et al., 1998; Herring and Wachter 1999; Hilbers, Lei and Zacho, 2001; Niinimäki; 2009). In times of previous house price appreciations, CBs lend generously, further driving prices upwards while in times of decreasing house prices, they restrict lending and thus exacerbate downturns. BLs in contrast also consider customer information to decide about mortgage lending. This lending behavior is less dependent on prevailing market conditions and leads to less volatile housing markets.

The share price fluctuations are also more distinct in a CB market. Especially in times of falling housing prices, they invest liquid funds in shares. Increased market activities and speculations about future fundamental values of the share portfolio lead to increasing share prices. The agents' interactions lead to comparably distinct share price movements. Share price cycles are shorter than housing market cycles. This mirrors the high fungibility of shares in comparison to dwellings and reflects that investing in the capital market is a complementary business, especially in the case of CBs. As BLs are restricted to invest in the capital market, capital market cycles are less pronounced.

Due to the attractive alternative investment opportunities of CBs, the mortgage interest rates charged by them for housing investment exceed those of the BL market. The same holds true for the share interest rate which reflects the rate of an alternative investment on the capital market that the respective institutional bank type can achieve. The higher average yield of shares coincides, however, with a larger standard deviation which is associated with a higher return uncertainty. The achievable rate of return of BLs out of shares is strictly limited by their special ruling law.[73] This prohibits risk-bearing capital investments and leads to a low rate of trading activities in an undiversified BL market and very low standard deviations of both interest rates. The number of granted loans is

[72] To ensure that those are representative and consistent, robustness checks have been performed which are provided in the appendix. Small deviations may occur due to different simulation scenarios.

[73] Note: Operational costs for granting mortgages or trading shares are not considered in the model setting. Thus, mortgage and share interest rates indicate bank returns.

similar in both market settings. The variation of the mortgage and share interest rates is illustrated in Figure 3.2. The higher level in case of CBs as well as their high fluctuations are clearly visible.

The mean value of the Z-score in a CB market which is regulated in accordance with Basel III and calibrated to German conventional banks is 2.440. This indicates that the banking sector is relatively stable.[74] The Z-score of a BL market exceeds this value (3.040) revealing that a banking market in which solely BLs act as financial institutions is more stable and less prone to insolvencies. The respective Z-scores are displayed in Figure 3.3. Existing literature supports these findings and reveals that commercial banks lag behind cooperative banks and savings banks regarding their stability. Lepetit and Strobel (2015) measure a mean Z-score of 3.113 for OECD commercial banks in the period of 1998-2012. During this time, cooperative banks reach a value of 3.533. Hesse and Čihák (2007) calculate a Z-score of German commercial banks in the period of 1994-2004 of 3.61 and one of 4.36 for German cooperative banks. Although BLs are not equivalent to cooperative banks, they share similarities by following the cooperative idea to bring people together to save jointly to achieve a common purpose. The advantageous Z-scores of BLs are driven by the fact that the standard deviation of BLs' return is lower than this of CBs. This suggests that BLs' specified regulation creates a concentrated business model which is more solid than this of CBs and more persistent in times of crises. Furthermore, the Z-scores examined in the empirical analyses are very close to those generated in the model. This indicates the model's goodness of fit in replicating real market conditions.

3.4.3. Simulation Results of a Diversified and Homogenously Regulated Market

In a second scenario, we evaluate the stability of the housing market, the share market, and the bank soundness if the banking sector is diversified and all financial intermediaries need to comply with Basel III accords. In this model, a diversified banking sector is characterized by two types of financial institutions, CBs, and BLs. As BLs' business model is particularly aligned to housing financing, they appropriately fit to evaluate how divergent regulatory requirements impact housing market conditions as well as banking stability and represent specialized financial intermediaries. This diversified market constitution mimics the German banking sector and represents those of other European countries. For the evaluations in section 3.4.4, this model setting serves as a base scenario.

Evaluating the development of housing market cycles, the model reveals what is already figured out by Braun et al. (2022). If different types of mortgage lenders with differing loan granting policies finance residential property, the price movements are less distinct and the housing market is less volatile. This is indicated by the lowest standard deviation compared to undiversified lending markets (Table 3.3). As BLs do not primarily focus on collateral values but also account for customer information, the commitments are less biased by previous market developments and the market is stabilized.

[74] Higher Z-scores imply a lower probability of insolvency while a lower Z-score corresponds to a higher insolvency risk. (Hesse and Čihák, 2007; Lepetit and Strobel, 2015).

Table 3.3: Statistical market measures of homogeneously regulated financial intermediaries[75]

Scenario		CBs	BLs	CBs & BLs
House Price	Min	1924.135	2379.848	2243.045
	Max	3513.619	3729.699	3785.579
	Mean	2637.800	2851.304	2836.199
	Std	354.833	339.165	304.539
Share Price	Min	977.771	982.991	994.467
	Max	1114.107	1091.861	1108.201
	Mean	1044.360	1039.126	1038.547
	Std	32.297	27.811	31.279
Mortgage Interest Rate	Min	0.006	0.013	0.013
	Max	0.081	0.015	0.066
	Mean	0.038	0.014	0.030
	Std	0.013	0.000	0.014
Share Interest Rate	Min	0.002	0.010	0.017
	Max	0.084	0.084	0.060
	Mean	0.039	0.019	0.026
	Std	0.011	0.003	0.012
Mortgage Market Penetration	CBs	1.000	0.000	0.600
	BLs	0.000	1.000	0.400
Capital Market Penetration	CBs	1.000	0.000	0.753
	BLs	0.000	1.000	0.247
No. of Loans	sum	1996	1925	2352
No. of Trades	sum	292	102	377
Z-score	Min	1.992	2.584	2.380
	Max	2.942	3.279	3.262
	Mean	2.440	3.040	2.552
	Std	0.165	0.100	0.177

Notes: Table 3.3 displays the statistical results of the estimated variables of the housing market and the financial market in the three evaluated simulation scenarios: a CB-only market, a BL-only market, and a joint market. All financial institutions are regulated similarly. We report minimum values, maximum values, means, and standard deviations for all variables and all simulation scenarios except for the number of loans and the number of trades. For these measures, the aggregate sum of all simulation periods is reported for all simulation scenarios.

The fluctuation of the share market prices is higher than this of the BL market but lower than this of the CB market. CBs tend to substitute mortgage granting with higher-yield share investments because the cheap mortgage granting of BLs lowers the average mortgage interest rate and reduces the return on housing financing. BLs trading volume is comparably low and dampens share price oscillations. This is visible in Figure 3.1. In a BL market, the prices hover slightly around their mean, while price movements are distinct in a CB market. In a CB & BL market, the price movements are a combination of both. This also holds true for the mortgage and the share interest rates.

[75] Note: The number of interacting banks and balance sheet ratios is held constant for each scenario. This ensures that the results are not affected by differences in scale.

Figure 3.2 depicts the interest rate movements of the different market constitutions and clearly shows the dampened fluctuations in a diversified market setting in comparison to a CB only market.

On the mortgage market, CBs reach a greater market penetration than BLs. This is induced by the assumed positive time preference of home buyers. If BLs finance owner-occupied property mainly using CSH contracts, a savings phase precedes the loan and postpones the time of acquisition. Borrowers who are granted a mortgage by both types of banks thus decide in favor of CBs. An even more distinct pattern is evident in the capital market. Because of the restricted market access of BLs, CBs clearly dominate the share market.

As CBs and BLs both act on the share market, the number of trades exceeds those of the undiversified market settings. The loan volume also increases in a market in which CBs and BLs originate mortgages. CBs usually demand a minimum level of equity to finance residential property. This credit constraint only allows those customers to purchase residential property who are able to provide the required equity capital. The contractually defined savings phase of CSH allows BLs' customers to accumulate equity steadily over time. As BLs may directly observe the savings performance of their customers, they forgo strictly constraining mortgage granting according to equity requirements. This loan granting feature of BLs raises the number of accepted mortgages and widens the accessibility to real estate financing within the population.

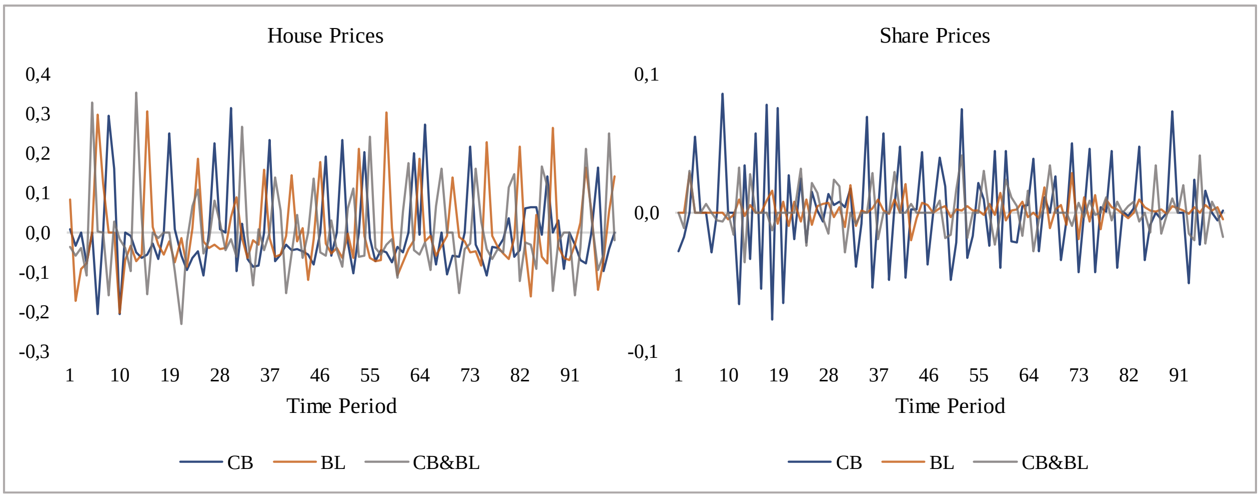

Figure 3.1: Deviation of house and share prices in an undiversified and diversified homogenously regulated simulation scenario[76]

Notes: Figures 3.1 and 3.2 report the results for house prices, share prices, mortgage interest rates and share interest rates of simulating the model for three different scenarios each for 100 draws. The blue line denotes the scenario with only CBs on the market, the orange line a market with only BLs, and the grey line the scenario with CBs & BLs. In every simulation scenario, financial institutions are regulated similarly. The development of all variables is expressed in log differences. The figures reflect trend-adjusted market cycles. Exogenous factors such as inflation are not considered.

[76] Note: The variation in share prices only arises by the interaction of the operating banks in the prevailing scenario. Institutional and private investors are not modeled. On top, only one standardized market portfolio is traded. These characteristics reduce the comparability with real-world stock markets. Nevertheless, the disregarded properties do not directly influence the behavior of participants and therefore do not affect the results of the model.

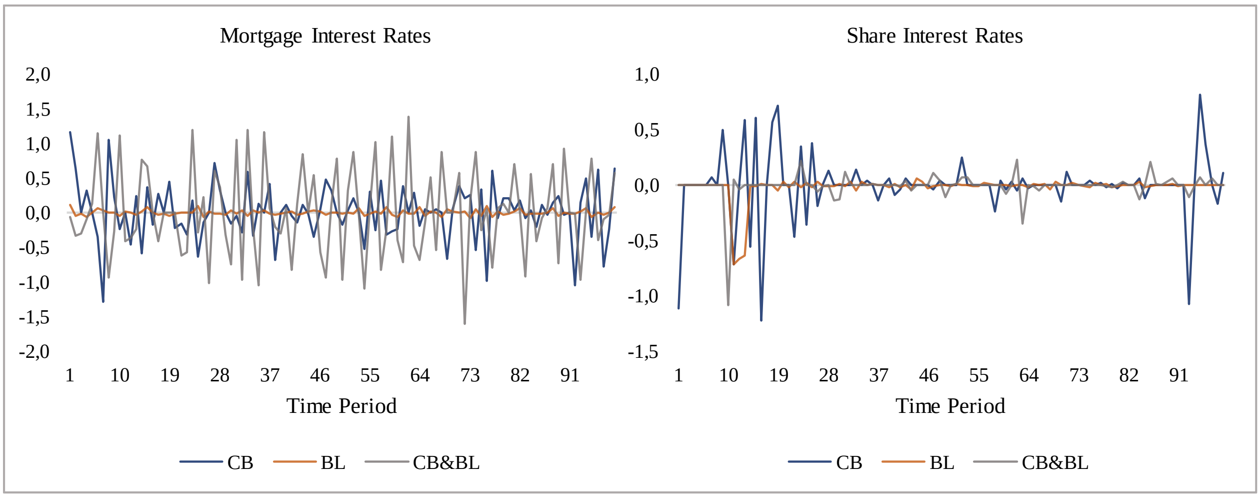

Figure 3.2: Deviation of mortgage and share interest rates in an undiversified and diversified homogenously regulated simulation scenario

The Z-score reaches a value of 2.552. This score falls between the two undiversified market settings. While the CB market features the lowest banking soundness, the BL market reaches the highest one. CBs' business practices are primarily aligned to profit maximization. These strongly pronounced financial goals bear a proportional degree of risk which is evident in the volatility of returns and lead to a vulnerable banking system. The definition of BLs' business model demands that the objective of financial profitability shall be harmonized with following their cooperative idea. The two-sided regulatory requirements on top clearly define their business strategy. These institutional features provide profound and stable business practices so that BLs not only stabilize housing price fluctuations and expand homeownership but also strengthen the solidity of the banking sector. The Z-scores of the respective market settings are illustrated in Figure 3.3. The graph reveals that the lowered mean Z-score in comparison to the BL market is induced by CBs. The positive outliers mainly represent BLs.

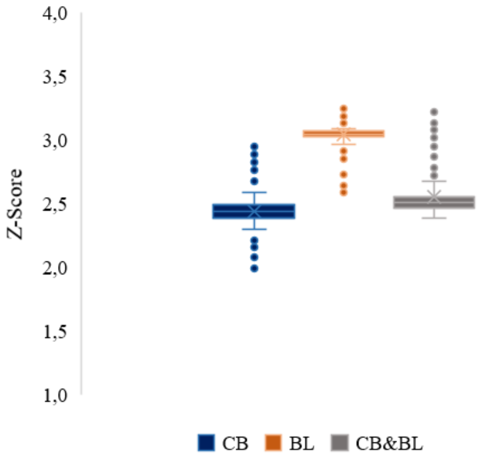

Figure 3.3: Z-Scores of an undiversified and diversified homogenously regulated simulation scenario

Notes: Figure 3.3 shows the mean Z-scores of financial institutions overall simulation periods in the respective simulation scenario. Three simulation scenarios are depicted: only CBs in blue, only BLs in orange, and a joint market of CBs & BLs in grey.

3.4.4. Simulation Results of a Diversified and Heterogeneously Regulated Market

This section analyses whether the standardized regulation properly fits a diversified banking market and effectively stabilizes housing and capital markets as well as the banking sector. The results of the previous section reveal that due to their specifically aligned business model and their specialized regulation, BLs cushion the housing market, prevent high mortgage and share interest rates and increase banking soundness. Due to BLs dual regulation, they are limited in activity. Thus, CBs dominate both, the share and the mortgage market. To examine whether it is reasonable to subject BLs to the same Basel III CAR as CBs, we conduct several computational experiments, varying the level of required CAR for BLs. Those of CBs are held fixed and mimic the prevailing rules of Basel III. Table 3.4 summarizes the statistical measures of the evaluated markets.

The intensity of housing market fluctuations varies depending on the level of BLs' regulatory capital requirements. If BLs would be solely regulated by their special law and no CAR were mandatory, the standard deviation of house prices reaches a value of 354.833. This exceeds the base scenario. Exempting BLs from holding equity when risky business is conducted negates housing market stability. Also, share prices vary more strongly. If BL's business is not restricted by the obligation to maintain a specified equity ratio, they lend and trade shares more extensively. This is evidenced by the highest loan originations and the highest share trades compared to all other scenarios. In this context, BLs expand their market shares in both markets heavily and almost achieve a balanced market distribution between BLs and CBs. BL's high market share induces comparatively low mortgage interest rates. Attractive share interest rates are further increased by high trading activities. Brisk market interactions spur the volatility of banks' returns. The standard deviations of interest rates are comparably high. Volatile returns, in turn, lead to unpredictable and unstable financial intermediaries. This is evidenced by the low Z-score. In the 0% CAR scenario, the Z-score falls below the base scenario and gets very similar to this of an undiversified banking market, consisting solely of CBs. If BLs are only subject to their individual law, they lose their stabilizing effect on the housing market, and the risk of bank insolvencies increases. These results infer that imposing CAR on banks stabilizes the banking sector and prevents bankruptcies. Based on these findings, it is not sure whether the stabilizing effects observed in the undiversified BL market can be attributed to the specific regulation of BLs or to the Basel III CAR. The fact that BLs are more stable than CBs (see Table 3.3) provides an indication in favor of the special regulation of BLs. The following experimental scenarios provide further clarification.

Table 3.4: Statistical market measures of heterogeneously regulated financial intermediaries

CAR - Scenario		0%	>= 1%	>= 2%	>=4.5%*	>= 6%	>= 8%
House Price	Min	2510.428	2123.755	2090.533	2243.045	1836.699	1419.353
	Max	4003.883	3512.834	3456.274	3785.579	4110.236	3972.940
	Mean	2778.749	2803.380	2845.355	2836.199	2892.712	2787.857
	Std	354.833	244.169	258.321	304.539	402.646	413.623
Share Price	Min	958.361	987.543	986.473	994.467	978.803	954.376
	Max	1144.508	1093.263	1092.949	1108.201	1137.635	1160.465
	Mean	1042.433	1040.908	1046.978	1038.547	1041.884	1037.272
	Std	33.888	28.769	29.155	31.279	32.922	31.520
Mortgage Interest Rate	Min	0.001	0.012	0.010	0.013	0.008	0.012
	Max	0.066	0.058	0.054	0.066	0.077	0.069
	Mean	0.029	0.033	0.033	0.030	0.037	0.038
	Std	0.013	0.011	0.012	0.014	0.015	0.014
Share Interest Rate	Min	0.002	0.015	0.012	0.017	-0.003	0.022
	Max	0.084	0.084	0.084	0.060	0.084	0.084
	Mean	0.030	0.028	0.028	0.026	0.029	0.028
	Std	0.014	0.007	0.008	0.010	0.013	0.012
Mortgage Market Penetration	CBs	0.554	0.563	0.568	0.600	0.618	0.636
	BLs	0.446	0.438	0.432	0.400	0.382	0.364
Capital Market Penetration	CBs	0.581	0.693	0.723	0.753	0.820	0.868
	BLs	0.419	0.352	0.277	0.247	0.180	0.132
No. of Loans	sum	2563	2470	2393	2352	2319	2305
No. of Trades	sum	559	418	399	377	368	266
Z-score	Min	1.732	2.507	2.542	2.380	2.062	2.584
	Max	2.785	3.384	3.682	3.262	3.452	3.197
	Mean	2.365	3.023	2.989	2.552	2.470	2.789
	Std	0.165	0.139	0.282	0.177	0.342	0.105

*Base Scenario

Notes: Table 3.4 displays the statistical results of the estimated variables of the housing market and the financial market if BLs need to comply with different levels of CAR. We report minimum values, maximum values, means, and standard deviations for all variables and all simulation scenarios except for the number of loans and the number of trades. For these measures, the aggregate sum of all simulation periods is reported for all scenarios.

As exempting BLs from CAR negatively impacts the stability of the housing market, the share market, and banking stability, it is tested how market conditions change if BLs must meet a CAR of at least 1%. In this scenario, house price fluctuation drastically decreases and reaches the lowest level of all experimental scenarios indicating the most stable housing market. The same effect can be observed in the share market. The duty to meet the CAR of 1% limits BLs business activities. That is why they are losing market shares in mortgage lending and the share market. The loss of market penetration in the share market, however, is higher than this of the mortgage lending market. As BLs business model is aligned to finance housing investments, market shares of the stock market are given up in favor of market shares in the real estate market. The decreased market penetration leads to higher mortgage interest rates and lower share interest rates compared to the 0% CAR scenario. The limited possibility to participate in business activities correlates with a lower number of loans granted and less trade on the share market. Comparatively low variations in banks' returns impact banking soundness. The Z-score of the 1% CAR scenario is 3.023. This value exceeds those of the other scenarios and indicates the most stable banking sector. Compared to the undiversified market settings, the Z-score is very close to the BL-only market. As stated previously, a market setting in which solely BLs act as financial intermediaries is hypothetical. Therefore, it is particularly noteworthy that such a stable banking environment can be created for real market constitutions by an appropriate combination of regulatory requirements.

Imposing a CAR of 2% for BLs has similar effects to the 1% CAR scenario. However, not that distinct. In comparison to the scenario in which BLs must not comply with CAR, house and share prices are less volatile. On the other hand, they are more volatile than in the 1% scenario. The higher CAR further constrain BLs in conducting business. As a result, BLs lose market shares in both markets. As evidenced in the previous scenario, the market penetration in the share market is more strongly reduced than in the mortgage market. On the one hand, this is ensured by BLs individual regulation. On top, holding shares is more costly than granting mortgages because shares are assigned a risk weight of 100% whereas the risk weight of mortgage loans depends on the custom LTV. The reduced lending activities by BLs coincide with the fact, that the loan requests of those customers with the lowest LTVs will be rejected. This restricts access to the housing market for low-LTV borrowers. Because of the slight changes in market penetration, the mortgage interest rate, as well as the share interest rate, are rather unaffected. Though, the standard deviations of both rates are higher. As a result, banking stability suffers and reaches a somewhat lower Z-score (2.989). As the stability indicators of all investigated market settings lag behind that of the 1% CAR scenario, the 2% CAR scenario indicates that CAR have a stabilizing effect on the housing market, the share market, and banking solidity. It also shows that the positive effects of introducing CAR to BLs are higher than increasing them. The observable market mechanisms indicate that it is the specialized business model of BLs and their special regulation which adds to market and banking stability.

Instead of only testing the effects of subjecting BLs to lower CAR requirements than CBs, we also evaluate the impact on market stability if BLs must meet a higher equity ratio than currently imposed by Basel III. As a next simulation scenario, we evaluate market conditions if BLs must maintain an equity ratio of at least 6%. Table 3.4 reveals that an exceeding CAR for BLs negatively impacts housing market stability. The volatility increases indicating more distinct housing market cycles and a higher risk of extreme price outbreaks. These effects can be seen in Figure 3.4. The high CAR limit the BLs' mortgage supply to the housing market and residential property tends to be financed by CBs. As stated in section 3.4.2, CBs focus to a great extent on collateral values to decide about mortgage originating. This mortgage granting behavior intensifies prevailing market cycles and spurs volatility. In comparison to the base scenario, the share price volatility also increases. Compared to the 2% scenario, both markets experience an increase in volatility while that of the real estate market substantially exceeds that of the share market. These effects demonstrate BLs' significant impact on the housing market and underline their importance in achieving stable market conditions. High regulatory requirements of BLs cause further loss of market penetration in both markets. As observed in the previous scenarios, BLs defend market shares in the mortgage market while giving up more market shares in the share market. In the 6% CAR scenario, BLs experience the highest drop in the capital market compared to the other scenarios. As a result, both types of interest rates increase. On the mortgage market, the increase is induced by a higher volume of housing financing originated by CBs that have a higher indifference rate for granting loans. The rise in share interest rates may be due to augmented trading activities of CBs that are more speculative. This is evidenced by the higher standard deviations of mortgage and share interest rates. In line with those changes in market constitutions, the total number of mortgages originated diminishes just as the number of trades that are conducted. As CBs increase their trading activity on the share market, they do not substitute the omitted mortgage supply of BLs. This limits the population's opportunity to acquire residential property. The higher uncertainties of interest rates coincide with less stable banks. The Z-score of the banking sector falls below that of the base scenario and claims a higher risk of bank insolvencies. The results of the 6% CAR scenario show that the positive effects of subjecting BLs to CAR diminish when they are strongly increased. Especially subjecting BLs to higher CAR than CBs worsen market conditions in the mortgage market and intensify the fragility of the banking sector. These effects evidence that it is BLs that contribute to more stable market conditions.

To test the dynamics of the results of the previous scenarios, we investigate market conditions under further intensified CAR for BLs. Imposing BLs with an equity ratio of 8% creates the same effect observed before on housing market stability. Housing prices get even more volatile and recognize the highest standard deviation of all scenarios. The share prices achieve a slight decrease in volatility compared to the 6% scenario. In comparison to the other scenarios, however, the fluctuation in share prices outperforms. Considering market shares, BLs reach the lowest market penetration in both markets. As business activity is strongly restricted by the high level of CAR, BLs continue to scale down trading and mortgage lending. According to mortgage interest rates, the trend from the previous sections continues. Mortgage interest rates rise whereas their standard deviation decreases in contrast to the scenarios where CAR are increased. The share interest rates experience a drop just as their fluctuation. The level of mortgage and share interest rates as well as the standard deviations of both get similar to those of the CB-only market described in section 3.4.2 (see Table 3.3). Imposing a CAR level of 8% on BLs strongly increases the costs of conducting business. Because of the focused business practices of BLs as well as the lump sum assigned risk weight for holding shares, investments in the capital market are less attractive for BLs. Excessive capital requirements forces BLs to focus on those borrowers with the highest LTV. As a consequence, BLs are forced to let go of their traditional mortgage granting decisions. Instead of also accounting for endogenously created customer information, BLs need to highly focus on the LTV of the requested loan. Thus, a high level of CAR forces BLs to align their mortgage lending decision to that of CBs. The stabilizing effects of BLs on the housing market are suffocated by excessive CAR. This leads to limited loan commitments, especially for those parts of the population with higher LTV ratios. The number of loans and share trades further decreases and reaches the lowest level. The lower volatility of mortgage and share interest rates, yet positively affect banking stability. The Z-score in this scenario reaches a value of 2.789 and thus exceeds the one of the 6% CAR scenario and the base scenario. The financial sector gets more stable because BLs need to hold a high ratio of equity. But at the same time, they are restricted in conducting their traditional business model. This high solidity of the banking sector is achieved at the expense of the stability of the housing market and at the expense of potential home buyers as the accessibility to mortgage lending is restricted.

Conducting several experimental simulations reveals that imposing CAR that consist of a base CAR and a countercyclical capital buffer on financial institutions has stabilizing effects on the housing market, the share market, and the banking sector. This also holds true for specialized financial intermediaries. Thus, one could assume that Basel III regulations are effective in creating solid financial intermediaries. However, this only holds true partially. Testing the housing market stability, the financial market stability, and the banking soundness at different levels of CAR which must be met by BLs show that the height of CAR is decisive. The simulation scenarios reveal that the lowest volatility of housing and share prices are achieved in the 1% CAR scenario. Thus, the most stable market conditions and the highest level of banking soundness occur in a diversified banking market in which financial intermediaries must maintain CAR at individual levels. In addition to that, the experiments highlight the importance of BLs specialized regulations. These rules tailor their business model in a way that has stabilizing effects on market conditions. This leads to the fact that the intensity of CAR must be tailored to individual institutional bank types, their business practices, and, if any, their respective regulations to achieve the most stable market conditions.[77] This can also be seen in Figure 3.4 and 3.5 which show the house and share price oscillations of the CAR levels. Especially those cycles of the 0%, the 6%, and the 8% CAR scenario are very pronounced. The same holds true for mortgage rates which are depicted in Figure 3.6. The highest variation of share interest rates occurs in the 0% and the 6% CAR scenario. This is displayed in Figure 3.7. Figure 3.8 shows the Z-scores of the different CAR levels of BLs. The graphical illustration underlines that financial institutions are the most stable in the 1% CAR scenario. It is not only the case that the mean Z-score reaches the highest value but also the individual institutions are more stable which is indicated by the high Z-scores of underscoring outliers.

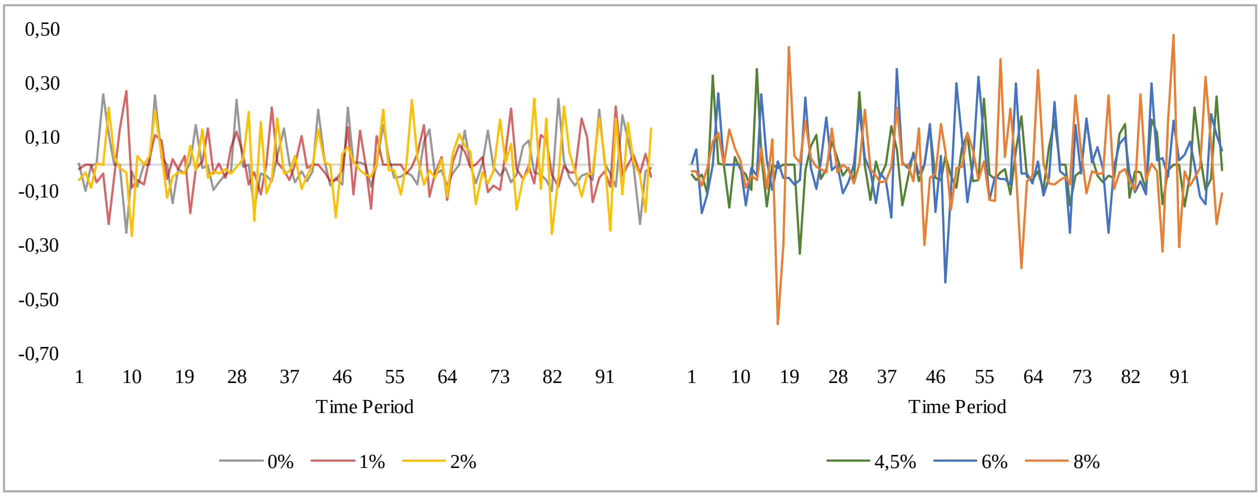

Figure 3.4: Deviation of house prices in heterogeneously regulated simulation scenarios

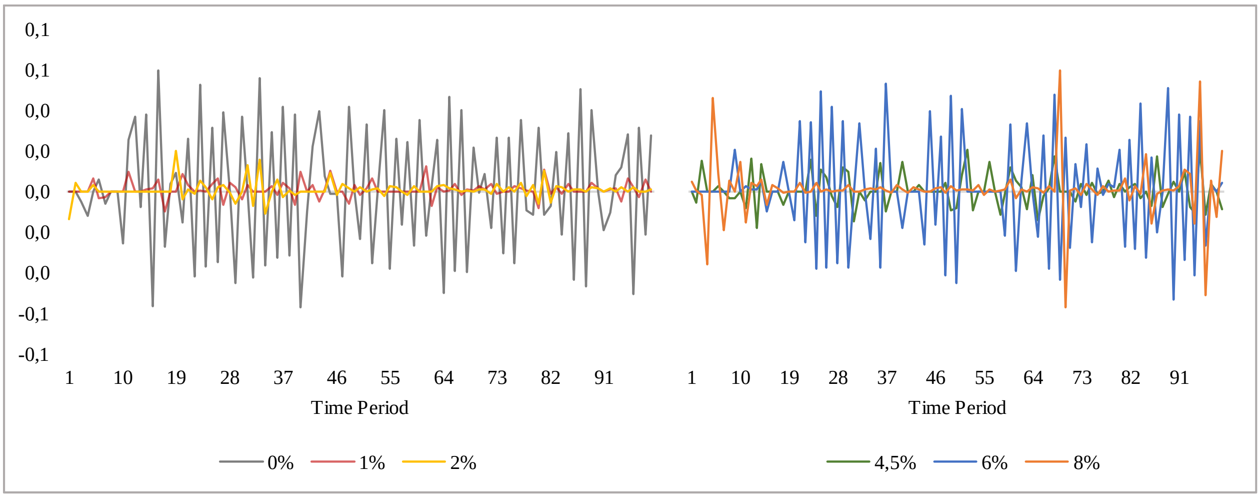

Figure 3.5: Deviation of share prices in heterogeneously regulated simulation scenarios

[77] Note: The levels of CAR in the different simulation scenarios are chosen for illustrative purposes. They do not provide evidence that one of them is the most effective CAR ratio for BLs.

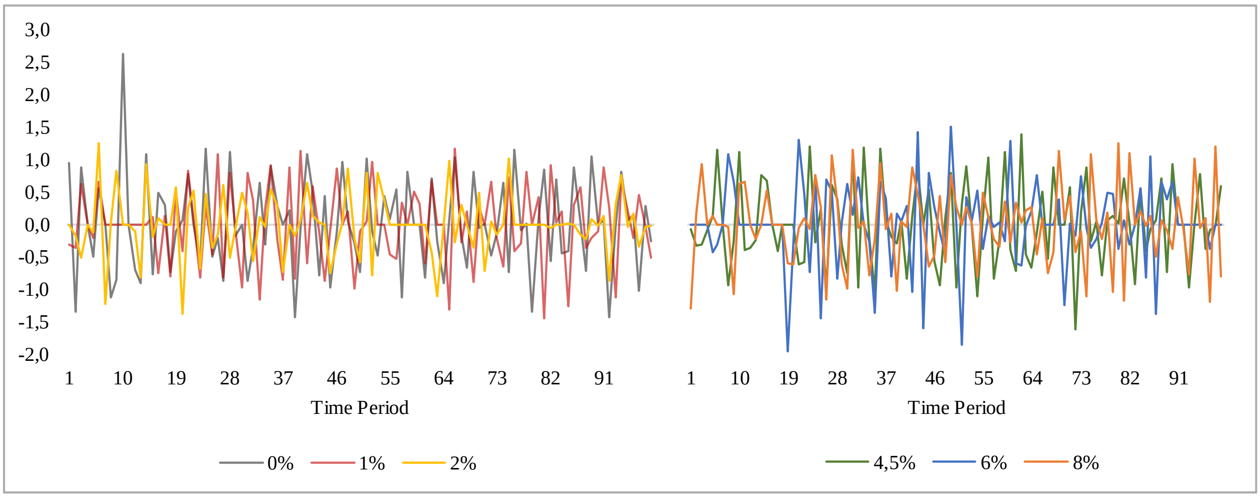

Figure 3.6: Deviation of mortgage interest rates in heterogeneously regulated simulation scenarios

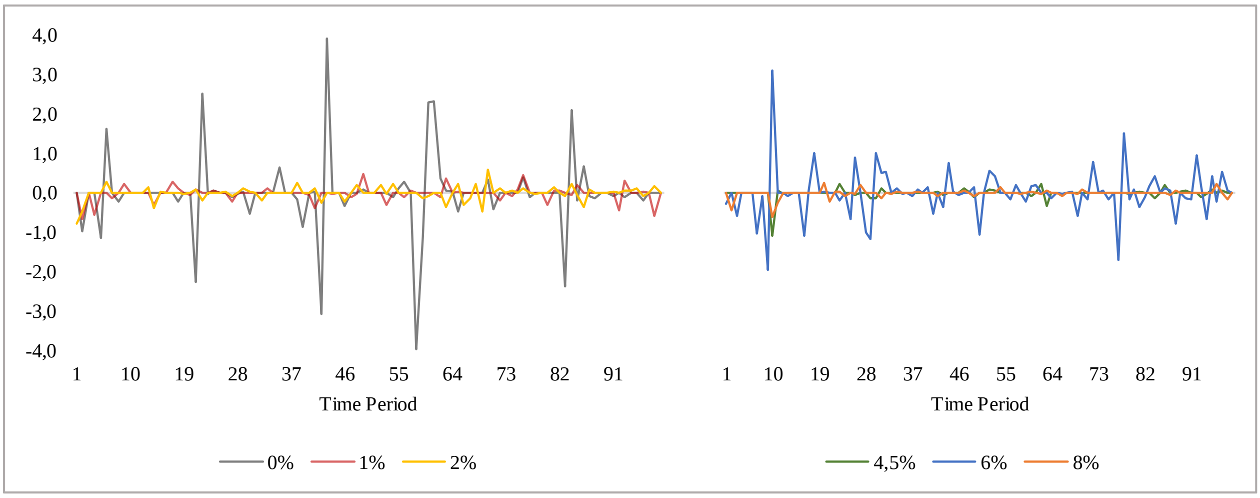

Figure 3.7: Deviation of share interest rates in heterogeneously regulated simulation scenarios

Notes: Figures 3.4, 3.5, 3.6, and 3.7 visualize the development of house prices, share prices, mortgage interest rates and share interest rates under six different CAR levels for BLs simulating each for 100 periods. The grey line denotes the 0% CAR scenario, the red line 1% CAR, the yellow one 2% CAR, the green line denotes the base scenario of 4.5% of CAR while the blue line shows the development of the variables if BLs must hold 6% of CAR and the orange line 8%. The development of all variables is expressed in log differences. The figures reflect trend-adjusted market cycles. Exogenous factors such as inflation are not considered.

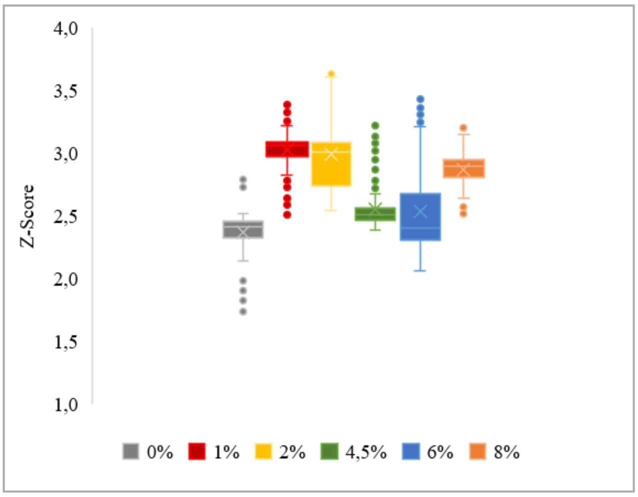

Figure 3.8: Z-Scores in heterogeneously regulated simulation scenarios

Notes: Figure 3.8 displays the mean Z-scores of financial institutions overall simulation periods in the simulation scenarios in which BLs must meet different CAR levels.

3.5. Conclusions

Especially the events of the latest financial crisis have ignited huge debates about banking regulation. A first result is the Basel III accords which impose microprudential and macroprudential regulatory instruments on banks to address various types of systemic risk. These regulations apply to all types of banks equally. Although most of the financial markets of the world consist of different forms of banking institutions and diversification is steadily increasing, the diversity of financial intermediaries has not yet been addressed in the regulations. This paper investigates whether homogeneous capital adequacy requirements are suitable to achieve stable and solid market conditions on a micro- and macroprudential level.

We develop a heterogeneous agent-based model (ABM) of the housing market and the capital market in which autonomous agents are interacting with each other and creating endogenous market conditions. The housing market is chosen as it is one of the most important markets in an economy that highly affects banks' financial constitution. To complement banks' business practices, the capital market is modeled, representing alternative investment opportunities. An ABM can depict the interdependent relationship between different markets and heterogeneous agents and incorporate dynamics that help to identify mutual feedback effects of interactions. The opportunity to mimic real market conditions and individual decision-making structures of agents is a suitable approach for policy analysis.

On the housing market, buyers and sellers use recent price information to decide about buying or selling residential property. Banks finance housing if this yields a higher return than investing their capital in the capital market. In the capital market, banks trade a standardized share portfolio. The banking sector consists of two types of financial intermediaries: conventional banks (CBs) and building and loan associations (BLs). Both are characterized by individual business models and strategies and represent a diversified financial market. Furthermore, BLs are subject to specialized legal requirements. All financial institutions are heterogeneous across and within branches and have custom beliefs about future house prices and market portfolio development. The incorporation of two types of risky assets allows analyzing the credit and trading activity of banks and the resulting changes in market conditions in both markets. While home buyers are restricted in buying dwellings by individual income levels, banks' business activities are restricted by the prevailing capital adequacy requirements of Basel III. To study homogeneous versus bank-specific equity regulations and their impact on the housing market, the capital market, and banking stability, we use the estimated model and conduct several computational experiments.

The first simulation setting represents an undiversified banking market in which either CBs or BLs grant mortgages and trade shares. The results reveal that with regard to market stability, BLs' business practices are favorable. Their special ruling law is designed in a way to heterogenize the behavior of participating financial institutions. In the case of mortgage lending, it detaches loan granting decisions from previous market conditions and also focuses on customers' creditworthiness. This smoothens fluctuations in house prices. The limitation of BLs' investment opportunities in the capital market prevents excessive risk-taking and herding behavior of financial institutions which mitigates share price oscillations. As a result, the institutions of BLs are more stable, grant less risk of insolvencies, and have positive feedback effects on the housing and the financial market.

In a second simulation scenario, CBs and BLs depict the banking sector jointly. This market setting further mitigates house price movements. Because of the limited trading activity of BLs, the volatility of share prices is higher than in the BL-only market but lower than this in the CB-only market. The business practices of CBs ensure thriving market conditions while those of BLs prevent both markets from sharp outbreaks and crashes. The Z-score reveals that the specialized institutions of BLs not only smoothen housing market cycles and dampen share price oscillations but also stabilize the banking sector. Thus, a diversified banking market positively impacts the micro- and macroprudential levels.

Since BLs' institutional constitution has been found to be resistant and market enhancing, we test the market stability indicators for varying CAR levels of BLs. These tests reveal different results. First of all, the computational experiments show, that not imposing any regulatory capital requirements on BLs worsens market stability in comparison to the base scenario in which both bank types need to comply with the 4,5% CAR of Basel III. House and share price movements outperform and the banks' stability decreases. These findings point out that CAR, consisting of a fixed requirement and a countercyclical capital buffer, are effective in strengthening micro- and macroprudential dimensions of an economy and contribute substantially to the resilience of the financial system. Introducing CAR for BLs but at a lower level than this of CBs finds the most stable market conditions for all of the tested CAR levels. The 1% CAR scenario even outperforms the 2% scenario. Further increasing CAR for BLs negatively impacts the housing and share market stability and the banking sector gets more prone to insolvencies. The high level of regulation limits BLs in their business practices which, in turn, mitigates the stabilizing effects of BLs and their regulation. Furthermore, their reduced supply of mortgages dampens housing market activities and limits access to adequate housing financing within the population. Very high CAR have an even more distinct effect. The highest level tested (8%) reveals an increase in banking solidity coinciding with the most volatile housing prices. There are two decisive circumstances: First, BLs are further squeezed out of the market. Second, they need to adapt the business practices of CBs. As mortgage lending gets more and more costly, they are forced to decide about mortgage lending according to LTVs, as CBs do.

The experiments reveal that a diversified banking sector that must comply with CAR helps to mitigate house and share price volatilities and is able to create banking soundness. However, the level of CAR for different interacting financial intermediaries is decisive. Because of the inherently stable business practices of BLs, homogeneity of regulation mitigates their positive impact on market stability. Even though very high regulations for BLs improve the resilience of the banking sector, macroeconomic stability is violated. Such a regulation imposes endogenously created risk on the markets, amplifies market instability, and is deficient in reaching regulatory aims. Lowering the CAR of BLs and still subjecting them to their own specific regulatory requirements creates the most stable market conditions. This provides evidence that effective regulatory requirements need to address the different features of interacting financial intermediaries. The specialized regulation of BLs imposes a risk-mitigating effect on market conditions. From the perspective of BLs, however, their individual rules restrict flexibility and business activities. In order to affect market stability positively and to compensate for the restrictions of BLs, regulators should avoid homogenous CAR. Heterogeneous CAR shape the market structures and help to create the most stable market conditions.

An aspect that is not sufficiently researched yet is the legal implementation of heterogeneous CAR and the costs associated with regulatory requirements. Setting up, introducing, and monitoring compliance with regulatory requirements might be costly not only for financial institutions but also for an entire economy. Too strict and complex regulations may rise incentives to evade regulations and cause overall welfare losses. As the costs associated with regulatory requirements are diverse, opaque, and hard to measure, we refrain from modeling those in the current paper. This leaves room for further research.

Given the negative impacts of volatile housing and financial markets, the findings of this paper provide insights and have important political implications. As the debate about banking regulation has not come to an end yet, they can help to further stabilize the banking sector while at the same time enhancing housing and financial market stability.

3.6. Appendix Chapter 3

To test the robustness of the results presented above and to ensure that the model is structurally coherent and consistent, we analyze the model via computer simulations by running extensive Monte Carlo simulation experiments composed of 100 independent runs, whose time span covers 100 periods each.

Table 3.5 provides the average values and their standard deviations of the simulation scenarios of an undiversified financial market, consisting either only of CBs or only of BLs, and those of a diversified market, in which CBs and BLs conduct business and are homogenously regulated. Table 3.6 contains the same measures for the simulation scenarios of a diversified banking sector in which financial intermediaries are heterogeneously regulated. The results of the robustness check confirm those of the specific analysis presented in the sections 3.4.2, 3.4.3 and 3.4.4. Table 3.7 summarizes the requested risk weights of LTV levels according to the BCBS (BCBS, 2017b).

Table 3.5: Robustness check of homogeneously regulated financial intermediaries

Scenario		CBs	BLs	CBs & BLs
House Price	Min	1913.725	2321.440	2267.927
		(264.131)	(65.228)	(313.869)
	Max	3572.941	3674.365	3756.802
		(228.901)	(160.869)	(167.304)
	Mean	2668.220	2863.921	2896.486
		(389.678)	(293.302)	(285.483)
Share Price	Min	975.340	985.271	995.746
		(5.966)	(5.112)	(5.523)
	Max	1095.336	1093.487	1090.247
		(18.256)	(4.898)	(21.849)
	Mean	1105.862	1040.225	1036.486
		(38.311)	(21.817)	(29.866)
Mortgage Interest Rate	Min	0.009	0.012	0.003
		(0.006)	(0.001)	(0.003)
	Max	0.074	0.016	0.072
		(0.011)	(0.000)	(0.013)
	Mean	0.041	0.014	0.032
		(0.011)	(0.000)	(0.013)
Share Interest Rate	Min	0.003	0.010	0.006
		(0.025)	(0.001)	(0.017)
	Max	0.082	0.080	0.069
		(0.011)	(0.017)	(0.009)
	Mean	0.031	0.013	0.027
		(0.014)	(0.002)	(0.010)
Mortgage Market Penetration	CBs	1.000	0.000	0.589
		(0.000)	(0.000)	(0.022)
	BLs	0.000	1.000	0.411
		(0.000)	(0.000)	(0.017)
Capital Market Penetration	CBs	1.000	0.000	0.804
		(0.000)	(0.000)	(0.014)
	BLs	0.000	1.000	0.196
		(0.000)	(0.000)	(0.022)
No. of Loans	sum	2005	1880	2223
		(345.682)	(83.276)	(479.173)
No. of Trades	sum	435	213	427
		(75.000)	(12.000)	(49.000)
Z-score	Min	1.999	2.365	2.445
		(0.420)	(0.419)	(0.419)
	Max	3.098	3.161	3.222
		(0.316)	(0.338)	(0.321)
	Mean	2.438	3.137	2.505
		(0.461)	(0.150)	(0.248)

Table 3.6: Robustness check of heterogeneously regulated financial intermediaries

Scenario		0%	>= 1%	>= 2%	>=4,5%*	>= 6%	>= 8%
House Price	Min	2160.662	2010.971	1872.177	2015.222	2276.803	2015.779
		(384.928)	(327.573)	(352.067)	(362.446)	(333.359)	(349.743)
	Max	3630.687	3604.413	3578.227	3584.491	3622.724	3533.407
		(217.347)	(208.857)	(194.420)	(181.813)	(195.435)	(168.693)
	Mean	2752.787	2909.315	2915.968	2896.599	2938.520	2877.341
		(360.039)	(212.357)	(224.582)	(373.683)	(400.321)	(486.812)
Share Price	Min	986.216	987.675	985.880	986.309	986.538	985.445
		(6.349)	(6.258)	(5.290)	(6.702)	(4.487)	(2.834)
	Max	1090.045	1095.481	1093.187	1092.842	1085.436	1091.760
		(28.381)	(24.455)	(25.000)	(21.326)	(28.058)	(16.313)
	Mean	1035.148	1037.165	1035.105	1036.625	1034.291	1036.186
		(33.213)	(28.964)	(30.263)	(31.099)	(32.825)	(31.940)
Mortgage Interest Rate	Min	0.011	0.009	0.010	0.010	0.011	0.011
		(0.005)	(0.004)	(0.003)	(0.003)	(0.005)	(0.002)
	Max	0.072	0.071	0.074	0.072	0.073	0.075
		(0.012)	(0.014)	(0.014)	(0.016)	(0.013)	(0.021)
	Mean	0.030	0.034	0.033	0.034	0.038	0.039
		(0.013)	(0.012)	(0.013)	(0.015)	(0.017)	(0.012)
Share Interest Rate	Min	0.011	0.007	0.007	0.006	0.015	0.015
		(0.017)	(0.019)	(0.017)	(0.017)	(0.019)	(0.014)
	Max	0.078	0.080	0.080	0.080	0.075	0.077
		(0.013)	(0.012)	(0.012)	(0.009)	(0.018)	(0.015)
	Mean	0.028	0.027	0.028	0.027	0.029	0.026
		(0.012)	(0.011)	(0.012)	(0.010)	(0.013)	(0.013)
Mortgage Market Penetration	CBs	0.548	0.568	0.569	0.629	0.591	0.618
		(0.074)	(0.024)	(0.020)	(0.042)	(0.094)	(0.086)
	BLs	0.452	0.432	0.431	0.371	0.409	0.382
		(0.052)	(0.012)	(0.002)	(0.017)	(0.049)	(0.041)
Capital Market Penetration	CBs	0.598	0.715	0.740	0.753	0.815	0.879
		(0.068)	(0.021)	(0.043)	(0.014)	(0.014)	(0.015)
	BLs	0.402	0.285	0.260	0.247	0.185	0.121
		(0.051)	(0.017)	(0.022)	(0.022)	(0.010)	(0.020)
No. of Loans	sum	2712	2551	2519	2323	2027	1921
		(597.876)	(496.545)	(548.811)	(479.173)	(646.721)	(453.058)
No. of Trades	sum	618	416	405	427	330	279
		(86.000)	(69.000)	(71.000)	(49.000)	(37.000)	(42.000)
Z-score	Min	2.193	2.126	2.128	2.085	2.284	2.236
		(0.383)	(0.395)	(0.374)	(0.419)	(0.379)	(0.384)
	Max	3.271	3.160	3.255	3.234	3.295	3.247
		(0.410)	(0.350)	(0.519)	(0.364)	(0.402)	(0.334)
	Mean	2.639	3.252	3.058	2.593	2.530	2.698
		(0.437)	(0.414)	(0.449)	(0.439)	(0.471)	(0.053)

*Base Scenario

Table 3.7: Risk weight table for residential real estate exposure

	LTV ≤ 50%	60% < LTV ≤ 80%	80% < LTV ≤ 90%	90% < LTV ≤ 100%	LTV > 100%
Risk weight	20%	25%	30%	40%	70%

3.7. Bibliography Chapter 3

Ackerman, F. (2002). Still dead after all these years: interpreting the failure of general equilibrium theory. *Journal of economic methodology*, *9*(2): 119-139.

Ambrose, B. W. and Capone, C. A (2000). The Hazard Rates of First and Second Defaults. *The Journal of Real Estate Finance and Economics* 20: 275-293. https://doi.org/10.1023/A:1007837225924.

Baily, M. N., Litan, R. E., and Johnson, M. S. (2008). The origins of the financial crisis.

Arnold, B., Borio, C., Ellis, L., and Moshirian, F. (2012). Systemic risk, macroprudential policy frameworks, monitoring financial systems and the evolution of capital adequacy. *Journal of Banking & Finance*, 36(12): 3125-3132.

Balasubramanyan, L. and VanHoose, D. D. (2013). Bank balance sheet dynamics under a regulatory liquidity-coverage-ratio constraint. *Journal of Macroeconomics*, 37: 53-67.

BCBS (2017a). High level summary of Basel III reforms, *Bank for International Settlements.* URL *https://www.bis.org/bcbs/publ/d424_hlsummary.pdf*.

BCBS (2017b). Basel III: Finalising post-crisis reforms, *Bank for International Settlements.* URL *https://www.bis.org/bcbs/publ/d424.htm*.

BCBS (2019a). Risk-based Capital requirements – Calculation of minimum risk-based capital requirements, *Bank for International Settlements.* URL *https://www.bis.org/basel_framework/standard/RBC.htm*.

BCBS (2019b). LCR – Liquidity Coverage Ratio, *Bank for International Settlements.* URL *https://www.bis.org/basel_framework/standard/LCR.htm*.

BCBS (2019c). Risk-based Capital requirements – Buffers above the regulatory minimum, *Bank for International Settlements.* URL *https://www.bis.org/basel_framework/chapter/RBC/30.htm?inforce=20191215&published=20191215*.

Bean, C. (2010). The great moderation, the great panic, and the great contraction. *Journal of the European Economic Association*, *8*(2-3): 289-325.

Benetton, M. (2021). Leverage regulation and market structure: A structural model of the UK mortgage market. *The Journal of Finance*, *76*(6): 2997-3053.

Bernanke, B. S. et al. (2007). The financial accelerator and the credit channel, *Technical Report*.

Bester, H. (1985). Screening vs. rationing in credit markets with imperfect information. *The American economic review*, 75(4): 850-855.

Bezemer, D. J. (2012). The economy as a complex system: the balance sheet dimension. *Advances in Complex Systems*, *15*(supp02), 1250047.

Bhutta, N., Dokko, J., and Shan, H. (2017). Consumer ruthlessness and mortgage default during the 2007 to 2009 housing bust. *The Journal of Finance*, 72(6): 2433-2466. https://doi.org/10.1111/jofi.12523.

Bienert, S. and Brunauer, W. (2007). The mortgage lending value: prospects for development within Europe, Journal of Property Investment & Finance, 25(6): 542-578. https://doi.org/10.1108/14635780710829289.

Blanchflower, D. G., and Oswald, A. J. (2013). Does high home-ownership impair the labor market? (No. w19079). National Bureau of Economic Research.

Blundell-Wignall, A. and Atkinson, P. (2010). Thinking beyond Basel III: Necessary solutions for capital and liquidity, *OECD Journal: Financial Market Trends*, 2010(1): 9-33.

Bookstaber, R., Paddrik, M., and Tivnan, B. (2018). An agent-based model for financial vulnerability. *Journal of Economic Interaction and Coordination*. 13(2): 433-466.

Boos, K.-H.; Fischer, R.; Schulte-Mattler, H., and Schäfer, F.A. (2016). KWG § 3: Zwecksparunternehmen, *Kommentar zum KWG – CRR-VO* (5) Band 1: Rn. 14-18.

Borio, C. (2011). Rediscovering the macroeconomic roots of financial stability policy: Journey, challenges, and a way forward. *Annu. Rev. Financ. Econ.*, *3*(1): 87-117.

Boyd, J. H., and Runkle, D. E. (1993). Size and performance of banking firms: Testing the predictions of theory. *Journal of monetary economics*, *31*(1): 47-67.

Braun, J., Burghof, H. P., Langer, J., and Einar Sommervoll, D. (2022). The Volatility of Housing Prices: Do Different Types of Financial Intermediaries Affect Housing Market Cycles Differently? *The Journal of Real Estate Finance and Economics*: 1-32. https://doi.org/10.1007/s11146-022-09907-y.

Cincotti, S., Raberto, M., and Teglio, A. (2012). Macroprudential policies in an agent-based artificial economy, *Revue de l'OFCE*, (5): 205-234.

Collyns, C. and Senhadji, A. (2003). Lending booms, real estate bubbles, and the Asian crisis. *Asset price bubbles: the implication for monetary, regulatory and international policies, MIT Press*, Cambridge and London: 101-25.

De Wit, E. R., and Van der Klaauw, B. (2013). Asymmetric information and list-price reductions in the housing market. *Regional Science and Urban Economics,* 43(3): 507-520.

Delli Gatti, D., M. Gallegati, B. Greenwald, A. Russo and J. E. Stiglitz (2010). The financial accelerator in an evolving credit network, *Journal of Economic Dynamics and Control*, 34: 1627–1650.

Diamond, D. B. and Lea, M. J. (1992). The decline of special circuits in developed country housing finance, Housing Policy Debate, Informa UK Limited 3: 747-777. https://doi.org/10.1080/10511482.1992.9521107.

Dosi, G. (2012). Economic Coordination and Dynamics: Some Elements of an Alternative ‘Evolutionary’ Paradigm, *Economic Organization, Industrial Dynamics and Development*, Selected Essays, 2.

Drescher, I., Fleischer, H., and Schmidt, K. (2019). Verbot von Zwecksparunternehmen. *Münchener Kommentar zum HGB* (4) Band 6: Rn. 168-179.

Dyrberg, A. (2001). Indicators of financial instability. *Danmarks Nationalbank Monetary Review 1st Quarter, 57.*

Erbs, G.; Kohlhass, M., and Häberle, P. (2021). KWG § 3: Zwecksparunternehmen, *Beck'sche Kurzkommentare* Band 17: Rn. 8.

Euro Area Statistics (2020). Growth rates in housing loans are steadily increasing in the euro area. URL https://www.euro-area-statistics.org/statistics-insights/growth-rates-in-housing-loans-are-steadily-increasing-in-the-euro-area?cr=eur&lg=en&page=0.

Farmer, J. D., and Foley, D. (2009). The economy needs agent-based modelling. *Nature*, *460*(7256), 685-686.

Filatova, T., Parker, D. C., and Van der Veen (2007). Agent-based land markets: heterogeneous agents, land prices and urban land use change, *Proceedings of the 4th Conference of the European Social Simulation Association (ESSA'07)*.

Foote, C. L. and Willen, P. (2017). Mortgage-default research and the recent foreclosure crisis. *Available at SSRN* 3082773.

Freund, J., Curry, T., Hirsch, P., & Kelly, T. (1998). Commercial real estate and the banking crises of the 1980s and early 1990s. *History of the eighties: Lessons for the future (an examination of the banking crises of the 1980s and early 1990s)* 1: 137-165.

Gaffeo, E., Delli Gatti, D., Desiderio, S., and Gallegati, M. (2008). Adaptive microfoundations for emergent macroeconomics. *Eastern Economic Journal*, *34*(4): 441-463.

Gatti, D. D., Gaffeo, E., and Gallegati, M. (2010). Complex agent-based macroeconomics: a manifesto for a new paradigm. *Journal of Economic Interaction and Coordination*, *5*(2): 111-135.

German Central Bank (2019). The Role of the Real Estate Sector in Financial Stability. URL https://www.bundesbank.de/de/presse/reden/die-rolle-des-immobiliensektors-fuer-die-finanzstabilitaet-814682.

German Central Bank (2020). Banking Supervision and Real Estate Financing: The Risks at a Glance. URL https://www.bundesbank.de/de/presse/gastbeitraege/bankenaufsicht-und-immobilienfinanzierung-die-risiken-im-blick-836218.

Gilchrist, S. and Zakrajšek, E. (2012). Credit supply shocks and economic activity in a financial accelerator model. *Rethinking the Financial Crisis*, 1: 37-72.

Glaeser, E. L. and Shapiro, J. M. (2003). The benefits of the home mortgage interest deduction. *Tax policy and the economy* 17: 37-82. https://doi.org/10.1086/tpe.17.20140504.

Goodhart, C. and Hofmann, B. (2007). House Prices and the Macroeconomy – Implications for Banking and Price Stability, *Oxford University Press*.

Hakim, S. R. and Haddad, M. (1999). Borrower attributes and the risk of default of conventional mortgages. *Atlantic Economic Journal* 27.2: 210-220. https://doi.org/10.1007/BF02300240.

Herring, R. J. and Wachter, S. M. (1999). Real estate booms and banking busts: An international perspective. *Wharton School Center for Financial Institutions*, Working Paper 99-27.

Hesse, H. and Čihák, M. (2007). Cooperative banks and financial stability, *International Monetary Fund.*

Hilbers, P., Lei, Q., Zacho, L. (2001). Real estate market developments and financial sector soundness. Working paper 01/129, IMF.

Kirman, A. (2016). Ants and nonoptimal self-organization: Lessons for macroeconomics. Macroeconomic Dynamics, 20(2): 601-621.

Klebaner, F. C. (1999). Introduction to stochastic Calculus with Applications, London, *Imperial College Press*.

Kowalik, M. (2011). Countercyclical capital regulation: should bank regulators use rules or discretion?, *Economic Review*, Federal Reserve Bank of Kansas City, 63.

Krug, S., Lengnick, M., and Wohltmann, H. W. (2015). The impact of Basel III on financial (in) stability: an agent-based credit network approach. *Quantitative Finance*, 15(12): 1917-1932.

Lehmann, W. (1983). *Abriß der Geschichte des deutschen Bausparwesens*, Domus Verlag, Bonn.

Lengwiler, Y. and Maringer, D. (2011). Autonomously Interacting Banks (No. 2011/07). WWZ Discussion Paper.

Lepetit, L., and Strobel, F. (2015). Bank insolvency risk and Z-score measures: A refinement. *Finance Research Letters, 13*: 214-224.

Müller, M. L. (1999). Bausparen in Deutschland zwischen Inflation und Währungsreform 1924-1948, C. H. Beck, München. http://dx.doi.org/10.2139/ssrn.2873919.

Niinimäki, J. P. (2009). Does collateral fuel moral hazard in banking? *Journal of Banking & Finance*, 33(3): 514-521.

Oswald, A. J. (1996). A conjecture on the explanation for high unemployment in the industrialized nations: Part I (No. 2068-2018-901).

Popoyan, L., Napoletano, M., and Roventini, A. (2020). Winter is possibly not coming: Mitigating financial instability in an agent-based model with interbank market, *Journal of Economic Dynamics and Control*, *117*, 103937.

Poterba, J. M. and Sinai, T. (2011). Revenue costs and incentive effects of the mortgage interest deduction for owner-occupied housing. *National Tax Journal* 64(2): 531-564. https://doi.org/10.17310/ntj.2011.2S.05.

Rohe, W. M., Van Zandt, S., and McCarthy, G. (2013). The social benefits and costs of homeownership: A critical assessment of the research. The affordable housing reader, 40, 00-01.

Roy, A. D. (1952). Safety first and the holding of assets, *Econometrica* 20: 431-449.

Schäfer, O., Cirpka, E., and Zehnder, A. J. (1999). Bausparkassengesetz und Bausparkassenverordnung: Kommentar. Domus-Verlag.

Scholten, U. (2000). Rotating Savings and Credit Associations in Developed Countries: The German-Austrian Bausparkassen, *Journal of Comparative Economics* 28(2): 340-363. https://doi.org/10.1006/jcec.2000.1657

Schularick, M. and A. M. Taylor (2012). Credit booms gone bust: Monetary policy, leverage cycles, and financial crises, 1870-2008. *American Economic Review*, 102: 1029–61.

Sheldon, M. R. (1999). An Introduction to Mathematical Finance: Options and Other Topics, *Cambridge University Press.*

Sinai, T. and Souleles, N. S. (2005). Owner-occupied housing as a hedge against rent risk. *The Quarterly Journal of Economics* 120.2: 763-789. https://doi.org/10.1093/qje/120.2.763.

Sommervoll, D. E., Borgersen, T.-A. and Wennemo, T. (2010). Endogenous housing market cycles, *Journal of Banking & Finance* 34(3): 557-567.

Stiglitz, J. E. (2009). The anatomy of a murder: Who killed America's economy? *Critical Review*, 21(2-3): 329-339.

Sundararajan, V., Enoch, C., San Jose, A., Hilbers, P., Krueger, R., Moretti, M., and Slack, G. (2002). Financial soundness indicators: analytical aspects and country practices (Vol. 212). *Washington, DC: International Monetary Fund.*

Tovar, C. E. (2009). DSGE models and central banks. *Economics, 3(1).*

Yang, T. T., Buist, H., and Megbolugbe, I. F (1998). An analysis of the ex ante probabilities of mortgage prepayment and default. *Real Estate Economics* 26.4: 651-676. https://doi.org/10.1111/1540-6229.00760.

The Effect of the Countercyclical Capital Buffer on the Stability of the Housing Market

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Abstract

After the great turmoil of the latest financial crisis, the criticism of the regulatory frameworks became increasingly stronger. The rules that banks needed to comply with are presumed to be procyclical and unable to prevent and mitigate the extent of strong financial and economic cycles. As a result, Basel III introduced a set of macroprudential tools to overcome these regulatory shortfalls. One tool that strives to counteract the issue of procyclicality is the countercyclical capital buffer ($CCyB$). This paper introduces a heterogeneous agent-based model that investigates the implication of the new regulatory measure. We develop a housing and a financial market where economic agents trade residential property that is financed by financial institutions. To examine the macroeconomic performance of the $CCyB$, we evaluate the dynamics of key stability indicators of the housing and the financial market under four different market conditions: in an undisturbed market and in times of three different structural shocks. Computational experiments reveal that the $CCyB$ is effective in stabilizing the housing and the financial market in all market settings. The new macroprudential tool helps to mitigate economic fluctuations and to stabilize market conditions, especially in the aftermath of a crisis. It is not able to prevent any of the crises tested. However, the extent of the stabilizing effect varies according to market conditions. In the shock scenarios, the $CCyB$ performs better in dampening market fluctuations and increasing banking soundness than in the base scenario.

Keywords: Real estate finance, housing market cycles, housing market stability, Basel III, financial regulation, countercyclical capital buffer, agent-based model, computational economics

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4. The Effect of the Countercyclical Capital Buffer on the Stability of the Housing Market

4.1. Introduction

Financial accelerator theories have long been indicating the close interconnectedness between financial and real markets (Bernanke and Gertler, 1995; Bernanke et al., 1999; Kiyotaki and Moore, 1997; Hammersland and Jacobsen, 2008). Though, the mutual effects of the finance sector and the real economy as well as the impact of occurrences on the financial market on adjacent economic sectors have been overlooked in regulatory frameworks. The latest financial crisis and its aftermath triggered a large debate among policymakers and academics about banking regulation. The major contribution of the banking sector to the Great Recession led to the strong agreement that current frameworks were not sufficient. Especially, the microprudential focus was criticized. Instead of only supervising the soundness of individual institutions, the emphasis on interdisciplinary regulation arose and the design and the implementation of macroprudential policies drew attention.

As a consequence, banking regulation authorities passed the Basel III Accords which aim at strengthening the regulation, supervision, and risk management of banks by introducing a diverse set of macroprudential measures (BCBS, 2011). They are intended to enhance the stability of the financial sector and avoid destabilization of the economy by limiting the build-up of systemic risk (IMF, 2011). One dedicated tool of the set of macroprudential policies is the countercyclical capital buffer ($CCyB$). It is designed to mitigate the procyclicality of previous regulatory requirements and alleviate the magnitude of the financial accelerator. It extends the established capital adequacy requirements (CAR) by Basel II and allows national authorities to require an additional capital ratio in times of excessive credit growth (BCBS, 2019b). This build-up buffer shall protect financial institutions against future potential losses. In recessional times, it can be released to ensure sufficient credit supply. Adjusting CAR in a countercyclical manner, the $CCyB$ shall act as an automatic stabilizer, leaning against the financial cycle. By now, however, the contribution of the $CCyB$ to the resilience of the banking sector remains unclear. Higher CAR might alter the quality of borrowers, lessen bank lending and relocate the business activities of financial intermediaries.

The aim of this paper is to assess the effectiveness of the $CCyB$ in mitigating fluctuations in mortgage loans and the extent of booms and busts in house prices. Existing literature that investigates the new macroprudential tool often examines its design (Lambertini, Mendicino, and Punzi, 2013; Liu and Molise, 2019; Lozej, Onorante, and Rannenberg, 2022; Tölö, Laakkonen, and Kalatie, 2018). Some studies assess its impact on producing economies (Cinotti, Raberto, and Teglio, 2012; Popoyan, Napoletano, and Roventini, 2020). However, although the housing market is one of the most important markets of an economy and it is considered to be the main catalyst of the latest Great Recession, to the best of our knowledge, no study exists that evaluates the $CCyBs$ impact on the housing and the mortgage market and its effectiveness in reaching regulatory goals. The empirical work of Basten (2019) reveals that the introduction of a $CCyB$ changes the composition of mortgage supply. Mortgage-specialized banks slow down their mortgage growth and rebuild capital cushions while market-wide mortgage growth does not slow down significantly. These results are based on Swiss market conditions and exemplify possible impacts. Insights about the $CCyBs$ general effects, especially in times of abnormal market conditions do not yet exist.

We introduce a macroeconomic agent-based model of a real estate market in which housing is financed by financial intermediaries to evaluate the effectiveness of the $CCyB$ as a macroprudential tool to mitigate fluctuations in house prices and credit and at the same time, stabilize the financial sector.

The interaction between the economic agents creates endogenous housing market cycles. The resulting market conditions resemble realistic market structures that allow assessing the effect of introducing a $CCyB$ on the real estate market and the solidity of the banking sector. Furthermore, we introduce different external shocks to test the effectiveness of the $CCyB$ of being a preventive and stabilizing tool during times of exceptional market occurrences.

Conducting computational experiments, we show that the newly introduced macroprudential tool succeeds in mitigating housing market cycles, excessive credit growth, and increasing the resilience of the banking sector in all of the investigated scenarios. If national authorities oblige banks to extend their equity capital in times of excessively rising house prices, the procyclicality of banks' mortgage lending practices is reduced, sharp price booms are prevented, and deep downturns are flattened. The stability-increasing effects coincide, however, with a decreasing rate of homeownership, transactions, and constructions in the housing market. In the aftermath of a crisis, the $CCyB$ helps to create stabilized house price oscillations. However, if a market is hit by a shock, the macroprudential measure is not able to prevent the market from a recession. The results further indicate that the extent of the shock and the timing of the installation of an additional CAR requirement is decisive for achieving regulatory goals.

This study contributes to existing research as it evaluates the impact of the $CCyB$ on the housing and mortgage lending market. The huge importance of the real estate market was evidenced during the latest financial crisis where the great potential of the real estate market to destabilize the whole economy was expounded. By elaborating on whether the new regulatory macroprudential tool serves its purpose, the insights of this study have important implications for the current policy discussion in different EU legislative frameworks and other global countries about introducing the $CCyB$ based on an excessive increase in house prices and mortgage volume in the previous years.

The rest of the paper is organized as follows. In Section 4.2, we introduce the model structure and provide a detailed description of the agents' characteristics and their behavioral features. Section 4.3 presents the results of the computational experiments in the baseline scenario. Section 4.4 introduces three different shocks and compares the outcomes of the tested scenarios. Section 4.5 concludes.

4.2. Model Structure

Our model is a macroeconomic real estate business-cycle model featuring a housing market and a banking sector. The model builds on Braun et al. (2022) and incorporates banks' limitations in business practices introduced by regulatory micro- and macroprudential CAR that aim at strengthening the financial market and avoiding macroeconomic destabilization.

The model is populated by three types of heterogeneous agents: buyers, sellers, and stylized conventional banks. Buyers and sellers constitute the housing market. Potential buyers demand housing units according to their individual preferences for housing investment and consumption. Sellers form expectations about future market developments and decide whether to provide housing supply. Banks either finance residential property or invest in an alternative asset portfolio. They need to comply with the CAR of Basel III and are thus constrained in business activities.

The model considers individual penchants of agents and creates a generally applicable, globally transferrable market setting. It incorporates the heterogeneity inherent in the real estate market, allowing agents to align their actions to individual expectations about future market conditions. As cyclical patterns of house prices and mortgages differ according to external circumstances, we introduce three types of external shocks to test the effectiveness of the macroprudential $CCyB$ under different economic circumstances. The method of agent-based modeling allows for assessing agents' interactions, market conditions, and the resilience of market sectors in these different scenarios.

4.2.1. The Housing Market

The housing market consists of buyers and sellers, while sellers can either be households or residential construction firms. All of the agents are characterized by individual characteristics and considerations of market conditions. They trade housing units, thus forming endogenous market conditions. The housing market is competitive. No real estate seller has market power and not every potential buyer who aims at homeownership may buy one.

4.2.1.1. Buyers

Potential real estate buyers enter the housing market at the beginning of each period, demanding self-occupied residential property. They derive utility from owning a housing unit h and consuming any other consumption good c. This relationship is stated by a Cobb-Douglas utility function in the form of $U_b = c^{\alpha} * h^{\beta}$ where c^{α} states the utility buyer b derives from consuming any consumption goods except housing investment and h^{β} states the utility he derives from being a homeowner. Buyers are heterogeneous in terms of their preferences with $\alpha \sim N(0,1)$ and $\alpha + \beta = 1$. They are assumed to be households that earn a periodical income Y_t that is fully spent in each period. The herewith related budget constraint is given by $Y_t = P_{c,t}c + P_{h,t}h$. Furthermore, buyers are capitalized with a fixed amount of equity E that is derived from a uniform distribution on $E \sim U(0, 0.35)$[81]. Available equity is fully spent on buying residential property.

Potential buyers seek to maximize their utility. Following this maxim and solving a buyer's utility function for P_t while $h = 1$ using the method of Lagrange multipliers, we obtain the highest possible periodical expenditure b can afford for housing investment given its budget constraint. This can be stated to be the potential buyer's b reservation price:

$$P_{res,b,t} = \left(\frac{Y}{\left(\frac{\alpha}{\beta}+1\right)}\right) - (r(P_t - E). \quad (1)$$

The amount exceeding the buyer's equity is mortgage financed which bears interest cost r_t on the loan volume $(P_t - E)$ and a periodical redemption r_p.[82]

[81] The equity distribution reflects the distribution of German households in the year 2021. Data is obtained from the German Federal Statistical Office.
[82] We assume a redemption period of 10. This leads to 10 payments on the principal and $r_p = 0.1$. Interest and redemption sum up to $r = r_t + r_p$.

While the reservation price states the upper threshold a buyer is able to raise for buying a dwelling, he forms an expected market price, based on past market conditions and expectations about future market developments before stating a bid. The expected market price of a potential buyer b is:

$$P_{expected,b,t} = (1 + e_b) * (P_{t-1} + \Delta P_{t-1}), \quad (2)$$

where e_b designates a buyer's expectation about future market conditions while $e_b \sim U(-0.1,0.1)$, P_{t-1} designates the price level of the previous market period, and ΔP_{t-1} the price change during the last period. Considering his budget constraint and individual market sentiments, a potential buyer only places a bid if $P_{expected,b,t} \leq P_{res,b,t}$. A household's demand for housing thus is:

$$Bid_b = min(P_{expected,b,t}, P_{res,b,t}). \quad (3)$$

4.2.1.2. Sellers

Real estate sellers state the housing supply in the real estate market. They are assumed to be households, too, who sell already established owner-occupied dwellings, or residential construction firms that build and sell new houses. At the beginning of each period, sellers evaluate current market conditions and form expectations about future price developments. Seller s only offers a dwelling for sale if this promises a higher profit than keeping it and selling it in subsequent periods, speculating for house price appreciations. Just as buyers, sellers differ in terms of their attitudes toward upcoming market conditions. The future price s expects follows this of buyers which is $P_{expected,s,t} = (1 + e_s) * (P_{t-1} + \Delta P_{t-1})$, where e_s indicates the seller's belief of market changes and $e_s \sim U(-0.1,0.1)$. Considering profits from future sales discounted to today compared to profits out of selling the dwelling in the prevailing period and investing freed-up liquidity in an alternative investment AI that bears interest at the risk-free interest rate r_f, a seller only places an offer if:

$$P_{t-1} + \frac{(r_f AI)}{(1 + r_f)} \geq \frac{(1 + e_s) * (P_{t-1} + \Delta P_{t-1})}{(1 + r_f)}. \quad (4)$$ [83]

If (4) holds, s offers his house for sale at the last observable market price which is P_{t-1}. This determines the seller's reservation price which may differ from his ask price. Before stating his offer, he figures out whether a buyer or a seller market exists. For this purpose, he calculates $\varphi = \frac{(NB-NS)}{(NB+NS)}$ where NB states the number of buyers and NS the number of sellers on the market. If $\varphi > 0$ and buyers exceed sellers, s adjusts the ask price upwards. If the opposite holds and $\varphi < 0$, the seller's ask price equals his reservation price which is P_{t-1}.

Buyers and sellers are restricted to buying/selling one unit of housing per period and leave the market if their purpose is served. Furthermore, a seller cannot be a buyer in the same period. Depending on market activities, it may happen that a house is not sold in t. This property remains on the market and is offered in t_{+1}. To increase the probability of sale, the seller lowers the price by a markdown ratio ς for which $0 < \varsigma < 1$ applies. The same holds for t_{+2} if the dwelling stays unsold in t_{+1} and applies for all subsequent periods until the house is sold. Considering all the circumstances and the herewith related decision criteria, a seller's ask price is:

[83] The interest of the alternative investment is paid out at the end of a period.

$$P_{ask,s,n} = \begin{cases} \left(P_{t-1}(1+\varphi)\right)\varsigma^{n} & for\ \varphi_t > 0 \\ P_{t-1}\varsigma^{n} & for\ \varphi_t < 0 \end{cases}, \tag{5}$$

where n denotes the number of periods a dwelling is offered for sale. If a house is not sold for 30 periods, it is assumed to be depreciated and removed from the market.

4.2.1.3. Housing Price

The price index of houses and its development over time is the key measure for agents to assess current market conditions and form expectations about future developments. As real-world economies are complex adaptive systems in which agents with deviating beliefs interact with each other, we deviate from classical approaches that determine the equilibrium price. Instead, we follow Filatova, Parker, and van der Veen (2007) and allow prices to be built by bilateral bidding.

Buyers and sellers are matched and a sale takes place if a buyer's bid equals or exceeds a seller's ask price. The matching process follows a first-price-sealed-bid auction in which bids are assigned to offers in descending order. This auction process implicitly accounts for quality differences of dwellings as it can be assumed that more expensive houses have a superior quality which is appreciated by buyers placing higher bids. The transaction price of a single deal is the mean of the matched bid and offer.

The price index of houses for one period is calculated as the mean of all transactions that have taken place during this time:

$$p_{h,t} = \left(\frac{1}{N_{transactions},h}\right)\sum_{h=1}^{N} P_h, \tag{6}$$

where $N_{transactions}$ indicates the sum of conducted transactions in one period and P_h indicates the transaction price of the sold unit h.

4.2.1.4. Number of Properties

The number of properties available for sale on the market is determined by the sellers' evaluation of current and prospective market conditions. Both types of sellers, households[84] and residential construction firms, aim at profit maximization and align their offers accordingly. Those offers from sellers are either first-time sales, $N_{new\ sellings}$, or unsold dwellings from previous periods, $N_{left\ over}$.

Construction firms assess various market condition indicators to decide whether to build new houses and if yes, how many. By computing $\varphi_{t_{-2}}$ they consider whether the market lacks or exceeds supply. This measure is extended by the number of buyers who did not succeed in acquiring property two periods ago, $N_{remaining\ buyers,t-2}$. The price changes of previous periods are calculated by $\rho_{t-2} = \left(\frac{P_{t-2}+\Delta P_{t-2}}{P_{t-2}}\right)$. The number of houses for first-time occupations accordingly is:

$$N_{constructions,t} = N_{remaining\ buyers,t-2} * \varphi_{t-2} * \rho_{t-2}.^{85} \tag{7}$$

[84] In the following, the term ‚seller' designates households while 'residential construction firms' means those agents who sell newly constructed houses for initial occupancy.

[85] For the number of constructions, $N_{constructions,t} \geq 0$ holds.

The construction period is assumed to last one period. Therefore, the information to decide on how many dwellings to build at the beginning of t_{-1} stems from t_{-2}. Following this approach, we adjust supply to prevailing market conditions and, at the same time, account for the delay in supply because of long construction periods. The ask price formation of residential construction firms follows this of sellers, stated in equations (4) and (5).

The stock of houses available for sale in one period is the sum of the previous components:

$$N_{h,t} = N_{new\ sellings,t} + N_{left\ over} + N_{constructions,t}. \tag{8}$$

4.2.2. The Financial Market

The financial market is populated by a set of heterogeneous banks. Each of them aims at profit maximization. Following their perceptions of market conditions and beliefs about future price developments, they form individual investment strategies and decide how to allocate funds. The model setting offers three investment opportunities. Banks can either hold cash, grant mortgages to potential real estate buyers or invest capital in another risky asset which is supposed to be a diversified market portfolio of financial assets that represents any alternative investment opportunities of banks. Cash earns no interest and is supposed to be risk-free. Mortgages and the alternative investment portfolio AI generate returns but are associated with default or price risk. Conducting such risky business is constrained by Basel III regulations. If financial agents decide to either grant mortgages or invest in AI, they need to comply with the regulatory capital adequacy requirements (CAR), including a countercyclical capital buffer ($CCyB$).

In addition to the individual market assumptions and investment strategies, each bank is characterized by distinct balance sheet positions. These are displayed in Table 4.1. The composition of balance sheets is initially calibrated on the German banking sector and can be seen as a reasonable proxy for any other countries. To extract any stationary balance sheet compositions, we use the average of the last ten years which is the period from 2012-2021. Conducting business and following their investment strategies, the balance sheet positions vary every period. At the end of each period, the respective balance sheet positions are recalculated.

Table 4.1: Balance sheet structure of banks

Assets			**Liabilities**
Cash (C)		Debt (D)	
Risky Assets		Equity *(E)*	
	Mortgages (T)		Free equity
	Alternative Investment (AI)		Regulatory equity for *T*
			Regulatory equity for *AI*

Cash is used to buy AI and to comply with liquidity requirements introduced by Basel III. Bought shares decrease the cash position whereas sold shares increase it. The opposite effect is realized for the AI-Portfolio. An excess in cash is mainly held by risk-averse agents. The volume of mortgage loans expands if new mortgages are granted. Repayments and defaults make the mortgage portfolio shrink.[86] The equity position changes according to

[86] The repayment period is assumed to be 10. A respective fraction of mortgages is repaid in every period. Mortgage default rates are obtained from the statistical data warehouse of the ECB from the periods 2015 –2021.

accrued gains and losses. Depending on the development of prices of the alternative investment portfolio, banks might face gains or losses. These as well as losses out of defaulted mortgages are directly translated into changes in equity. As banks have various funding opportunities, which do not directly influence the impact of the $CCyB$, we forgo modeling those. Instead, the debt position is calculated as the difference between total assets and equity and develops passively. According to this recalculation process, it is assessed whether banks comply with or violate Basel III rules. The change in balance sheet positions is the result of individual agents' expectations and interactions. The financial market is competitive and no single institution has market power.

4.2.2.1. Regulatory Capital Adequacy Requirements including CCyB

As a response to the latest financial crisis, the Basel Committee on Banking Supervision (BCBS) introduced a new regulatory framework that tightens microprudential regulations on the banking sector and adds macroprudential requirements. The microprudential rules comprise the minimum risk-based capital adequacy requirements (CAR) that require banks to hold a minimum amount of equity. The revised framework sets higher quality standards for loss-absorbing capital than its predecessor and raises the level of the required core capital ratio. The minimum CAR are defined as the bank's Common Equity Tier 1 capital ($CET1$) relative to its total risk-weighted assets (RWA). The static minimum level of CAR the regulator requests is:

$$CAR = \frac{CET1}{RWA} = \frac{CET1}{(rw_T * T) + (rw_{AI} * AI)} \geq \bar{\epsilon} \text{ with } \bar{\epsilon} = 4.5\%. \quad (9)$$

where a bank's RWA represent its assets weighted each by their corresponding probability of default according to the guidelines of the BCBS (BCBS, 2019a).

The risky assets a bank can invest in this model are either mortgage loans or a market portfolio of financial assets. As we calibrate banks' balance sheets on BankFocus data from 2012 to 2021, we ensure that the distribution of RWA mimics reality sufficiently close. According to the regulatory setup, cash is supposed to be risk-free. The risk weight of mortgages is determined according to the custom LTV of potential borrowers.[87] The market portfolio is supposed to be a diversified asset portfolio for which the BCBS risk weight of 100% is assigned (BCBS, 2017b).

The $CCyB$ is one of the newly established macro-financial tools of the Basel III Accords that aims at augmenting overall financial stability and avoiding destabilization of the economy by mitigating credit booms and related procyclicality in the financial system (BCBS, 2017a). To lean against financial cycles, the regulator allows national authorities to impose further capital requirements on banks when excess aggregate credit growth is judged to be associated with a build-up of system-wide risk (BCBS, 2019b). This increase in capital ratios shall moderate upswings and build a cushion to render banks more resilient to potential losses. In adverse market periods, this buffer shall be released to counteract credit constraints when capital is scarcely available.

By now, there is no clear specification by the regulator and no consensus in the literature on which variables to use to decide about imposing the $CCyB$. As the main objective of macroprudential policy is to protect the financial system from the risks associated with excessive credit growth without compromising macroeconomic

[87] The BCBS defines the LTV ratio as the loan amount divided by the value of the financed property (BCBS, 2017b). Following this definition, the LTV ratio of a borrower in this model is $LTV = \frac{(T-E)}{P_h}$. Table 4.11 in the appendix depicts the risk weights of the respective LTV ratios according to the BCBS.

stability, in our model, previous credit growth serves as a measure to detect economic up- and downswings. This follows the approach of Braun (2022). To set the $CCyB$ accordingly, we calculate the $CCyB$ as:

$$\kappa_t^m = \begin{cases} \kappa_{min} & for\ \frac{\Delta M}{M} \leq 0 \\ \kappa_{max} * \frac{\Delta M}{\Theta M} & for\ 0 < \frac{\Delta M}{M} < \Theta \\ \kappa_{max} & for\ \frac{\Delta M}{M} \geq \Theta \end{cases}, \tag{10}$$

where $\frac{\Delta M}{M}$ indicates the percentage change of the aggregate loan portfolios of banks from the previous to the current period and Θ indicates the threshold of mortgage growth above which κ_t^m is set at its maximum.[88]

The $CCyB$ varies between $0 \leq \kappa_t^m \leq 2.5\%$ of risk-weighted assets and complements the narrowed CAR stated in (9) (BCBS, 2019b). Accordingly, summed up CAR for one period, considering prevailing market conditions is $CAR = \frac{CET1}{(rw_T*M)+(rw_{AI}*AI)} \geq \bar{\epsilon_3} + \kappa_t^m$ where $4.5\% \leq \bar{\epsilon_3} + \kappa_t^m \leq 7.0\%$. Using this approach, we follow the request of the regulator to introduce a mechanism that encourages banks to build up and release capital buffers according to the economic conditions.

4.2.2.2. Mortgage Supply

The fundamental process of mortgage supply also builds on Braun et al. (2022) and Braun (2022). As banks are the economic agents that distribute funds to potential home buyers and originate mortgage loans, they play an indispensable and decisive role in market activities. Their decision about mortgage lending determines the possibility of acquiring residential property which transforms into the exercised demand for residential real estate. While potential house buyers and sellers create market interactions in the real estate market, banks inextricably link the housing and the financial market.

Banks are assumed to be risk-neutral agents that seek to maximize profit. Therefore, their decision about approving or rejecting loans primarily depends on the expected profit of mortgage lending in comparison to any other investment opportunities. Considering that potential buyers become borrowers when a loan is affirmed who embody an individual risk of default, banks only approve a mortgage if:

$$(\mathrm{q}r_t + (1-q)r_d) - c_t \geq r_{AI}, \tag{11}$$

where q represents a potential borrower's non-default probability, r_t the mortgage interest rate, r_d the rate of return in case of default,[89] c_t the opportunity costs of lending that arise due to the capital requirements of Basel III, and r_{AI} the expected return of AI.

Solving (11) for r_t, we achieve a lender's indifference rate for loan granting which is the lowest mortgage interest he would accept as a function of an applicant's non-default probability:

$$r_t = r_d + \left(\frac{r_{AI}-r_d}{q}\right) - c_t. \tag{12}$$

[88] For the simulations, we set $\Theta = 5\%$. This mimics the average long-time increase of mortgage loans in Germany (German Central Bank, 2019).

[89] As Sommervoll, Borgersen and Wennemo (2009), Braun et al. (2022), and Braun (2022) we allow for $r_{AI} = r_d$. Following this approach, agents may decide about mortgage lending according to individual market expectations and balance sheet compositions.

The model is populated by a diverse set of heterogeneous financial agents which ensures that no single institution has market power and excess return on mortgage lending is eliminated by competition. Correspondingly, $r_t = r_{min}$.

In return for conducting risky business, the regulator imposes the prudential Basel III rules on banks which require them to comply with the CAR presented in section 4.2.2.1. These rules constrain business activities and cause opportunity costs out of forgone investments which are given by:

$$c_t = r_{wT} * \left(\frac{\emptyset r_t + \emptyset r_{AI}}{2}\right), \tag{13}$$

where r_{wT} indicates the custom mortgage's risk weight, $\emptyset r_t$ the average of past mortgage returns, and $\emptyset r_{AI}$ the average of past returns of AI.[90] The effective indifference return of a mortgage T is $r_{T,eff,m} = \left(r_d + \left(\frac{r_{AI} - r_d}{q}\right)\right) - \left(r_{wT} * \left(\frac{\emptyset r_t + \emptyset r_{AI}}{2}\right)\right)$.

Even if (11) holds, financial intermediaries might not approve loan requests. Especially if the relation of loan exposure to an applicant's net worth is comparatively high, lenders reject mortgage applicants in order to moderate default risk. Except for a fixed fraction of equity, residential property is mortgage financed which must be redeemed by periodical income. According to the applicant's budget constraint, a bank limits his mortgage exposure to his highest possible expenditure for housing purposes which forms a first mortgage lending constraint:

$$C1: T_{max,i,1} = \frac{Y}{\left(\frac{\alpha}{\beta}+1\right)}. \tag{14}$$

As evidenced in previous research, the mortgage-to-income ratio, herein expressed by γ, serves as a reliable indicator to estimate borrower default (Yang, Buist, and Megbolugbe, 1998; Hakim and Haddad, 1999; Ambrose and Capone, 2000).[91] Thus, potential lenders calculate $\gamma = \left(\frac{T-E}{Y}\right)$ which is assumed to be oppositely associated with a borrower's probability of not defaulting. Resulting of this, q can be expressed by a decreasing function of γ, $q = q(\gamma)$. This leads to the second constraint of mortgage volume according to which a potential lender would only grant a loan that is not higher than the opposite of a borrower $i's$ mortgage-to-income ratio times i's income, given his non-default probability:

$$C2: T_{max,i,2} = (1 - \gamma_i)Y_i. \tag{15}$$

It is a common business practice that in housing finance, loan requests are confirmed against pledged collateral (Bester, 1985). Usually, the housing loans are secured by the financed property itself. Relying lending decisions on the collateral values of houses is a convenient way for banks to forgo costly screening of customers while at the same time being protected in the case of borrower default and reducing the risk of moral hazard (Aghion and Bolton, 1992; Hart, 1995; Manove, Padilla, and Pagano, 2001). Several studies exist that evidence that banks base their lending approval on collateral values (Collyns and Senhadji, 2005; Freund et al., 1998; Herring and Wachter, 1999; Hilbers, Lei and Zacho, 2001; Niinimäki, 2009).

[90] The opportunity costs c_t only consider costs out of forgone investments. To determine those, the mean of past average returns of T and AI is used since the potentially invested asset as well as its return is unknown. Operating costs that might derive for mortgage lending are not considered.

[91] In this model setting, we restrain from modeling strategic default. By calculating the individual utilities of potential customers that are derived from owning housing, we ensure that only those agents enter the housing market who positively assess owning residential property and thus, want to avoid default.

Corresponding to this, we model a third credit constraint that relies on the collateral value of the financed dwelling. This in turn is highly associated with ongoing market dynamics and may be imposed by fluctuations. To determine the collateral value $CV_{k,i}$, banks refer to recent price information and adapt their own expectations. If real estate prices were flourishing in previous periods, banks imply a further appreciation and lend generously. In adverse market conditions, mortgage lending is restricted. Due to decreasing house prices, collateral values diminish making mortgage lending riskier. For diversification reasons, banks consider approving real estate loans despite falling prices up to a certain threshold. In this case, potential lenders also account for customer information. If price depreciations exceed this threshold, lending is further limited. Formally, banks constrain the applicant's i loan exposure to:

$$C3: T_{max,i,3} = CV_{k,i} = \begin{cases} (1+e_h)(1+\rho)^2 P_{t-1} & for\ \rho^+ \\ \chi\,(1+e_h)(1+\rho)P_{t-1} & for\ \rho^- > \psi\ , \\ \chi\,(1+e_h)(1+\rho)\dfrac{Y}{\left(\dfrac{\alpha}{\beta}+1\right)} & for\ \rho^- < \psi \end{cases} \tag{16}$$

where e_h is a bank's perception of future price developments, ρ^+ is a positive, and ρ^- a negative price change, χ is a risk discount, and ψ the threshold until which mortgage lending is advantageous out of diversification reasons although prices fell in previous periods.

This loan approval process is inherently procyclical and amplifies house price fluctuations. From the perspective of financial stability, the real estate market is one of the most decisive markets as due to collateralization practices, the financial accelerator mechanism occurs highly intensified. Since increasing housing prices increase the loan amounts needed to afford a residential property, house price appreciations put upward pressure on credit demand. As houses serve as collateral, higher property valuations in turn boost households' net worth which elevates borrowing capacity. These market mechanisms are further intensified by banks' expanded lending practices which are based on appreciated collateral values (Anundsen and Jansen, 2013). The excessive amplification of market fluctuations bears an enormous risk to the overall economy. Whether the $CCyB$ succeeds in its purpose to minimize this is to be examined in the following of this research.

On top of collateralization, banks usually demand an initial amount of equity capital from potential borrowers. The required volume of down payment constitutes a fixed share of equity in relation to the price of the desired residential property which is $\varepsilon = \frac{E}{P_i}$. According to this, a fourth credit constraint banks impose is:

$$C4: \frac{E}{P_i} \geq \varepsilon, \tag{17}$$

where E indicates the disposable amount of equity of a potential buyer which is derived from a uniform distribution on $E \sim U(0, 0.35)$, P_h the price of the dwelling the buyer desires to buy and ε indicates the demanded equity ratio. The equity constraint is an enclosed constraint that must invariably be met. A mortgage application can either be approved fully or it is rejected. Partial commitments cannot be granted. Given (14), (15), (16), and (17), the approved mortgage exposure is denoted by $T_i = \min(C1, C2, C3)$ while $C4$ holds.

4.2.2.3. Alternative Investment

In this model environment, the alternative investment AI constitutes the second risky investment option for banks. It is assumed to be a fully diversified set of assets and is referred to be the market portfolio. To mimic a diverse investment universe that is as close to reality as possible, we allow its fundamental value to follow a continuous time stochastic process. To model the price path of AI we use a geometric Brownian motion in which AI's fundamental value follows a geometric random walk with a constant mean change and a drift. AI's fundamental value is:

$$f_t^V = f_{t-1}^V + \mu - \frac{\sigma^2}{2} + \eta_{t-1}, \tag{18}$$

where f_{t-1}^V designates AI's log fundamental value of the previous period, μ its long-term expected drift, σ its standard deviation, and η_{t-1} a random walk for which $\eta_{t-1} \sim N\left(0, \sigma_\eta^2\right)$ holds.

We follow the approach of Lengwiler and Maringer (2011) and Braun (2022) in which AI's market price is not equal to its fundamental value. Instead, it is the result of agents' interaction. According to their perceptions of market behaviors and their individual balance sheet compositions, they decide whether to invest or disinvest in AI. Trading occurs via one central order book in which bids and asks are collected and matched oppositely using price priority.[92] The AI's market price p_M is the log-transformed mean of all transactions that have been conducted during one period:

$$p_{M,t} = \left(\frac{1}{N_{transactions,AI}}\right) \sum_{p=1}^{N} P_{bid}, P_{ask}. \tag{19}$$

Deviating from the approach of Lengwiler and Maringer (2011) and Braun (2022) we model a constantly liquid share market and prevent liquidity to dry up by introducing a market maker. Thus, we ensure that banks can trade the market portfolio whenever they want or need to. This seems reasonable as in the prevailing model environment AI represents any other investment opportunity for banks.

To account for banks' own perceptions about market developments and thus, to incorporate different investment strategies of banks, we include an agent-specific term $e_{m,AI}$ for which $e_{m,AI} \sim N\left(0, \sigma_{e_{m,AI}}^2\right)$ holds that considers the variability in the perception of the fundamental value. At the beginning of each period, a bank m conducts some research and obtains a private noisy signal which is:

$$s_{m,t} = (f_{t-1}^V - p_{M,t-1}) + e_{m,AI}\,. \tag{20}$$

This signal compares the previous fundamental value of AI with its market price and includes a bank's individual market expectation. Based on this, the agent m forms his expected fundamental value:

$$f_{exp,m}^V = f_{t-1}^V + \mu + s_{m,t}. \tag{21}$$

As for any other risky business practices, Basel III rules apply when banks invest in AI. According to those, a specified amount of equity needs to be held to absorb potential losses (see section 4.2.2.1). Arising opportunity costs for tied-up equity reduce the expected profit out of AI which is $\frac{f_{exp,m}^V - p_{M,t-1}}{p_{M,t-1}}$. To decide between mortgage lending and investing in the alternative investment, banks calculate:

[92] Direct OTC trading is not possible.

$$r_{AI,eff,m} = \left(\frac{(f_{exp,m}^{V} - p_{M,t_{-1}})}{p_{M,t_{-1}}}\right) - \left(r_{wAI} * \left(\frac{\emptyset r_t + \emptyset r_{AI}}{2}\right)\right), \tag{22}$$

where the calculation of the opportunity costs equals the calculation of opportunity costs for mortgage lending (see equation (13)), adjusted to the respective risk weight.

If $r_{T,eff,m} \geq r_{AI,eff,m}$ holds, agent m decides in favor of financing housing investment. If the opposite is true, he buys AI. The decision between housing financing and investing in AI does, however, not only depend on the profit-maximizing investment opportunity. Instead, banks need to account for their current balance sheet composition as well as regulatory compliance before conducting business. If a bank fulfills regulatory requirements and has enough disposable free equity, it decides between the investment options with the intention to maximize profit. If disposable free equity is positive but scarce, banks may be limited in business activities. In case the CAR are violated, banks are forced to sell shares in order to generate profit and meet the CAR again. If this attempt is unsuccessful and all funds are exhausted which means that no saleable assets are left, the respective bank is declared to be bankrupt.

A buy order of an agent is placed at the expected fundamental value of AI plus a spread. Fire sales are placed diminishing the fundamental value by a spread to increase the probability of a sale. Accordingly, the bid / ask price of a bank m is:

$$\begin{aligned} P_{bid,m} &= f_{exp,m}^{V} + spread \\ P_{ask,m} &= f_{exp,m}^{V} - spread. \end{aligned} \tag{23}$$

4.3. Baseline Computational Experiment

To analyze the effectiveness of the $CCyB$ as a macroprudential tool of Basel III, we conduct a set of several computational experiments. The model designed and presented in the previous sections is used to generate numerical simulations that allow us to test whether the regulatory rule achieves its purpose to mitigate credit booms, to prevent spillover effects to the macroeconomy, and enhance financial stability.

To investigate these purposes, we create four different experimental environments: one standard scenario, and three shock scenarios. The first one represents an undisturbed market environment in the absence of any shocks that serves as a base scenario. The shock scenarios incorporate an exogenous shock that directly impacts endogenous market activity. In each experimental environment, we compare market conditions and the effectiveness of the regulatory rules in fostering financial and macroeconomic stability under two regulatory regimes. The CAR-regime represents market conditions in which banks need to comply with the microprudential rules only. The $CAR + CCyB$-regime reveals market conditions in which the national authority introduces the $CCyB$ as a macroprudential stabilization factor depending on previous credit growth. We simulate 100 periods for each scenario.

To consider whether the regulatory purposes are met, we detect excessive credit growth by examining the volatility of credit in terms of credit volume and the number of granted mortgage loans. To account for spillover effects on the housing markets, we measure the intensity of price movements by calculating their standard deviation. The Z-score is used to account for the resilience of the banking sector. It measures banks' distance from insolvency and is a key indicator of financial stability (Boyd and Runkle, 1993; Lepetit and Strobel, 2015; Roy, 1952). To assess borrowers' risk and overall economic wealth, we measure the borrowers' non-default probability, the transaction rate of houses, their construction rate, and the rate of homeownership.[93]

4.3.1. Calibration of the Simulation Setting

The model is calibrated on empirical evidence, data obtained from the literature, or according to parameters that mimic real economies in terms of relations and conditions. The computational experiments are initially performed in a setting with a number of 60 potential buyers, 30 sellers, and 53 banks. Each of these agents owns a diverse set of individual features and market perceptions which ensures a high degree of heterogeneity. The initial market price of one unit of housing is set to $P_{h,t} = 2{,}500$ and the price development in previous periods is $\Delta P_{h,t-1} = 50$, and $\Delta P_{h,t-2} = 50$. After a sale has been conducted, the respective buyer and seller leave the market. The same holds true if a buyer was unsuccessful to buy a house for 10 periods. In this case, he is assumed to be too old to afford a future debt burden and he stays a tenant. In each period, a random number of potential buyers in a range of [60,66] and potential sellers in a range of [20,22] enter the housing market. Buyers' initial debt burden rate for investing in residential property is $r = 0.12$. This is the sum of a fixed redemption rate of $r_p = 0.1$ and an initial mortgage interest rate of $r_t = 0.02$.[94]

The financial market is populated by 53 banks.[95] Their initial balance sheet positions are calibrated on data obtained from BankFocus and thus mimic real market conditions. Just like sellers and buyers, each bank is characterized by individual market perceptions and, according to this, forms its own investment strategy. In times of depreciating house prices, banks assess a risk discount to determine the collateral value of the financed property. According to German conditions, this is assumed to be 0.2 so that $\chi = 0.8$ (Bienert and Brunauer, 2006). The loan default rate for banks is set to $D = 0.01$.[96] If one bank leaves the market because of insolvency, a new bank enters it with the same initial balance sheet positions but with different expectations about market developments. Following this approach, we hold the number of banks on the market fix and rule out any effects that might occur because of changing market size while at the same time ensuring agents' heterogeneity.

The measures that determine the alternative investment AI are initialized to mimic the German stock index (DAX). The past return rate of AI is set to $r_{AI} = 0.084$, its past fundamental value to $f_{t-1}^{v} = 1{,}008$. To determine $AI's$ fundamental value we use a drift of $\mu = 0.1215$ and an annual volatility of $f_t^V = 0.192$.[97] The parameters to initially calibrate the model are summarized in Table 4.2.

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[93] The transaction rate, the homeownership rate, and the construction rate are calculated as follows: $Transaction\ Rate = \frac{N_{transactions,t}}{\min(N_{buyers,t}, N_{sellers,t})}$, $Homeownership\ Rate = \frac{N_{transactions,t}}{N_{potential\ buyers,t}}$, $\text{Construction Rate} = \frac{N_{constructions,t}}{(N_{new\ sellings,t} + N_{left\ over})}$.

[94] A rate of $r_t = 0.02$ represents the average mortgage interest rate in Germany from January 2012 until December 2021. This data is available at the German Bundesbank.

[95] This is the number of banks obtained from the BankFocus database which are classified as commercial banks according to the national Banking Act (sect. 1 KWG), either grant mortgage loans to households or invest in alternative investment opportunities, and for which the respective balance sheet data was available. Group companies are represented by the parent company.

[96] The default rate of commercial banks is obtained from the ECB Statistical Data Warehouse.

[97] These parameters are calculated based on the daily price history of the German stock index (DAX) over the period from January 2012 to December 2021. The data is obtained from the Refinitiv Eikon database.

Table 4.2: Initial simulation parameters

Parameter	Description	Value
	Buyers	
α	Preference for consumption	[0, 1]
Y	Income	[100, 1000]
e_b	Individual market expectation	[-0.1, 0.1]
E	Equity	[0, 0.35]
	Sellers	
e_s	Individual market expectation	[-0.1, 0.1]
ς	Markdown ratio	0.95
	Housing Market	
$P_{h,t}$	Price index	2500
ΔP_{t-1}	Price change in t-1	50
ΔP_{t-2}	Price change in t-2	50
N_{Buyers}	Number of buyers	60
$N_{Sellers}$	Number of sellers	30
r_p	Redemption rate	0.1
r_t	Loan interest rate	0.02
	Credit Institutions	
e_h	Individual market expectation	[-0.1, 0.1]
e_{AI}	Individual market expectation	[-0.192, 0.192]
r_d	Default rate of return	0.001
χ	Loan-to-value	0.8
Ψ	Threshold of price decline	0.03
D	Loan default rate	0.01
	Financial Market	
r_f	Risk free interest rate	0.01
r_{AI}	Market return	0.084
f_{t-1}	Fundamental value of AI	1008
μ	Drift	0.1215
σ	Volatility	0.192
p_m	Market price of AI	1000
Θ	Threshold of mortgage growth	0.05

4.3.2. Base Scenario

In the first simulation scenario, we create an experimental environment that mimics the housing market in the absence of any shocks. The economic agents enter the market, evaluate ongoing market conditions and form individual behavioral strategies. According to their utility for housing investment, buyers seek to buy a home, limited by their budget constraints. Sellers track previous market developments and decide whether to state an offer. Following the purpose to maximize profit but being constrained in business activities due to the regulatory requirements of Basel III, banks opt for financing residential property or investing in an alternative investment portfolio. The interaction of market participants creates endogenous housing market cycles. Changing market conditions feedback on the financial market and vice versa and the interplay between mortgage borrowers and banks impact the stability of the financial sector.

To analyze the effectiveness of the regulatory policies, we evaluate the dynamics of the key variables during the simulation runs. Table 4.3 reports the statistical values of the baseline CAR-scenario and contrasts them to those of the $CAR + CCyB$-scenario. The measures reveal that in both experimental environments, the house prices fluctuate cyclically around their mean. These movements are visualized in Figure 4.1. The minimum price of dwellings in the CAR-scenario falls below this of the $CAR + CCyB$-scenario (1595.263 vs. 1908.064). This indicates that the $CCyB$, whenever it is announced by national authorities, prevents house prices to fall down sharply. The indication is affirmed by the graphical illustration of house price movements in Figure 4.1. The ongoing dynamics in the CAR-scenario push prices to deep troughs if the real estate market experiences a downturn. If prices reached a peak and depreciated in previous periods, banks progressively constrain mortgage lending. As collateral values decline, they substitute higher-risk credit businesses with higher-yielding alternative investment opportunities. The downward trend ends in a real estate price crunch. Such deep price declines do not appear if banks need to comply with the $CCyB$ of Basel III. Following this regulatory rule, banks need to hold an additional amount of equity in times of excessive positive price trends. The built capital cushion shall be released in adverse market developments. Less strict equity requirements cheapen mortgage lending for banks and render it more attractive compared to investing in AI. As a result, in the $CAR + CCyB$-scenario, banks grant mortgages more generously in times of depreciating house prices than in the CAR-scenario. The release of the $CCyB$ ensures sufficient credit supply in downward trends. This induces prices to turn around earlier and thus averts deep price falls.

The maximum housing price, in contrast to the minimum price, is quite equal in both experimental environments. In times of excessive credit growth, the activated $CCyB$ is intended to stop disproportionate price increases by making lending more expensive. However, if prices are rising over time, collateral values rise likewise. Rising property values make banks less cautious and they lend more generously. Furthermore, increasing collateral values make the LTV of borrowers decline. This creates an offsetting effect. Although mortgage lending gets more expensive because of higher equity requirements, these requirements are based on the LTVs of home buyers which drop with rising collaterals. Whereas the $CCyB$ succeeds in preventing house prices from deep price falls, it often allows prices to appreciate nearly to the same extent as with microprudential CAR only. Nevertheless, the $CCyB$ is able to prevent very high peaks as can be seen in Figure 4.1.

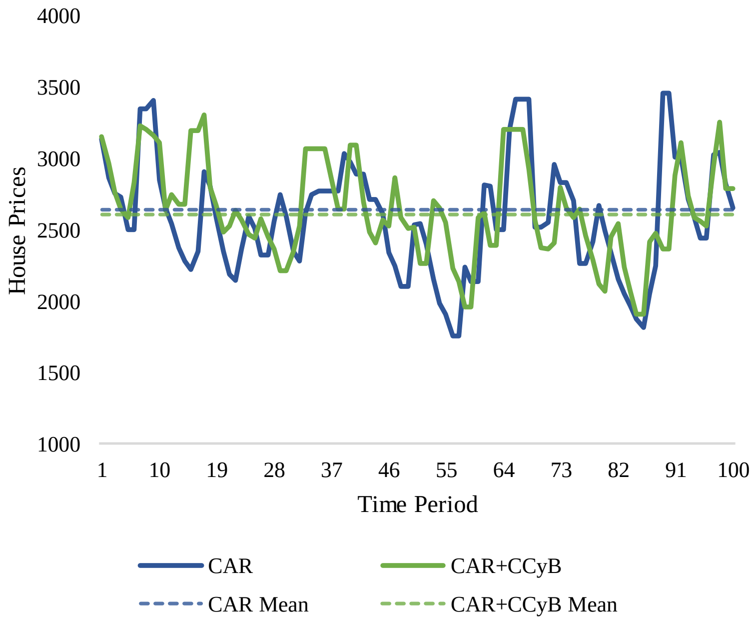

Figure 4.1: House price movements in the base environments

In both, the CAR-scenario and the $CAR + CCyB$-scenario, the lowest equity a bank needs to hold is the microprudential CAR-level. In the second scenario, however, the equity requirements are extended in times of excessive house price appreciations. The average amount of equity that needs to be held in the $CAR + CCyB$-scenario thus exceeds this of the CAR-scenario. An increase in the cost of lending lifts mortgage interest rates and, conversely, leads to a marginally lower mean real estate price which is 2609.623.

According to macroeconomic stability, the $CCyB$ succeeds well. The macroeconomic tool manages to reduce the standard deviation of housing prices and thus their volatility and stabilizes housing market cycles. Table 4.4, which displays the properties of the endogenously created housing market cycles, confirms this conclusion. The $CAR + CCyB$-scenario features an average cycle length of approximately 9 periods (8.9) which is lower than approximately 10 periods in the CAR-scenario. Thus, a higher number of cycles due to faster-induced turnarounds of price trends occur in the $CAR + CCyB$-scenario (10.0 vs. 10.4). The lower number of outbreaks (36.0) fosters the previous indication that the $CCyB$ stabilizes housing market cycles.

As rising interest rates to 0.043 instead of 0.041 make housing investment more expensive, more prosperous borrowers in terms of higher initial equity and lower LTVs will get a loan preferentially. This makes the non-default probability in the $CAR + CCyB$-scenario exceed this of the CAR-scenario (0.780 vs. 0.764). This apparently positive effect coincides, however, with a lower transaction rate of houses (0.216 vs. 0.257), a lower rate of homeownership (0.105 vs. 0.124), and a lower construction rate (0.103 vs. 0.109). In line with the preceding results, the average loan amount granted for residential purposes as well as the total number of mortgages is less in the $CAR + CCyB$-scenario than in the CAR-scenario.

Table 4.3: Statistical key variables of the base environments

Base Scenario		**CAR**	**CAR + CCyB**
House Price	Min	1595.263	1908.064
	Max	3473.162	3407.500
	Mean	2646.506	2609.623
	Std	438.846	351.094
Mortgage Interest Rate	Min	0.013	0.008
	Max	0.067	0.060
	Mean	0.041	0.043
	Std	0.012	0.010
Non-Default Probability	Min	0.000	0.000
	Max	0.895	0.926
	Mean	0.764	0.780
	Std	0.059	0.057
Transaction Rate	Min	0.000	0.000
	Max	1.000	0.913
	Mean	0.181	0.170
	Std	0.257	0.216
Homeownership Rate	Min	0.000	0.000
	Max	0.598	0.670
	Mean	0.124	0.105
	Std	0.029	0.042
Construction Rate	Min	0.000	0.000
	Max	2.600	2.818
	Mean	0.109	0.103

	Std	0.061	0.056
	Min	1.000	1.000
Loan Amount	Max	1,103,256.65	914,432.12
	Mean	176,888.61	163,829.18
	Std	23,222.66	49,163.38
No. of Loans	sum	1963	1957
	Min	1.808	2.255
Z-score	Max	3.162	3.128
	Mean	2.405	2.753
	Std	0.245	0.169

To measure the solidity of the banking sector, we account for the overall Z-score of the financial market in both experimental environments. The mean Z-score in the $CAR + CCyB$-scenario is 2.753 and outperforms this in the CAR-scenario of 2.405. This holds true for the whole set of interacting banks. Figure 4.2 illustrates the distribution of the Z-scores. It reveals that not only the mean resilience of the banking sector increases which could have been caused by a few very stable institutions but also the resilience of all banks. Figure 4.3 shows the evolution of the mean-Z-Sore over time. In both scenarios, the development is very stable and without remarkable outbreaks. This indicates that on average financial institutions conduct business steadily in both experimental environments. Over the whole simulation period, the mean value of the Z-score in the $CAR + CCyB$-scenario reaches the same or a higher level than in the CAR-scenario. The higher banking soundness in the $CAR + CCyB$-scenario is due to two different reasons. First, the higher average equity conditions for banks equip the financial market with more loss-absorbing capital and make banks more resilient in times of economic downturns. Second, lower standard deviations of mortgage interest rates and less risky borrowers in the $CAR + CCyB$-scenario indicated by a higher non-default probability lower banks' business risk.

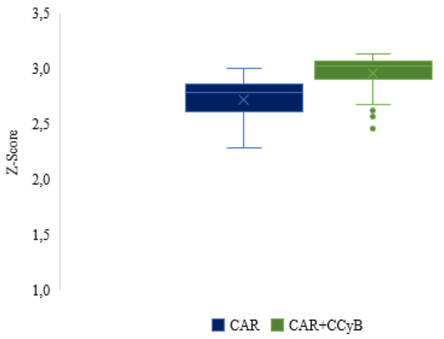

Figure 4.2: Z-scores of the base environments

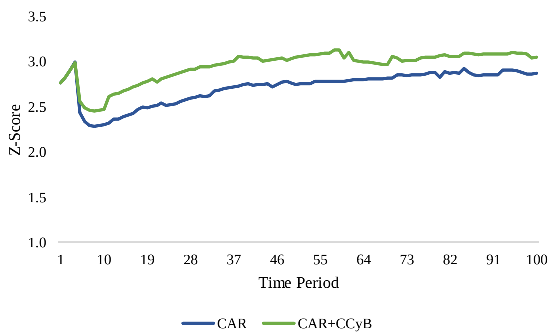

Figure 4.3: Development of Z-scores in the base environments

According to the experimental results, we conclude that in dynamic market conditions and in the absence of any shocks, the $CCyB$ is an effective macroeconomic tool as it succeeds in stabilizing the housing market and the financial market. However, it should be taken into account that despite positive impacts, it also constrains macroeconomic market activities in the housing market and restricts homeownership for borrowers with lower initial wealth or lower income. This, in turn, might negatively impact an economy's wealth, health, and social concerns.

Table 4.4: Market cycle properties of the base environments

Base Scenario	CAR	CAR + CCyB
Average Cycle Length	9.9	8.9
No. of Cycles	10.0	10.4
No. of Outbreaks	47.0	36.0

Notes: Table 4.4 displays some properties of the housing market cycles occurring in the two regulatory regimes. One cycle starts and ends with the mean of the respective housing price. An outbreak is defined as a price movement up or below the mean, +/- its standard deviation. The measures are computed for the whole simulation of 100 periods.

4.4. Simulation of Shocks

Due to the close interconnectedness of the financial markets and the real economy, endogenously created market conditions may be disturbed by occurrences in adjacent markets. Thus, we examine the impact of several shocks from different origins on the dynamics of the housing and the financial market. These shocks are a financial shock, a positive housing demand shock and a housing bubble and will be investigated in the following sections.

4.4.1. Financial Shock

The first shock we investigate is a financial shock incorporated by an exogenous increase in interest rates.[98] To let the model develop its endogenous dynamics, we run 10 periods in the absence of any shocks. In period 11, the shock hits the market unexpectedly. Following this approach, we incorporate the randomness of shock occurrences at any state of the housing market cycle.[99]

Figure 4.4 shows the effects of a positive interest rate shock on the development of housing prices and their means in an environment in which banks need to comply with CAR only and one in which they need to build a $CCyB$ additionally. In both scenarios, the shock spreads to the housing market and prices are clearly affected by the rise in interest rates. The positive shock boosts mortgage interest rates. This elevates expenditures for residential property and makes housing investment less affordable. Higher lending rates, in turn, depress demand for mortgage loans. The decline in credit diminishes the demand for homeownership, dragging down house prices. These attenuation effects are amplified by banks' borrowing constraints. In times of depreciating house prices, banks narrow loan offers (see equation 16) due to rising risk and the gain of the attractiveness of alternative investment opportunities. The decline in house prices depresses collateral values, furtherly tightening borrowing conditions. This financial accelerator mechanism amplifies ongoing market conditions, pushing prices into recession.

[98] A rise in interest rates may have different reasons and might origin from different channels, e.g. an increase in the key interest rate by central banks, disruptions in the construction industry, war. We anticipate a general mark-up of mortgage interest rates by banks of 0.05. Table 4.12 in the appendix summarizes the variations of model assumptions in the shock scenarios. For the rest of the model parameters, the calibration stated in Table 4.2 holds.
[99] The average length of housing market cycles in the base scenario is 10 (see Table 4.4). Introducing a shock right afterwards ensures that the impact of the shock develops freely unaffected by a prevailing up- or downswing.

In both the CAR- and the $CAR + CCyB$-scenario the implications of the shock only set in with a delay. Even after the shock occurs in period 11, prices follow the usual cyclical patterns developed by the behavior of interacting agents and experience an upturn. This mimics the real-world sluggishness of housing prices. Economic agents perceive ongoing market changes and update their expectations afterwards. These processes cause the market to react within a time lag. As soon as agents' perceptions are updated, the housing market experiences a deep bust. Due to the previously described interdependent mechanisms, prices are pushed down sharply. Although small corrections occur (Figure 4.4), they are not able to reverse the ongoing depression for about 20 periods. Neither does the macroeconomic $CCyB$ mitigate its extent. The price behavior in the micro- and macroprudential regime is almost identical. Although the regulatory authority imposes banks to hold additional capital in appreciating times before the shock hits the market, the release of the previously implied buffer is not able to mitigate the extent of the exogenous interest rate shock that hit the market unexpectedly. This reveals that the effectiveness of the macroprudential tool depends on how much buffer has been built up in the previous periods and further indicates that its effectiveness might depend on the magnitude of the shock.

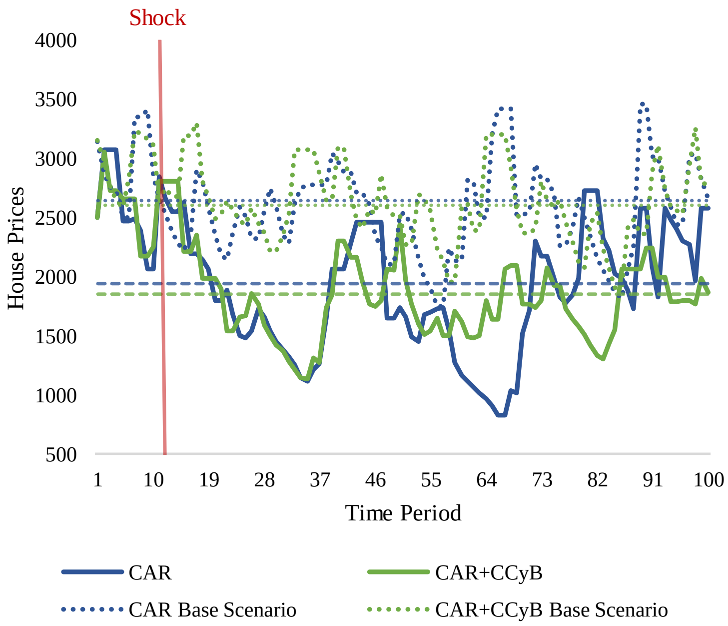

Figure 4.4: House price movements in the financial shock environments

After an extended period of depreciation in the housing market, the trend ends when market participants have factored in the changed market conditions. In both regimes, prices start to rise and proceed with their cyclical pattern. As mortgage lending is still expensive due to the increase in interest rates, the level of house prices falls below the base scenarios which are also portrayed in Figure 4.4. Although the $CCyB$ is not able to prevent the housing market to crash when a positive interest rate shock hits the market, it performs well in mitigating sharp price outbreaks in the aftermath of the crisis. When there is no macroprudential policy in place, housing market cycles are distinct with high peaks and deep troughs. Due to high lending costs, the demand for housing and credit fluctuates strongly. Uncertainties in market developments increase its vulnerability to crises. In the $CAR + CCyB$-regime in contrast, the cyclical movement of house prices is remarkably mitigated. Excessive upturns are prevented by higher capital requirements and downturns are softened by releasing them. Although the $CCyB$ fails to prevent a housing market crisis and to mitigate the recessionary effects of a financial shock, it performs well in dampening the amplification effects of the borrowing constraint channel in the aftermath of the shock.

Table 4.5 contains the statistical measures of the investigated key variables of the two regulatory regimes. The positive interest rate shock spreads to the housing market by the elevated mortgage interest rates which directly impact the demand for credit. Lowered credit volumes spill over to the demand for properties that negatively affects the price level of houses. In both the CAR- and $CAR + CCyB$-scenario the minimum, the maximum, and the mean price is lowered compared to the base scenarios. As in the environment without any shocks, the minimum value of the CAR-scenario which is 833.005 falls below that of the $CAR + CCyB$-scenario (1133.226) whereas maximum values are quite equal (3077.380 vs. 3053.900). Although the price development is nearly identical before the shock hits the market and during the recession, the $CAR + CCyB$-scenario outperforms the CAR-scenario in terms of housing market stability. This is indicated by a lower standard deviation in the $CAR + CCyB$-scenario that amounts 418.782. Due to the lowered house price fluctuations in the aftermath of the crisis, the $CCyB$ is effective in stabilizing the housing market overall.

Table 4.5: Statistical key variables of the financial shock environments

Financial Shock		CAR	CAR + CCyB
Market Price	Min	833.005	1133.226
	Max	3077.380	3053.900
	Mean	1939.886	1894.701
	Std	550.618	418.782
Mortgage Interest Rate	Min	0.059	0.062
	Max	0.114	0.121
	Mean	0.089	0.091
	Std	0.014	0.011
Non-Default Probability	Min	0.000	0.000
	Max	0.494	0.513
	Mean	0.322	0.337
	Std	0.110	0.107
Transaction Rate	Min	0.000	0.000
	Max	1.000	1.000
	Mean	0.122	0.082
	Std	0.280	0.254
Homeownership Rate	Min	0.000	0.000
	Max	1.000	0.600
	Mean	0.113	0.058
	Std	0.201	0.155
Construction Rate	Min	0.000	0.000
	Max	3.333	0.786
	Mean	0.064	0.028
	Std	0.082	0.034
Loan Amount	Min	1.000	1.000
	Max	630,728.99	493,486.46
	Mean	113,883.90	85,481.16
	Std	45,588.42	21,707.10
No. of Loans	sum	1011	837
Z-score	Min	2.569	2.769
	Max	2.919	3.289
	Mean	2.854	3.061
	Std	0.084	0.094

As mortgage interest rates are the channel through which the shock on the financial market spills over to the housing market, they are significantly increased. As in the base scenario, the mortgage interest rates with $CCyB$ are slightly higher (0.089 vs. 0.091). This is in line with the increased capital requirements during the shock recovery phase that prevent excessive credit growth. Through the inverse relationship of the mortgage-to-income ratio and the non-default probability of borrowers (see section 4.2.2.2), higher housing expenditures amplify the riskiness of credit exposures and sharply decrease borrowers' probability of not defaulting. As higher capital requirements tighten banks' business activities, banks will lend to customers with higher LTVs in the $CAR + CCyB$-regime which lifts the non-default probability to 0.337 compared to 0.322 the CAR-regime.

Similar to the base scenario, the lifted capital requirements in the $CAR + CCyB$-scenario affect activities in the housing market restrictively and limit transaction rate, homeownership rate, and construction rate to a lower level than without $CCyB$. In the $CAR + CCyB$-scenario, the mean transaction rate is 0.082, the homeownership rate 0.058, and the construction rate 0.028 while in the CAR-scenario they reach 0.122, 0.113, and 0.064. Compared to the base environment, the ratios are significantly reduced due to higher lending costs. The loan amount as well as the number of accepted credit exposures is significantly smaller in the shock environment than in the base environment and the values of the $CAR + CCyB$-regime fall below the CAR-regime.

Whereas the housing market is hit by an exogenous interest rate shock that generates high volatility in housing prices, the Z-scores of both regulatory schemes exceed this of the base scenarios, indicating higher banking soundness. Increased interest rates raise financial institutions' profits. These profits render the financial market a profound equity base that increases its solidity. Considering the low values of the non-default probability of borrowers, the assumed effect on banks' stability would be the other way around. The standard deviation of mortgage interest rates reveals, however, that profit out of mortgage lending is nearly as stable as in the base scenarios. This fact indicates that in an environment with a positive interest rate shock, banks, even more, constrain lending to borrowers with initial wealth or favorable LTV ratios. The impact of those loan-granting policies on the rest of the population is indicated by a decreasing transaction, homeownership, and construction rate in the shock scenario. Figure 4.5 displays the mean Z-scores of both regulatory regimes. As in the base scenarios, the $CAR + CCyB$-regime achieves higher values for the interactive banks and achieve a mean value of 3.016 vs. 2.854 in the CAR-scenario. The development of the mean Z-score over time (Figure 4.6) reveals that banking soundness is only slightly affected by the positive interest rate shock. In the aftermath of the shock, the values remain quite stable in both the CAR- and the $CAR + CCyB$-regime whereas the second one exceeds this of the first one steadily. The high values of Z-scores in this shock scenario indicate that only accounting for microprudential measures is not sufficient to evaluate the impact of occurrences on the overall economy. Instead, macroeconomic effects need to be investigated that can be effectively lowered by macroprudential policies.

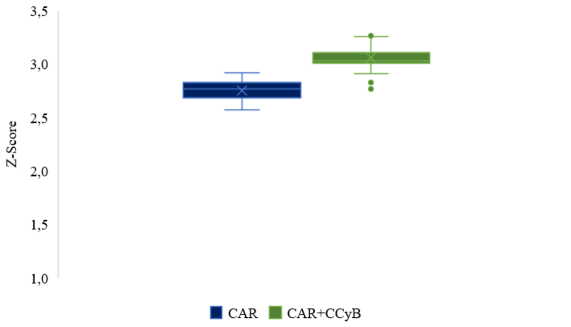

Figure 4.5: Z-scores of the financial shock environments

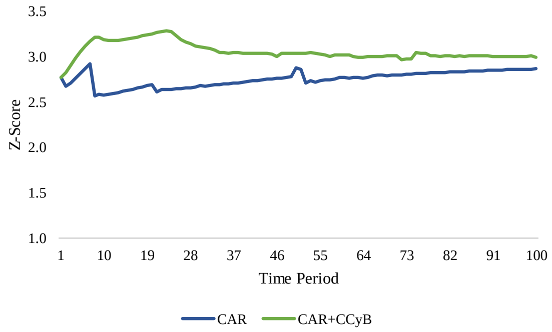

Figure 4.6: Development of Z-scores in the financial shock environments

Relating to overall stability measures, the $CCyB$ is effective in stabilizing the housing as well as the financial market in the aftermath of an exogenous positive interest rate shock. These results are verified by Table 4.6 which shows the properties of cycles under the CAR- and the $CAR + CCyB$-regime if a positive interest rate shock hits the market unexpectedly. Under the $CAR + CCyB$-regime, the average length of housing market cycles is lowered to 13.0 due to earlier initiated turnarounds and the number of outbreaks is reduced from 87.0 to 72.0.

Table 4.6: Market cycle properties of the financial shock environments

Financial Shock	CAR	CAR + CCyB
Average Cycle Length	27.5	13.0
No. of Cycles	2.0	6.0
No. of Outbreaks	87.0	72.0

Notes: Table 4.6 displays some properties of the housing market cycles occurring in the two regulatory regimes. For details see table 4.4.

4.4.2. Positive Demand Shock

The second shock we investigate is a positive housing demand shock incorporated as an increase in preferences for housing on the demand side.[100] Similar to the financial shock examined in the previous chapter, the housing demand shock is unanticipated by market participants and hits the market unexpectedly in period 11.

The shock generates expansionary effects in the housing market. The increase in the weight of residential property in the utility function for borrowers fuels the demand for housing. This pushes prices upwards and leads to high minimum, maximum, and mean prices under both regulatory regimes. In the CAR-scenario, the mean price level reaches 3320.839 which is slightly higher than this of the $CAR + CCyB$-scenario (3286.535). The supply still develops endogenously by the perceptions and expectations of the economic agents. The increased demand cannot fully be absorbed by the housing supply, generating a sellers' market and driving house prices upwards. Figure 4.7 contrasts the development of dwelling prices and their means of the CAR- and $CAR + CCyB$-regime in the demand shock environment and compares them to the baseline scenarios. Until the shock hits the market in period 11, in

[100] The increase in preferences for housing demand is incorporated in the utility function of potential buyers by the parameter α with the following properties from period 11 onward: $\alpha \sim N(0,1), \mu = 0.2$ and $\sigma = 0.02$. Table 4.12 in the appendix summarizes the variations of model assumptions in the shock scenarios. For the rest of the model parameters, the calibration stated in Table 4.2 holds.

both regimes, the price developments are quite similar to the base scenarios. As soon as potential house buyers put more emphasis on being a homeowner, prices drift upwards, experiencing high positive peaks during the simulation, especially in the CAR-only regime. Positive price trends reverse sharply to the upper price level of the baseline scenario. If banks only need to comply with microprudential regulatory measures, the house price cycles are distinct. Price appreciations lead to high peaks which are followed by recessionary periods that end in deep busts. The extent of the fluctuations strongly corresponds to those of the CAR base scenario (see Table 4.7). In the environment where the $CCyB$ is installed, house price movements are flattened. The macroeconomic tool mitigates excessive price increases and softens downturns also to a similar extent as it does in the $CAR + CCyB$ base scenario (Table 4.7). These results show that a positive housing demand shock directly affects housing prices, leading them to a higher level. However, compared to the baseline scenarios, the stability indicated by the standard deviation of housing prices in Table 4.7 amounts 421.831 in the CAR-scenario and 318.572 in the $CAR + CCyB$-scenario and thus, is not negatively impacted.

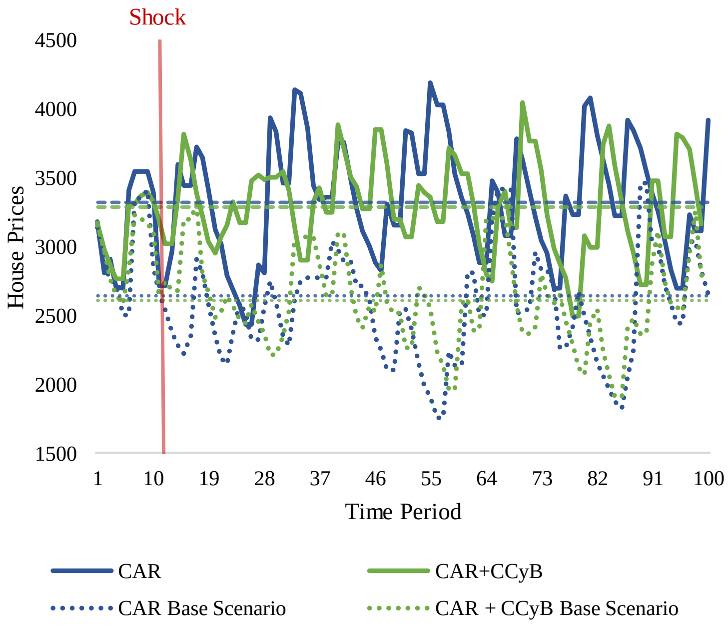

Figure 4.7: House price movements in the demand shock environments

Whereas the reactions of the housing market to the financial shock set in with a delay, the housing demand shock affects prices immediately. This reveals that the transmission time and the impact of the shock are addicted to its origin.

The increased demand for buying a residential property that fuels house prices spill over to the financial market through greater demand for credit. The mean mortgage volume granted per period of the CAR- and the $CAR + CCyB$-regime strongly exceeds this of the base scenarios and the financial shock scenarios (see Table 4.7). The number of granted loans, in contrast, is comparable to those of the base scenarios. This reveals that the increase in mortgage volume is induced by the rise in house prices and mimics one spillover effect from the housing market to the financial market. Rising house prices further impact mortgage lending as they soften the borrowing constraints for potential buyers. Higher collateral values allow borrowers to extend credit volume which in turn further drifts up prices, launching the financial accelerator mechanism and reinforcing ongoing market developments. The dampening effects of the $CCyB$ on these market dynamics are reflected in the loan amount (355,300.17) and the number of accepted mortgages (1837). Both measures are below those of the CAR-regime. Forcing banks to hold additional capital mitigates excessive credit growth and attenuates self-reinforcing effects that arise from the interplay of the housing and the financial market.

Table 4.7: Statistical key variables of the demand shock environments

Demand Shock		CAR	CAR + CCyB
Market Price	Min	2437.608	2497.032
	Max	4188.839	4044.763
	Mean	3320.839	3286.535
	Std	421.831	318.572
Mortgage Interest Rate	Min	0.009	0.022
	Max	0.088	0.097
	Mean	0.045	0.052
	Std	0.014	0.013
Non-Default Probability	Min	0.000	0.000
	Max	0.848	0.819
	Mean	0.645	0.662
	Std	0.106	0.080
Transaction Rate	Min	0.000	0.000
	Max	1.000	1.000
	Mean	0.191	0.176
	Std	0.024	0.023
Homeownership Rate	Min	0.000	0.000
	Max	0.358	0.373
	Mean	0.060	0.083
	Std	0.077	0.094
Construction Rate	Min	0.000	0.000
	Max	2.833	1.500
	Mean	0.137	0.134
	Std	0.343	0.244
Loan Amount	Min	4338.22	1.00
	Max	1,353,992.13	1,026,678.23
	Mean	572,608.71	355,300.17
	Std	36,506.15	28,752.83
No. of Loans	sum	1870	1837
Z-score	Min	1.662	2.617
	Max	3.426	3.096
	Mean	2.132	2.770
	Std	0.273	0.080

As a response to excessive demand for credit, banks raise their mortgage interest rates in comparison to the base scenarios (Table 4.7). Since the introduction of the $CCyB$ makes mortgage lending more expensive for banks, it has an additional increasing effect on interest rates. This cost-increasing effect of mortgage borrowing restrains the demand for housing and counteracts excessive house price appreciations. Higher collateral values counterbalance higher expenditures for housing investment, letting the non-default probability of borrowers decrease in comparison to the base scenarios. The need for additional capital in the $CAR + CCyB$-environment counteracts this effect and leads to an outperforming non-default probability of 0.662 compared to 0.645. The extended capital requirement has a tightening effect on mortgage granting and makes it more secure. It is able to cushion future probable losses and makes the probability of not defaulting increase compared to the CAR-environment.

The transaction rate and the construction rate exceed those of the base scenarios and the financial shock scenarios. As the existing supply of houses is not able to satisfy the extensive demand, construction firms extend their business activities and build new dwellings. Both variables are slightly depressed in the $CAR + CCyB$-scenario as the macroprudential measure has a restrictive effect on market activities. The homeownership rate of 0.060 in the CAR-scenario and 0.083 in the $CAR + CCyB$-scenario falls below this of the scenarios described in the previous chapters. Due to the positive housing demand shock that induces rising house prices, the number of potential home buyers rises excessively whereas the supply of dwellings is limited. A huge amount of unsatisfied housing demand diminishes the homeownership rate. As the $CCyB$ has a limiting effect on house price appreciations, it positively affects the rate of homeowners and generates a higher value than in the CAR-environment.

The Z-score of the two regulatory schemes in a market that experiences a positive housing demand shock is lower than in the respective baseline and financial shock scenarios. It amounts 2.132 under the CAR-regime and 2.770 under the $CAR + CCyB$-regime. This indicates that an external shock affects the soundness of the financial market more than a shock that has its origin in the financial market. And though, as in the previous simulation scenarios, the $CCyB$ performs well in stabilizing financial institutions in the event of a positive housing demand shock and makes them more resistant to potential crises. This can also be seen in Figure 4.8 which visualizes the mean Z-scores of the interacting banks in the CAR- and the $CAR + CCyB$-regime. Figure 4.9 shows the development of the Z-score over time. The Z-scores in the CAR-environment fluctuate more strongly than in the $CAR + CCyB$-environment. These variations also exceed those in the baseline and the financial shock scenarios.

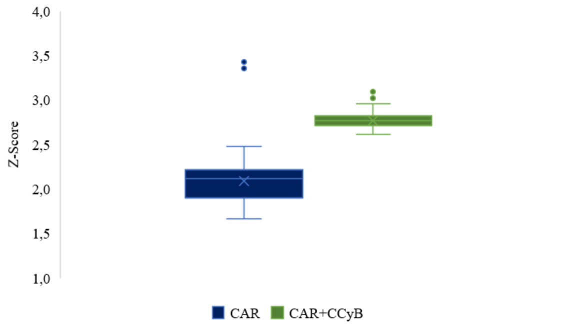

Figure 4.8: Z-scores of the demand shock environments

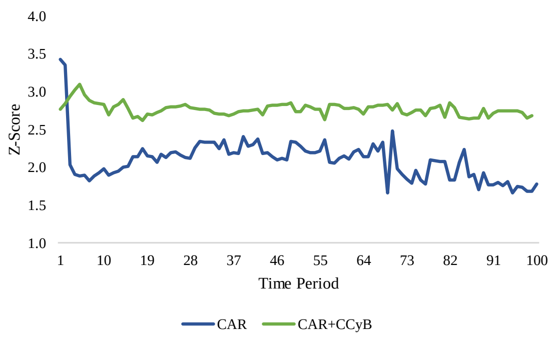

Figure 4.9: Development of Z-scores in the demand shock environments

Table 4.8 summarizes the cycle properties of both regulatory schemes in the event of a positive housing demand shock. The measures support previous results and reveal that the macroprudential $CCyB$ prevents excessive housing market cycles. It lowers ongoing price appreciations or depreciations and induces market trends to turn earlier. This is revealed by a lower average cycle length (6.8 vs. 10.4) which is accompanied by a higher number of cycles. Fewer outbreaks in the $CAR + CCyB$-regime (29.0 vs. 39.0) indicate that the cycles oscillate closer around their mean value.

Table 4.8: Market cycle properties of the demand shock environments

Demand Shock	CAR	CAR + CCyB
Average Cycle Length	10.4	6.8
No. of Cycles	9.0	13.0
No. of Outbreaks	39.0	29.0

Notes: Table 4.8 displays some properties of the housing market cycles occurring in the two regulatory regimes. For details see table 4.4.

As the simulations show, the $CCyB$ is an effective tool to mitigate excessive house price increases and to moderate spillover effects to the financial market in the event of a positive housing demand shock. Forcing banks to hold additional capital in times of excessive credit growth dampens house price appreciations. The smoother development of housing prices is transmitted to the rest of the economy more softly and thus, the $CCyB$ moderates the impact of a positive housing demand shock on the macroeconomy.

4.4.3. Housing Bubble

The perceptions and expectations of economic agents are decisive key indicators for the development of the housing market. In this section, we model a housing bubble similar to that which caused the latest financial and economic crisis and evaluate the impact of agents' distinct expectations about future housing demand appreciations on the key variables of the housing and the financial market. In this model environment, agents expect housing demand to rise at a certain point of time in the future. This expectation may be driven by different macroeconomic developments, such as a positive news shock about housing productivity, or housing supply, monetary policy that indicates a decline in future interest rates, or an upcoming subsidy for homeownership.

In contrast to the financial shock and the housing demand shock described in the previous sections, in this model environment, the agents anticipate a future change in market conditions. As a result, the investigated shock does not have a fundamental basis but is expectation driven by market participants. To simulate this, we assume that potential home buyers expect an increase in demand to occur in period 20. In period 20, however, the expectation does not materialize.[101]

The positive anticipations of the interacting agents generate expansionary effects in the housing market that are visualized in Figure 4.10. The expectations of a future increase in housing demand fuel prices immediately. Potential home buyers' assumptions of a higher demand for residential property are associated with rising expenditure for housing investment in the future and suppressed supply. As a result, potential buyers invest in housing today for speculative purposes, causing current demand to rise and inducing inflationary effects on prices. As in section 4.4.2, these market mechanisms spill over to the financial market and fuel mortgage lending as well as mortgage interest rates. Similar to the positive demand shock scenario (section 4.4.2), house prices react without any delay. This supports the hypothesis that those markets in which a shock originates record the first effects as transmission mechanisms are short. The expansionary effects appreciate house prices during the expectation period to a higher level compared to the base scenarios. The optimism about future housing demand generates a housing

[101] For a summary of the variations of model assumptions in the shock scenarios see Table 4.12 in the appendix. For the rest of the model parameters, the calibration stated in Table 4.2 holds.

bubble in both the CAR- and the $CAR + CCyB$-scenario inducing a macroeconomic boom characterized by a co-movement between excessive residential investment, house price increases, and granted mortgage loans. During the simulation, the price level of the $CAR + CCyB$-scenario is mostly lower than this of the CAR-scenario. This indicates the $CCyB's$ effectiveness in mitigating excessive price increases. However, it is not successful in preventing a housing bubble to occur. In the $CAR + CCyB$-scenario, expectations of a future increase in housing demand push current prices upwards nearly to the same extent as in the CAR-scenario. When the anticipated demand increase does not materialize in period 20, in both investigated regulatory regimes prices follow their ongoing trend for a few more periods and fall into recession afterward. The failed expectation makes the housing bubble burst and causes house prices to collapse. The previous self-reinforcing expansionary effects reverse and impact the macroeconomy oppositely. The release of the $CCyB$ in times of economic downturns only cushions the huge price decline marginally.

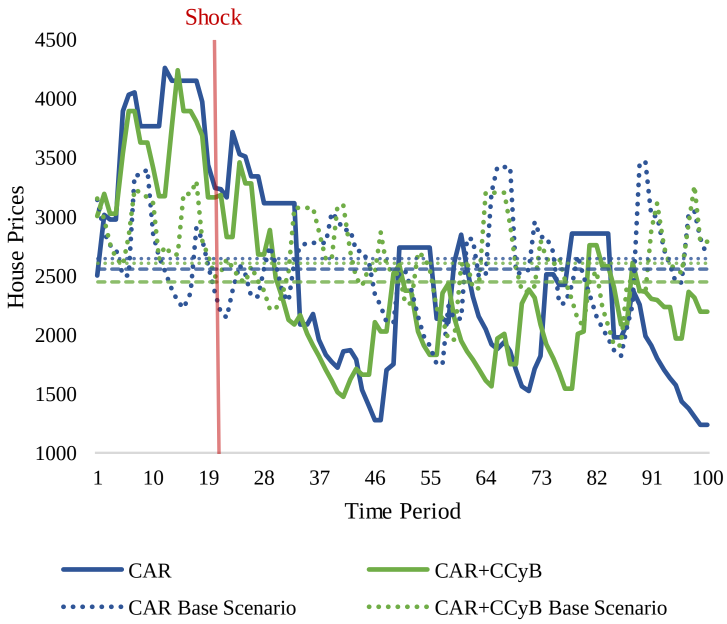

Figure 4.10: House price movements in the housing bubble environments

The impact of a housing bubble induced by an expected increase in housing demand in the future is more distinct than an unanticipated positive interest rate shock (section 4.4.1) and an unanticipated positive housing demand shock (section 4.4.2). The price drop that follows a housing bubble is deeper and it takes long for the housing market to recover. After an extended period of price depreciation, the market turns, and prices slowly approach the price level of the base scenarios. In the case of unanticipated shocks, economic agents price in changing environments earlier. Expectations about future market conditions distort the investment plans of potential home buyers, price levels, and mortgage borrowing levels that suddenly reverse when the expectations do not realize. The unrealized anticipations cause a dramatic drop in the housing market and aggregate variables fall below their initial level. During the recovery phase, the macroprudential $CCyB$ affects house price movements positively. It induces prices to turn around earlier ending the recession at a higher level. In the aftermath of the burst housing bubble, house price movements are more stable and less distinct in the $CAR + CCyB$-scenario. Similar to the financial shock environment, the $CCyB$ is not able to prevent the crisis caused by an anticipated increase in housing demand but it is successful in stabilizing housing markets in the aftermath of the crisis.

Table 4.9 contains the investigated key variables in the housing bubble environment. The presented measures summarize the occurrences in the housing and financial market which can be classified into three parts: an excessive boom during the expectation phase, a recession, after the housing bubble burst, and a recovery phase when the recession is overcome. The house price level indicated by the mean of all simulation periods amounts 2558.459 without $CCyB$ and 2448.987 with $CCyB$, and thus is a little lower than in the base scenarios. The excessive price increases during the expectation periods are compensated by the following price drops in the recession. Similar to the other investigated environments, the price level of the $CAR + CCyB$-regime falls slightly behind this of the CAR-regime as price outbreaks are mitigated by the additional capital requirement, and busts are flattened by its relief. The high standard deviation in both the CAR- and the $CAR + CCyB$-scenario (843.716 and 707.594) indicates the instability of the housing market if market conditions are disturbed by a housing bubble. The coefficients clearly exceed the fluctuations measured in the other shock scenarios. Although the macroeconomic buffer is not able to prevent a crisis caused by a housing bubble, it succeeds in extenuating its extent. The lower standard deviation of housing prices in the $CAR + CCyB$-scenario verifies the visualization of Figure 4.10. House price oscillations are flattened and cycles are less distinct if the macroprudential tool is installed.

As the three parts of the housing bubble environment partially offset market mechanisms from previous periods, the mean mortgage interest rate is quite similar to that in the base environment. The increased demand during the expectation phase transmits across the economy in a qualitatively similar manner as in the positive demand shock (section 4.4.2) and banks raise their lending rates. If banks need to hold additional regulatory capital, mortgage lending is more expensive which transmits to higher lending rates of 0.045 in the $CAR + CCyB$-regime. An offsetting effect sets in as soon as prices decline.

The compensating effects of market phases are also reflected in the non-default probability of borrowers. During the boom phase of the housing bubble environment, the probability of not defaulting is comparable to this of the housing demand shock environment. In the recession, it decreases heavily. When the market recovers, it recovers as well. As a result, the non-default probability in the housing bubble environment is lower but close to the values of the base scenarios. Similar to the base environment and the other shock environments, the $CCyB$ lowers default risk. The probability of not defaulting amounts 0.719 whereas this without an installed $CCyB$ reaches 0.683.

After the financial shock environment, the housing bubble environment reaches the second lowest transaction rate (0.161 for the CAR-regime and 0.153 for the $CAR + CCyB$-regime). The extended recession and the slow recovery of the market limit trading. The same holds true for the construction rates in both regulatory regimes. The pronounced price drops discourage construction firms from building first-time occupancies. As the $CCyB$ impacts market activities restrictively, the ratios are depressed in the $CAR + CCyB$-regime compared to the CAR-regime. The same effect can be seen in the homeownership rate which is lower if banks need to comply with the $CCyB$-regulation.

Table 4.9: Statistical key variables of the housing bubble environments

Housing Bubble		CAR	CAR + CCyB
House Price	Min	1234.091	1469.093
	Max	4263.339	4543.089
	Mean	2558.459	2448.987
	Std	843.716	707.594
Mortgage Interest Rate	Min	0.018	0.016
	Max	0.080	0.096
	Mean	0.041	0.045
	Std	0.017	0.013
Non-Default Probability	Min	0.000	0.000
	Max	0.961	0.940
	Mean	0.683	0.719
	Std	0.173	0.080
Transaction Rate	Min	0.000	0.000
	Max	1.000	1.000
	Mean	0.161	0.153
	Std	0.023	0.246
Homeownership Rate	Min	0.000	0.000
	Max	1.000	0.664
	Mean	0.107	0.102
	Std	0.170	0.152
Construction Rate	Min	0.000	0.000
	Max	4.429	4.444
	Mean	0.096	0.052
	Std	0.169	0.372
Loan Amount	Min	1.00	258.66
	Max	712,302.53	800,509.93
	Mean	189,069.44	185,341.38
	Std	38,081.04	58,919.72
No. of Loans	sum	2082	2013
Z-score	Min	1.819	2.284
	Max	2.853	3.290
	Mean	2.416	2.668
	Std	0.152	0.171

Considering all simulation periods, the mean values of the loan amount in both the CAR-scenario and the $CAR + CCyB$-scenario are slightly higher than in the base scenarios which is induced by the excessive boom phase during the first 20 periods. As identified in the other simulation scenarios and in line with the measures so far in the housing bubble environment, the amount of granted loans in the $CAR + CCyB$-scenario lies behind the CAR-scenario (185,431.38 vs. 189,069.44). The same holds true for the number of accepted mortgages (2013 vs.2082).

The stability of the financial market, indicated by the Z-score can be slightly increased if banks need to comply with the $CCyB$ and reaches a value of 2.668. As in the previous environments, the additional capital buffer creates a solid equity base and makes financial institutions less prone to crises. Figure 4.11 illustrates the distribution of Z-scores within the financial market between the interacting banks. Under both regulatory regimes, some banks feature quite high Z-scores which impact the mean Z-score of the financial market and thus the overall stability positively. As to be seen in Figure 4.12, the price appreciations during the expectation phase pushed Z-scores upwards. With ongoing market developments, these appreciations are reversed. Similar to the housing demand shock environment, the development of the Z-scores over time is less stable under the CAR-regime than under the $CAR + CCyB$-regime.

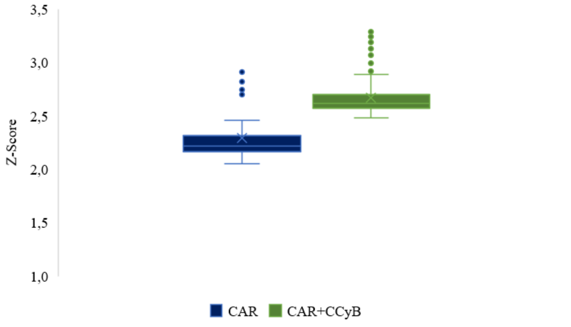

Figure 4.11: Z-scores of the housing bubble environments

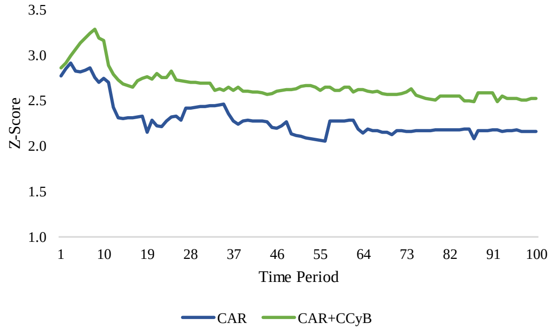

Figure 4.12: Development of Z-scores in the housing bubble environments

The stabilizing effects of the $CCyB$ are verified in Table 4.10. The length of housing market cycles is lowered to 19.3, the number of cycles increases (3.4), and the number of cycle outbreaks that exceed the standard deviation decreases to 35.0 compared to 65.0. Thus, the simulations show that in the event of a housing bubble, the $CCyB$ is not a prevention but a helpful tool to reduce spillover effects to adjacent markets and to stabilize the economy. Although house price appreciations are dampened during the boom phase, it goes on for too long even if the macroprudential feature is installed. The recession that follows the burst cannot be avoided; its extent can only slightly be mitigated. Overall, however, the $CCyB$ helps to attenuate the impacts of a housing bubble on the housing and the financial markets.

Table 4.10: Market cycle properties of the housing bubble environments

Housing Bubble	CAR	CAR + CCyB
Average Cycle Length	25.3	19.3
No. of Cycles	3.0	3.4
No. of Outbreaks	65.0	35.0

Notes: Table 4.10 displays some properties of the housing market cycles occurring in the two regulatory regimes. For details see table 4.4.

4.5. Conclusions

As the rules of Basel II were not able to prevent the latest financial crisis nor to mitigate spillover effects to the overall economy, the authority introduced a set of micro- and macroprudential measures that aim at strengthening the financial sector and dampening the economic impact. The $CCyB$ is one of the post-crisis reforms of Basel III that allows national authorities to adjust CAR in a countercyclical manner. To limit credit-based economic upturns, banks shall build additional equity capital in times of excessive credit growth that tightens their scope for economic activity. In recessionary times, in contrast, the built buffer shall be released to assist a sufficient supply of capital.

This paper investigates the effects of the new regulatory tool on the housing and the financial market and assesses its effectiveness in preventing excessive credit growth, increasing the resilience of the financial sector, and avoiding any destabilization of the economy. Due to the capital-intensive and collateral value-based lending practices in housing investment, the mortgage lending market acts as a direct transmission channel of occurrences in one of both markets to the next that fuels the financial accelerator. The resulting close interconnectedness of the two markets and the enormous impact of the turmoil in one of them on the overall economy raises particular interest in whether the $CCyB$ succeeds in achieving regulatory goals.

For this purpose, we extend the heterogeneous agent-based model (ABM) of Braun et al. (2022) and investigate key stability indicators of the housing and the financial market under undisturbed market conditions and in times of three different shocks. The model builds a network of potential home buyers, sellers, and financial institutions that build a decentralized credit market where heterogeneous borrowers and banks interact directly with each other. The model features two binding constraints: while potential buyers are constrained in borrowing, banks are constrained in conducting business according to the CAR including a $CCyB$ which is positively linked to credit growth.

The resilience of the housing and the financial market can be affected from both the inside of the market and its inherent structures and from the outside through exogenous shocks. Hence, to quantitatively evaluate the impact of the new macroprudential tool of Basel III, a model has to be used that incorporates these various sources of risk while at the same time considering the heterogeneity of economic agents. An ABM accounts for these characteristics and develops an artificial market environment that allows us to investigate endogenously created market conditions as well as to test the $CCyB's$ performance during times of exceptional market occurrences induced by external shocks.

In the context of this model, we conduct several computational experiments and examine four simulation scenarios: one in which market conditions evolve endogenously in the absence of any exogenous shocks which serves as a benchmark, and three shock scenarios where the markets face a financial shock, a positive housing demand shock, or a housing bubble. We find that in every scenario, the $CCyB$ performs well in stabilizing the housing market. House price fluctuations are dampened if the national authority forces banks to build an additional capital buffer in times of excessive increase in credit. The higher CAR increase the cost of mortgage lending. This induces banks to rise mortgage interest rates which, in turn, has a restraining effect on credit demand. The dissolution of the $CCyB$ in recessionary times softens banks previously tightened business activities, thus cushioning sharp price downturns. These mechanisms positively affect the non-default probability of borrowers and the resilience of the financial sector. The higher equity capital under the $CAR + CCyB$-regimes, the higher returns of mortgage lending as well as the lower riskiness of borrowers lead to increased banking soundness indicated by a higher Z-score. These positive effects coincide, however, with limited business activities in the housing market. The tightening effect of increased capital requirements distorts supply and demand in the housing market transmitted through the mortgage lending channel. The results are lower transaction and construction rates as well as a lower rate of homeownership in the base scenario, the financial shock scenario, and the housing bubble scenario. These effects might negatively impact overall prosperity, health, or social concerns.

Although the $CCyB$ performs well in stabilizing the housing and the financial market, the decision about mortgage lending of banks is still mainly based on collateral values and LTVs of borrowers. The $CCyB$ may moderate the effects of these lending practices but as they are inherently procyclical, sharp price outbreaks, induced by excessive generous or limited credit cannot be banned. This is revealed by the different shock scenarios. The development of house prices discloses that neither the financial shock, the housing demand shock nor the housing bubble can be prevented by the $CCyB$. Price trends are distorted by the external shocks that hit the markets quite similarly under both regulatory regimes. However, due to the restraining effect on procyclicality, the $CCyB$ helps to end a housing bubble earlier. On top, in the aftermath of the respective crisis, housing market cycles are significantly mitigated if banks need to comply with the macroprudential tool of Basel III. As such, the effectiveness of the $CCyB$ in mitigating downfalls and cushioning shocks can be judged positively.

Furthermore, the design of the $CCyB$ reduces the mutual dependencies of banking regulations and monetary policy. Introducing a measure that depends on ongoing market conditions counteracts the procyclicality of previous regulatory measures. The spillover effects of interest rate changes due to monetary policy may be cushioned by the $CCyB$ that prevents a sharp interest rate impact that is induced by political considerations rather than economic features.

Compared to the other shock scenarios, the housing bubble destabilizes the housing market the most. The standard deviation of house prices exceeds those of the other scenarios and the $CCyB$ has the highest stabilizing effect. The positive housing demand shock affects fluctuations the least. The highest banking soundness can be achieved in the financial shock scenario. This is due to the low standard deviation of high mortgage interest rates. The largest increase in banking stability in the $CAR + CCyB$-regimes can be recorded in the positive demand shock scenario. If prices rise excessively because of a huge increase in housing demand, which is further induced by procyclical mortgage lending practices, the limiting effect of the $CCyB$ forces banks to build a solid base of additional capital.

The shock scenarios further indicate that the effectiveness of the $CCyB$ depends on the magnitude of the shock and on how much buffer has been built up by banks in the previous periods. Accordingly, the time at which the buffer is introduced by the national authority is decisive for its effectiveness. Since banks follow their usual decision processes of mortgage lending, a $CCyB$ introduced at the wrong time might even affect market conditions procyclically, further fueling the financial accelerator mechanism.

This paper's findings provide insights for regulatory authorities about the effectiveness of the $CCyB$ in the context of the housing and mortgage lending market. It identifies the macroprudential tool of Basel III as a useful measure to stabilize the housing and the financial market in uneventful market conditions as well as in mitigating the aftermaths of different shocks. It is not able, however, to prevent any of the simulated crises to occur. The insights also contribute to a better understanding of how higher CAR impact the pricing and the availability of mortgage loans. Furthermore, the results highlight the decisiveness of the timing of the introduction of the $CCyB$ for its performance. As the simulations reveal, the $CCyB$ affects the housing market and the financial market noticeably. Thus, it may be assumed that an installation at the wrong time may have contradictive results. Discussions in the existing literature about regulatory measures that indicate the timing of installation have not come to an end yet. This leaves room for further research.

4.6. Appendix Chapter 4

The results presented in the main part of this paper constitute one exemplary simulation run each. To ensure that the findings are representative, we test the model's robustness and its structural consistency by running extensive Monte Carlo simulation experiments. We compute 100 independent simulation runs of the base and the shock scenarios that cover 100 periods each. Table 4.13 to Table 4.20 show the mean values of the examined key variables and their standard deviations for the different market settings under the two regulatory regimes: the CAR-only-regime and the $CAR + CCyB$-regime. The results of the Monte Carlo simulations validate the findings presented in sections 4.3.2 to 4.4.3 and affirm their robustness. Table 4.11 presents the requested risk weights depending on borrowers' LTV levels according to the BCBS (BCBS, 2017b). Table 4.12 summarizes the variations of model parameters in the different shock scenarios.

Table 4.11: Risk weight table for residential real estate exposure

	LTV ≤ 50%	60% < LTV ≤ 80%	80% < LTV ≤ 90%	90% < LTV ≤ 100%	LTV > 100%
Risk weight	20%	25%	30%	40%	70%

Table 4.12: Variation of simulation parameters in the shock scenarios

Scenario	Shock Type	Period	Parameter	Value
Financial Shock	exogenous, unanticipated	0-10	r_t	0.02
		11-100	r_t	$r_t + 0.05$
Positive Demand Shock	exogenous, unanticipated	0-10	α	$[0,1], \mu = 0.5, \sigma = 0.05$
		11-100	α	$[0,1], \mu = 0.2, \sigma = 0.02$
Housing Bubble	endogenous, anticipated	0-20	α	$[0,1], \mu = 0.2, \sigma = 0.01$
		21-100	α	$[0,1], \mu = 0.6, \sigma = 0.05$

Table 4.13: Robustness check of the statistical key variables of the base environments

Base Scenario		CAR	CAR + CCyB
House Price	Min	1670.076	1703.402
		(256.334)	(263.262)
	Max	3532.949	3528.123
		(204.975)	(227.975)
	Mean	2689.658	2672.283
		(400.635)	(303.490)
Mortgage Interest Rate	Min	0.010	0.011
		(0.006)	(0.007)
	Max	0.076	0.075
		(0.011)	(0.013)
	Mean	0.041	0.042
		(0.009)	(0.009)
Non-Default Probability	Min	0.000	0.000
		(0.000)	(0.000)
	Max	0.899	0.995
		(0.035)	(0.029)

	Mean	0.774	0.798
		(0.055)	(0.052)
	Min	0.000	0.000
		(0.000)	(0.000)
Transaction Rate	Max	0.984	0.981
		(0.078)	(0.093)
	Mean	0.174	0.166
		(0.032)	(0.036)
	Min	0.000	0.000
		(0.000)	(0.000)
Homeownership Rate	Max	0.715	0.701
		(0.219)	(0.213)
	Mean	0.112	0.108
		(0.021)	(0.024)
	Min	0.000	0.000
		(0.000)	(0.000)
Construction Rate	Max	3.431	4.296
		(4.345)	(5.006)
	Mean	0.098	0.095
		(0.061)	(0.065)
	Min	113.79	56.56
		(556.00)	(393.44)
Loan Amount	Max	851,608.26	824,415.51
		(175,308.08)	(179,606.43)
	Mean	176,859.06	169,901.08
		(38,767.48)	(43,360.82)
No. of Loans	sum	1977	1911
		(369.127)	(431.596)
	Min	2.194	2.109
		(0.451)	(0.432)
Z-score	Max	3.284	3.211
		(0.413)	(0.307)
	Mean	2.545	2.634
		(0.270)	(0.141)

Table 4.14: Robustness check of the market cycle properties of the base environments

Base Scenario	CAR	CAR + CCyB
Average Cycle Length	10.3	9.9
No. of Cycles	7.6	7.8
No. of Outbreaks	48.7	38.8

Table 4.15: Robustness check of the statistical key variables of the financial shock environments

Financial Shock		CAR	CAR + CCyB
House Price	Min	1397.440	1640.164
		(663.614)	(626.711)
	Max	3053.861	3068.614
		(135.731)	(120.712)
	Mean	2464.969	2297.596
		(566.265)	(428.027)
Mortgage Interest Rate	Min	0.067	0.069
		(0.012)	(0.012)
	Max	0.114	0.117
		(0.022)	(0.018)
	Mean	0.092	0.096
		(0.012)	(0.014)
Non-Default Probability	Min	0.000	0.000
		(0.000)	(0.000)
	Max	0.586	0.613
		(0.205)	(0.193)
	Mean	0.386	0.413
		(0.169)	(0.124)
Transaction Rate	Min	0.000	0.000
		(0.000)	(0.000)
	Max	0.806	0.771
		(0.310)	(0.320)
	Mean	0.129	0.088
		(0.094)	(0.081)
Homeownership Rate	Min	0.000	0.000
		(0.000)	(0.000)
	Max	0.724	0.687
		(0.299)	(0.306)
	Mean	0.100	0.063
		(0.072)	(0.056)
Construction Rate	Min	0.000	0.000
		(0.000)	(0.000)
	Max	2.640	1.396
		(5.003)	(2.672)
	Mean	0.056	0.035
		(0.070)	(0.045)
Loan Amount	Min	152.20	1.00
		(723.05)	(0.00)
	Max	362,36.77	360,065.61
		(257,381.14)	(197,599.36)
	Mean	63,296.83	56,915.41
		(48,153.20)	(57,778.42)
No. of Loans	sum	1236	976
		(93.248)	(97.285)
Z-score	Min	2.656	2.661
		(0.144)	(0.159)
	Max	3.491	3.511
		(0.344)	(0.367)
	Mean	3.191	3.226
		(0.354)	(0.377)

Table 4.16: Robustness check of the market cycle properties of the financial shock environments

Financial Shock	CAR	CAR + CCyB
Average Cycle Length	22.6	11.6
No. of Cycles	2.5	6.6
No. of Outbreaks	88.3	61.2

Table 4.17: Robustness check of the statistical key variables of the demand shock environments

Demand Shock		CAR	CAR + CCyB
House Price	Min	2494.941	2324.956
		(262.463)	(265.545)
	Max	4266.697	4287.206
		(148.606)	(155.222)
	Mean	3389.443	3320.846
		(418.743)	(304.527)
Mortgage Interest Rate	Min	0.014	0.014
		(0.007)	(0.007)
	Max	0.085	0.085
		(0.018)	(0.013)
	Mean	0.045	0.049
		(0.008)	(0.006)
Non-Default Probability	Min	0.000	0.000
		(0.000)	(0.000)
	Max	0.886	0.913
		(0.085)	(0.093)
	Mean	0.572	0.683
		(0.121)	(0.076)
Transaction Rate	Min	0.000	0.000
		(0.000)	(0.000)
	Max	0.975	0.989
		(0.051)	(0.032)
	Mean	0.181	0.177
		(0.008)	(0.008)
Homeownership Rate	Min	0.000	0.000
		(0.000)	(0.000)
	Max	0.366	0.531
		(0.111)	(0.183)
	Mean	0.064	0.083
		(0.005)	(0.009)
Construction Rate	Min	0.000	0.000
		(0.000)	(0.000)
	Max	5.062	5.302
		(6.209)	(6.936)
	Mean	0.133	0.133
		(0.082)	(0.082)
Loan Amount	Min	6,026.73	1,034.20
		(5,917.51)	(2,403.09)
	Max	1,364,444.39	1,206,265.53
		(142,080.13)	(146,269.66)
	Mean	541,263.43	385,793.71
		(45,557.88)	(37,543.47)
No. of Loans	sum	1912	1833
		(91.565)	(115.878)

Z-score	Min	1.523	2.063
		(0.697)	(0.369)
	Max	3.181	3.286
		(0.318)	(0.404)
	Mean	2.053	2.467
		(0.500)	(0.307)

Table 4.18: Robustness check of the market cycle properties of the demand shock environments

Demand Shock	CAR	CAR + CCyB
Average Cycle Length	9.6	7.5
No. of Cycles	9.8	12.0
No. of Outbreaks	41.0	33.9

Table 4.19: Robustness check of the statistical key variables of the housing bubble environments

Housing Bubble		CAR	CAR + CCyB
House Price	Min	1442.038	1471.342
		(262.463)	(373.380)
	Max	4204.159	4237.246
		(154.679)	(173.357)
	Mean	2648.447	2575.308
		(838.560)	(695.003)
Mortgage Interest Rate	Min	0.011	0.010
		(0.006)	(0.007)
	Max	0.079	0.080
		(0.013)	(0.015)
	Mean	0.041	0.042
		(0.008)	(0.013)
Non-Default Probability	Min	0.000	0.000
		(0.000)	(0.000)
	Max	0.972	0.929
		(0.235)	(0.229)
	Mean	0.674	0.750
		(0.164)	(0.145)
Transaction Rate	Min	0.000	0.000
		(0.000)	(0.000)
	Max	0.980	0.984
		(0.065)	(0.060)
	Mean	0.168	0.161
		(0.034)	(0.043)
Homeownership Rate	Min	0.000	0.000
		(0.000)	(0.000)
	Max	0.657	0.669
		(0.200)	(0.216)
	Mean	0.107	0.104
		(0.025)	(0.029)
Construction Rate	Min	0.000	0.000
		(0.000)	(0.000)
	Max	4.021	4.684
		(3.672)	(5.017)
	Mean	0.092	0.051
		(0.050)	(0.068)
Loan Amount	Min	461.49	118.91
		(5,917.51)	(773.89)

	Max	965,067.41	953,710.12
		(196,793.12)	(225,890.96)
	Mean	187,063.74	179,267.94
		(38,665.07)	(48,652.91)
No. of Loans	sum	1869	1822
		(398.930)	(515.468)
Z-score	Min	2.052	2.029
		(0.330)	(0.355)
	Max	3.035	3.047
		(0.246)	(0.260)
	Mean	2.448	2.571
		(0.286)	(0.322)

Table 4.20: Robustness check of the market cycle properties of the housing bubble environments

Housing Bubble	CAR	CAR + CCyB
Average Cycle Length	29.0	20.0
No. of Cycles	4.0	3.4
No. of Outbreaks	67.7	36.8

4.7. Bibliography Chapter 4

Aghion, P. and Bolton. P. (1992). An incomplete contracts approach to financial contracting. *The review of economic Studies* 59.3 (1992): 473-494. https://doi.org/10.2307/2297860.

Ambrose, B. W. and Capone. C. A (2000). The Hazard Rates of First and Second Defaults. *The Journal of Real Estate Finance and Economics* 20: 275-293. https://doi.org/10.1023/A:1007837225924.

Anundsen, A. K.. and Jansen. E. S. (2013). Self-reinforcing effects between housing prices and credit. *Journal of Housing Economics*. 22(3): 192-212.

BCBS (2011): Basel III. A global framework for more resilient banks and banking systems. *Bank for International Settlements*. URL https://www.bis.org/publ/bcbs189.pdf.

BCBS (2017a). High level summary of Basel III reforms. *Bank for International Settlements.* URL *https://www.bis.org/bcbs/publ/d424_hlsummary.pdf*.

BCBS (2017b). Basel III: Finalising post-crisis reforms. *Bank for International Settlements.* URL *https://www.bis.org/bcbs/publ/d424.htm*.

BCBS (2019a). Risk-based Capital requirements – Calculation of minimum risk-based capital requirements. *Bank for International Settlements.* URL *https://www.bis.org/basel_framework/standard/RBC.htm*.

BCBS (2019b). Risk-based Capital requirements – Buffers above the regulatory minimum. *Bank for International Settlements.* URL *https://www.bis.org/basel_framework/chapter/RBC/30.htm?inforce=20191215&published=20191215*.

Bester, H. (1985). Screening vs. rationing in credit markets with imperfect information. *The American economic review*. 75(4): 850-855.

Bernanke, B. S., and Gertler. M. (1995). Inside the black box: the credit channel of monetary policy transmission. *Journal of Economic Perspectives*. 9(4): 27-48.

Bernanke, B. S., Gertler. M.. and Gilchrist. S. (1999). The financial accelerator in a quantitative business cycle framework. In: Taylor. J.B.. Woodford. M.(Eds.). *Handbook of Macroeconomics*. vol. 1.

Bienert, S. and Brunauer. W. (2007). The mortgage lending value: prospects for development within Europe. Journal of Property Investment & Finance. 25(6): 542-578. https://doi.org/10.1108/14635780710829289.

Boyd, J. H. and Runkle. D. E. (1993). Size and performance of banking firms: Testing the predictions of theory. *Journal of monetary economics*. *31*(1): 47-67.

Braun, J., Burghof. H. P., Langer. J., and Einar Sommervoll. D. (2022). The Volatility of Housing Prices: Do Different Types of Financial Intermediaries Affect Housing Market Cycles Differently? *The Journal of Real Estate Finance and Economics*: 1-32. https://doi.org/10.1007/s11146-022-09907-y.

Braun, J. (2022). Different Business. Same Regulation: Does Homogenous Regulation Succeed in Taming Housing and Financial Market Instability? http://dx.doi.org/10.2139/ssrn.4232021.

Cincotti. S., Raberto. M., and Teglio. A. (2012). Macroprudential policies in an agent-based artificial economy. *Revue de l'OFCE* (5): 205-234.

Collyns, C. and Senhadji. A. (2003). Lending booms. real estate bubbles. and the Asian crisis. *Asset price bubbles: the implication for monetary. regulatory and international policies. MIT Press*. Cambridge and London: 101-25.

Filatova, T., Parker. D. C,. and Van der Veen (2007). Agent-based land markets: heterogeneous agents. land prices and urban land use change. Proceedings of the 4th Conference of the European Social Simulation Association (ESSA'07).

Freund, J., Curry. T., Hirsch. P., and Kelly. T. (1998). Commercial real estate and the banking crises of the 1980s and early 1990s. *History of the eighties: Lessons for the future (an examination of the banking crises of the 1980s and early 1990s)* 1: 137-165.

German Central Bank (2019). The Role of the Real Estate Sector in Financial Stability. URL https://www.bundesbank.de/de/presse/reden/die-rolle-des-immobiliensektors-fuer-die-finanzstabilitaet-814682.

Hakim, S. R. and Haddad, M. (1999). Borrower attributes and the risk of default of conventional mortgages. *Atlantic Economic Journal* 27.2: 210-220. https://doi.org/10.1007/BF02300240.

Hammersland, R. and Jacobsen, D. H. (2008). The financial accelerator: Evidence using a procedure of structural model design (No. 569). Discussion Papers.

Hart, O. (1995). Firms. contracts. and financial structure. *Clarendon press*.

Herring, R. J. and Wachter, S. M. (1999). Real estate booms and banking busts: An international perspective. *Wharton School Center for Financial Institutions*. Working Paper 99-27.

Hilbers, P., Lei. Q., and Zacho, L. (2001). Real estate market developments and financial sector soundness. Working paper 01/129. IMF. http://dx.doi.org/10.2139/ssrn.879898.

International Monetary Fund. Monetary and Capital Markets Department (2011). Macroprudential Policy: An Organizing Framework. *IMF: Washington D.C.* URL https://www.imf.org/external/np/pp/eng/2011/031411.pdf.

Kiyotaki, N. and Moore, J. (1997). Credit cycles. *Journal of political economy*. 105(2): 211-248.

Lambertini, L., Mendicino, C., and Punzi, M. T. (2013). Leaning against boom–bust cycles in credit and housing prices. *Journal of Economic dynamics and Control*. 37(8): 1500-1522.

Lengwiler, Y. and Maringer, D. (2011). Autonomously Interacting Banks (No. 2011/07). WWZ Discussion Paper.

Lepetit. L.. and Strobel. F. (2015). Bank insolvency risk and Z-score measures: A refinement. *Finance Research Letters*. *13*: 214-224.

Liu, G. and Molise, T. (2021). The effectiveness of the counter-cyclical loan-to-value regulation: Generic versus sector-specific rules. *International Review of Economics & Finance*. 72: 270-288.

Lozej, M., Onorante. L., and Rannenberg. A. (2018). Countercyclical capital regulation in a small open economy DSGE model. *Macroeconomic Dynamics:* 1-38.

Manove, M., Padilla, A. J., and Pagano, M. (2001). Collateral versus project screening: A model of lazy banks. *Rand Journal of Economics* (2001): 726-744. https://doi.org/10.2307/2696390.

Niinimäki, J. P. (2009). Does collateral fuel moral hazard in banking? *Journal of Banking & Finance*. 33(3): 514-521. https://doi.org/10.1016/j.jbankfin.2008.09.008.

Popoyan, L., Napoletano, M., and Roventini, A. (2020). Winter is possibly not coming: Mitigating financial instability in an agent-based model with interbank market. *Journal of Economic Dynamics and Control*. *117*. 103937.

Roy, A. D. (1952). Safety first and the holding of assets. *Econometrica* 20: 431-449.

Sommervoll, D. E., Borgersen, T.-A., and Wennemo, T. (2010). Endogenous housing market cycles. *Journal of Banking & Finance* 34(3): 557-567.

Tölö, E., Laakkonen, H., and Kalatie, S. (2018). Evaluating indicators for use in setting the countercyclical capital buffer. *International Journal of Central Banking*. 53rd issue (March 2018).

Yang, T. T., Buist, H., and Megbolugbe, I. F. (1998). An analysis of the ex ante probabilities of mortgage prepayment and default. *Real Estate Economics* 26.4: 651-676. https://doi.org/10.1111/1540-6229.00760.

5. Conclusions and Outlook

In this thesis, I research the impact of financial institutions, financial contracts, and financial regulation on the stability of the housing market. As one distinct characteristic of housing is its heterogeneity, the studies conducted put a special emphasis on diversity concerning the mentioned aspects. Although numerous different types of financial intermediaries exist that offer a variety of financial products, existing research, economists, and regulators mainly treat the financial market as a homogenous group of interacting agents. This may well reflect the reality of some financial systems. In the United Kingdom or Canada, for example, mortgage originations are heavily concentrated and dominated by conventional banks. Other financial systems, in contrast, display a high level of diversity. This holds true for Germany, for example. In addition to privately organized conventional banks, the banking system consists of co-operative banks, public savings banks, and other forms of specialized financial institutions. Given the increasing digitalization of banking and the evolution of FinTechs in the recent past, it can be assumed that the banking landscape is becoming increasingly diverse. Thus, researchers, economists, and regulators may fall short by neglecting the existing diversity in the financial market, especially when dealing with a market that is inherently diverse, such as the housing market.

The first project of this dissertation, which is presented in Chapter 2 of this thesis, investigates the impact of different financial intermediaries on housing market cycles. It contrasts the institutional frameworks and lending practices of two real estate financiers, CBs and BLs, and analyzes the effects of their institutional and behavioral features on housing market stability. We develop a heterogeneous agent-based model that simulates a housing and a financial market on which heterogeneous agents with individual circumstances and deviating expectations about future market conditions interact with each other. Potential home buyers and sellers constitute the housing market and trade residential property. Following the maxim of profit maximization, the two bank types decide whether to finance dwellings or invest in an alternative investment. Within the context of their individual business models, the mortgage lending practices of the two investigated bank types differ. CBs mainly base their lending decision on backward-looking, expectation-driven collateral values. BLs, in contrast, put more emphasis on endogenously created customer information out of relationship lending, using their core product, CSH. On top, the specialized regulation of BLs clearly defines their business model and limits alternative investment opportunities. Incorporating CBs and BLs, as well as conventional mortgages and CSH, we build a diversified financial market and a heterogeneous product landscape to finance a residential property. We set up a theoretical model that replicates real market conditions and conduct computational experiments in three market settings: one in which only CBs operate on the financial market, a second, in which only BLs grant mortgages, and a third, in which CBs and BLs serve the mortgage market jointly. Following this approach, we are able to draw conclusions about the impact of the strategies of the respective institution. The results show that CBs lending decisions affect the housing market procyclical. Prevailing up- or downswings are amplified which increases the risk of major crises and restricts transactions and homeownership. The business activities of BLs counteract these practices. They put less emphasis on collateral values and use information out of relationship lending which leads to less pronounced market cycles, a higher rate of property transactions, and promotes homeownership. The experiments reveal that a mortgage market that consists of CBs and BLs is the most stable. A diversified constitution of the financial market shows the least housing market volatility and maximizes transactions and homeownership. These results argue firmly in favor of a heterogeneous financial market and provide important political implications concerning the composition of the mortgage market.

The second study conducted within this cumulative dissertation extends the research scope of heterogeneity in housing financing by aspects of banking regulation. Since chapter 2 reveals that a diversified financial market that includes different financial institutions, especially ones that detach lending decisions from previous market developments, positively affects housing market stability, the second study investigates whether it is reasonable to imply the same regulatory rules to them. Although business models of bank types vary widely and some are, in addition to national requirements, subject to specialized regulations, the rules of Basel III apply to all internationally active banks. I develop an extended agent-based model that replicates a housing market, a capital market, and a financial market, and test how heterogeneous CAR for different banking institutions impact key stability indicators of these three markets. In this model, next to finance housing investment, banks can trade a standardized share portfolio at the capital market. In the case of both business activities, regulators require them to hold a specified amount of equity. According to previous share price developments and individual market expectations, banks form their own trading strategy. They can either trade voluntarily, expecting future profit, or they exercise fire sales to generate short-term capital in order to offset equity shortfalls and ensure compliance with the CAR of Basel III. Through this, I develop a sufficiently realistic capital market in addition to a housing and a diversified banking market that allow testing the implications of varying CAR for different bank types. As BLs are proven to have stabilizing effects on the housing market in Chapter 2, I vary their CAR holding those of CBs fixed. This study corresponds to chapter 3 of this thesis and finds that CAR generally meet their regulatory target to create solidity in the financial and related markets. If BLs do not have to comply with any CAR, they increase risky business activities which have stability-threatening effects on all of the incorporated markets. The obligation to hold a minimum amount of equity increases banks' loss absorbency capacity and forces BLs to focus on business activities that are aligned with their institutional framework. However, elevating CAR for BLs worsens stability measures and banking soundness. High CAR dampen the business activities of BLs. The associated lower market penetration prevents the stabilizing effects of the institutional type of BLs and their special regulation to occur in the market. Lower CAR, in contrast, promote the business activities of BLs, which again positively affects market conditions and banking soundness. As a result, the study finds that heterogeneous CAR for diversified bank types foster stability in the housing and the capital market and create a resilient banking system.

The third study of this thesis, which is outlined in Chapter 4, addresses a dedicated problem of common banking business: its procyclicality. Especially in housing financing, common banks usually align lending decisions with past developments and form expectations on them. Collateralizing practices reinforce procyclic lending activities and fuel financial accelerator mechanisms. These amplify ongoing market cycles, push housing prices into even higher busts or lower troughs and reinforce spillover effects to related markets. As evidenced in the latest financial crisis, existing banking regulations failed to mitigate ongoing processes. Instead, restrictive regulatory measures had an amplifying procyclical effect. To counteract these mechanisms, Basel III introduced the $CCyB$. This macroprudential tool aims to mitigate the issue of the procyclicality of the previous regulations. If the $CCyB$ is introduced by national authorities, banks shall build an additional capital buffer in times of excessive credit growth that can be released in adverse market conditions. Following this approach, generous lending behavior in favorable market conditions shall be dampened while ensuring sufficient credit supply in recessional times. In an artificial market setting, we evaluate key stability indicators of the housing and the financial market to identify whether this newly designed measure is able to achieve its regulatory objectives. In order to obtain a comprehensive idea about the functionality and the impact of the new macroprudential measure, we introduce four market settings: one, in which market conditions evolve endogenously in the absence of any shocks, and three shock scenarios where the markets face a financial shock, a positive housing demand shock, or a housing bubble. Each of those incorporates an exogenous shock that directly impacts endogenous market activity. In those experimental environments, we compare market conditions and the effectiveness of the regulatory rule in fostering financial and macroeconomic stability. Market stability indicators reveal that the $CCyB$ performs well in all of the tested environments. Introducing an additional component of CAR in a countercyclical manner has a restraining effect on procyclicality. It increases the cost of mortgage lending which induces banks to increase mortgage interest rates. This, in turn, dampens credit demand. Releasing the $CCyB$ in recessional times has the opposite effect. As banks need to build a more profound equity base under a $CAR + CCyB$-regime, the $CCyB$ also positively affects the resilience of the financial sector. Although the macroprudential measure is effective in moderating the amplifying effects of procyclic mortgage lending, it is not able to prevent crises. All of the shocks tested led to sharp price outbreaks. The shock scenarios further show that the effectiveness of the $CCyB$ depends on the magnitude of the shock and on how much buffer has been built up by banks in the previous periods. Thus, the timing of its implementation is crucial for achieving the desired effects. Introducing it in recessional times might even affect market conditions oppositely and fuel procyclicality. These findings provide useful insights for regulatory authorities about the effectiveness of one of its new macroprudential tools, the $CCyB$, and give implications about its introduction.

The three studies conducted for this dissertation contribute to the overall topic "*Institutions, Contracts, and Regulation of Housing Financing*" as follows: The first project assesses the aspect of heterogeneous financial institutions and products. The second one also incorporates the dimension of diverse financial intermediaries and extends this dimension by comparing homogenous and heterogeneous regulatory requirements. The third study focuses on one regulatory measure newly introduced by the Basel III Accords that aims to address the dedicated problems of housing financing: its procyclicality and elevated financial accelerator mechanisms.

With its three main parts, my thesis generates new insights into the relationship between financial and housing markets. Incorporating the special features of the housing market, they provide evidence of the advantageousness of a diversified financial market and the existence of specialized financial institutions and heterogeneous financial products. Furthermore, the main results argue in favor of a heterogeneous regulation and provide information about the effectiveness of a currently discussed regulatory component, the $CCyB$. Hereby, this dissertation contributes to existing literature and has important implications for the design of financial markets and regulatory capital requirements in order to stabilize one of the most important markets of an economy, the housing market.

The topics I have investigated in my studies offer some scope for further research. As one distinct characteristic of housing is its heterogeneity, one could assume that the financial system should be heterogeneous, too, to provide adequate financing to home seekers. As evidenced in Chapter 2, this holds true for a financial market consisting of CBs and BLs. As numerous types of other financial intermediaries exist, this research could be extended to test the impact of institutions others than CBs and BLs on housing market cycles. However, the market setting should be chosen cautiously. Analyzing more than two bank types simultaneously heavily increases the complexity of the model and makes effects difficult to assign.

The results presented in Chapter 3 suggest that CAR should be aligned with the institutional frameworks of bank types and their business models. This research can be extended in two ways. First, other regulatory measures than CAR can be tested. Furthermore, it may be interesting to test different policy options, especially when their introduction is currently being discussed. An aspect that is also not sufficiently researched yet is the costs associated with implementing heterogeneous CAR. Setting up, introducing, and monitoring compliance with regulatory requirements might be costly not only for financial institutions but also for an entire economy. Too strict and complex regulations may rise incentives to evade regulations and cause overall welfare losses. This leaves room for further research.

Chapter 4 provides insights into the effectiveness of the $CCyB$. The findings show that the macroprudential tool fulfills its regulatory purpose to counteract procyclicality in mortgage lending and thus alleviate financial accelerator mechanisms. This holds true for the four tested market scenarios: an undisturbed market that is not hit by any shocks, an exogenous financial shock scenario, a positive housing demand shock scenario, and a housing bubble. To get more profound knowledge, other market scenarios could be tested on top.