

Assessing Systemic Risk: An Analysis of the German Banking Sector

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Abstract

This paper examines the impact of heterogeneity on the assessment of systemic risk in the context of the German banking sector. Precisely, it is questioned whether currently employed systemic risk indicators are able to account for banks' heterogeneity and to signal systemic risk reliably regardless of different bank types' individual characteristics. For the assessment, currently employed systemic risk indicators are applied to bank-type-specific data for six different bank types from 1990 until 2018 and benchmarked against crises that occurred during the assessment period. The findings suggest that the indicators are indeed able to account for the German banking sector's heterogeneity, providing insight into different bank types' behavior. Moreover, the indicators allow for the identification of individual bank types' role in the accumulation of systemic risk. Yet, they are only partially able to signal crises correctly and behave more like thermometers than barometers of risk. Lastly, structural features of the German banking sector amplify the risk of individual institutions and thus their contribution to systemic risk at large.

1. Introduction

Since 2011, the European Systemic Risk Board (ESRB) has presided over macroprudential supervision in the euro area. Accordingly, assessment methods implemented to detect systemic risk apply a common methodology across different banking systems and examine financial stability in the aggregate, on a country or Eurozone basis respectively. This top-down approach in financial supervision arguably does not only neglect national differences, but also trends underlying aggregate data which derive from heterogeneity on the meso level. Therefore, this paper investigates whether currently employed risk indicators, such as those of the ESRB risk dashboard, are appropriate for assessing systemic risk in heterogeneous contexts such as the German banking sector with its various institutional types, for instance. “Appropriateness” implies that indicators are able to reliably identify past periods of systemic risk on the meso level, on the one hand. On the other hand, “appropriateness” suggests that indicators are able to account for the German banking sector’s heterogeneity, providing insight into bank types’ behavior and its implications for systemic risk. Since it is highly likely that heterogeneous signals for systemic risk and banks’ behavior emerge when indicators are applied to bank-type-specific data, the question arises of whether reoccurring clusters, corresponding to institutional type and size, manifest. May stabilizing or destabilizing forces, as well as dynamics driving the aggregate trend, be detected and associated with specific bank types?

Besides testing the ESRB risk dashboard’s indicators, the following assessment primarily intends to shed light onto the development of systemic risk in the German banking sector. Generally, studies on the German banking sector’s stability are scarce, which coincides the conventional wisdom that the German financial system is highly stable. The 2008/09 financial crisis sparked some interest in the topic (e.g. Black et al., 2016; Dietrich & Vollmer, 2012; Dovern et al., 2008). Yet, current systemic risk assessments are mainly confined to those routinely conducted by regulators. European regulators focus either on the aggregate, macro level, as mentioned above, or concentrate on micro supervision. Conversely, the German Bundesbank takes into account the banking sector’s heterogeneity, though its annual financial stability reports do not systematically study and account for heterogeneity among banks alongside its implications for systemic risk. Explicit assessments of the questions outlined above remain outstanding, although experts on the German financial system seem well aware of potential divergences among bank types with regard to systemic risk contributions.

To evaluate the appropriateness of the official systemic risk indicators and the effects of the German banking sector' heterogeneity on systemic risk developments, the following assessment applies selected indicators to bank-type-specific data, distinguished by institutional type and size, for the period from 1990 until 2018¹. Past periods during which systemic risk materialized in Germany provide a benchmark for the indicators' ability to detect systemic risk. Simultaneously, the assessment investigates whether bank-type-specific behavior and the according risk properties emerge alongside how these might interact with sectoral particularities.

The remainder of the paper is structured as follows: Chapter two summarizes the concept of systemic risk and how it is assessed. Chapter three outlines the structure of the German banking sector. Chapter four compiles the indicators for the subsequent assessment and reviews them. In doing so, data availability and its effects on the selection process are discussed. Thereafter, chapter five applies the selected indicators to the data and assesses the results. Finally, chapter six summarizes and concludes.

2. Systemic risk

2.1. The concept of systemic risk

The concept of systemic risk emerged as synonym for financial vulnerability or fragility² and derives from academics' and regulators' desire to quantify financial (in)stability. Generally, financial (in)stability is inherently difficult to define (Bisias et al., 2012) because of its multi-dimensional nature. Typically, it describes a condition under which the financial sector is able to function properly and to support economic growth and welfare. Moreover, financial stability implies the financial system's ability to withstand endogenous or exogenous disturbances. The effect of distortions depends on a financial system's vulnerability (Adrian et al., 2015), whereby the distinction between a vulnerability and shock is sometimes subtle (Adrian et al., 2015). Consequently, one can think of financial (in)stability as evolving in a continuum or range (Houben et al., 2004; Schinasi, 2004). Yet "the range of what is normal is broad and multi-dimensional" (Schinasi, 2004, p.7) and does not imply peak performance.

Systemic risk and financial instability respectively may arise exogenously or endogenously³. A systemic perspective is, however, always necessary as financial institutions, infrastructures, and markets are tightly connected and linked to the macroeconomy as well as the

¹ The assessment is confined to reunified Germany.

² Hereafter, the terms will be used interchangeably.

³ See ECB (2005, p.132) for an overview on exogenous and endogenous sources of risk and the latter's sub-groups.

monetary system. Atomistic behavior, in collective, gradually undermines systemic stability (Borio & Drehmann, 2008) by building up financial imbalances – called the endogenous nature of systemic risk (Borio, 2011; Hannoun, 2010). At the same time, endogenously developing interconnections and networks give way to systemic risk by establishing contagion channels. Against this background, Crockett (2000) assesses that, although shocks to the financial system may be exogenous, it is the system’s endogenous forces that will eventually lead to financial distress.

The most common framework to explain the emergence of systemic risk and financial instability respectively is the “financial cycle” and the associated “paradox of financial instability” (see for example Borio, 2011 or Hannoun, 2010).^{4,5} A financial cycle characterizes, in an analogy of the business cycle, the up- and downswing or boom and bust (Borio, 2011; Hannoun, 2010) of a financial system. Hence, pro-cyclicality is an inherent feature of the financial cycle. As for the business cycle, a financial system operates well and increasingly extends its activities during the upswing. Yet, this is also the phase during which imbalances establish and systemic risk accumulates. With the outbreak of financial distress, the system experiences a downswing.⁶ Therefore, financial cycles emerge from self-reinforcing fluctuations in risk perception and attitude, financing constraints, and asset prices that tend to amplify real business fluctuations (Arnold et al., 2012). Hence real and financial fragility mutually reinforce one another (Dow, 2011), although financial cycles tend to have a lower frequency than business cycles⁷ (Schoenmaker & Wiert, 2016).

2.2. Assessing systemic risk

Despite abstracting to the concept of systemic risk, the financial system remains complex, evolving, and adaptive (Bisias et al., 2012). Against this background, capturing systemic risk requires more than one measure (Bisias et al., 2012; Borio, 2011), multiple perspectives, and a continuous evaluation (Bisias et al., 2012). Three facts further complicate the supervision of systemic risk: First, the paradox of financial instability lulls supervisors into a false sense of security, making them underestimate the underlying fragility of the system (Borio, 2011). Second, financial innovation is endemic to financial markets and grows in tandem with the system’s complexity (Bisias et al., 2012). Finally, systemic risk supervision practices rely heavily on

⁴ The concept derives from Hyman Minsky’s financial instability hypothesis and Charles P. Kindleberger’s succeeding work.

⁵ The paradox of financial instability says that financial vulnerability is at its peak when the system appears the most stable (Borio, 2011).

⁶ During a recovery phase, imbalances reduce and stability is restored so that, eventually, a new upswing begins.

⁷ Scholars are, however, divided with regard to their actual length (Schoenmaker & Wiert, 2016).

experience of past financial distress. In that sense, it might prove difficult for regulators to foresee the evolution of systemic risk.

Generally, supervisors assess systemic risk by two dimensions: the time dimension, which reflects the evolution of risk over time, and the cross-sectional dimension, which provides insight into the distribution of risk at one point in time (Galati & Moessner, 2013). Both dimensions evolve, to a large extent, in conjunction with one another and cannot be separated strictly (Frait & Komárková, 2010/2011). Additionally, network analysis is used as a complement to the cross-sectional dimension to support the identification of key actors and of propagation channels.

The assessment of the time dimension aims to identify a system's financial cycle, which is inherently linked to endogenous factors of risk (Borio, 2003), and thus driven by procyclicality (Borio, 2011). The main tool for a time dimension assessment is the usage of lead indicators. Lead indicators relate to variables which have been found to drive and/or be closely tied to the financial cycle, such as credit and property prices (Schoenmaker & Wierds, 2016). Yet, according to the paradox of instability, market volatility, risk, and leverage in market prices seem unusually low at the high of the cycle (Borio, 2011). Therefore, Borio (2011) concludes that market-based measures are not well suited as lead indicators. Generally, Borio (2011) urges caution as lead, i.e. real-time indicators, are rather thermometers than barometers due to their contemporaneous rather than truly leading nature.

The cross-sectional dimension seeks to assess institutions' individual contribution to systemic risk, meaning default probabilities alongside common exposures and correlations. Essentially, the cross-sectional dimension assesses the implication of interconnectedness by "exploit[ing] the analogy between the financial system and a portfolio of securities" (Borio, 2011, p.9). For the assessment, a range of techniques is employed which take macroeconomic dynamics as exogenous (Galati & Moessner, 2013). They rely heavily on market prices which are combined with balance sheet information⁸ (Borio, 2011). All techniques focus on the risks emitted or incurred by individual institutions and aim to uncover links between distressed financial institutions and the financial distress of the system as a whole (Adrian et al., 2015). The Conditional Value at Risk (CoVar), the Marginal Expected Shortfall (MES), the Distress Insurance Premium (DIP), and the systemic risk indicator called SRISK are among the most popular measures in this category.⁹ The identification of systemically important financial institutions

⁸ Note that balance sheet data unites the time and cross-sectional dimension. It displays positions' evolution over time as well as the distribution of and exposure to certain risks deriving from positions.

⁹ See, for example, Benoit et al. (2013) for an overview on these indicators.

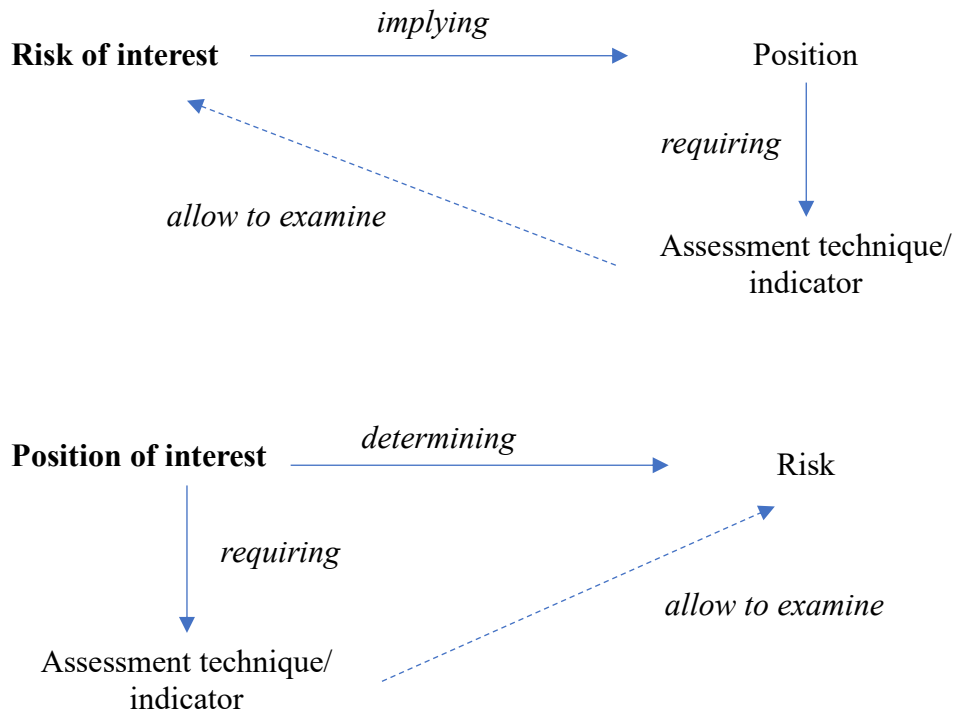
(SIFIs) is also a key feature of a cross-sectional assessment, which in turn feeds into network analyses. Furthermore, another essential technique of a cross-sectional analysis is stress testing. Stress tests either estimate the expected capital shortfall of an institution or of specific sectors under adverse, specifically defined scenarios or assess the dynamics that would lead to a specific outcome (Adrian et al., 2015; Frait & Komárková, 2010/2011).¹⁰

Finally, network analysis constitutes a third way to assess systemic risk. Network analysis addresses the potential for contagion and spillovers deriving from direct and indirect linkages between market participants (Frait & Komárková, 2010/2011). The goal is to map the direct and indirect interlinkages and to identify key nodes as well as clusters (Adrian et al., 2015) to support the mapping of the propagation of distress by simulating the amplification of shocks and behavior of institutions (Adrian et al., 2015). Network analysis thus extends systemic risk's cross-sectional dimension and emphasizes that, apart from being too big to fail, institutions may be too interconnected to fail.

Grasping systemic risk in terms of its time and cross-sectional dimension alongside network properties thus provides a broad methodological scope according to which specific changes in positions, the evolution of specific risks, and associated assessment techniques can be clustered. As alluded, certain risks derive from the financial cycle's evolution and are closely associated with specific cross-sectional/network properties at one point in time. In this sense, specific positions determine individual risks and certain risks imply specific positions. To derive suitable assessment techniques or indicators, one may thus either choose to assess a position, object, or item which then indicates a specific risk or one may choose to study a certain risk which then implies the assessment of (a) certain position(s) (Figure 1). Potential assessment positions comprise, for example, balance sheet positions, funding structures, or networks and their nodes. In turn, individual risks include market, infrastructure, and institutional or counterparty risk. The IMF, for example, employs the former approach (see for example IMF, 2006) and the ESRB risk dashboard, the latter.

¹⁰ Due to the limited scope, this paper will not elaborate on criticism voiced with regard to the adequacy of stress tests. For further information see, for example, Arnold et al. (2012) or Galati & Moessner (2013).

Figure 1: Assessing systemic risk



Source: Author's own presentation

The ultimate goal of assessing systemic risk is thus to obtain early warning signals and knowledge on the propagation of disruptions. Still, the ex-ante measurement of systemic risk, as opposed to ex-post measurement, remains difficult. Financial distress is characterized by unpredictable non-linearities (ECB, 2005) and has the potential for long lags between disturbances and the materialization of risk (Borio, 2011). In this regard, the assessment of financial (in)stability is subject to greater uncertainty than other assessments (ECB, 2005). Furthermore, quantifying the multidimensional and uncertain nature of systemic risk is difficult because “[t]here will always be noise and conflicting signals” (Bisias et al., 2012, p.264). Hence systemic risk “cannot be summarized in a single quantitative indicator” (Schinasi, 2004, p.11) and it is important to acknowledge that individual risks do not simply sum up to aggregate risk (Laeven et al., 2014). Also, for most indicators, no absolute benchmarks exist (Geršl & Heřmánek, 2006), making their assessment subject to comparative analyses and experience. In this respect, a large part of systemic risk cannot be grasped properly, not to mention be quantified.

3. The Structure of the German Banking Sector

The following chapter introduces the reader to the German banking system, outlining the system's basic structure and identifying key characteristics.

3.1 The three-pillar system

The German financial system is traditionally referred to as bank-based (Hüfner, 2010; Levine, 2005).¹¹ The banking sector itself exhibits a three-pillar structure¹², which was established more than 150 years ago. Banks are distinct by their ownership structure and business orientation (IMF, 2011). Today, most institutions are, however, universal banks. The traditional pillars divide between private commercial banks, public savings banks, and cooperative banks. Each pillar exhibits institutions of various sizes, which affects their scope of action and thus risk profile. According to the IMF (2016a), the banking sector is domestically oriented. Still some banks are heavily involved in activities abroad via foreign branches and subsidiaries. Likewise, branches of foreign banks operate in Germany and have increasingly expanded their activities. Due to the limited scope of this paper, however, the foreign bank branches which operate in Germany or the operations of German banks abroad will not be explicitly examined.¹³

Private commercial banks constitute the first pillar. These banks are owned by private shareholders (IMF, 2016b) and usually cover the “full range of banking services” (IMF, 2016b, p.8). For the analysis, this paper distinguishes between “big private banks”, i.e. large, internationally operating private commercial banks, and “regional private banks”, i.e. small, regionally operating banks.¹⁴ The most popular major German banks are Deutsche Bank and Commerzbank¹⁵. Yet, Deutsche Bank's balance sheet was more than three times as large as Commerzbank's balance sheet (die bank, 2018), making Deutsche Bank's activities and results weigh heavily on the aggregate statistics of (large) private banks.

Public savings banks (“Sparkassen”) constitute the system's second pillar. Operating according to the regional principle and in the framework of regional associations, savings banks are “incorporated as institutions under public law” (IMF, 2016b, p.12). As banks to their regional authority (Detzer et al., 2017) and to promote their region's development (IMF, 2016b), savings banks are not required to maximize profits. Generally, one can distinguish between three types

¹¹ Up until today, bank assets constitute more than 60% of the financial sector's total assets (IMF, 2016a).

¹² Reducing the German banking sector to three pillars falls somewhat short of reality. The Bundesbank, for instance, also distinguishes, e.g., mortgage banks or building and loan associations as individual type.

¹³ German banks that are majority-owned by foreigners (reported as “banks majority-owned by foreign banks”) are included in the by-bank-type-consolidated statistics. These banks, although Bundesbank statistics provide a memo-item on foreign banks, cannot be excluded from the data categories used for this work.

¹⁴ See the appendix for information on bank types' name in this work and the corresponding names in the Bundesbank database. For information on banks in Germany see Bundesbank (2019a).

¹⁵ Commerzbank bought Dresdener Bank, the traditionally third major bank, in 2009 due to Dresdener Bank's losses during the 2008/09 financial crisis.

of savings banks. Smaller savings banks, operating in their regional associations, provide services to retail customers and small- and medium-sized enterprises (IMF, 2016b). They are subordinated to the larger “Landesbanken”, which cover multiple regional savings banks associations. Landesbanken are owned by the regional government as well as their subordinated savings banks (IMF, 2011, 2016b). Originally, they were established as clearing institutions and liquidity managers to their subordinated banks (IMF, 2016b). But for the time period considered, Landesbanken have also provided other banking service to larger customers, including investment banking and international activities (Hüfner, 2010). Therefore, Landesbanken have been in direct competition with private commercial banks (Detzer et al., 2017; IMF, 2011). Finally, all savings banks own the Dekabank, which manages their assets (Detzer et al., 2017; IMF, 2016b). The subsequent analysis examines small, regionally operating savings banks and Landesbanken separately. The Dekabank will not be covered explicitly.

Cooperative banks constitute the third pillar of the German banking system. Their key role has been to support their members, usually their depositors and borrowers (IMF, 2011), but they also provide services to non-members. Cooperative banks’ service provision and customer base matches those of the savings banks and, like savings banks, cooperative banks are per se non-profit maximizing. Moreover, cooperative banks are, like savings banks, confined to operate within a certain region (Detzer et al., 2017) in the framework of according associations. Equivalent to the savings banks’ Landesbanken, cooperative banks have central institutions which provide them with clearing and liquidity funding services. Up until 2016, two institutions existed, the DZ Bank and WGZ Bank. Both central institutions merged in 2016, establishing one central institution for all cooperative banks.¹⁶ Next to clearing and liquidity funding services to their subordinated banks, cooperative banks’ central institutions have provided services to larger customers, competing with Landesbanken and private commercial banks for commercial and investment banking activities (Detzer et al., 2017). Both regionally operating cooperative banks and the central institutions will be assessed.

3.2 Key characteristics

Due to their organization in regional associations and the ownership of their superior institutions, savings and cooperative banks have specific guarantee schemes in place. Generally, savings and cooperative banks are liable for their fellow institutions in their regional association

¹⁶ Because of the merger central institutions can only be examined until 2016. With the merger, the data on the cooperative banks’ central institutions became part of the group “banks with special, development and other central support tasks”.

and their superior body. Furthermore, until 2005, savings banks enjoyed government guarantees, which only phased out in 2015 (Hüfner, 2010). These guarantees allowed especially Landesbanken to obtain AAA ratings (IMF, 2011) as well as funding at slightly lower interest rates than private banks (Detzer et al., 2017). In light of the dependencies established via the outlined mutual guarantee schemes, another important feature is the tiered structure in the German interbank market, as identified by Craig & von Peter (2010). Few banks sit at the interbank market's core, acting as intermediaries to the rest of the system.¹⁷ Core banks channel the periphery banks' lending, and thereby ensure the periphery's liquidity. Banks become core banks primarily due to their balance sheet size. It is thus relatively straight forward that large private banks and superior savings and cooperative banks are part of the interbank market's core.¹⁸ Furthermore, when assessed at the national level, Germany exhibits one of the least concentrated banking sectors (Detzer et al., 2017), but when examining specific markets or regions and consolidating savings or cooperative banks' associations, Detzer et al. (2017) find higher concentration ratios.¹⁹ Despite great consolidation, particularly during the 1990s and early 2000s, the majority of German banks remain per se non-profit maximizing (in total numbers).²⁰ Cooperative banks consolidated especially strongly, but the consolidation among savings banks is not negligible either.²¹ Consolidation occurred mostly within the same pillar (IMF, 2011, 2016b), which sustained the fragmentation of the sector by type and size. Consequently, banks' balances disappeared in the balance sheet of newly founded larger, regionally operating institutions or were simply taken up by institutions with the greatest regional proximity. The market has thus consolidated but not necessarily cleared. In terms of competition, the picture is equally mixed. On the one hand, according to Detzer et al. (2017), private, savings, and cooperative banks compete strongly, particularly for customer deposits. On the other hand, because savings and cooperative banks are confined to operations in their regions, a high number of institutions does thus not necessarily indicate competition among them (Detzer et al., 2017). Certainly, competition has increased since 1990, not at least due to financial deregulation and opening of new markets.²² Still, average profitability of the German banking sector has been low compared to other countries (Hüfner, 2010).²³ Different scholars identify the weak revenue generation as

¹⁷ Craig & von Peter (2010) identify only 45 banks, or 2% of all banks in the sample/network, at the core of the interbank market.

¹⁸ Which coincides with the IMF's (2016b) finding of Landesbanken and the DZ Bank being key nodes through which savings banks channel most of their cross-pillar investments.

¹⁹ Koetter et al. (2004) have similar findings.

²⁰ In December 2018, 80% of all institutions have been either cooperative or savings banks (Bundesbank, 2019d).

²¹ See Table 2 in the appendix.

²² See Detzer et al. (2017) for more information.

²³ Indicating a high degree of competition (Detzer et al., 2017).

a reason, whereby higher operational costs play a smaller role in this context (Detzer et al., 2017; Hüfner, 2010). Furthermore, the per se non-profit-maximizing nature of the majority of institutions, which enables banks to maintain non-profitable activities (Hüfner, 2010) and provide credit below market rates (Detzer et al., 2017), has typically been cited as one potential reason (Detzer et al., 2017; Hüfner 2010). Yet, it is important to note that profitability is heterogeneous across bank types and sizes with higher but also more volatile returns on equity (ROE) before tax for big and especially private institutions (Graph 13a-c).

4. Selected systemic risk indicators

4.1 The selection process

This paper uses the ESRB risk dashboard as starting point for the selection of systemic risk indicators as the ESRB is part of the European financial supervision scheme which presides over German regulators. Generally, The ESRB risk dashboard assesses “a set of quantitative and qualitative indicators of systemic risk in the EU financial system” (ESRB, 2019b).²⁴ The indicators are structured according to the following risk categories: macro risk, credit risk, liquidity and funding risk, market risk, profitability and solvency risks, structural risk, and risk related to central counterparties (ESRB, 2019a). Moreover, the ESRB risk dashboard (2019a) comprises a category of interlinkages and composite measures. For each risk category, the ESRB risk dashboard specifies analysis items and according indicators, which draw on different data types, e.g. balance sheet or market data.

Relevant indicators need to be bank-related and it must be possible to break them down by bank type such that different banks groups’ behavior can be studied and heterogeneous signals may emerge. Against this background, the ESRB risk dashboard’s indicators for central counterparty risk, which mainly comprise policy variables, are not well suited. Furthermore, the ESRB risk dashboard’s composite measures of systemic risk are left out because their calculation goes beyond data availability and the scope of this paper. Also, the assessment omits the ESRB risk dashboard’s structural risk indicators. In turn, the effects of the German banking sector’s key characteristics, as outlined in chapter 3, on systemic risk are taken into consideration. The category of market risk is also discarded, because indicators are either not bank-relevant or cannot be broken down by bank type. Alternatively, banks’ exposure to market risks, such as short- and long-term interest rate volatility and/or exchange rate volatility, can be analyzed via banks’ balance sheet positions and their evolution over time. The assessment of macro

²⁴ The ESRB risk dashboard is part of a larger collection of indicators which monitors systemic risk in the EU financial system (see ECB Statistical Data Warehouse (2019)).

risk is mainly confined to the evolution of German banks' financial cycle, complemented with the credit-to-GDP gap. The presented financial cycle includes some of the dashboard's macro risk indicators, such as real GDP growth. Macro risk stemming from sovereign debt considerations are left out for two reasons. First, public debt had not been a problem until the financial and sovereign debt crisis which started in 2008/09. Second, in the course of the financial and sovereign debt crisis banks increased their sovereign bond holdings' home bias (Battistini et al., 2014). Accordingly, German banks should gradually hold more German bonds which are considered safe and liquid. Therefore, public debt should not state a great risk for German banks.²⁵ Other omitted indicators from the remaining risk categories, as they cannot be broken down by bank type, include: over-/undervaluation of residential property prices, expected default frequency of the corporate sector, cost of borrowing from for households (for house purchase) and non-financial corporations (NFCs), interbank interest rate spreads, and EUR/USD cross-currency basis swap spreads. Table 1 displays the emerging, more concise set of indicators. Yet, data availability imposes restrictions on the applicability of these indicators²⁶. Consequently, only a few indicators can actually be replicated for each bank type with the available data. The remaining indicators applicable to the assessment are: Banks' liabilities at the central bank, the loan-to-deposit ratio, ROE, and net interest margins in percentage of total operating income (highlighted in Table 1).

Table 1: Systemic risk measures by risk category

Interlinkages	Cross-border claims of banks
	Credits and deposits by counterpart sector
	Loans for home purchases
Credit risk	Annual growth rates of loans to households and NFCs
	Lending margins of monetary financial institutions – loans to households (for house purchase) and to non-financial corporations
	Foreign currency loans
Funding and liquidity risk	Banks' funding by the central bank
	Maturity profile of banks' outstanding debt securities
	Banks' long-term debt securities issuance
	Loan-to-deposit ratio
	CDS spreads between senior and subordinated debt

→ continuation on the next page

²⁵ Excluding considerations on non-German sovereign bond holdings.

²⁶ The appendix thoroughly elaborates on the unavailable data and excluded indicators.

Profitability and solvency risk	Return on equity (ROE)
	Return on assets (ROA)
	Cost-to-income ratio
	Net interest income-to-total operating income ratio
	CET1 to risk weighted assets ratio
	Non-performing loans to total gross loans and advances
	Ratio of liquid assets to short term liabilities
	Asset encumbrance ratio

Source: ESRB (2019a); author's presentation

The severe reduction of indicators suggests that current data availability and collection processes are inappropriate to assess systemic risk in the heterogeneous context of the German banking sector. The main reason for this discrepancy should be the different objectives of banking and financial stability statistics. The statistics' legal frameworks differ. Accordingly, both statistics employ separate methodologies which are not coherent. To compensate for the reduction in numbers and to implicitly analyze the lost indicators, banks' asset and liability structures²⁷, alongside short-term borrowing and lending positions are considered. Whereas the former comprises growth dynamics, credit, funding and liquidity risk as well as risks from inter-linkages, the latter specifically enables the assessment to gauge banks' maturity profiles and associated risks, such as maturity mismatch. To substitute for the indicator of common equity tier 1 (CET1) to risk-weighted assets, the assessment uses capital-to-asset ratio, an IMF's financial soundness indicator. Capital is defined according to banking statistics. To obtain another angle on capitalization, the assessment complements the capital-to-asset ratio with that capital-to- NRWA (non-risk-weighted asset) ratio, which also proxies the CET1-to-RWA ratio. Finally, the loan-to-asset ratio shall provide insight into banks' involvement in unconventional, i.e. non-lending activities, activities, which appears especially relevant in the case of the Landesbanken in the run-up of the 2008/09 financial crisis. The final set of systemic risk indicators is thus comprised of the following:

- **Macro environment**
 - Financial cycles
 - Credit-to-GDP gap
- **Balance sheet structures (general)**
 - Asset and liability structures

²⁷ Inspired by the Liikanen report (Liikanen et al., 2012), which is a key document on processing the 2008/09 financial crisis in Europe.

- ***Maturity and funding structures***

Short-term borrowing to total borrowing and short-term lending to total lending ratios

Loan-to-deposit ratio

- ***Distress***

Asset and liabilities with the central bank

- ***Capitalization and solvency***

Capital-to-asset ratio

NRWA-to-capital ratio

ROE

- ***Activity profile***

Net interest income as percentage of total operating income

Loan-to-asset ratio.

Note that instead of selecting and classifying the indicators by risk type, as in the ESRB risk dashboard, this paper focuses on specific positions and groups them accordingly.

4.2 Selected indicators in detail

Macro environment

As mentioned, the financial cycle provides an overview of the macro environment, meaning property prices,²⁸ real GDP and real credit^{29,30,31}. Following Borio (2011), the presentation displays the data in growth rates. Although plotting real credit in the aggregate as well as for each individual bank type, the here displayed financial cycle graph does not provide insight into causalities or actual co-integrations. It remains indicative of the variables' relationships. Furthermore, high frequency data harbors the risk of signaling volatility. To obtain a clearer picture, the cycle would need to be smoothed and adjusted for, e.g., seasonality.

The aggregate credit-to-GDP gap echoes the aggregate financial cycle(s).³² A positive gap signals an overextension of credit in relation to the real economy and vice versa for a negative value.

²⁸ Property prices correspond to the bulwiengesa AG property price index. The index comprises residential and commercial property prices.

²⁹ Nominal credit and GDP are transformed into real variables by using the World Bank's GDP-deflator. Unfortunately, the Bundesbank does not provide a GDP-deflator, which would provide the price level of the economy as a whole, but only a consumer and producer price index.

³⁰ Comprising loans to banks and non-banks.

³¹ Typically, equity prices, which correspond to the DAX price index, should also be included. But because equity prices are noisy, which other empirical findings, such as Claessens et al., 2011 in Schoenmaker & Wierds, 2016, confirm, and coincide little with real credit and GDP growth in Germany the following obtains from a presentation of equity prices.

³² Note that the credit-to-GDP gap comprises total credit and not only bank credit, which is likely to indicate higher credit growth.

Balance sheet structures

Asset and liability structures' presentation is inspired by Liikanen et al. (2012). Cash and reserves, lending to banks and non-banks, alongside participation interest and other assets are plotted for the asset side and capital, deposits of banks and non-banks, alongside bearer debt securities and other liabilities for the liability side. Generally, asset and liability structures illustrate the expansion of different bank types' balance sheets and business activities, hence their *modus operandi*. Also, asset and liability positions allow to study banks' risk exposure, for instance funding risks for banks who rely heavily on market finance instead of customer deposits. Unfortunately, however, balance sheet data does not provide information on quality and liquidity. Also, the actual assets and liabilities in the "others" categories are not fully clear. Therefore, risks arising from specific debt instruments, for example, cannot be examined.³³ Also, balance sheet data is, by definition, unable to grasp off-balance sheet activities which have proven the most dangerous for banks and financial system's stability in 2008/09. Finally, banking statistics define capital in a broader sense than financial stability statistics. Since Basel III, financial statistics define three types of capital 1) core/common tier 1 (CET1), emphasized by regulators, which includes common equity, retained earnings, and portions of minority interests; 2) additional tier 1 capital which comprises certain preference shares and portions of minority interest; and 3) tier 2 capital which includes, among others, undisclosed reserves and subordinated debt (ECB, 2010).³⁴ Conversely, banking statistics' capital includes, apart from equity, retained earnings, participations rights capital, and funds for general banking risks. Especially banks' participations rights typically count as capital tier 2 (Centrum für Europäische Politik, 2011). The term "capital" is thus enlarged by banking statistics. Consequently, any assessment in this work relying on capital is at risk of providing higher numbers/ratios than if CET1 would be used. The assessment is thus prone to indicating a higher capitalization and soundness accordingly, which falsifies the assessment by an unknown amount/percentage. Using the broader definition of capital remains, however, the only way to examine banks' capitalization and solvency for the kind of work envisioned in this paper.

³³ The Bundesbank published data on banks' securities portfolio and their bearer debt securities. Yet, the different presentations mutually include items, carrying the danger of counting certain objects twice and omitting others. Furthermore, the problem of quality and liquidity remains.

³⁴ For further information, see Bank for International Settlements (2010).

Maturity and funding structures

Short-term borrowing as a percentage of total borrowing (from banks and non-banks) alongside short-term lending as a percentage of total lending (to banks and non-banks) allows for the examination of banks' dependency on short-term financing and maturity structures accordingly, whereby short-term is defined as up to one year³⁵. Increased short-term lending signals banks' unwillingness to engage in long-term business relationships, for example, due to increased uncertainty about economic prospects or debtors' ability to repay. But, it might also indicate banks' participation in an expanding liquidity supply that is associated with the build-up of systemic risk. A great dependency on short-term borrowing could furthermore indicate banks' difficulties to establish a long-term funding structures and/or their need for fast liquidity/funding for certain (short-term) business practices or due to distress. Higher short-term borrowing exposes banks disproportionally to liquidity and funding risks, hence disruptions in interbank markets. Unfortunately, short-term lending and borrowing may increase before or after the financial cycle's peak. In the upswing, it hints toward those short-term engagements which are often highly profitable but also highly risky. In the downswing, such could derive from increased uncertainty and banks' attempt to consolidate their balance sheets. In order to abstract from short-term lending from the central bank and the effect of the ECB's long-term refinancing operations (LTROs), lending and borrowing data excluding the Bundesbank is used. In turn, the exclusion of Bundesbank assets and liabilities might mask a substantial amount of short-term borrowing. Lending and borrowing data is not available for foreign and domestic banks as consolidated counterpart before 1999. Therefore, the ratios include only lending to and borrowing from domestic banks before 1999.³⁶ Both ratios thus do not capture part of banks short-term borrowing/lending before 1999. Such was accepted under the hypothesis that only the introduction of the euro in 1999 greatly facilitated banks' short-term foreign business so that the omitted fraction before 1999 should be small. Sudden spikes in 1999 thus signal either a) substantial higher foreign borrowing/lending that was concealed by the data before 1999; and/or b) banks now seizing the opportunity to engage in business abroad.

A high loan-to-deposit ratio indicates banks greater dependency on wholesale funding which tends to be more volatile than customer deposits (ESRB, 2019a). In this context it is important to emphasize that sudden, sharp drops in the loan-to-deposit ratio might derive from non-performing loans and according consolidations during crises.

³⁵ Since Basel II, financial statistics define short-term as up to three months. Hence, here again, the divergence between financial (stability) and banking statistics is apparent.

³⁶ See the appendix for information on the precise calculation

Distress

Banks' assets at and liabilities to the central banks are indicators to proxy market distress as well as funding constraints. In times of uncertainty, banks would prefer to deposit their funding with the central bank instead of providing it as liquidity to other banks. Thus central bank deposits should increase. Yet, higher deposits at the central bank may also be a sign of excess liquidity that cannot be put to use otherwise. Vice versa, a high amount of central bank liabilities should indicate banks' proper distress. A high dependence on central bank funding indicates difficulties in accessing traditional funding sources (ESRB, 2019a).

Nonetheless, the ECB's unconventional monetary policy affected both indicators. First, because the asset purchase program (APP) artificially inflated deposits with the central bank, the indicator could have ceased to appropriately proxy interbank distress since the implementation of the program in 2015. Second, negative deposit rates incentive banks to deposit their excess liquidity only under greatest distress and/or if running out of other options with the central bank. Third, ECB's LTROs could arbitrarily increase banks' liabilities with the central bank. They offer secure, 3-month funding at low rates which could offer better conditions to certain banks than interbank lending or regular refinancing operations. Hence, the meaning of liabilities with the central bank could also be impaired since the LTROs' implementation in 2011.

Capitalization, solvency, and banks' activity profile

A high capital-to-asset and low NRWA-to-capital ratio indicate high capitalization. As mentioned, however, banking statistics' broader definition of capital tends to increase banks' capital, the indicators should signal higher capitalization ratios than if using CET1. The NRWA-to-capital ratio omits cash and central banks deposits. Under the ECB's APP, and with a constant balance sheet size, banks' capitalization would seem to increase as "other assets" are exchanged for central bank deposits.³⁷ In turn, the capital-to-asset ratio should not be affected. Only if the balance sheet expands, with assets increasing faster than capital, the capital-to-asset ratio should indicate a lower capitalization. Capitalization should decrease during the up- and downswing of the cycle. During the upswing, assets expand faster than capital and leverage increases. During the downswing, losses reduce banks' capital disproportionately to its assets.

ROE and net interest income as percentage of total operating income traditionally signal banks' solvency and associated solvency risks, too³⁸. Furthermore, the ROE is commonly used

³⁷ A balance sheet expansion, should however dampen, cancel out, or even reverse the effect of the APP on the NRWA-to-capital ratio.

³⁸ Clearly, competition affects banks' ability to raise interest income.

as proxy for leverage³⁹. ROE increases with leverage if returns are constant but also with returns if leverage is constant. Unfortunately, both leverage and return behave procyclically, increasing before crises. It is thus delicate or even impossible to assess leverage with ROE without any further information on returns, as in this case.⁴⁰ Lower net interest income as percentage of total operating income⁴¹ signals not only profitability risks, it also indicates banks' shift toward non-interest-based business. In this sense, this work uses the indicator to proxy banks' activities. The loan-to-asset ratio, which may proxy for banks' involvement in unconventional activities, complements the net interest income as percentage of total operating income. The lower the ratio, the stronger the engagement into unconventional business lines, and the greater the exposure to adverse market movements which could severely affect banks' assets, and hence pose risks to their solvency.

4.3 Additional notes on data

For the assessment, the ESRB risk dashboard data or the ECB's data warehouse data cannot be used because the relevant data a) is collected on the aggregate, and b) in most cases, only dates back to 2008⁴². Therefore, mainly Bundesbank data, which provides the only bank-type-specific data, has been used. Precise information on the variables used can be found in the appendix. Generally, this paper tries to keep the data sources as parsimonious as possible in order to prevent heterogeneous methodologies and according data issues. Also, it was attempted to use data that covers the entire assessment period from 1990 until 2018. Only in exceptional cases, as for the macro data and ROE, time series beginning in the early 1990s and/or ending in 2017 were accepted. In this context, it is important to note that developments in 1990/91 are difficult to interpret due to market reorganization processes. Also, banks' balance sheet data exhibits many structural breaks which derive from changes in reporting standards. For example, only since 2010, derivatives have to be accounted for under "other assets". Moreover, one should be careful in interpreting every individual spike/slump because of the structural breaks and the high frequency of the data (monthly data). Data frequency has also been a problem when plotting the financial cycle because certain data was only available in monthly and other data in annual

³⁹ Leverage exposes banks to risks connected to cash flow disruptions, such as credit, market, macro, and funding risk.

⁴⁰ Leverage itself cannot be assessed because data on equity and return are not available.

⁴¹ Decreasing interest rates may coincide with a stable net interest income if banks' interest expenses decrease too.

⁴² Few time series go back to 1999. Most of the relevant data series, however, only start in 2013/14 or later as they are related to the implementation of the Single Supervision Mechanism.

frequency. All data is in (hypothetical) euro values and has been derived as such from the Bundesbank website. Furthermore, the appendix provides information on the precise calculation of ratios used in the assessment.

As alluded to in the introduction, crises, as identified by the ESRB's European financial crisis database (ESRB, 2017a), are used as benchmark for the emergence and manifestation of systemic risk in the German banking sector. For the assessment period from 1990 until 2018, the ESRB defines three crisis events. Their start dates correspond to the start date as defined by the ESRB and end dates correspond to the "end of crisis management" date rather than the "system back to normal" date (see ESRB, 2017a).⁴³ The first crisis, during July 1991 and October 1994, was connected to the recession following the German reunification in 1990. The second crisis took place from January 2001 to November 2003 and emerged from a domestic credit boom, the bursting of the Dotcom bubble, and the recession of the export-oriented German economy. Finally, the third crisis began in August 2007 with the outbreak of the American subprime crisis and active crisis management ended in June 2013. (ESRB, 2017b)⁴⁴

5. Assessment

5.1 Macro environment

As suggested, the representation of the key macro variables real credit, real GDP, and property price following Borio (2011) shall provide information on banks' behavior in the broader macro context and macroeconomic risks.

For the aggregate, Graph 1 displays the financial cycle for total credit, i.e. real credit growth of all German banks. Between the mid-1990s and the 2001 crisis, total credit evolved broadly in conjunction with property prices^{45,46} but largely independent of real GDP growth. Thereafter, real credit growth seems largely independent of both property prices and real GDP growth. Moreover, total credit reacts sluggishly, and is volatile to the systemic crisis used as benchmarks in this work.⁴⁷ Especially during the 2007 crisis, real credit growth exhibits boom-bust-like features that do not coincide both macro variables. In this respect, other factors than

⁴³ The European Systemic Risk Board (ESRB) has not signaled that the German banking sector is back to a "normal" state (ESRB, 2017b) after the 2008/09 crisis as especially large, systemically important banks continue to perform poorly.

⁴⁴ For further information on the crises see ESRB (2017b).

⁴⁵ Slightly preceding property prices

⁴⁶ The variables' co-movement corresponds to other empirical findings on credit and property prices (e.g. Claessens et al., 2011 in Schoenmaker & Wierds, 2016).

⁴⁷ The sharp decrease in 1991 probably derives from consolidations in the process of reunification, which cannot be interpreted correctly.

real GDP and property prices seem to drive aggregate real credit growth in Germany. Furthermore, total real credit growth did not indicate increasing systemic risk by excessive and/or volatile growth rates before the 2007 crisis and only partially before the 2001 crisis. Accordingly, the here displayed financial cycle for total credit does not allow to draw meaningful conclusions for banks' behavior and systemic risk in the broader macro context.

The credit-to-GDP-gap (Graph 3) naturally corresponds to the development of total real credit growth. With the real credit expansion in the 1990s the credit-to-GDP gap became positive. Thereafter until 2007, real credit grew at constant rates. The credit-to-GDP gap narrowed accordingly since 1999 before becoming negative in 2002. Finally, since 2007 boom-bust in real credit, the credit-to-GDP gap entered a renewed upward trend. Generally, the credit-to-GDP gap has been unable to signal two systemic crises of the assessment period but indicated a reduction in systemic risk instead. Accordingly, the credit-to-GDP gap, as the aggregate financial cycle, proves inappropriate to monitor systemic risk in the German banking sector – which coincides with findings of the ESRB (2018).

Private banks

Big private banks' behavior is highly volatile with a high amplitude and frequency (Graph 2a). Especially before the 2001 crisis credit growth was strong, whereby the spike/dip in 1999/2000 is likely to be an outlier deriving from the introduction of the euro. In hindsight, this strong credit expansion points toward the build-up of systemic risk which unraveled in 2001. Conversely, the credit reduction right before the 2007 crisis did not contradict the emergence of the second systemic event. Generally, private banks' credit growth appeared largely unconnected to real GDP and property price developments. But big private banks seem to drive total credit's dynamics and thus systemic risk as their credit growth's behavior largely exceed total real credit's dynamics as displayed in Graph 1. Regional private banks greatly contribute to aggregate dynamics too (Graph 2b).⁴⁸ Their real credit grows even more volatile than that of big private banks, with the same amplitude. Moreover, regional private banks' real credit evolved largely independent of the macro environment too. Their credit cycle did not peak before the 2001 and 2007 crises but was in decline, not indicating an overexertion of credit. Accordingly, the financial cycle of big and regional private banks does not allow to draw proper conclusions for when credit overextends and overall macro risks. However, their real credit growth suggests private banks as key contributors to aggregate dynamics and drivers of volatility in the sector.

⁴⁸ Their latest strong expansion of credit seems the main contributor to the closing of the credit-to-GDP gap.

Savings and cooperative banks

For the second and third pillar, the volatile behavior ceases. Landesbanken experienced a strong real credit expansion in the 1990s with more moderate growth rates during the 2000s (Graph 2c), which, in both periods, seemed to coincide with real GDP and property price growth. In the 2007 crisis Landesbanken suffered severe setbacks and seem still unrecovered as their real credit growth rates are still negative. Conversely, central institutions of cooperative banks show a greater stability during and after the 2007 crisis (Graph 2e). Their lending behavior seems connected to both accompanying macro variables throughout the entire assessment period⁴⁹. For both superior institutional types, real credit growth was generally in decline before all systemic crises. Regional savings and cooperative banks' credit growth profiles largely coincide with each other, underlining the banks' similarities outlined in chapter 3 (Graph 2d and 2f). Both bank types oppose the credit reductions by private banks and Landesbanken during crises, thus compensating other banks' credit cuts. As for their superiors, regional savings and cooperative banks' credit was in decline before the period's crises. Generally, their behavior seems continuous, on a smaller scale than the credit growth of other banks,⁵⁰ and largely separate from both other macro variables. Accordingly, regional savings and cooperative banks provided a reliable supply of credit over the assessment period and contributed seemingly less to the dynamics of total real credit and systemic risk.

Synthesis

Individual credit cycles confirm the presumed heterogeneity of different bank types and their behavior in the greater macro context. Total credit seems to exhibit one financial cycle over the assessment period. It is mainly driven by private banks and the large institutions of pillar two and three as their real credit growth visibly determined total real credit's development. Banks' heterogeneity, however, points toward individual cycles that underlie an aggregate trend. Yet, the presented financial cycles proved only partially able to connect macroeconomic developments with individual banks' real credit growth and behavior.⁵¹ Consequently, a more thorough assessment of systemic risk is necessary.

⁴⁹ Preceding property price growth and expanding with real GDP.

⁵⁰ Whereby cooperative banks' credit growth exhibits outliers in 1994, 1996, and 2009.

⁵¹ Which might also be due to the fact that no econometrics interference was used to verify the variables' relations.

5.2 General balance sheet structures

Big private banks continuously expanded their balance sheet over the assessment period (Graph 4a/5a).⁵² Cutbacks due to crises abstain, with exception of 2009. It is likely that “other assets”, thus the actual balance sheet and losses, accordingly had been much larger before 2010 if, e.g., derivate products had been taken into account. “Other assets” appear mainly financed by “other liabilities” and bearer debt securities. Accordingly, market risk had been and remains substantial. Furthermore, the change in accounting illustrated the importance of market funding in big private banks’ liability structures. The balance sheet affirms their unconventional funding structure indicated in chapter 3, which subjects these banks to market, funding, and liquidity risks. Since the 2007 crisis, non-bank deposits seem to slightly regain importance. Conversely, lending to banks further expands its relative importance, which also illustrates big private banks’ role in the interbank market’s core. Still, interbank lending exposes them to the counterparty risk of fellow banks. Capitalization increased moderately but steadily, which coincides with stronger capital regulations such as Basel III. Yet, capital losses are hard to identify which seems odd and might derive from the definition of capital used in this work. Lastly, as expected, the APP inflated central bank deposits, which also exhibit signs of distress during the 2007 crisis.

Regional private banks’ balance sheet/business volume is about half as large as big private banks’ balance sheet (Graph 4b/5b). Interbank lending constituted about ¼ of regional private banks’ assets and “other assets” and participations only a small share. Primary assets are credits to non-banks, which suggests that regional private banks mainly conduct conventional business activities. Consequently, their exposure to credit risk mainly derives from non-bank counterparts and risks for assets and banks’ solvency stemming from market turmoil are low. Moreover, regional private banks have become largely reliant on customer deposits, which indicates a conventional and rather stable funding structure alongside low exposure to funding/liquidity risks. Yet, capital expanded only very moderately, but without visible losses, and cash and deposits at the central bank increased seemingly independent of the APP after 2013. Regional savings and cooperative banks behave similar to regional private banks (Graph 4d/5d and 4f/5f) with comparable balance sheet sizes today.⁵³ As for regional private banks, regional savings banks’ increasing lending to and deposits from non-banks suggest conventional, stable business activities and dependable funding structures. Furthermore, the reduction in interbank

⁵² The sharp expansions in 1999 and 2010 drive from the introduction of the euro and change in derivative accounting which were referenced in chapter 4.3 as statistical breaks.

⁵³ Regional savings banks started with much higher business volumes to which regional private and cooperative banks caught up over the assessment period.

lending and borrowing since the 2007 crisis indicates a withdrawal from the interbank market activities.⁵⁴ Market finance via debt securities and other liabilities had traditionally been low and further decreased. Cash and deposits at the central bank remained fairly stable, with little impact of the APP, and their capital base seemed strong, expanding without apparent signs of losses. Regional cooperative banks' capital, cash, and central bank deposits developed alike. Overall, regional cooperative banks' balance sheet expansion was, however, more similar to regional private banks' expansion than to regional savings banks' expansion. Non-bank lending and deposits are the most important positions, which expanded gradually and eventually strongly. Interbank lending was low and decreased in importance.⁵⁵ Therefore, regional cooperative banks' main lending counterpart are non-banks too. Furthermore, regional cooperative banks' holdings of "other assets and liabilities" has been even smaller than the holdings of regional savings banks and their liability side indicates a stable funding structure which relies on non-bank deposits. Accordingly, regional savings and cooperative banks are confined to credit and counterparty risks associated with non-bank actors. Moreover, their funding risk via interbank borrowing and market finance is greatly restricted.

Conversely, superior savings and cooperative banks are highly heterogeneous (Graph 4c/5c and 4e/5e). Central institutions of cooperative banks' balance sheets are even smaller than that of their regional institutions and only expanded moderately. According to their character as liquidity and funding management vehicle for subordinate cooperative banks, lending to and borrowing from banks' constitutes the largest share of this type's balance sheet.⁵⁶ Lending to and borrowing from non-banks has been small and remained fairly stable over the assessment period, which suggests a stable customer base. Against this background, central cooperative banks' balance sheet expansion was mainly financed with help of bearer debt securities and "other liabilities", exposing central cooperative banks to increasing funding risks. Also, the change in derivative accounting uncovered central cooperative banks' other assets. Since, financial products constitute about 1/5 of their assets, indicating greater market risk than visible before. Still, central cooperative banks' main risks derive from counterparty and credit risk with regard to other banks. Ergo, central cooperative banks are less engaged in unconventional business lines than their competitors, large private banks and Landesbanken.⁵⁷

The balance sheet of the Landesbanken is the only balance sheet with a contraction in size. Until 2007, lending to banks and non-banks expanded greatly, whereby lending to banks

⁵⁴ Putting them at the periphery of the interbank market.

⁵⁵ Putting them at the periphery of the interbank market too.

⁵⁶ Regional savings and cooperative banks' bank deposits should mainly consist of liquidity provisions by their superior institution and the central bank.

⁵⁷ Capital, cash, and reserves are almost negligible and will be assessed later.

increased more strongly. The expansion was mirrored by rising bank deposits and, in particular, greater bearer debt securities. The change in derivate accounting also unveiled Landesbanken's substantially higher "other assets and liabilities". Accordingly, Landesbanken most likely exhibited and continue to exhibit higher market, credit/counterparty, and funding risks via their unconventional funding structures and business activities, similar to that of big private banks. The consolidation, which started in the course of the 2007 crisis, shrunk the balance sheet almost by 1/3. Yet, proportions remained fairly constant such that the overall risk profile changed little. Only the provision of safe assets via the APP improved Landesbanken's overall liquidity situation.

In summary, asset and liability structures underlined banks' heterogeneity. Regional banks developed constantly with sustainable, low risk business models, evolving with but not driving systemic risk. Conversely, big private banks and Landesbanken appear as main drivers of systemic risk. Central institutions of cooperative banks take an intermediate position with tendencies toward the behavior of big private banks/Landesbanken. Before the 2007 crisis, a strong expansion of lending/borrowing on behalf of big private banks, Landesbanken, and central cooperative banks signaled an ease in liquidity, which is associated with the upswing of a financial cycle and the accumulation of systemic risk. However, the analysis is incomplete. Off-balance sheet positions decisively shape individual and systemic risk but cannot be taken into account. The revelations by the 2010 accounting change provided only one example of the risks that could be concealed. Moreover, the balance sheets' size and presentation in levels paired with missing information on quality and maturity only provides a broad overview. Hence, asset and liability structures are a good way to gain insight into risks and their evolution over time but are inappropriate as systemic risk indicator. They simply provide important complementary information for a comprehensive assessment.

5.2 Maturity and funding structures

Concerning short-term borrowing (Graph 6a-c): All three big/superior institutions exhibit overall higher levels of short-term financing and more noise in their short-term-borrowing-to-total-borrowing ratio, indicating higher liquidity need and greater funding risks for these institutions. Especially after the introduction of the euro until the 2007 crisis, all three bank types established significantly higher levels of short-term borrowing. Increases in short-term liquidity signaled the rise of liquidity demand and thus build-up of risk for Landesbanken before 2001 and 2007 and for central cooperative and big private banks before 2001. Furthermore, the indicator shows distress reactions during the 2007 crisis for all three big/superior institutions, which ceased

quickly due to the ECB's liquidity injections. Accordingly, a substantial part of banks' short-term funding should be masked because the data does not take into account short-term financing by central banks. In turn, after 1999 regional savings and cooperative banks exhibit almost no sign of foreign short-term borrowing but reduced their short-term-borrowing-to-total-borrowing ratio substantially since. Furthermore, the indicator does not signal increased short-term financing on behalf of regional savings and cooperative banks before both systemic crises. Hence, regional savings and cooperative banks do not require high short-term liquidity and are able to establish long-term funding structures. Regional private banks behave similar to big private banks but with a much lower short-term-borrowing-to-total-borrowing ratios after 1999, indicating little foreign short-term borrowing. Regional private banks thus take an intermediate position with regard to their funding risk and short-term liquidity demand. Overall, the indicator issues heterogeneous signals for different bank types and behaves more like a contemporaneous than an early warning indicator.

With regard to short-term lending (Graph 7a-c), the structural break of the short-term-lending-to-total-lending ratio in 1999 affects private banks and the superior institutions of pillar two and three.⁵⁸ Especially, big private banks' and central cooperative banks' short-term lending increases between 1999 and the 2007 crisis, with ratios of almost 60% and 50% respectively. Short-term lending by Landesbanken already increased before the euro's introduction but only amounted to about 40%. Swings due to uncertainty during crises are only visible occasionally, e.g. around 2012 for big private banks. Therefore, the indicator appears rather an indicator of big/superior banks' liquidity provision and according counterparty risk than an indicator of their uncertainty. Conversely, small swings due to uncertainty during crises are more apparent for all regional banks. Ratios overall decreased over the period covering both systemic crises for regional savings and cooperative banks. The steady reduction of their short-term lending ratio suggests not only greater certainty with regard to their counterparties and market risk but it also mirrors banks' conventional business strategies, i.e. long-term lending to the real sector. Regional private banks occupy again an intermediate position with features similar to regional savings and cooperative banks since the 2007 crisis. Accordingly, the indicator's signals are again heterogeneous. For big/superior institutions the indicator reveals their business activities. For regional savings and cooperative banks, the indicator functions as distress signal.⁵⁹

⁵⁸ For regional private banks, the great spike seems to derive from foreign lending that had not been accounted for before because the ratio decreases quickly after 1999.

⁵⁹ The quality of the indicator as distress signal is improved by the ratio's constantly declining level.

Lastly, concerning the loan-to-deposit ratio (Graph 8a-c): As assessed above, regional savings and cooperative banks mainly rely on traditional deposits with a fairly stable loan-to-deposit ratio that was largely unaffected by crises or the introduction of the euro. In conjunction with little short-term borrowing and lending, a low loan-to-deposit ratio underlines regional savings and cooperative banks' stability and low risk profile. Regional private banks occupy again a special position. After a slump in 1998/99 that coincides with their reduction in other liabilities and bearer debt securities, they behave more like big private banks. Big private banks' ratios increased until 2007. The indicator signaled both systemic crises for big private banks because increased reliance on wholesale funding not only implies funding risks but also business activities that need financing beyond customer deposits. For central cooperative banks' the indicator only cautioned the 2001 crisis and declined before the 2007 crisis. Landesbanken exhibit the largest reliance on wholesale funding, although it declined greatly since 1990s. The ratio's level suggests that regional savings banks do not provide sufficient excess deposits to cover Landesbanken's funding needs. Such raises the question of which activities and volumes need financing and points toward Landesbanken's balance sheet which has indicated unconventional lines of business and thus high market and funding risks. Overall, the loan-to-deposit ratio is not appropriate to indicate crises. But it identifies actors that are exposed to greater funding risk and their business practices, which both drive systemic risk. The loan-to-deposit ratio is thus a good complement to the assessment of maturity structures.

5.3 Distress

To examine market distress and funding constraints, the following studies central bank asset and liabilities in banks' balance sheets.

Until the APP, the central bank asset indicator seemed fitting to signal increased market distress for big private banks (Graph 9a-c). In hindsight, it is even apparent that early warning signals of distress were issued right before the 2001 crisis. In turn, the indicator is fairly steady for both cooperative types and thus fails to proxy distress. Savings banks exhibit a slightly more volatile time series and distress signal during some crises.^{60,61} Overall, the central bank asset indicator is able to issue early warnings for one bank type, contemporaneous signals for three bank types, and is ineffective for the remaining two. Yet the effects of the APP seem to have rendered the indicator obsolete. The program drastically increased the central bank assets of private banks and Landesbanken, and even regional private banks' central bank assets, which

⁶⁰ Not taking into account individual spikes.

⁶¹ Regional private banks evolve similar to Landesbanken.

were previously tough to be independent of the APP, now clearly exhibit effects of the APP and distress reactions at the end of the 2007 crisis. Of all banks only cooperative banks seem largely unaffected by the APP.⁶²

Conversely, banks' central bank liabilities show little effect of the ECB's LTROs (Graph 10a-c). For all banks, the indicator signaled distress during the 2007 crisis before the ECB's liquidity injections eased distress. Similarly, in 2001, demand for central bank funding seemed to increase even before the crisis for Landesbanken, central cooperative banks, and regional private banks.⁶³ Yet, the indicator also displayed elevated levels independent of crisis for regional savings and cooperative banks during the 1990s and for big private banks between the 2001 and 2007 crisis, which cannot be put into context. Broadly speaking, the indicator seemed a good thermometer, and, partly, barometer of distress. Nevertheless, the indicator also issued warnings that cannot be associated with known events of risk and distress. Hence, relying on the indicator as an early warning signal could lead to wrong conclusions.

5.4 Capitalization and solvency

To assess banks' capitalization and solvency, Graph 11a-c display the capital-to-asset ratio, which is complemented by the NRWA-to-capital ratio thereafter.⁶⁴ Using the capital-to-asset ratio, regional savings and cooperative banks show nearly no sign of capital losses. But their capitalization increased steadily and eventually strongly which, paired with the above-detected asset structure, covers regional savings and cooperative banks from solvency risks. Landesbanken and central cooperative banks increased their capitalization in line with their subordinate institutions but started at lower levels.⁶⁵ Both bank types took hits during the 2007 crisis, yet losses occurred before private banks' losses suggest different origins. Big private banks had the best capitalization in 1990. However, throughout the 1990s and early 2000s, big private banks reduced their capital and experienced losses during crises. Consequently, their capital-to-asset ratio fell below 4%, compared to almost 8% in the beginning of the assessment period, which thus substantially increased big private banks' solvency risk. Regional private banks were also well capitalized in 1990. After reductions over the 1990s, their capitalization restored even before 2007 and losses during the crisis have also been compensated since. Generally, the

⁶² It suggests that cooperative banks' assets are less eligible to the APP.

⁶³ The indicator also signaled distress of savings banks and cooperative banks before the 2001 crisis but eased with the crisis' beginning.

⁶⁴ It is important to keep in mind that the assessment's definition of capital is larger than the capital with which financial supervisors conduct assessments. Capitalization is thus likely to be skewed upward.

⁶⁵ Landesbanken's and central cooperative banks' solvency risk was higher than solvency risk of their regional institutions due to their sluggish accumulation of funding capital.

capital-to-asset ratio indicates distress under some circumstances and for some bank types. The indicator presides crises for private and central cooperative banks, which exhibited lower capitalization upfront. Yet, because lower capitalization before 2007 may also derive from losses in assets during the 2001 crisis, it is difficult to judge whether the indicator is truly valid for these bank types. To obtain another angle on the question, the NRWA-to-capital ratio is consulted (Graph 12a-c). The indicator broadly echoes the capital-to-asset ratio.⁶⁶ It now clearly appears that the reduction in central cooperative banks' capital before the 2007 are the effect of asset losses in the 2001 crisis instead of an accumulation of risk. Accordingly, both indicators only point toward crises in the case of private banks and behave contemporaneous for all bank types, issuing warnings on solvency risks in times of distress.⁶⁷

As mentioned, the ROE is another way to proxy solvency risk (Graph 13a-c), but it is also used to assess leverage. Regional institutions display a greater stability in their ROE than big/superior institutions. Regional savings and cooperative banks outperformed all other bank types, when abstracting from short hikes in big private banks' ROE, and continue to do so today.⁶⁸ Yet for all banks, including regional institutions, the ROE has decreased since the 1990s. Banks' business has thus become less profitable, independent of crises. Regional private banks occupy, again, an intermediate position. Conversely, especially big private banks seem vulnerable to crises, underlying the impression that their business lines are more risk-prone. Furthermore, the high ROE before the 2007 crisis points toward higher returns from investment activities paired with increased leverage for this period. The ROE of central cooperative institutions decreased over time. However, it is less volatile than the ROE of big private banks and more robust to crises than big private banks' and Landesbanken's ROE. Landesbanken suffer from low profitability and proneness to losses during crisis. Generally speaking, solvency risk seems higher for all six bank types due to steadily lower ROEs. Yet, the robustness of certain bank types' ROE during crises qualifies the risk and suggests again that these banks' business lines are less risky and thus vulnerable to market risks than those of banks with sharp reductions in ROE during crises. Accordingly, banks with higher volatility tend to exhibit higher losses.

⁶⁶ The presumed effect of the APP on capitalization fails to appear.

⁶⁷ Increases in capitalization that started in the latest phase of the 2007 crisis can be understood as a consequence of stronger capital regulations that were implemented with Basel III. Against this background, it is interesting that regional banks have higher capital ratios than large banks. Throughout the assessment, regional banks made the impression to have less risky business activities than big/superior institutions. Ergo their risk-weighted assets, which significantly affect banks' capital requirements, should be lower. Unfortunately, this phenomenon cannot be studied in more depth due to data constraints and the limited scope of this paper.

⁶⁸ Such supports the argument that regional savings and cooperative banks' business is less risky and vulnerable to adverse market movements.

But ROE-levels are only partially connected to banks' behavior during crises. Ergo, the indicator's signals are, as expected, heterogeneous and crises are not detected in a timely manner.

5.5 Activity profile

In order to gain further insight into banks' presumed unconventional activities, the loan-to-asset ratio acts as a proxy for banks' non-lending positions (Graph 14a-c). Until the late 1990s, the loan-to-asset ratio had been high for all bank types,⁶⁹ and remained stable for regional savings and cooperative banks. Regional savings and cooperative banks hence displayed again a low-risk profile and likelihood to follow rather than drive systemic risk. Landesbanken's loan-to-asset ratio behaved alike until 2010 when derivatives had to be accounted for, which revealed a substantial exposure to market risk and engagement into unconventional business practices. Still, the revelation and thus the hidden risk was much larger for big private banks, whose ratio dropped by about 30 percentage-points and remained between 50% and 60% since. In turn, the change in accounting had smaller effects on the loan-to-asset ratio of central cooperative banks and regional private banks, which subsequently revealed somewhat greater market exposure. Central cooperative banks had already begun to expand their unconventional assets in 1999 and expanded their activities more strongly before 2010. Similarly, big private banks exhibited declining loan-to-asset ratios after 1999 too, but largely recovered their loan-to-asset ratios before the 2007 crisis.⁷⁰ The latest reductions since 2015 are likely to derive from higher central bank deposits. Therefore, the APP also affects this indicator, reducing its indicative power for the bank types impacted by the program. Overall, the loan-to-asset ratio has only indicated the emergence of a crisis once.^{71,72} Accordingly, the indicator is unable to issue early warning signals on systemic risk and crises. Nevertheless, part of the indicators' inappropriateness stems from the fact that many risky positions cannot be grasped by an indicator which relies on balance sheet data. But as result of accounting changes, today's statistics are at least able to indicate bank types which, via their activities, drive systemic risk and are accordingly more exposed to market risk.

The indicator of net interest income to total operating income acts as a proxy for banks' activities, too (Graph 15a-c). Again, the indicator is more volatile for the big/superior institutions, whereby spikes during crises derive from the sudden reduction of other expenses. For all three big/superior banks, the indicator dips in advance of crises. Likewise, slight drops can be

⁶⁹ Abstracting from reductions during the reunification process.

⁷⁰ The drop for regional private banks in 1999 was small. Thereafter, the ratio immediately increased again.

⁷¹ For big private banks before the 2001 crisis.

⁷² Not counting the reductions in central cooperative banks' and regional savings banks' ratios before the 1991 crisis because these changes right after German reunification are difficult to contextualize.

found for regional savings and cooperative banks, which have otherwise behaved rather stable. Generally, savings banks and regional cooperative banks exhibited the lowest levels of non-lending activities. Private banks alongside central cooperative banks exhibited the highest levels. In hindsight the indicator's drop can be interpreted as early warning signal. They are issued for almost all bank types. The signal's heterogeneity is thus small. But, as for all indicators, total benchmarks do not exist which renders the detection of systemic risk with the help of this indicator difficult and impairs the appropriateness.

5.6 Synthesis

All indicators issue heterogeneous signals for different bank types. Accordingly, the indicators are indeed able to account for the heterogeneity of the German banking sector. Yet, for most indicators, signals are not uniform before and during crises. In this sense, almost no indicator of the selected set has been able to reliably identify crises beforehand.⁷³ Multiple indicators, however, have been good thermometers of distress, indicating risk contemporaneously. Balance sheet structures provide good information on banks' behavior and overall risk profile. Accordingly, asset and liability structures furnish an overarching framework for a more detailed systemic risk assessment. Indicators of maturity are partially able to detect systemic risk during crisis and in the accumulation phase, with the exception of the short-term-borrowing-to-long-term-lending ratio. Both indicators' complementary features, however, attribute a good indicative power to them. Distress indicators demand more caution, correctly signaling risks in some cases but issuing false warnings in others. Solvency risk indicators appear to be good thermometers of distress with the least heterogeneous signals. Finally, indicators on banks' activity profile provide an idea of banks' practices and their assets' evolution. However, these indicators are not well suited to signal crises or distress. For all indicators, the following issues remain: First, causalities cannot be proven by descriptive analyses. Second, benchmarks for indicators are difficult to define and remain unclear. Accordingly, systemic risk can often only be detected in hindsight or, at most, contemporaneously. The assessment of systemic risk thus continues to rely on experience. Third, great data issues remain such that available data structurally conceals risks and thus the build-up of systemic risk.

Throughout the assessment, returning clusters emerged. Big/superior institutions, i.e. big private banks, Landesbanken, and central cooperative banks, often behave similarly. Their behavior suggests that they drive aggregate dynamics and thus systemic risk as their indicators are

⁷³ Interestingly, most indicators did not show the build-up risk for Landesbanken before the 2007 crisis.

very much alike visually, and typically overamplify dynamics. This is particularly true for big private banks who behave in an especially volatile way and have a large impact on aggregate dynamics. In this sense, superior cooperative and savings banks tend to act in accordance with big private banks but are unlikely to preside over developments. The findings coincide with other empirical studies which suggest that, because of their higher leverage, more market-based activities, and higher complexity, big banks contribute more to systemic risk than smaller banks (Laeven et al., 2014). On the other hand, regional savings and cooperative banks tend to sit out short-term developments, attenuating aggregate volatility and systemic risk. Accordingly, regional savings and cooperative banks seem to truly exhibit the stabilizing features attributed to them by conventional wisdom. Finally, regional private banks often take an intermediate position, featuring characteristics of big and regional institutions, such that it is difficult to depict their clear role in systemic risk developments. Subsequently, knowledge of German banks' heterogeneity is key to a profound assessment of systemic risk. Simply focusing on big/superior institutions is, however, insufficient or even dangerous and not the implication of this work. Regional institutions cannot be underestimated. As credit risk is the fundamental risk of banks' business, regional banks are by no means risk-free. The German banking sector's heterogeneity must thus be embraced to totality for a correct risk monitoring.

The unique features of the German banking sector as outlined in chapter 3 further emphasize the necessity to account for structural features emerging from different banks types' heterogeneity in behavior and set-up. Mutual guarantee schemes of savings and cooperative banks are likely to induce excessive risk-taking on behalf of individual institutions. In this sense, despite their stable, conventional business and risk-attenuating properties displayed here-above, regional savings and cooperative banks are not protected from excessive risk-taking.⁷⁴ Furthermore, mutual guarantee schemes legally require regional savings and cooperative banks to take responsibility for their superiors, which are, as pointed out, likely to be subject to greater risks and drive systemic risk. Regional savings and cooperative banks are therefore exposed to the greater risks of their superiors through their ownership of these institutions.⁷⁵ Accordingly, mutual guarantee schemes are likely to amplify risks to individual banks the sector as a whole, which is a structural risk not echoed by the indicators used in this assessment.

⁷⁴ It does not even necessitate a change in business lines but a reduction in, for instance, credit standards is already sufficient to increase systemic risk. Such risk can, however, not be assessed with the indicators employed in the assessment as they do not survey information on banks business' quality.

⁷⁵ Regional institutions most likely have no control of their superiors' activities.

The tiered structure of the interbank market leads the majority of banks to rely on few core institutions' liquidity provision which results in another structural risk. The structural risk emerging from the tiered interbank market is closely connected to infrastructure and funding/liquidity risks and has a twofold implication. First, as suggested, large/superior banks are likely part of the interbank market's core. Therefore, the core of the interbank market is subject to substantially higher volatility and adverse forces during crises than the periphery's institutions. Consequently, the core-periphery structure of the interbank market elevates the funding and liquidity risks of peripheral institutions. Also, due to core banks' greater subjection to procyclicality, the procyclical risk for the peripheral banks, who usually behave rather steadily, increases. Second, Landesbanken and central cooperative banks' role is to provide liquidity and funding services to their subordinated banks. Yet, not only the subordinate banks rely on their superior's service provision to them. But superior institutions are equally dependent on their subordinated institutions' excess liquidity, which prevents them from having to rely on market funding. If the liquidity provision of regional savings and cooperative banks abstain, superior institutions need to turn to market liquidity which increased their funding and market risk and their overall risk profile accordingly. Consequently, the tiered interbank market subjects banks to (structural) risks that above-used indicators were unable to detect and for which it is necessary to embrace the German banking sector's heterogeneity in total.

Finally, with regard to concentration, competition, and profitability, the above-conducted assessment confirms the suggestion that regional savings and cooperative banks compete strongly at the regional level as their behavior largely coincides and affirms the suggested competition between big/superior institutions in different markets. "On the one hand, competition may enhance financial stability by pushing unstable banks out of the market" (Pawłowska, 2015, p.15). Concentration increases accordingly but market fragmentation remains too because market ousts in the German banking sector typically occur within the same pillar and imply the incorporation of ousting institutions into larger/proximate institutions. Therefore, the consolidation pattern of the German banking sector calls into question whether systemic risk is actually reduced. Unstable positions and destabilizing behavior could remain in new institutions such that these institutions exhibit a similar risk profile as the ousted ones. "On the other hand, competition can encourage banks to take greater risks in order to become more profitable (Bikker & Leuvenstein, 2014)" (Pawłowska, 2015, p.15). As mentioned above, big/superior institutions are more prone to higher risk behavior. However, regional institutions are not covered from such risks, despite seemingly stable business activities in a highly competitive environ-

ment. Similarly, low concentration at the national but high concentration in certain markets/regions echoes that few big private banks and Landesbanken have the largest balance sheets. Especially big private banks' contribution to systemic risk detected by the indicators corresponds to empirical findings (Laeven et al., 2014). Moreover, due to their size and their position in the interbank market, these banks are likely too big or too interconnected to fail, which might further increase their contribution to the development systemic risk via ever more excessive risk taking. The low concentration among regional savings and cooperative banks thus is again a stabilizing factor. Also, regional institutions' profitability has been rather stable and well, implying that these banks have little incentive to push their profitability via greater risk taking. Conversely, the great volatility of especially big private banks and central cooperative banks further induces risk-prone actors to greater risk taking. Accordingly, the structural risk emerging from concentration, competition, and profitability properties reinforces the risks assessed by the indicators used above. In this sense, structural features underline the necessity to thoroughly monitor large/superior institutions, yet it also emphasizes the fact that regional and private banks are dependable but not risk-free actors, requiring equally strong supervision.

Latest developments of the selected systemic risk measures are difficult to classify. It seems that the recovery from the 2007 crisis is still ongoing. Certain indicators, such as capitalization and short-term borrowing, have improved or even returned to the 1990s levels. In turn, other indicators, such as short-term lending or the loan-to-asset ratio, remained elevated or even worsened. Additionally, critical levels of indicators are vague and the individual contributions of different bank types to current dynamics/systemic risk require a deeper assessment. Therefore, the question on whether systemic risk has substantially improved since the last crisis remains unanswered by the selected indicators.

It is likely that with the 2008/09 financial crisis, the German banking sector entered a new phase. Generally, one can distinguish between three episodes over the assessment period, i) between 1990 until the introduction of the euro/the 2001 crisis; ii) between the 2001 crisis and 2008/09 financial crisis; and iii) since the 2008/09 financial crisis. Each episode seems driven by distinct features.⁷⁶ Hence heterogeneity not only prevails at the bank-type level but also with regard to the time dimension and the distinct phases. Furthermore, bank-type heterogeneity and periodic heterogeneity interact. Regional savings and cooperative banks, for example, exhibit fairly stable behavior over all three phases, but regional private banks decisively alter their performance after the first period. Overall, different determinants of the financial

⁷⁶ The assessment of these determinants goes beyond the scope of this assessment and paper.

cycle(s) and (systemic) risk(s) in each period complicate the correct benchmarking of individual indicators as well as the selection of meaningful indicators at large.

6. Conclusion

This paper examined the impact of heterogeneity on the assessment of systemic risk. Precisely, this work called into question whether currently employed systemic risk indicators are able to account for the German banking sector's heterogeneity and to signal systemic risk reliably regardless of banks' individual characteristics. In order to assess these research questions, the work applied currently employed risk indicators to bank-type-specific data for six different bank types from 1990 until 2018. The indicators were benchmarked against crises that occurred during the assessment period. Indicators were selected from the ESRB risk dashboard according to their applicability to the research question and data availability. Data availability severely constrained the usage of the ESRB risk dashboard's indicators such that only four indicators of the initial template remained. Therefore, other commonly used systemic risk indicators were used to complement to the final set. Beforehand, this paper provided background information on the German banking sector's set up and specific characteristics which were later taken into account for the assessment of the sector's risk profile. To inform the analysis and the selection process of the indicators, it was outlined how systemic risk is defined and assessed.

The final set of indicators is indeed able to account for the German banking sector's heterogeneity, providing insight into bank types' behavior. Moreover, the indicators' distinct development for different bank types enabled the author to identify individual bank types' role in the accumulation of systemic risk. In this sense, clusters emerged. Big private banks, Landesbanken, and central cooperative banks often behaved alike, driving aggregate dynamics and systemic risk. In particular, big private banks are typically at the forefront of risk developments, whereby Landesbanken and central cooperative banks tend to coincide their developments. In turn, regional savings and cooperative banks appear risk attenuating and stabilizing, confirming commonly held beliefs. Regional private banks take an intermediate position, exhibiting features of the risk-driving and risk-attenuating clusters, hence their overall role for systemic risk remains inconclusive.

Structural risks stemming from the sector's architecture particularly amplify the risk of regional institutions and thus jeopardize their low-risk profile to some extent. Therefore, regional savings and cooperative banks should not be underestimated in their risk contribution. Assessments accounting for the heterogeneity of the German banking sector should avoid the pitfall

of focusing on seemingly high-risk actors and neglecting the remaining institutions. In this sense, this paper illustrates that top-down approaches toward financial supervision are not adequate in the context of the German banking sector. Systemic risk assessment techniques for the German banking sector need to be rethought, building on indicated sectoral structures and their suggested implications for systemic risk, in order to properly account for the dynamics underpinning aggregate phenomena of financial (in)stability in Germany.

Furthermore, the selected indicators were only partially able to signal crises correctly. Not only have signals differed for bank types, mostly in accordance with banks (de-)stabilizing properties), but the indicators' efficacy also differed from crisis to crisis. Apart from warning against some crises but not against others, some indicators also urged caution in risk-/distress-unrelated contexts. Overall, most indicators behave more like thermometers than barometers of risk and distress. Benchmarking the indicators remains highly difficult, which is rendered more complex by the fact that the assessment period seems to exhibit three distinct phases. Consequently, systemic risk assessments with the help of systemic risk indicators continue to rely on supervisors' experience. Necessarily, systemic risk thus remains inherently difficult to grasp and is further complicated if evolving in ways outside a regulator's expertise. Moreover, data availability severely constrains assessments by bank type and masks the impact of different bank types' heterogeneity for systemic risk, hindering the assessment of systemic risk itself. Therefore, this work displays again the severe limits to systemic risk assessments, deriving from data availability and, eventually, from the uncertainty and unpredictability of systemic risk itself.

The analysis of this paper has been purely descriptive, and therefore, the results are more suggestive than conclusive. Moreover, this work constitutes only a first step toward approaching the question of the contribution of the German banking sector's heterogeneity to systemic risk in a formalized way. Empirical/quantitative assessments are necessary to confirm, for instance, the causalities or the drivers of banks' behavior. Furthermore, quantitative assessments could support the benchmarking of indicators and identification of specific phases. In the long-run, an attempt could be made to create a composite indicator of systemic risk for the German banking sector which takes into account the risk-driving and risk-attenuating properties of different bank types.

7. References

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8. Appendix

8.1 Data availability

The Deutsche Bundesbank provides bank-specific data tables, which allow for an overview of the available time series. The overview tables can be accessed with the following link:

<https://www.bundesbank.de/en/statistics/banks-and-other-financial-institutions/banks/banks-745162>⁷⁷.

Interlinkages

- Data on cross-border claims by country and volume is only available for the banking sector as a whole and not for the required time period.
- Data on credit by counterpart sector to depict risk stemming from specific sectors as well data on loans for home purchases is only available for the domestic sector and in quarterly data. Statistics, however, do not provide a comparator, such as total credit, on a quarterly basis which disables a proper assessment. Moreover, data on deposits by counterpart sector is not available. Consequently, the analysis does not assess cross-border claims, credits and deposits by counterpart sector, and loans for home purchases.

Credit risk

- Data on annual growth rates of loans to households and NFCs by debtor type is only available for domestic debtors.
- Data on lending margins is not available.
- Foreign currency loans cannot be studied because data on banks' total foreign currency positions is missing. The Bundesbank only provides data on lending and borrowing to and from foreigners as well as on assets and liabilities denominated in foreign currency vis-à-vis residents.

Funding and liquidity risk

- No data is available on the maturity profile of banks' outstanding debt securities as well as on banks' long-term debt securities issuance. The Bundesbank only provides data on the different type of debt securities held by various bank types and on the maturity profile of bearer bonds.
- Data on CDS on senior and CDS on subordinated debt not publicly available.

⁷⁷ Accessed on 28th May 2019.

Profitability and solvency risk

- Data on ROA and the cost-to-income ratio is not available. The Bundesbank only provides data on certain costs, such as expenditure on staff as percentage of total operating income.
- No data is publicly available on banks risk-weighted assets as well as on their CET1, especially not by banks type.
- The Bundesbank does not collect data on non-performing loans by bank type.
- No information is available on the liquidity properties of banks' assets.
- No data is available on banks' asset encumbrance ratio.

8.2 Relevant variables from the Deutsche Bundesbank database

The names used for different bank types correspond to the following names/codes in the time series database for banks at the Deutsche Bundesbank:

In this work	At the Deutsche Bundesbank
Total/all banks	All categories of banks
Big private banks	Big banks
Regional private banks	Regional banks and other commercial banks
Landesbanken	Landesbanken
Regional savings banks	Savings banks
Central institutions of cooperative banks/central cooperative banks	Regional institutions of credit cooperatives (up to June 2016)
Regional cooperative banks	Credit cooperatives

8.3. Equations for the calculation of indicators

Short-term borrowing to total borrowing ratio

1990 – 1998

$$\frac{(\text{short-term borrowing from all non-banks}) + (\text{short-term borrowing from domestic banks})}{(\text{total borrowing from all non-banks}) + (\text{total borrowing from domestic banks})}$$

1999 – 2018

$$\frac{(\text{short-term borrowing from all non-banks}) + (\text{short-term borrowing from all banks})}{(\text{total borrowing from all non-banks}) + (\text{total borrowing from all banks})}$$

Short-term lending to total lending ratio

1990 – 1998

$$\frac{(\text{short-term lending to all non-banks}) + (\text{short-term lending to domestic banks})}{(\text{total lending to all non-banks}) + (\text{total lending to all banks})}$$

1999 – 2018

$$\frac{(\text{short-term lending to all non-banks}) + (\text{short-term lending to all banks})}{(\text{total lending to all non-banks}) + (\text{total lending to all banks})}$$

Loans to deposits (loan-to-deposit ratio)

$$\frac{\text{Total lending}}{\text{Total deposits}}$$

Capital to assets (capital-to-asset ratio)

$$\frac{\text{Capital}}{\text{Total assets}}$$

NRWA to capital (NRWA-to-capital ratio)

$$\frac{\text{NRWA}}{\text{Capital}}$$

Loans to assets (loan-to-asset ratio)

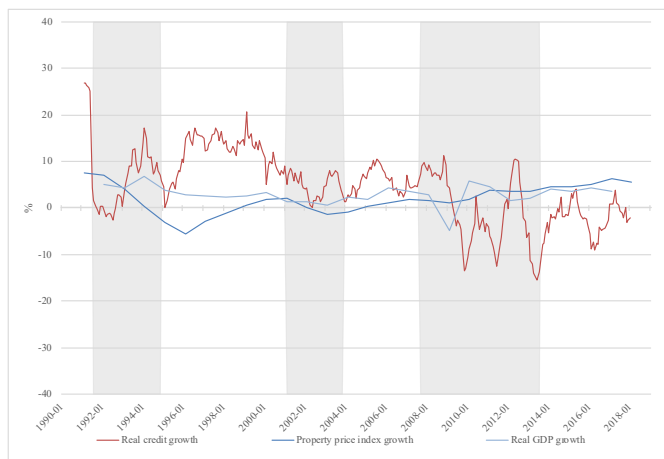
$$\frac{\text{Total lending}}{\text{Total assets}}$$

If not differently specified, “total” always combines data on banks and non-banks as counterpart.

8.4. Graphs for the assessment of systemic risk indicators' appropriateness

8.4.1 Macro environment

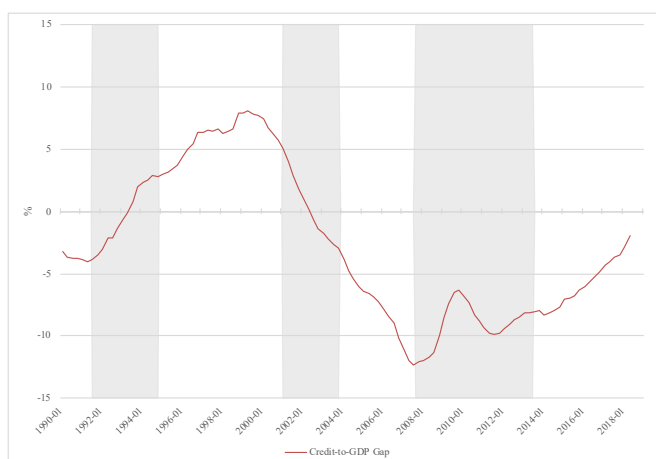
Graph 1: Financial cycle of all banks comprising real credit growth, property price index growth, and real GDP growth (1990 – 2018, monthly and annual data in percentage points)



Source: bulwiengesa AG (2018); Deutsche Bundesbank (2019d, 2019f); ESRB (2017b); The World Bank (2019); author's own calculations and presentation

Graph 2a-f can be found on the next page.

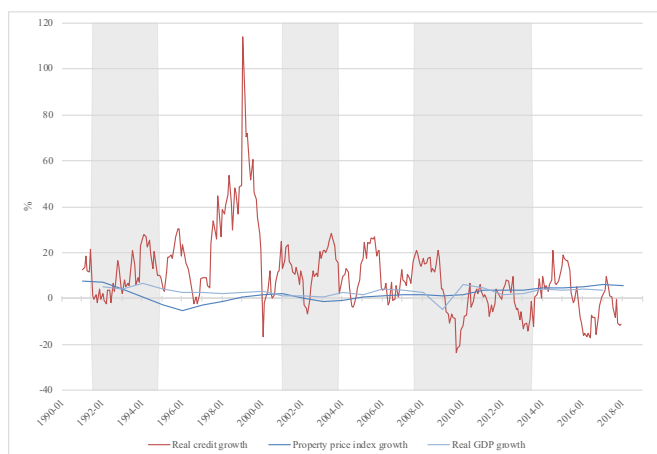
Graph 3: German credit to GDP gap (1990 – 2018, quarterly data)



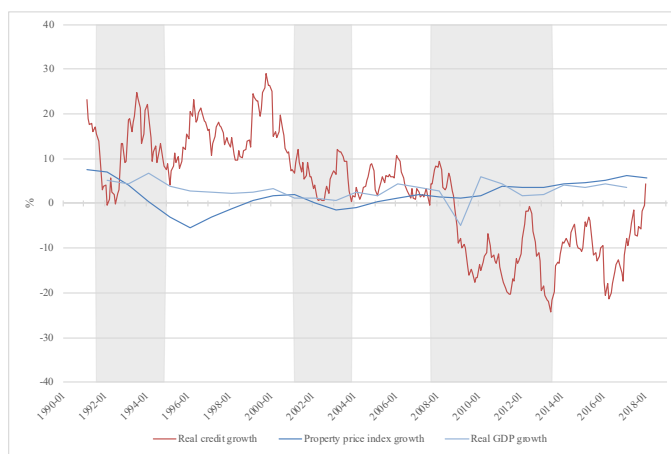
Source: Deutsche Bundesbank (2019e); ESRB (2017b); author's own presentation

Graph 2: Financial cycle comprising real credit growth, property price index growth, and real GDP growth (1990 – 2018, monthly and annual data in percentage points)

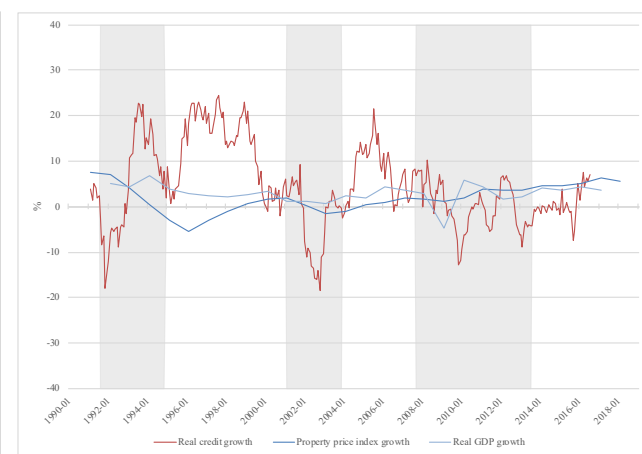
Graph 2a: Big private banks



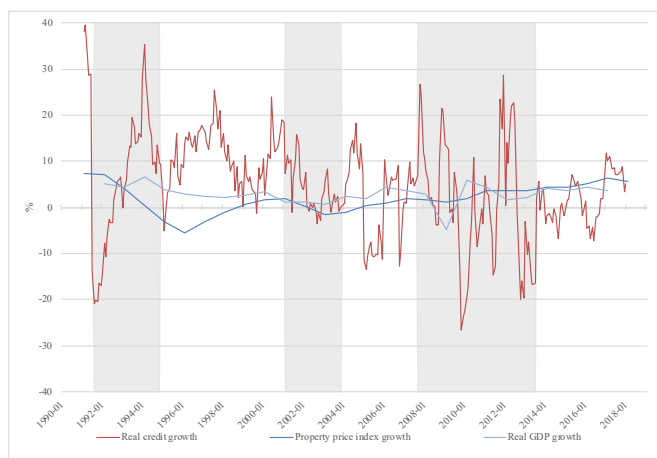
Graph 2c: Landesbanken



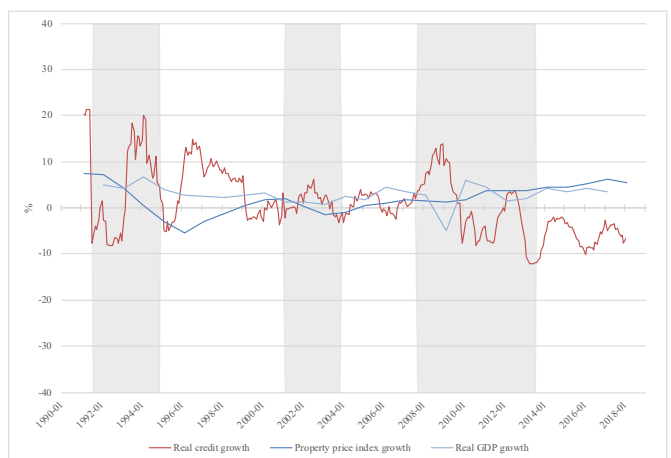
Graph 2e: Central institutions of cooperative banks



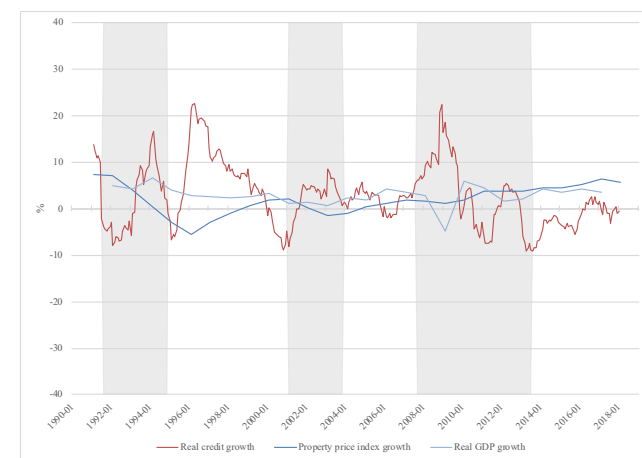
Graph 2b: Regional private banks



Graph 2d: Regional savings banks



Graph 2f: Regional cooperative banks

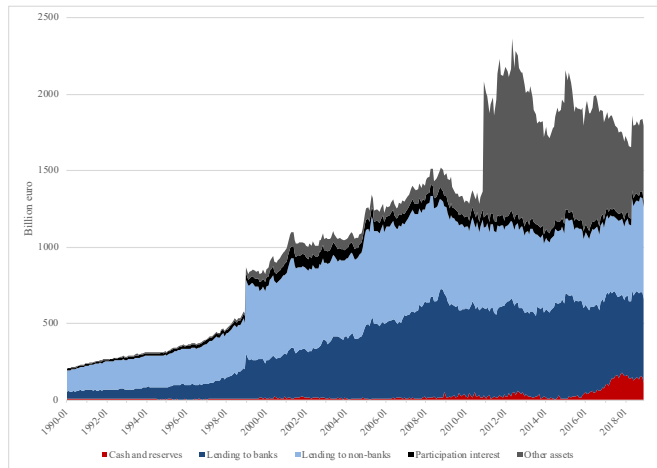


Source: bulwiengesa AG (2018); Deutsche Bundesbank (2019d, 2019f); ESRB (2017b); The World Bank (2019); author's own calculations and presentation

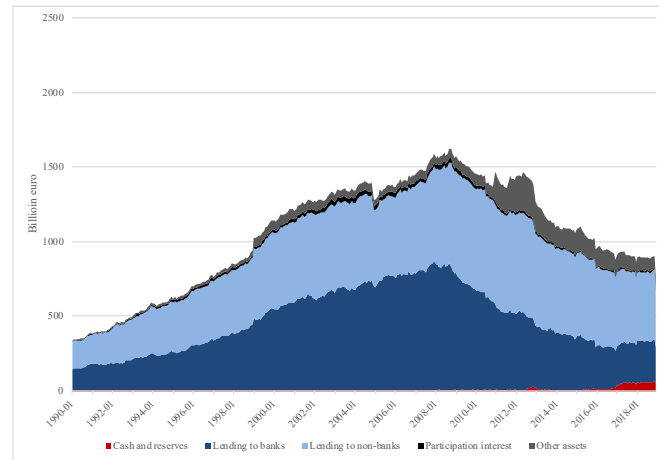
8.4.2 General balance sheet

Graph 4: Asset structures (1990 – 2010, monthly data in billion euro)

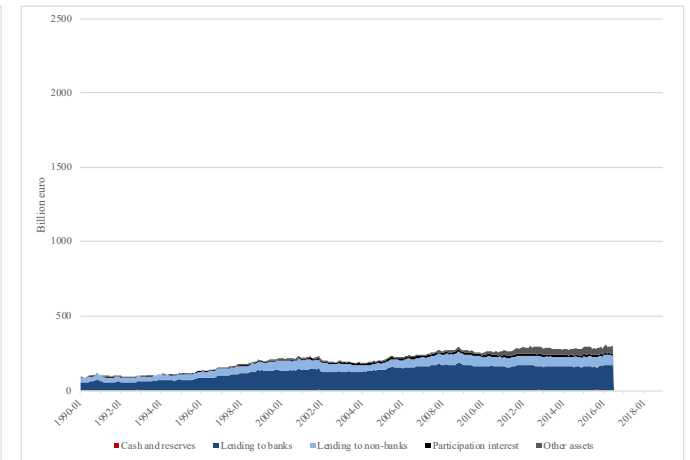
Graph 4a: Big private banks



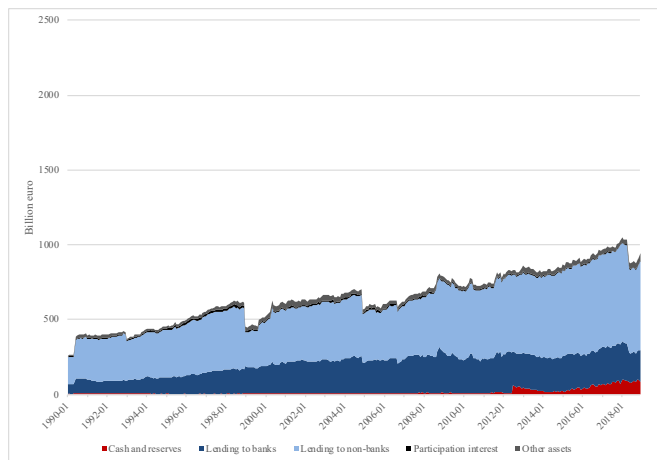
Graph 4c: Landesbanken



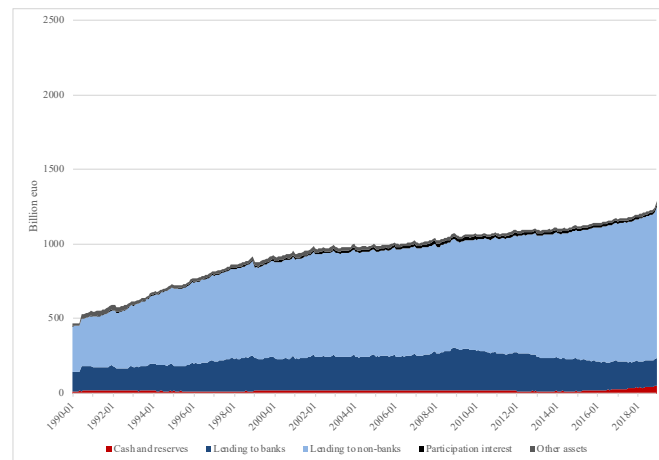
Graph 4e: Central institutions of cooperative banks



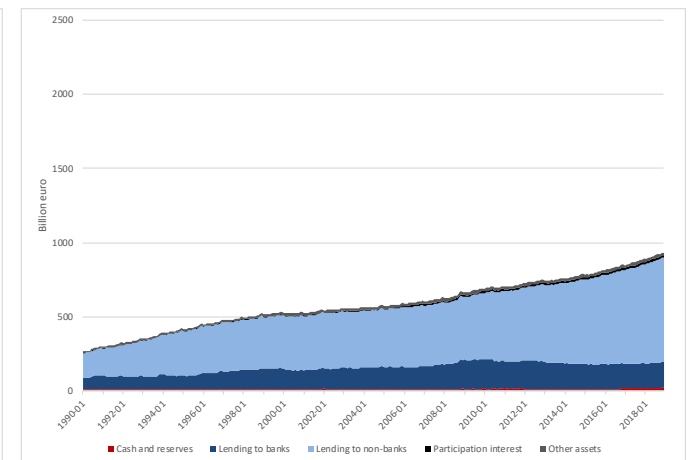
Graph 4b: Regional private banks



Graph 4d: Regional savings banks



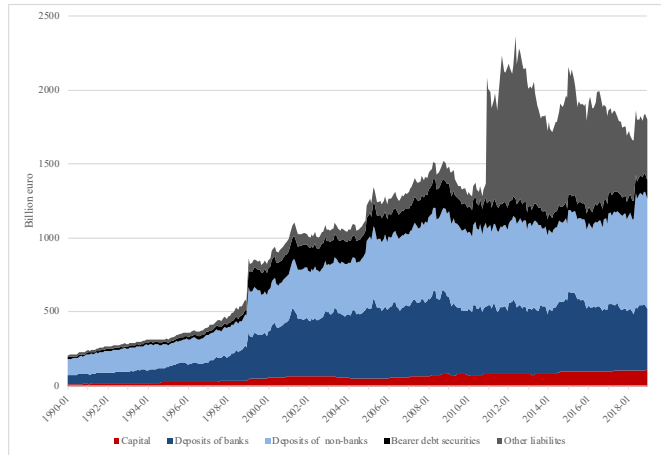
Graph 4f: Regional cooperative banks



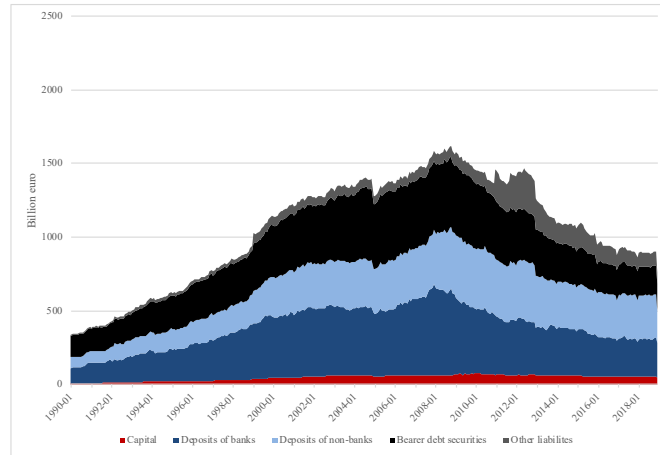
Source: Deutsche Bundesbank (2019d); author's own presentation

Graph 5: Liability structures (1990 – 2010, monthly data in billion euro)

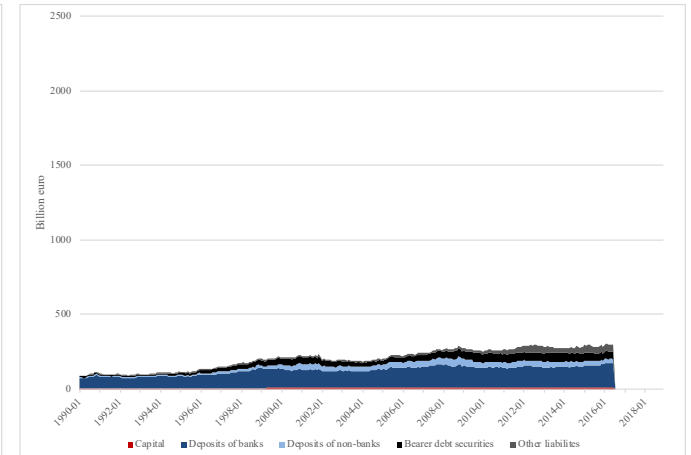
Graph 5a: Big private banks



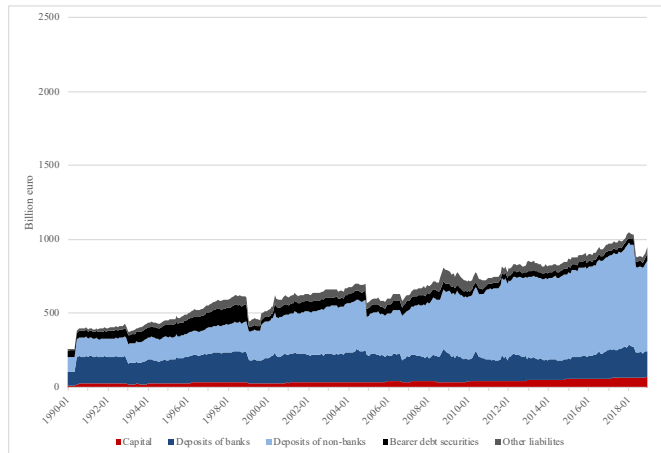
Graph 5c: Landesbanken



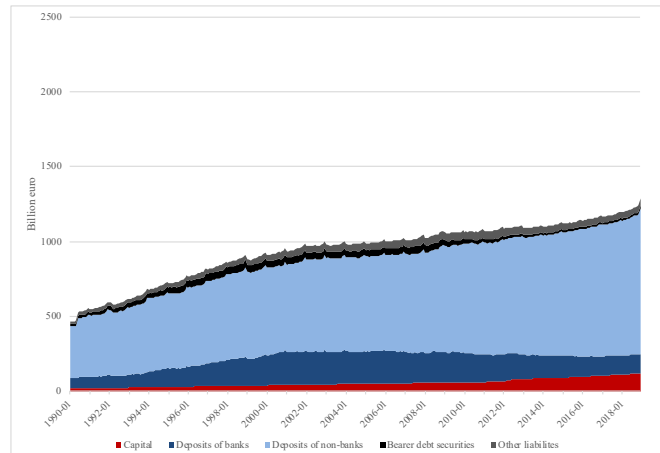
Graph 5e: Central institutions of cooperative banks



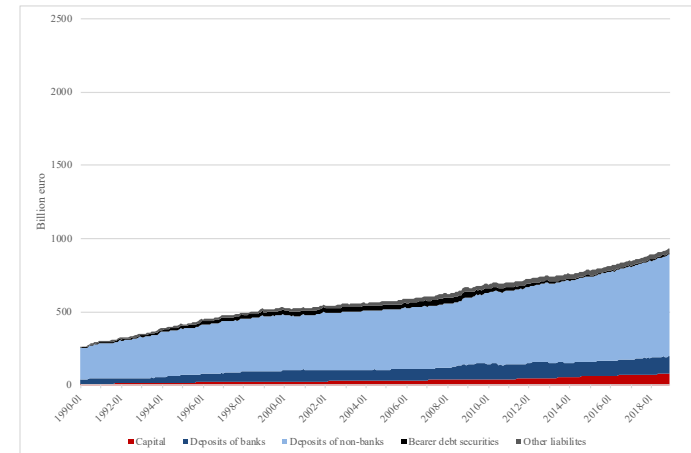
Graph 5b: Regional private banks



Graph 5d: Regional savings banks



Graph 5f: Regional cooperative banks

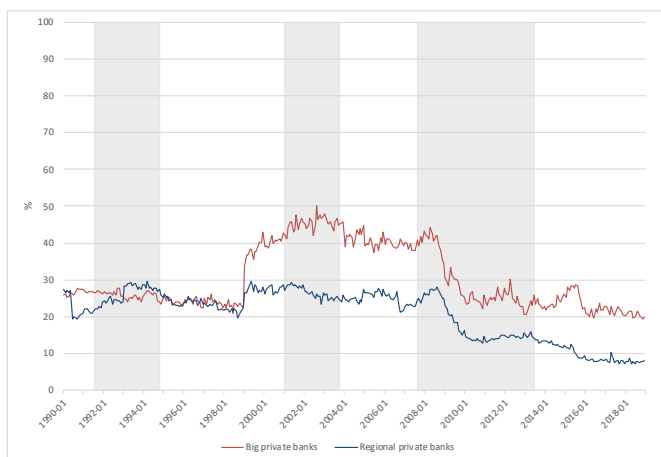


Source: Deutsche Bundesbank (2019d); author's own presentation

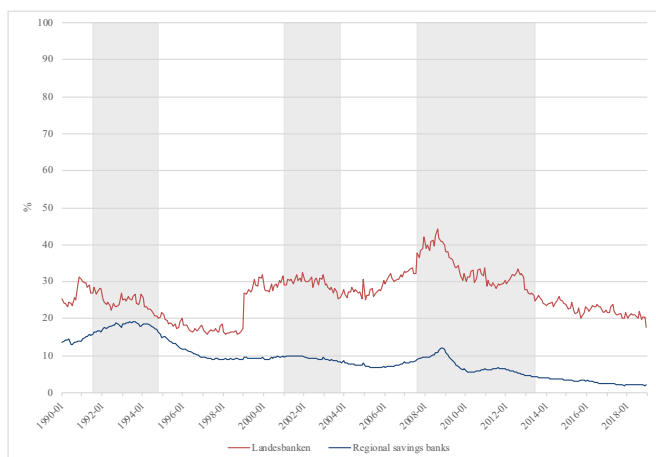
8.4.3 Maturity and funding structures

Graph 6: Short-term-borrowing-to-total-borrowing ratio (1990 – 2018, monthly data in percentage points)

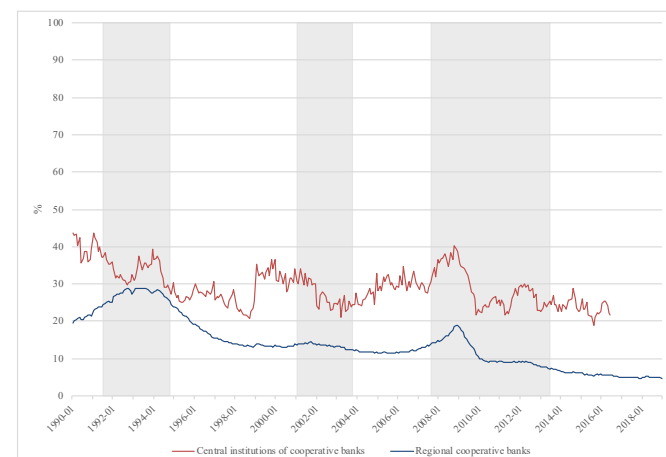
Graph 6a: Private banks



Graph 6b: Savings banks



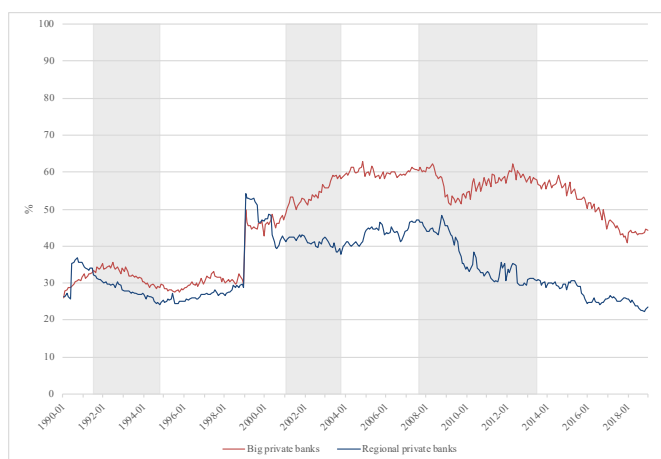
Graph 6c: Cooperative banks



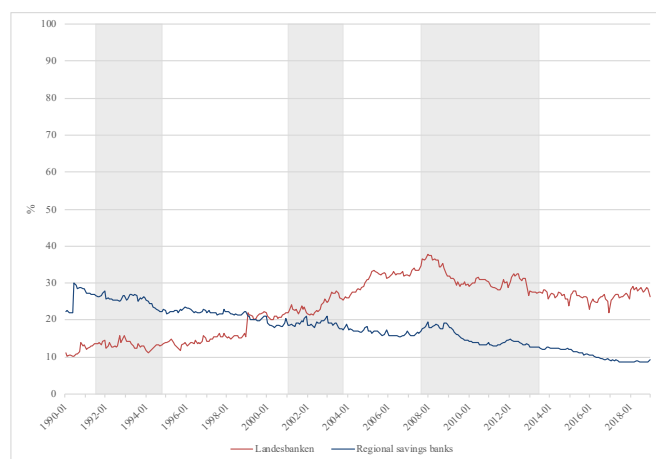
Source: Deutsche Bundesbank (2019d); ESRB (2017b); author's own calculations and presentation

Graph 7: Short-term-lending-to-total-lending ratio of private banks (1990 – 2018, monthly data in percentage points)

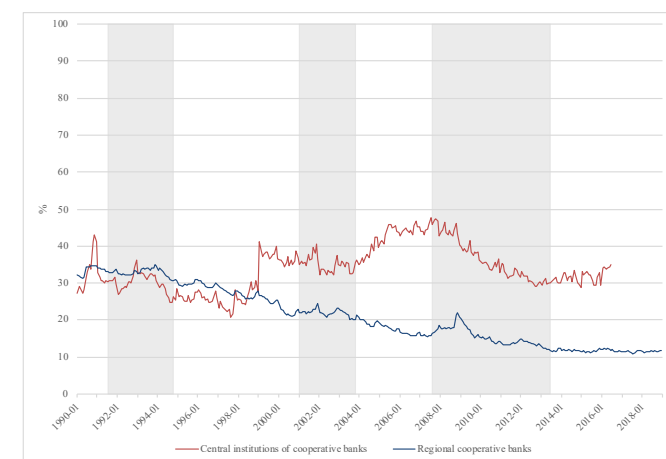
Graph 7a: Private banks



Graph 7b: Savings banks



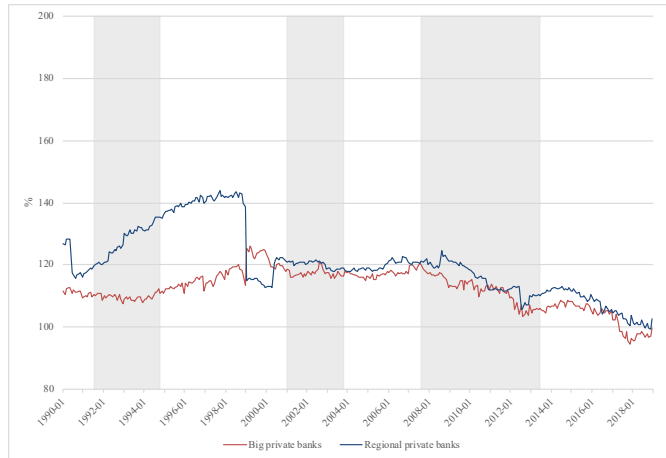
Graph 7c: Cooperative banks



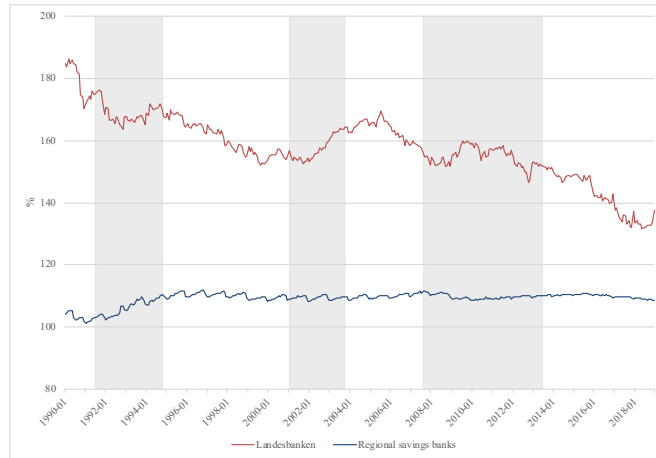
Source: Deutsche Bundesbank (2019d); ESRB (2017b); author's own calculations and presentation

Graph 8: Loan-to-deposit ratio (1990 – 2018, annual data in percentage points)

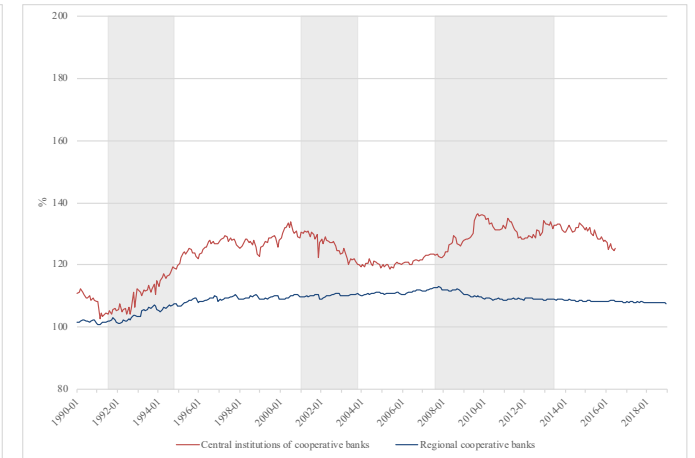
Graph 8a: Private banks



Graph 8b: Savings banks



Graph 8c: Cooperative banks

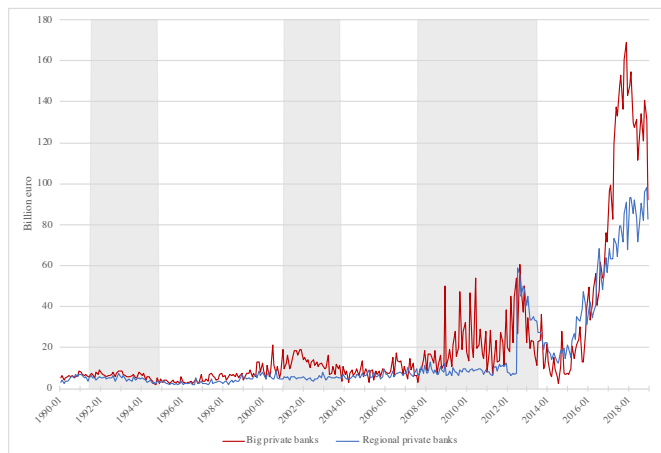


Source: Deutsche Bundesbank (2019d); ESRB (2017b); author's own calculations and presentation

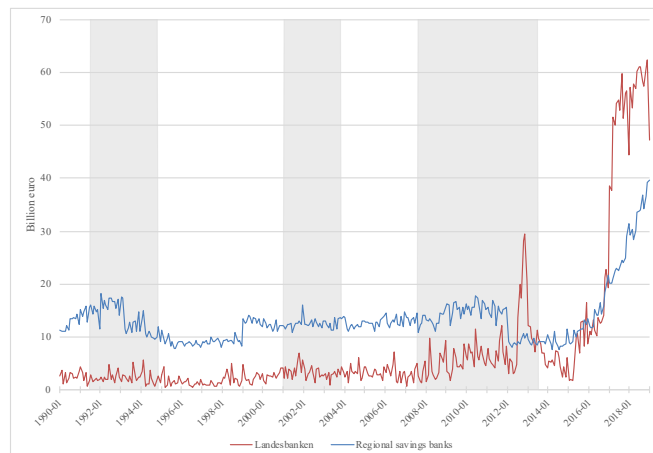
8.4.4 Distress

Graph 9: Central bank assets of banks (1990 – 2018, monthly data in billion euro)

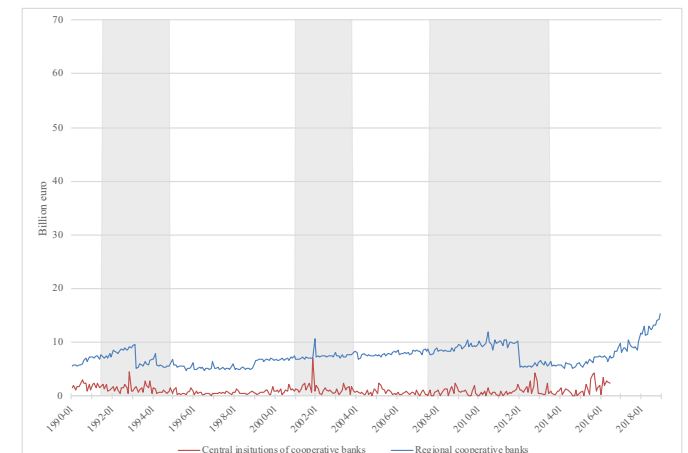
Graph 9a: Private banks



Graph 9b: Savings banks



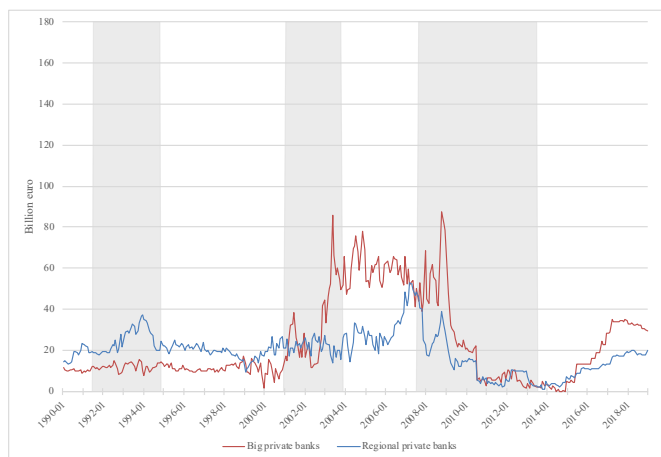
Graph 9c: Cooperative banks



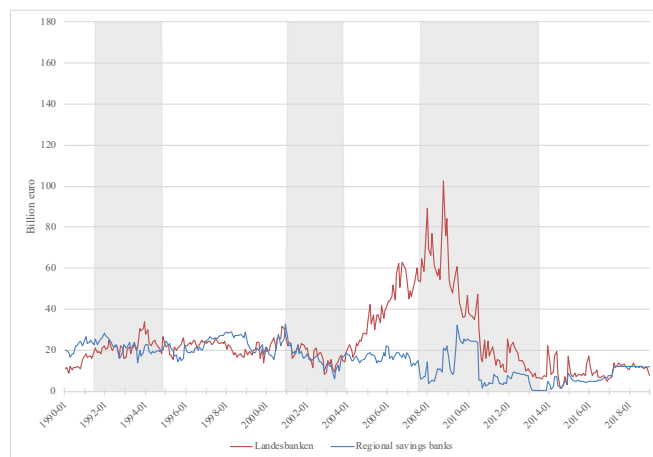
Source: Deutsche Bundesbank (2019d); ESRB (2017b); author's own calculations and presentation

Graph 10: Central bank liabilities of banks (1990 – 2018, monthly data in billion euro)

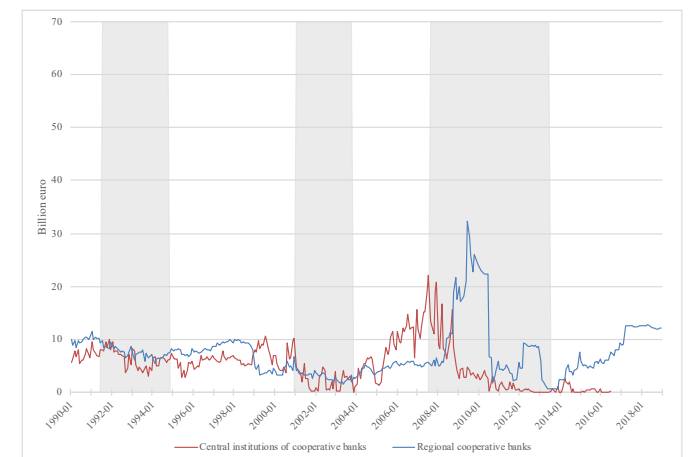
Graph 10a: Private banks



Graph 10b: Savings banks



Graph 10c: Cooperative banks

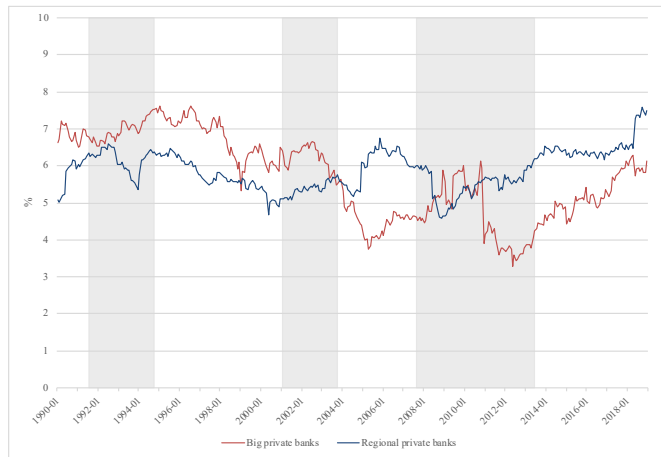


Source: Deutsche Bundesbank (2019d); ESRB (2017b); author's own calculations and presentation

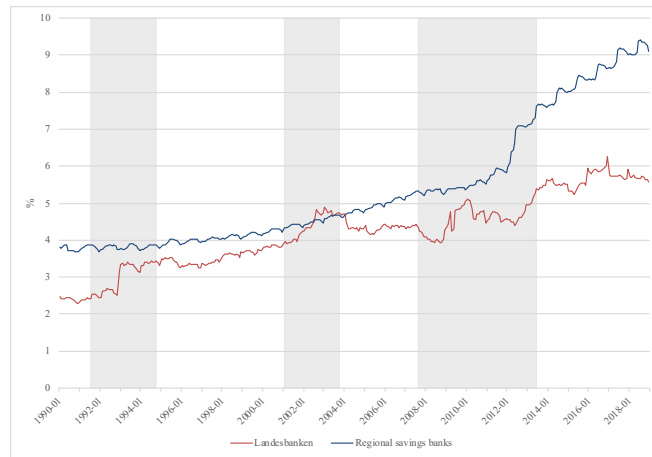
8.4.5 Capitalization and solvency

Graph 11: Capital-to-asset ratio (1990 – 2018, monthly data in percentage points)

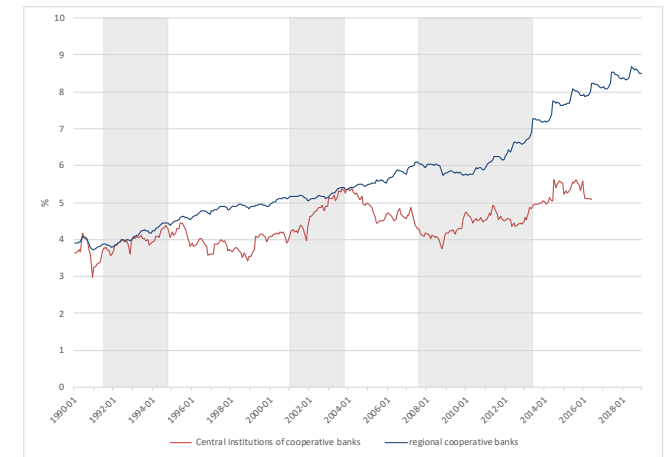
Graph 11a: Private banks



Graph 11b: Savings banks



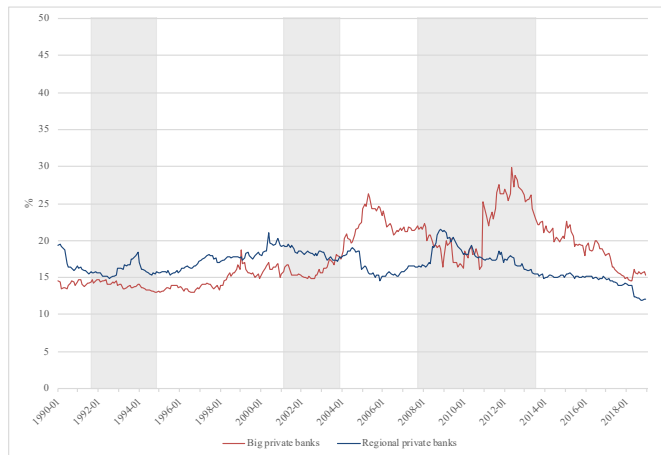
Graph 11c: Cooperative banks



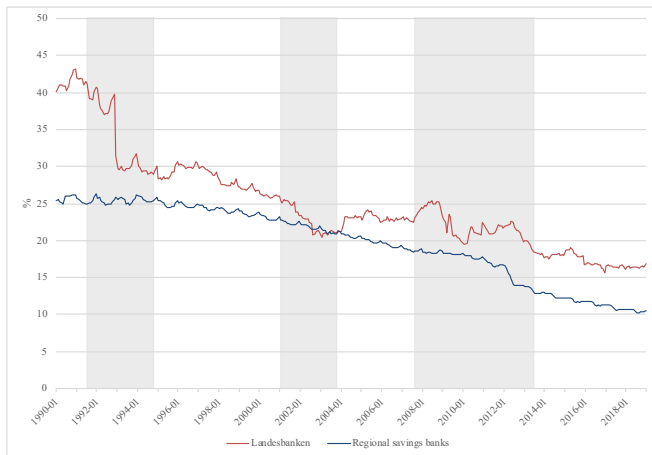
Source: Deutsche Bundesbank (2019d); ESRB (2017b); author's own calculations and presentation

Graph 12: NRWA-to-capital ratio (1990 – 2018, monthly data in percentage points)

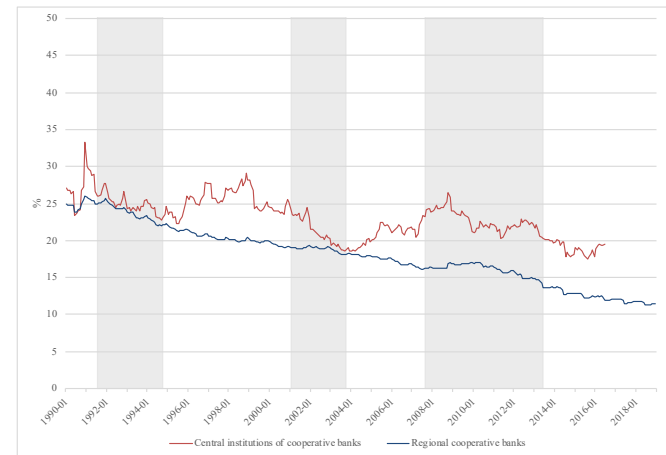
Graph 12a: Private banks



Graph 12b: Savings banks



Graph 12c: Cooperative banks



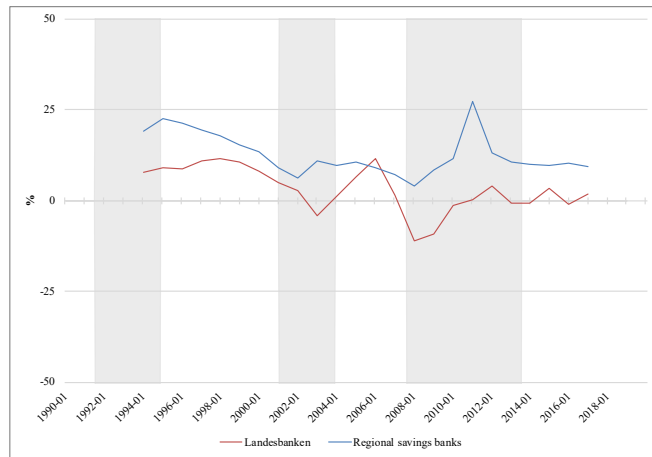
Source: Deutsche Bundesbank (2019d); ESRB (2017b); author's own calculations and presentation

Graph 13: Return on equity (1994 – 2017, annual data in percentage points)

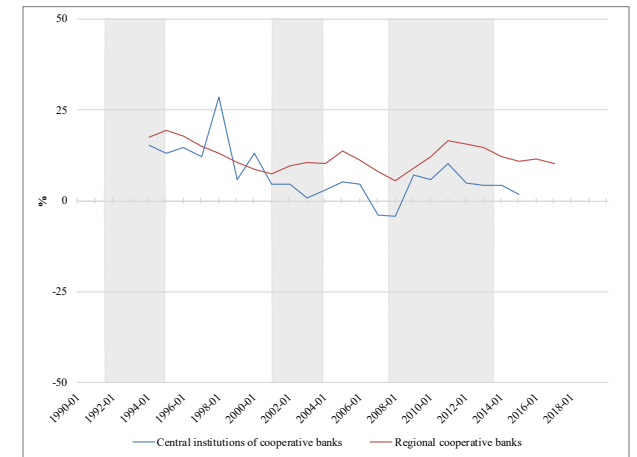
Graph 13a: Private banks



Graph 13b: Savings banks



Graph 13c: Cooperative banks

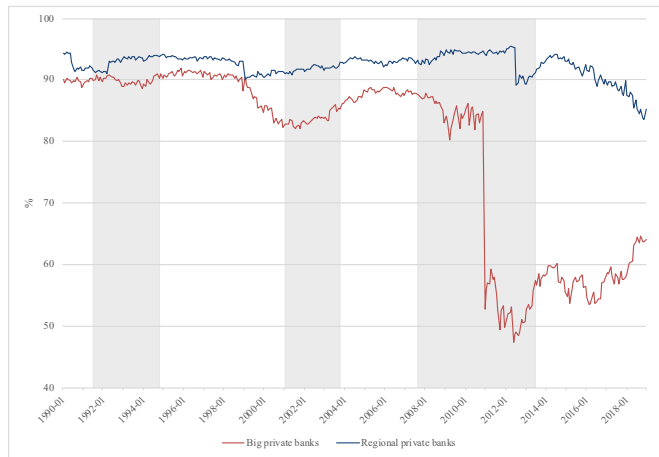


Source: Deutsche Bundesbank (2019b); ESRB (2017b); author's own presentation

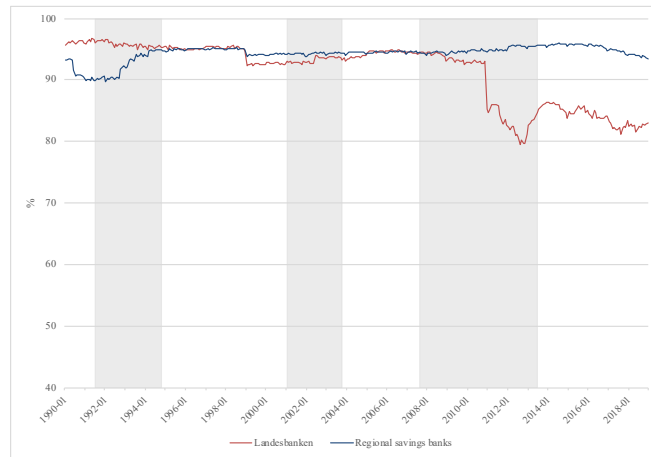
8.4.6 Activity profile

Graph 14: Loan-to-asset ratio (1990 – 2018, monthly data in percentage points)

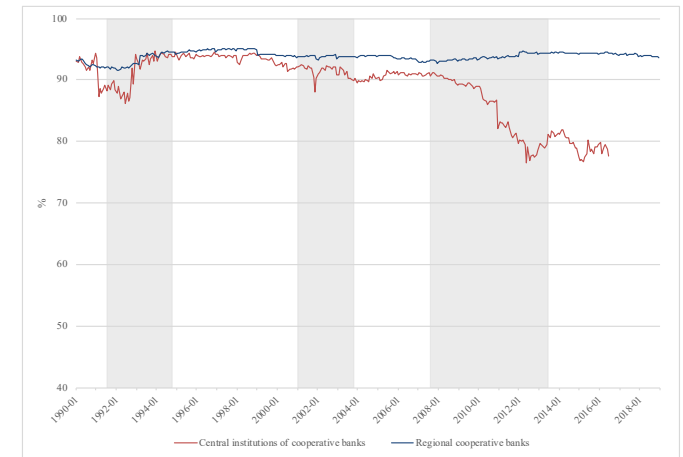
Graph 14a: Private banks



Graph 14b: Savings banks



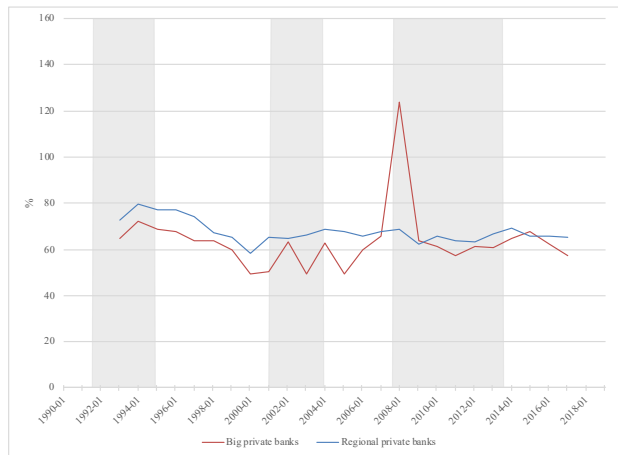
Graph 14c: Cooperative banks



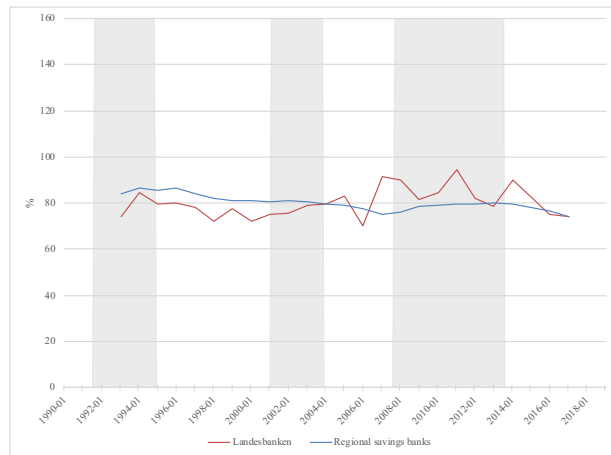
Source: Deutsche Bundesbank (2019d); ESRB (2017b); author's own calculations and presentation

Graph 15: Net interest income to total operating income (1993 – 2017, monthly data in percentage points)

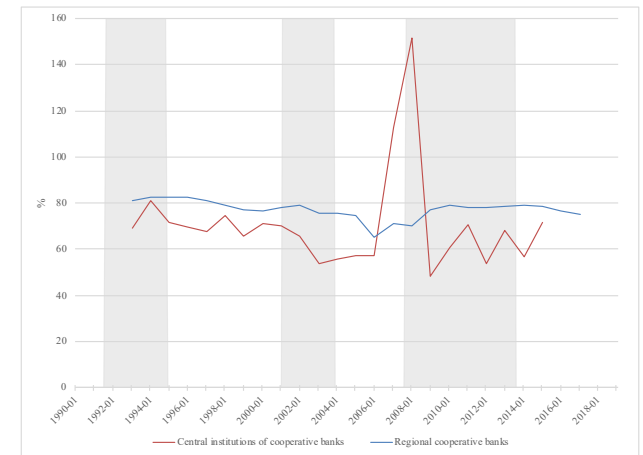
Graph 15a: Private banks



Graph 15b: Savings banks



Graph 15c: Cooperative banks



Source: Deutsche Bundesbank (2019c); ESRB (2017b); author's own presentation

8.5. Complementing figures

Table 2: Number of private banks, savings banks, and cooperative banks as of December of the respective year (1990 – 2018, monthly data in total numbers)

Year	Private banks	Savings banks	Cooperative banks
1990	217	784	3416
1995	201	639	2591
2000	204	575	1796
2005	163	475	1296
2010	172	439	1140
2015	163	423	1025
2018	155	392	875

Source: Bundesbank (2019d), author's own presentation

Table 3: Number of big private banks, Landesbanken, and central institutions of cooperative banks as of December of the respective year (1990 – 2018, monthly data in total numbers)

Year	Big private banks	Landesbanken	Central institutions of cooperative banks	New central institutions of cooperative banks
1990	10	12	6	
1995	3	13	4	
2000	4	13	4	
2005	5	12	2	
2010	4	10	2	
2015	4	9	2	
2018	4	6		1

Source: Bundesbank (2019d), author's own presentation