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 are obliged to meet type-specific capital adequacy requirements. The results point out that capital adequacy requirements are, in principle, effective in stabilizing the banking sector. However, the most stable housing and share prices and the most solid banking sector are achieved 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 for financial intermediaries with different institutional settings.

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

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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. 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). Nevertheless, the Basel III accords apply similarly to every kind of bank.

In this paper, we develop a heterogeneous agent-based model 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. 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 vary widely.

The interaction of potential home buyers, sellers and financial institutions create 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. The aim of this paper is to examine whether banking regulation is more effective and 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 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 are subject 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).[2] 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.

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 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 regulatory requirements are superior in terms of stable and resilient market conditions.

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

The remainder of this paper is organized as follows. Section 2 introduces the specialized institutions of building and loan associations. Section 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 4 after which section 5 concludes.

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 various 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 and to overcome capital-market imperfections. 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. Driven by the aim to overcome loan shortage and capital-market imperfections, they attracted members to step together and save collectively to afford residential property.[3]

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, their market share in housing finance significantly decreased until 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 not only constitute an essential real estate financier in Germany but also in other European countries. In

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

Austria, almost every second citizen uses CSH which equals a market penetration of 43%. The Czech Republic records a market penetration of 33%, Slovakia 16%, and Hungary 8%. Smaller but stable rates can be observed in Croatia and Romania.[4] Also in Luxembourg, BLs enjoy high popularity. Similar concepts of BLs exist in UK and Ireland and even in Australia and New Zealand.[5]

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. This grants potential borrowers a high degree of predictability and independence of market developments. 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.[6] In order to nevertheless ensure a sufficient degree of customer protection, BLs were subject to legal requirements nearly directly after their foundation. In Germany, in 1925, they were governed by the general law of deposit banking (*Reichsgesetz über Depot- und Depositengeschäft*) after which they were subject to the statutory provisions for insurance companies (*Versicherungs- und Bausparkassenaufsichtsgesetz*). Since the establishment of the German Banking Act (*Kreditwesengesetz*) in 1961, BLs have been regulated by this legislation and have been overseen by the

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

[5] 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/.

[6] 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.

Federal Financial Supervisory Authority. These laws, however, did not appropriately address the unique characteristics of BLs. Thus, the Building Society Act (*Bausparkassengesetz*) and the Building Society Decree (*Bausparkassenverordnung*) were drawn up.[7] The early and sufficiently detailed legal regulation of BLs reflects the need for appropriate regulation of these specialized financial intermediaries. This, however, was not only due to customer protection but also to ensure that these institutions are able to fulfill their specialized business purpose of granting residential loans and to achieve 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.[8]

Similar to conventional banks, BLs are usually publicly[9] 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 convergence 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 is to be explored within this research.

[7] A detailed description of the evolution of the German regulatory requirements of BLs is provided by Schäfer, Cirpka, and Zehnder, 1999.

[8] The type and the amount of state subsidies for CSH varies between different countries.

[9] 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. The Model

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 investigating endogenously created market conditions.

Due to the close interconnectedness of the housing and the mortgage market, changes of 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.

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.

3.2.1.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 $\alpha \sim N(0,1)$. Potential buyers have a disposal period income of Y_t which is fully spent in each period. Their 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 $E \sim U(0, 0.35)$[10] 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.[11]

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:

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

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 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: $Bid_b = min\left(P_{expected,b,t}, P_{res,b,t}\right)$.

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:

$$P_{t-1} + \frac{(r_f AI)}{(1 + r_f)} \geq \frac{(1 + e_s) * (P_{t-1} + \Delta P_{t-1})}{\left(1 + r_f\right)}.\text{[12]} \qquad (3)$$

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.

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

[11] 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 $r = r_t + r_p$.

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

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. 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:

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

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.

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 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.

3.2.4. 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 $\rho_{t-2} = \left(\frac{P_{t-2}+\Delta P_{t-2}}{P_{t-2}}\right)$.[13] The number of newly constructed houses accordingly is:

[13] 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}.

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

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. 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 two. 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 1. All investments or disinvestments are accounted for in the respective balance sheet variables. They vary every period and are the result of individual expectations and agent interaction.[14] 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.

[14] Funding opportunities are not specifically modelled. Instead, the amount of debt is calculated as the difference of total assets and equity and develops passively.

Table 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

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).[15] 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).[16] The framework requests a static minimum level of CAR which is:

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

The banks' RWA of this model are either mortgage loans or a risky market portfolio of financial assets.[17] 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

[15] 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.

[16] 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 7 in the appendix. For detailed information see BCBS (2017b).

[17] The market portfolio is assumed to consist out of shares. Therefore, the BCBS risk weight of 100% is assigned.

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 simulation 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.[18] The $CCyB$, denoted by κ_t^m, varies between $0 \leq \kappa_t^m \leq 2.5\%$ and is calculated as:

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

[18] 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.[19] 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 $4.5\% \leq \bar{\epsilon_3} + \kappa_t^m \leq 7.0\%$.

3.3.2.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,[20] c_t the opportunity costs of lending due to the capital requirements of Basel III, and r_{AI} the expected return of AI.

Solving (7) 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:

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

If banks engage in risky business, Basel III requires them to hold a specified amount of equity (see section 3.3.1). The retained equity cannot be invested alternatively, and, thus, causes opportunity costs.[21] These costs are given by:

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

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

[20] 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.

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

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.[22] The opportunity costs lower the return out of mortgage lending. The effective mortgage return r_{eff} of a mortgage T is:

$$r_{T,eff} = \left(r_d + \left(\frac{r_{AI}-r_d}{q}\right)\right) - \left(r_{wT} * \left(\frac{\emptyset r_t + \emptyset r_{AI}}{2}\right)\right).^{23} \tag{12}$$

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 $\gamma = \left(\frac{M-E}{Y}\right)$ 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:

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

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.[24] 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.

[22] 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.

[23] 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.

[24] 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).

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 $C3_{BL}\colon T_{max,i,3}=0$ 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. 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 $\eta_{t-1}\sim N\left(0,\sigma_\eta^2\right)$ holds. The annual volatility of f_t^V is set to 19,2% and its drift to 12,5%.[25]

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 period as the mean of all transactions during one period $p_{M,t}=\left(\frac{1}{N_{transactions}}\right)\sum_{p=1}^{N}P_{bid},P_{ask}$. 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 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 $e_{CB,AI/BL,AI}\sim N\left(0,\sigma_{e_{CB/BL}}^2\right)$:

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

The expected fundamental value of an agent m is:

$$f_{exp,m}^V=f_{t_{-1}}^V+\mu+s_{m,t}. \tag{19}$$

As for mortgage lending, Basel III rules require banks to hold equity when investing in the risky market portfolio. The tied-up equity al causes opportunity costs which must be considered to determine the effective

[25] 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.

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:

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

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

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: voluntarily 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 $f_{exp}^{V} > p_{M,t_{-1}}$, the market portfolio is undervalued and the agent decides to buy. If the opposite is the case and $f_{exp}^{V} < p_{M,t_{-1}}$, 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:

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

The desire to buy or sell shares also depends on the current state of the balance sheet and the free equity available to fulfill regulatory requirements of each individual bank. If a bank fulfills 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.[26] 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.[27]

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*).[28]

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, we account for the intensity of price movements in terms of the standard deviation of house and share prices to measure market (in-)stability. Furthermore, we address prevailing mortgage and share interest rates, 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. 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

[26] 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.

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

[28] 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.

Strobel, 2015) and is calculated as $Z_{i,t} = \frac{ROA_{i,t}+(\frac{E}{A})}{\sigma(ROA_{i,t})}$.[29] 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.

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 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.

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.[30] 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.[31]

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 diversified market portfolio which has an initial rate of return of $r_{AI} = 0.084$, a past fundamental value of

[29] 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 $\ln(Z_{i,t}) = \ln(\frac{ROA_{i,t}+(\frac{E}{A})}{\sigma(ROA_{i,t})})$.

[30] 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.

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

$f_{t-1}^{v} = 1008$, 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.[32]

Table 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

[32] 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.

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 3.3.1). 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 those 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.

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 dynamics of the house prices and the share prices are displayed in Figure 1. Figure 2 shows the mortgage interest rates and the share interest rates that develop through interactions between participants for both market constitutions. Table 3 provides the statistical properties of the evaluated market settings. The values reported are those of single simulation runs. To ensure that those are representative and consistent, robustness checks have been performed which are provided in the appendix.[33]

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.

[33] Small deviations may occur due to different simulation scenarios.

The share price fluctuations are also more distinct in CB markets. 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. Upturns are flattened when house prices begin to rise again, inducing a turnaround in the share market. These agent interactions lead to comparably distinct share price movements. As can be seen in Figure 1, share price cycles are way 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.[34] 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 similar in both market settings. The development of the mortgage and share interest rate is illustrated in Figure 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.[35] 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 also displayed in Figure 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' concentrated business model is more solid than this of CBs and more persistent in times of crises. Furthermore, the Z-

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[34] 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.

[35] 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).

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.

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 that finance homeownership and trade shares, 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 such as Austria, the Czech Republic, Slovakia, Luxembourg, and Hungary. For the following evaluations in section 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). 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.

Table 3 Statistical market measures of homogeneously regulated financial intermediaries[36]

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	1996,000	1925,000	2352,000
No. of Trades	sum	292,000	102,000	377,000
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

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 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. Figure 2 depicts the interest rates 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

[36] 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.

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.

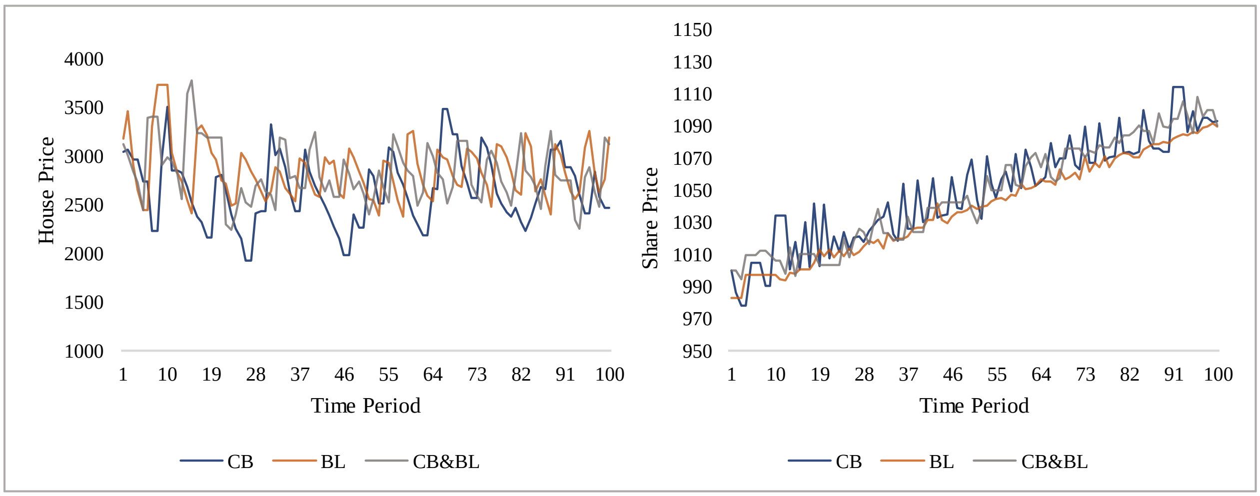

Fig. 1 House and share price dynamics in an undiversified and a diversified homogenously regulated simulation scenario[37]

[37] Note: The higher fluctuations in house prices than in share prices are due to the lack of diversification in investors and shares. 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.

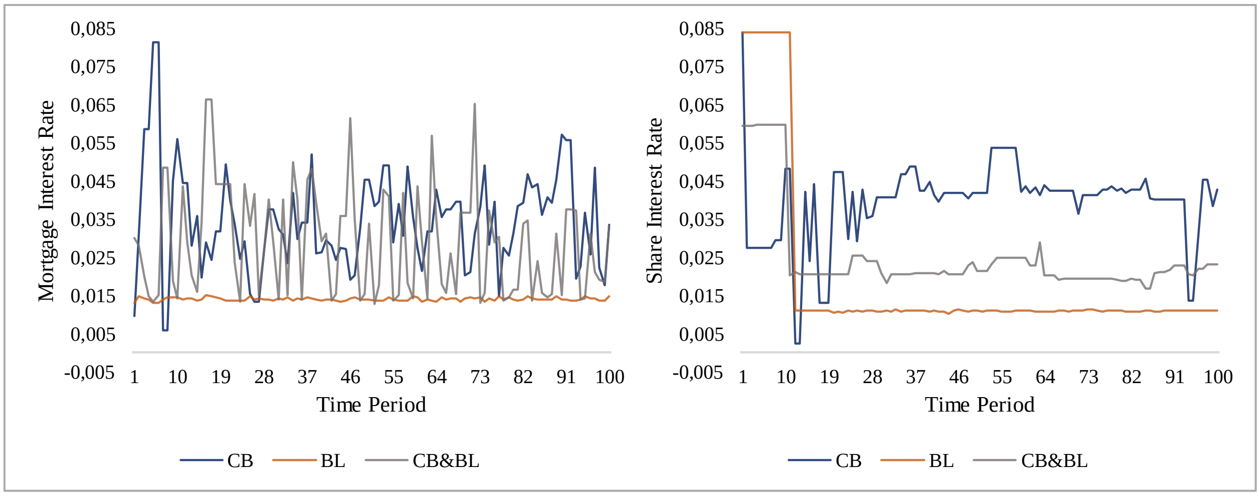

Fig. 2 Mortgage and share interest rate dynamics in an undiversified and a diversified homogenously regulated simulation scenario

The Z-score, which provides a baseline assessment of banking stability, 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. 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.

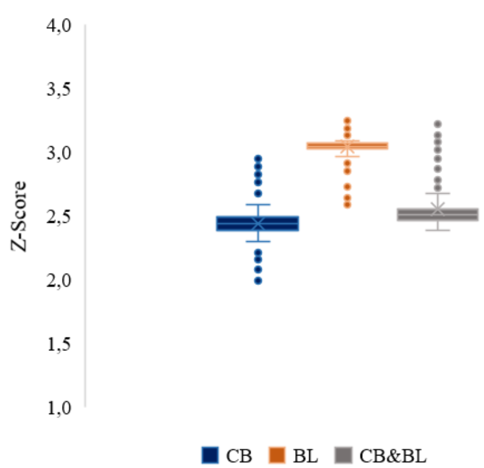

Fig. 3 Z-Scores of an undiversified and a diversified homogenously regulated simulation scenario

4.4. Simulation Results of a Diversified and Heterogeneously Regulated Market

Although business models, lending standards, and individual constitutional requirements vary across banking landscapes, regulatory compliance according to Basel III is mandatory for all institutional bank types. 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 4 summarizes the statistical measures of the investigated 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 in which both bank types have to comply with the prevailing Basel III CAR. Exempting BLs from holding equity when risky business such as mortgage lending or share trading is conducted negates housing market stability. Also, share prices vary more strongly in the 0% CAR scenario for BLs. 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 that conduct risky business 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) provides an indication in favor of the special regulation of BLs. The following experimental scenarios provide further clarification.

Table 4 Statistical market measures of homogeneously 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	0,012	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	2563,000	2470,000	2393,000	2352,000	2319,000	2305,000
No. of Trades	sum	559,000	418,000	399,000	377,000	368,000	266,000
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

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. Price fluctuations decrease at the lowest level compared to the other CAR scenarios. 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 and does not exist in reality. 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 further 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 not only does CAR have stabilizing effects on the housing market, the share market, and banking solidity. It 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 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 also be seen in Figure 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 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 by an imposed CAR of 6% for BLs. 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 on 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 as well as the favorable effects of a diversified financial market 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. The same holds true for the mortgage market on which market shares must be relinquished. 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 4.2 (see Table 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, however, do also affect the mortgage lending business. As the risk weights for mortgages are assigned to the individual LTV of potential borrowers, BLs will 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, the criteria for mortgage granting get very similar to those of CBs. 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 in the 8% CAR scenario. 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, first of all, 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 show 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 but at individual levels. 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.[38] This can also be seen in Figure 4 and 5 which show the house and share price movements 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 and share interest rates which are depicted in Figure 6 and Figure 7. Figure 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 comparably high Z-scores of underscoring outliers.

[38] 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.

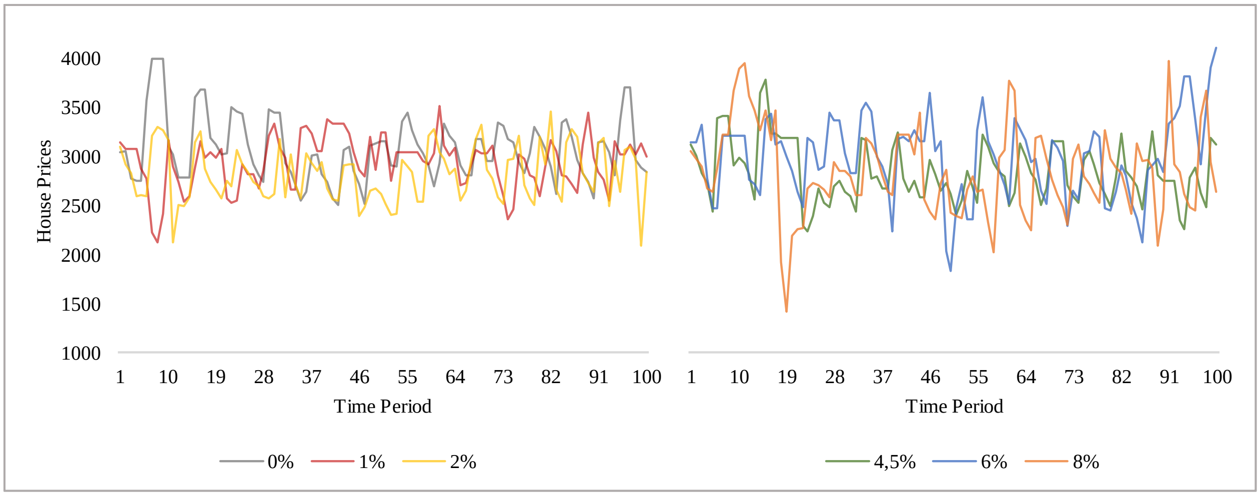

Fig. 4 House price dynamics in heterogeneously regulated simulation scenarios

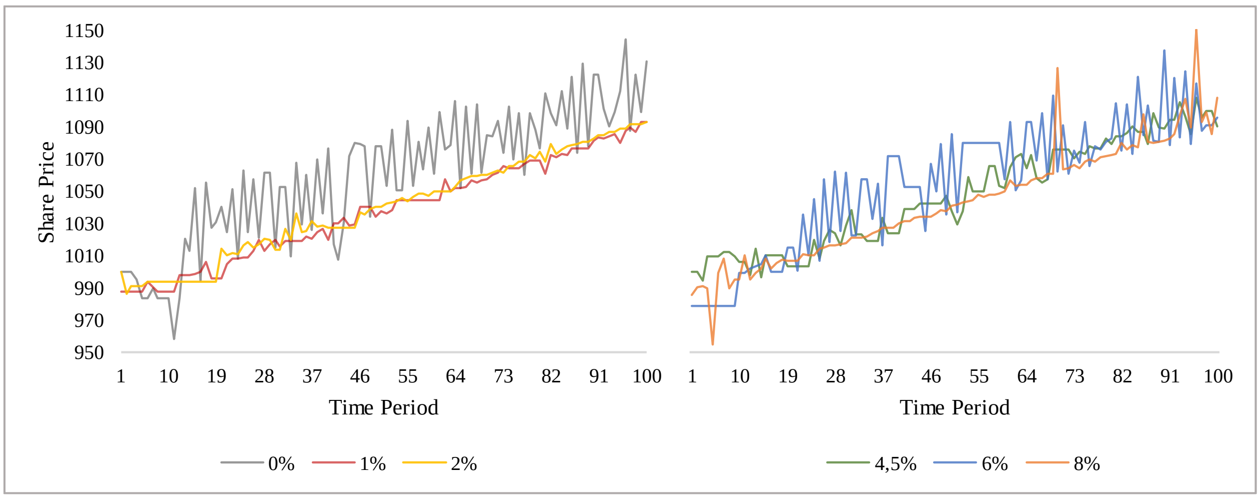

Fig. 5 Share price dynamics in heterogeneously regulated simulation scenarios

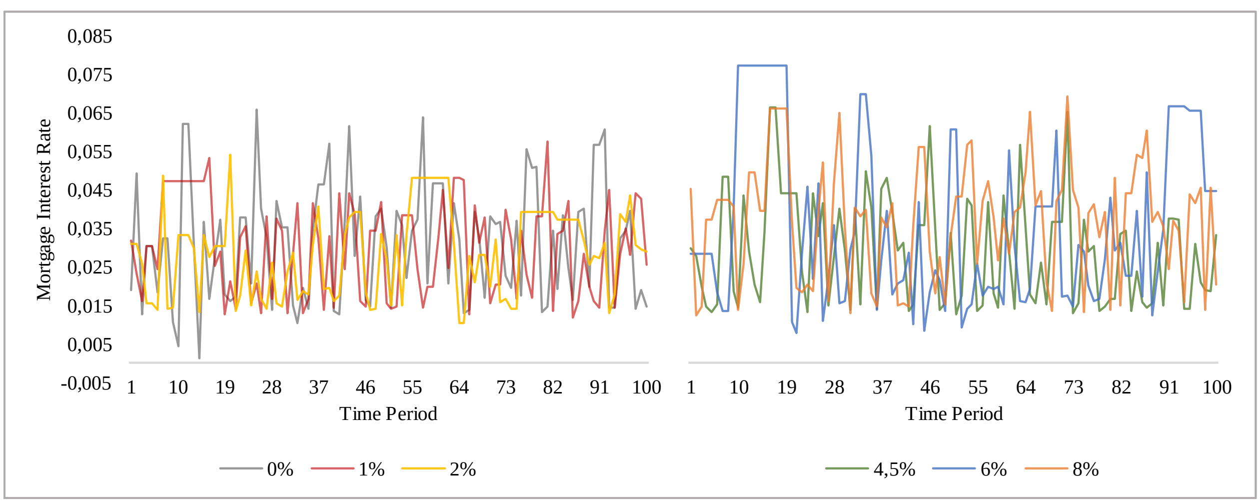

Fig. 6 Mortgage interest rate dynamics in heterogeneously regulated simulation scenarios

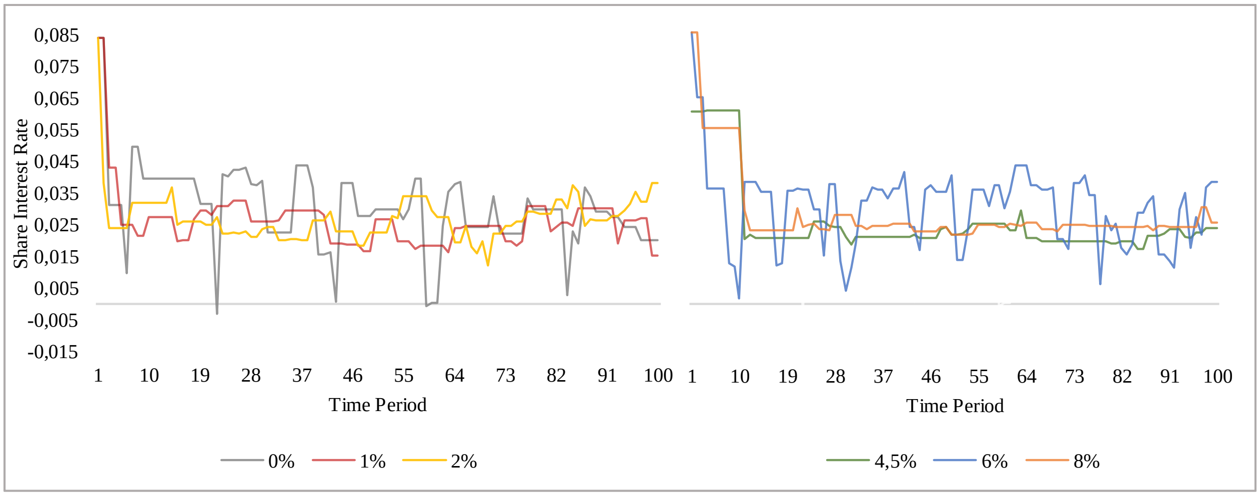

Fig. 7 Share interest rate dynamics in heterogeneously regulated simulation scenarios

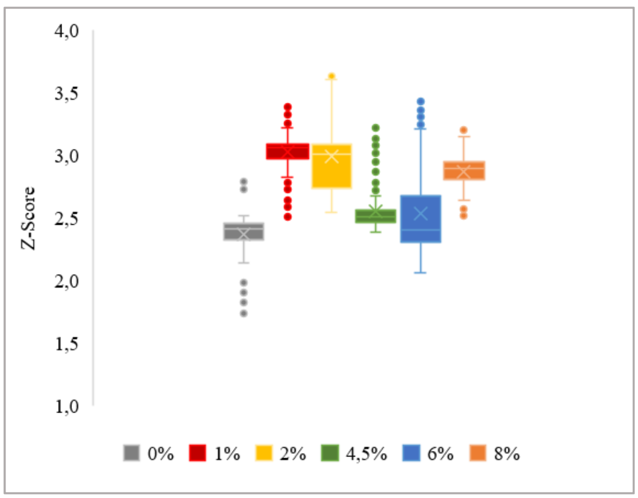

Fig. 8 Z-Scores in heterogeneously regulated simulation scenarios

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 regulatory 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. 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' credit worthiness. 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 have 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. 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. Heterogeneous CAR shape the market structures and help to create the most stable market conditions, endogenously created by mutual feedback effects of interacting economic agents. To achieve this, CAR must be aligned to the individual business models of institutions to be the most effective.

Given the negative impacts of volatile housing and financial markets, these findings 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.

Appendix

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 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 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 4.2, 4.3 and 4.4. Table 7 summarizes the requested risk weights of LTV levels according to the BCBS (BCBS, 2017b).

Table 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	2005,000	1880,000	2223,000
		(345,682)	(83,276)	(479,173)
No. of Trades	sum	435,000	213,000	427,000
		(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 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	2712,220	2551,900	2519,490	2323,830	2027,600	1921,380
		(597,876)	(496,545)	(548,811)	(479,173)	(646,721)	(453,058)
No. of Trades	sum	618,000	416,000	405,000	427,000	330,000	279,000
		(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 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%

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