

# Discussion Paper

Deutsche Bundesbank  
No 27/2012

## Early warning indicators for the German banking system: a macroprudential analysis

Nadya Jahn

(University of Münster)

Thomas Kick

(Deutsche Bundesbank)

**Editorial Board:** Klaus Düllmann  
Heinz Herrmann  
Christoph Memmel

Deutsche Bundesbank, Wilhelm-Epstein-Straße 14, 60431 Frankfurt am Main,  
Postfach 10 06 02, 60006 Frankfurt am Main

Tel +49 69 9566-0

Telex within Germany 41227, telex from abroad 414431

Please address all orders in writing to: Deutsche Bundesbank,  
Press and Public Relations Division, at the above address or via fax +49 69 9566-3077

Internet <http://www.bundesbank.de>

Reproduction permitted only if source is stated.

ISBN 978-3-86558-853-1 (Printversion)

ISBN 978-3-86558-854-8 (Internetversion)

## **Abstract**

Over the past two decades, Germany experienced several periods of banking system instability rather than full-blown banking system crises. In this paper we introduce a continuous and forward-looking stability indicator for the banking system based on information on all financial institutions in Germany between 1995 and 2010. Explaining this measure by means of panel regression techniques, we identify significant macroprudential early warning indicators (such as asset price indicators, leading indicators for the business cycle and monetary indicators) and spillover effects. Whereas international spillovers play a significant role across all banking sectors, regional spillovers and the credit-to-GDP ratio are more important for cooperative banks and less relevant for commercial banks.

**Keywords:** Early Warning Indicators, Banking System Stability, Regional Spillover Effects, Panel Regression Techniques.

**JEL classification:** C23, E44, G01, G21.

## **Non-technical Summary**

Regular financial stability assessment and the identification of early warning indicators signaling emerging risks to the banking system are major tasks of central banks and supervisory authorities. The stability and efficiency of a banking system ensures the optimal allocation of capital resources in an economy, and regulators therefore aim to prevent banking system crises and their associated adverse feedback effects on the real economy. This paper introduces a continuous and forward-looking stability indicator for the German banking system which is used to identify early warning indicators and spillover effects in both regional banking and international financial markets.

Over the past two decades, Germany experienced several periods of banking system instability rather than full-blown banking system crises. Instability could be observed across banking sectors either as a consequence of reforms in banking legislation or resulting from national and international developments in financial markets. To describe the condition of the banking system, we develop an indicator compiling a basket of banks containing both major financial institutions and smaller banks. The indicator comprises three components: an institution's score (i.e., the standardized probability of default), a credit spread and a stock market index for the banking sector. The probabilities of default are derived from the Bundesbank's hazard rate model for small banks; for large institutions, Moody's Bank Financial Strength Ratings (BFSR) are used. The empirical study is based on confidential supervisory reporting data provided by the Deutsche Bundesbank comprising up to 3,330 institutions over the period 1995 to 2010.

Stability determinants of the national banking system can be classified into macroeconomic, financial and structural variables. Applying panel regression techniques, we find that asset price indicators, leading indicators for the business cycle and monetary indicators are reliable early warning indicators. In addition, international spillover effects play a significant role for stability across all banking sectors, whereas regional spillover effects and the credit-to-GDP ratio significantly affect credit cooperatives but are less important for commercial banks. These findings indicate that the heterogeneous structure of the German three-pillar banking system features a diversification effect (according to which each banking sector is affected by different shocks in different ways) and in this way may contribute to the stability of the banking system as a whole.

## **Nicht-technische Zusammenfassung**

Frühwarnindikatoren für drohende Risiken im Bankensystem leisten einen wichtigen Beitrag für die regelmäßige Finanzstabilitätsanalyse und die Identifizierung von systemischen Risiken. Die Stabilität und Effizienz eines Bankensystems ist für die Gewährleistung einer optimalen Kapitalallokation in einer Volkswirtschaft von besonderer Bedeutung. Aus diesem Grund zielen Regulatoren darauf ab, Bankenrisiken und ihre damit verbundenen, negativen Feedbackeffekte auf die Realwirtschaft zu vermeiden. Die vorliegende Arbeit leistet einen Beitrag bezüglich der Entwicklung eines kontinuierlichen, zukunftsgerichteten Stabilitätsindikators für das deutsche Bankensystem, welcher zu der Identifizierung vorlaufender Frühwarnindikatoren sowie internationaler und regionaler Ansteckungseffekte im Bankensystem verwendet wird.

Während der letzten zwei Jahrzehnte erfuhr Deutschland mehrere Perioden von Bankensysteminstabilität. Diese konnten zum einen über die Bankensektoren hinweg aufgrund von Gesetzesänderungen beobachtet werden oder resultierten zum anderen aus (inter)nationalen Entwicklungen auf den Finanzmärkten. Um die Stabilität im Bankensystem überwachen zu können, entwickeln wir einen Stabilitätsindikator, welcher Informationen sowohl von großen Finanzinstituten, als auch von kleineren Banken enthält. Der Indikator besteht aus drei Komponenten: Einem Bonitätsindikator (basierend auf der normierten Ausfallwahrscheinlichkeit eines Instituts), einem Credit Spread (d.h. der durchschnittlichen Risikoprämie verfügbarer Institute) und einem Aktienindex für den Bankensektor. Die Ausfallwahrscheinlichkeiten werden für kleinere Banken aus dem Bundesbank-Hazardratenmodell und für die großen Institute aus dem Moody's Bank Financial Strength Rating herangezogen. Die empirische Studie basiert auf einem von der Deutschen Bundesbank bereitgestellten, vertraulichen Datensatz und enthält bis zu 3,330 Institute über einen Zeitraum von 1995 bis 2010 auf jährlicher Basis.

Die Determinanten für Bankensystemstabilität können in makroökonomische, finanzielle und strukturelle Variablen klassifiziert werden. Unter Anwendung von Panelregressionstechniken können wir Vermögenspreisindizes, Frühindikatoren für den Konjunkturzyklus und monetäre Indikatoren als robuste Frühwarnindikatoren identifizieren. Während internationale Ansteckungseffekte für alle Bankensektoren von Bedeutung sind, erweisen sich regionale Ansteckungseffekte und die nationale Kreditvergabe an den privaten Sektor im Verhältnis zum BIP als relevante Determinanten für Kreditgenossenschaften, sind aber weniger bedeutsam für Kreditbanken. Diese Ergebnisse deuten darauf hin, dass die heterogene Struktur des deutschen 3-Säulen-Systems einen Diversifikationseffekt aufweist (innerhalb dessen jeder Bankensektor durch verschiedene Schocks unterschiedlich beeinflusst wird) und damit einen Beitrag zu der Stabilität des gesamten Bankensystems leisten kann.



## Contents

I	Introduction	1
II	Literature Review	2
III	Stability Indicator for the German Banking System	5
	1. <i>Deriving the Stability Indicator</i>	5
	2. <i>Assigning Weights to Stability Indicator Components</i>	10
	3. <i>Evolution of the Stability Indicator</i>	12
IV	Macroprudential Leading Indicators for the German Banking System	12
	1. <i>Macroeconomic Variables</i>	12
	2. <i>Financial Variables</i>	13
	3. <i>Structural Variables and Regional Spillover Effects</i>	14
V	Empirical Analysis	15
	1. <i>Data and Descriptive Statistics</i>	15
	2. <i>Panel Regression Model</i>	16
VI	Results	18
	1. <i>Macroprudential Indicators</i>	19
	2. <i>Analyses by Banking Sector</i>	21
	3. <i>International and Regional Spillover Effects</i>	22
VII	Concluding Remarks	23
	References	25
	Appendix	28



# Early Warning Indicators for the German Banking System: A Macroprudential Analysis\*

## I Introduction

Regular financial stability assessment and the identification of macroprudential leading indicators signaling emerging risks to the banking system are of major importance for central banks and supervisory authorities. The stability and efficiency of a banking system ensures the optimal allocation of capital resources in an economy, and regulators therefore aim to prevent banking system crises and their associated adverse feedback effects on the real economy. This paper introduces a stability indicator for the German banking system which is used to identify macroprudential early warning indicators and spillover effects in regional banking and from international financial markets.

Over the last two decades, Germany experienced several periods of banking system instability rather than full-blown banking system crises. Around the burst of the dotcom bubble in 2000, especially German cooperative banks suffered from increased credit defaults. Furthermore, particularly Landesbanks had to realign business models and refinancing conditions in response to the abolition of state guarantees (“Gewährträgerhaftung” and “Anstaltslast” in German) in 2004/2005. On the other hand, although savings banks and cooperative banks are still predominantly regionally centered, foreign lending of all banks (bonds included, in terms of balance sheet total) almost doubled from 14.3% to 27.2% between 1999 and 2010, reflecting the increasingly international nature of the German banking system. This corresponds to a high dependence on international developments that played a crucial role for banking system instability during e.g. the financial crisis in 2008/2009. Despite a slight recovery of our stability indicator for the overall banking system in 2010, major German banks, in particular, are still suffering from increased stress in financial markets caused by the European sovereign debt crisis. Therefore, the importance of our study remains elevated.

---

\* Information on the authors: Nadya Jahn (corresponding author), Finance Center Münster, University of Münster, Universitätsstraße 14-16, 48143 Münster, Germany, E-mail: nadya.jahn@wiwi.uni-muenster.de, Tel.: +49 (0)251-83 21881, Thomas Kick, Deutsche Bundesbank, Wilhelm-Epstein-Str. 14, 60431 Frankfurt am Main, Germany, E-mail: thomas.kick@bundesbank.de. We are grateful to the participants of the BCBS, CEPR and JFI Workshop 2012, the 15th Conference of the Swiss Society for Financial Market Research 2012, the Bundesbank Seminar on Banking and Finance and one anonymous referee. We would also like to thank Klaus Düllmann, Julia Giese, Christoph Memmel, Andreas Pfingsten, Natalia Podlich, Stefano Puddu and Christian Wildmann for helpful comments and advice. The views expressed herein are our own and do not necessarily reflect those of the Deutsche Bundesbank. All remaining errors are, of course, our own.

The aim of this paper is to provide tools for banking supervisors to monitor and assess banking system stability and its determinants. We address two research questions. First, against the background of above mentioned periods of observed banking system instability instead of banking system crises we develop a continuous and forward-looking stability indicator for the German banking system. To this end, we use information on all financial institutions in Germany between 1995 and 2010, and we aggregate three important indicators to one stability measure: the institutions' individual standardized probabilities of default (PDs), a credit spread (i.e., the average bank risk premium) and a stock market index for the banking sector ("Prime Banks Performance Index"). Second, in line with the body of empirical literature on early warning indicators for banking system crises and -instability, we analyze the impact of macroprudential leading indicators on the stability of the German banking system. Our findings suggest that asset price indicators, leading indicators for the business cycle and monetary indicators prove to be relevant early warning indicators. Furthermore, structural indicators such as international and regional spillover effects also have a significant impact on banking system stability in Germany.

The paper proceeds as follows. Section II gives an overview of present indicators of banking system stability and its determinants. Section III introduces the stability indicator for the German banking system and derives weights for its individual components. Section IV provides a discussion of macroprudential determinants of banking system stability, followed in Section V by a description of the data and the introduction of the empirical model. Results are discussed in Section VI, and Section VII concludes.

## **II Literature Review**

Within the literature on financial stability analysis we focus on existing measures of banking system stability and its determinants based on theoretical and empirical considerations.

Although evidence on ordinal or continuous stability indicators for the banking system is less comprehensive, some important studies can be noticed. Bordo et al. (2001) develop and examine a discrete financial stress index including time series on business failures, banking conditions, the real interest rate and a quality spread describing the condition of the US financial sector. Puddu (2008) constructs a real continuous indicator for the US banking system by aggregating balance sheet variables of the commercial banking sector and examines the impact of different weighting schemes on the replication ability of financial crisis events. Illing and Liu (2006) develop a financial stress index for the Canadian sector by variance-equal weighting several

financial market indicators into one single index.<sup>1</sup> Its calculation for the US and euro-area financial market can be found in Borio and Drehmann (2009); it correctly signals future risks from 2007 onwards. Hanschel and Monnin (2005) both develop and examine a continuous stress index for the Swiss banking sector by equal-weighting market price, balance sheet, nonpublic and other structural data. For highly industrial countries that did not suffer full-blown banking system crises in the past two decades and rather experienced periods of banking system instability, e.g. Germany, ordinal indicators allowing for more than two categories, or, at best, continuous stability indicators describing the condition of the banking system are needed to support banking supervisors in financial stability analysis.

As we are interested in a macroprudential analysis, theoretical literature and empirical evidence provides deep insight into the second core research question of our study: the interaction between the financial and real sector which helps to derive explanatory variables and leading indicators as determinants of banking system stability. Among the first authors who theoretically proved an existing macro-financial linkage have been Bernanke et al. (1996), who initially formulated the financial accelerator mechanism. Lorenzoni (2008) shows that credit and investment booms can be inefficient as market participants do not internalize their impact on general market equilibrium. In his model, higher levels of ex ante credit, investment and associated high asset prices may induce a stronger reduction of market participants' net worth and in turn financial stability in case of a negative shock. Thereby, credit and investment booms precede financial instability with a longer lead time than higher growth rates of asset prices, whereas exogenous real economic shocks contemporaneously accompany financial turmoil. We test the implications of this theoretical evidence in our empirical analysis. New strands of macroeconomic models directly address deficiencies inherent in previous models that became evident in the recent financial crisis of 2008/2009. These include the role of interbank markets, liquidity and political crisis management.<sup>2</sup> For example, Gertler and Kiyotaki (2010) explicitly take into account the role of financial intermediaries rather than addressing the financial friction itself. In their model, special attention is given to the interbank market within DSGE models as an important driver of financial stability.

Empirical studies of determinants of banking system crises and –instability have a long history. Whereas some studies capture periods of crisis for several countries with a binary variable and explain the latter with macroeconomic factors applying either logit/probit or signaling approaches, other studies focus on a single country only and identify appropriate country-specific determinants of banking system stability.

---

<sup>1</sup> The financial stress index contains indicators from the banking sector, foreign exchange markets, debt markets and equity markets.

<sup>2</sup> A good overview on new strains of macro-financial models can be found in ECB (2010), Financial Stability Review, December.

Important studies have been implemented by Demirgüç-Kunt and Detragiache (1998, 2005) who focus on leading indicators for banking crises. Applying a multivariate logit approach, the authors link a set of explanatory variables to the probability of occurrence of a binary crisis variable. Their results for both industrial and emerging market economies indicate that low real economic growth, high inflation and high real interest rates impact significantly on the probability of a banking crisis. In contrast, Hardy and Pazarbasioglu (1999) examine a sample that covers 50 predominantly emerging market economies between 1977 and 1997 and do not back overall evidence of macroeconomic factors preceding banking crises and rather support both country- and crisis specific determinants that can only be identified ex post. The authors conclude that national factors are relevant for banking instability, whereas international factors play a role in determining banking crises.<sup>3</sup> Borio and Lowe (2002) extend the signaling approach by applying so-called composite leading indicators which improve the predictive power in their sample that contains both industrial and emerging market economies.<sup>4</sup> The results indicate that the common use of credit-to-GDP, gross fixed investment and asset prices (especially property prices) are among the best indicators in predicting banking system crises. Their results have been confirmed by an in-sample and out-of-sample prediction of the recent financial crisis of 2008/2009 by Borio and Drehmann (2009), who also highlight the important role of property prices in predicting banking crises. At the country-specific level, Hanschel and Monnin (2005) confirm the leading indicators identified by Borio and Lowe (2002) to be likewise relevant determinants for the Swiss banking system. Misina and Tkacz (2008) forecast the indicator developed by Illing and Liu (2006) and find lending in combination with housing-sector asset price indicators to be the best predictors at the 1-2 year horizon for Canada.

In line with the second strand of empirical studies, we address the banking system of one of the most important industrial countries in the European Monetary Union: Germany. Our contribution to the literature is threefold. First, we develop a continuous stability indicator which describes future-oriented the state of the banking system in Germany and suggest a new weighting procedure. Second, we derive potential macroeconomic leading indicators from the existing theoretical and empirical studies and test their ability to predict the condition of the German banking system. Third, we take into account the experience of the financial crisis 2008/2009 and incorporate

---

<sup>3</sup> Here, the term “banking instability” is related to “banking sector difficulties” that do not result in a systemic crisis; see p. 10. Whereas the literature review presents studies that either examine banking or financial (system) stability and/or -crises, our study addresses the banking system as important part of the overall financial system.

<sup>4</sup> According to the authors, composite indicators signal a crisis if the “coexistence” of two or three indicators passes a certain threshold. Indicators are calculated in deviation from their one-sided HP trend to approximate the idea of financial imbalances. In addition, the authors focus on ex ante information only accounting for the policy maker’s decision horizon, consider a small set of core variables and allow for the relevance of multiple horizons.

measures for regional and international spillover effects as further early warning indicators.

### **III Stability Indicator for the German Banking System**

To start with, we develop a continuous and forward-looking stability indicator for the German banking system. This stability indicator is our proxy for national banking system stability, lower values indicating banking system instability. Based on a definition provided by the Deutsche Bundesbank (2003) we interpret banking system stability as “steady state in which the [banking] system efficiently performs its key economic functions, such as allocating resources and spreading risk as well as settling payments”.<sup>5</sup> In other terms, we understand banking system stability as a condition of a sound banking system that constitutes of solvent financial institutions fulfilling above named functions. Against this background, we derive an appropriate indicator for this state and comprise suitable indicator components that constitute banking system stability in either direction. Following definitions by IMF (2003) and Segoviano et al. (2009) we suggest that banking system instability “can arise either through idiosyncratic [components] related to poor banking practices adversely affecting an individual bank’s solvency, from systematic [components] initiated by aggregate shocks entailing financial strains for the banking system or a combination of both”.<sup>6</sup> Therefore, we select an institution’s score (i.e. the standardized probability of default) as an idiosyncratic indicator component, whereas both a stock market index for the banking sector and a credit spread reflect systematic indicator components as they measure listed institution’s return on equity capital and an average bank risk premium, respectively.

As outlined in the literature review in the previous section, recent empirical studies develop stress indexes for the banking system by merging different relevant variables into a single measure. We proceed in line with this work while we argue that our variables are more forward-looking and introduce a novel procedure for assigning weights to single indicator components.

#### *1. Deriving the Stability Indicator*

The German banking system is subdivided into a three-pillar structure of savings banks and Landesbanks, cooperative banks and their central institutions, as well as commercial banks.<sup>7</sup> The lattermost are privately organized and follow a profit seeking

---

<sup>5</sup> See Deutsche Bundesbank (2003), p. 8.

<sup>6</sup> See IMF (2003), p. 4 and Segoviano and Goodhart (2009), p. 6.

<sup>7</sup> In addition to universal banks, the German banking sector consists of specialized banks which do not belong to the German three-pillar banking system, the market share of which stood at 17.4% at the end of 2010. Although

business model. The market share of private banks in terms of domestic business volume stood at 38.1% (end-2010).<sup>8</sup> Savings banks, on the other hand, are predominantly owned by the public sector and fulfill their public mandate of supporting the lower and middle classes as well as small and medium-sized enterprises as part of their business model, with a market share of 32.4% (end-2010). Finally, cooperative banks are owned by their members and support the idea of encouraging their associates by focusing on regionally located small and middle-income entrepreneurs as well as retail clients. Their market share amounted to 12.1% (end-2010). While international activities and business in securities are rather important for private banks, savings deposits belong to the business concept of savings banks and cooperative banks.

The composite stability indicator is constructed by compiling a basket of banks containing both major financial institutions (i.e., big private banks, Landesbanks, central institutions of cooperative banks, and large special-purpose banks) and smaller banks (i.e., small private banks, savings banks, cooperative banks). The measure covers a total of between 3,330 institutions (in 1995) and 1,685 institutions (in 2010). The indicator comprises three components that well describe the current and expected condition of the German banking system: The individual institutions' scores (i.e., standardized PDs), a credit spread (i.e., the average bank risk premium) and a stock market index for the banking sector ("Prime Banks Performance Index"). Whereas the bank-individual indicator reflects the idiosyncratic component, the latter two indicators are intended to capture the overall evolvement of banking system stability. In the following, we characterize the formation of these three indicator components. We start with the presentation of a bank rating model to derive the individual institutions' scores and subsequently describe the credit spread and the stock market index in more detail.

The main component of the stability indicator for the banking system is information on each individual bank's solvency in terms of its PD which we understand as primary factor of banking system stability according to our above named definition. For major banks we incorporate PDs which are derived from Moody's Bank Financial Strength Ratings (BFSR). As, however, ratings from the rating agencies are only available for major institutions, we use an additional bank rating model ("Bundesbank hazard rate model") to estimate PDs for small private, savings, and cooperative banks in the German banking system as well, which is described below.<sup>9</sup> This bank rating model is

---

the stability indicator also comprises special-purpose banks they are dropped from the empirical analysis, as the number of these banks is small, their business strategy is totally different from universal banks, and their stability is closely linked to the creditworthiness of the government. Source: Deutsche Bundesbank.

<sup>8</sup> Business volume refers to domestic business according to the definition of the Deutsche Bundesbank's banking statistics without branches abroad.

<sup>9</sup> In the bank rating model institutions are regarded as "defaulted" if their existence is endangered within the one-year forecast horizon without support measures.

intended to capture microeconomic bank risk factors, whereas the basket stability indicator is used for the identification of macroeconomic leading indicators in later empirical analysis.

Following Porath (2004) as well as Kick and Koetter (2007), we specify a bank rating model that is based on the logistic link function which transforms a set of bank-specific covariates and a financial variable observed in year  $t - 1$  into the probability of default of that particular bank in year  $t$ . The right-hand side of the regression equation is based on the CAMELS taxonomy: Capital adequacy, Asset quality, Management, Earnings, Liquidity, and Sensitivity to market risk. In the model, the banks' liquidity situation is proxied at an aggregate level by including the yield curve (which is described by the 10-year minus 1-year government bond rate).<sup>10</sup>

On the left-hand side of our logistic regression we use a unique data set of bank distress events collected by the Deutsche Bundesbank over the time period 1994 to 2006 which is only available for small banks. In contrast to previous studies (e.g., Porath (2004), Kick and Koetter (2007), etc.) this data set consists of a more detailed distress definition and also covers a longer time period (up to 2006) for which distress data is available.<sup>11</sup>

The bank rating model is based on the following logistic link function, which is estimated by a panel population-averaged logit model.

$$P(y_{i,t} = 1) = \frac{e^{\alpha + \beta X_{i,t-1} + \pi M_{t-1}}}{1 + e^{\alpha + \beta X_{i,t-1} + \pi M_{t-1}}} \quad (1)$$

Here,  $P(y_{i,t} = 1)$  denotes the probability that bank  $i$  will be distressed in year  $t$ . It is estimated from a set of covariates  $X_{i,t-1}$  observed for bank  $i$  in period  $t - 1$  to which a financial variable (the yield curve)  $M_{t-1}$  is added;  $\alpha$ ,  $\beta$  and  $\pi$  are the parameters to be estimated. Based on the logistic link function, the bank rating model transforms this set of covariates into bank-specific default probabilities which are used (along with other stability indicators) in the further financial stability analysis.<sup>12</sup> As the basket stability indicator is used as dependent variable in empirical analysis, we exclude all factors from the logistic link function that might cause a biased panel regression set up. Regression statistics are reported in Appendix I.

---

<sup>10</sup> Porath (2004) points out that banks' real liquidity risk cannot be measured adequately with the data available at the Deutsche Bundesbank which is still to be improved. In particular for small cooperative and savings banks a high cash and interbank-loans to total assets ratio is rather an indicator for lacking business opportunities than for low liquidity risk.

<sup>11</sup> The definition of distress events comprises -among others- compulsory notifications of the German Banking Act or capital support measures. According to Porath (2004), "default is defined as any event that jeopardizes the bank's viability as a going concern", p.II. Hence, extending the analysis to 2010 implies forecasting the PDs based on the rating model up to 2006 which includes inevitable forecast uncertainty. In addition, although the available time period does not include the recent financial crisis 2008/2009 it nevertheless covers significant stress events in the German banking market.

<sup>12</sup> See De Graeve et al. (2008).

With regard to the goodness of fit, it turns out that the discriminatory power of the panel logit model, measured by the Area Under the Receiver Operating Characteristics Curve (AUC), is excellent at 87.7%.<sup>13</sup> Coefficient estimates for the CAMEL vector and the yield curve are in line with both expectations and the findings in the literature. Moreover, most of the coefficients show significance at the 1% level. The regression statistics indicates that better capitalization and more bank reserves, as well as a higher profitability reduce the likelihood of bank distress. Lower bank distress can also be shown for a higher concentration in the banks' loan portfolios (measured by the Herfindahl-Hirschman Index of over 23 industry sectors) which means that specialized banks tend to be more stable than more diversified banks.<sup>14</sup>

In turn, a high reduction of bank reserves, a large share of customer loans (which can be assumed to be riskier than interbank loans), avoided write-offs on a bank's assets (also known as "hidden liabilities"), and a higher bank market concentration (measured as Herfindahl-Hirschman Index across bank branches per state) imply a higher PD. The management's ability to avoid the more risky fee-generating business in favor of the more stable interest business<sup>15</sup> is reflected by a (highly significant) positive coefficient for the share of fee income.<sup>16</sup> At the aggregate level, a more favorable yield curve increases the likelihood of bank distress. On the one hand, a widening spread between long-term and short-term risk-free rates allows banks to generate more profits through maturity transformation. On the other hand, however, such a trend in the banking industry creates incentives for excessive risk taking and moral hazard. Finally, when controlling for the major risk factors, we find that banking group dummies (savings banks, cooperative banks) are not significant in the bank rating model.

Turning to the other components of the stability indicator, the credit spread is calculated as the difference between the arithmetic means of returns on bank debt securities outstanding and those on listed Federal securities of Germany with the same residual maturity.<sup>17</sup> The spread is understood as the average risk premium, which is higher the worse the banks' overall creditworthiness is and, thus, accurately reflects expected banking system instability by market participants and is included as the

---

<sup>13</sup> In the context of bank rating models AUC values measure the ability of the model to discriminate between distress and non-distress events for a range of cut-off probabilities from zero to one. According to Hosmer and Lemshow (2000) values above 80% show an "excellent discrimination", and values above 90% an "outstanding discrimination" of the model. In comparison to regularly estimated Bundesbank Hazard Rate Models, an AUC between 80-90% varies in normal range.

<sup>14</sup> This result is in line with Behr et al. (2007) who find for the German banking market that specialized banks have a slightly higher return, as well as lower relative loan loss provisions and lower shares of non-performing loans, than diversified banks.

<sup>15</sup> Concerning the riskiness of different income components De Jonghe (2007) points out that "Interest income is less risky than all other revenue streams", see p. 3.

<sup>16</sup> The share of fee income and also the RoE are highly correlated with the cost-income ratio used in many bank rating studies. Hence, the latter variable is removed from this regression.

<sup>17</sup> According to the Bundesbank statistic, bank debt securities in our analysis refer to "other bank debt securities" outstanding for those the credit spread is calculable for about 200 German banks.

second component of the stability indicator. The third indicator component is the “Prime Banks Performance Index”. This index contains the share prices of those banks that are listed in Germany. The growth rate of the index reflects market expectations regarding listed institutions’ return on equity capital and thus their current and expected profitability and development, indicating future (in)stability of the banking system.

In a second step constructing the stability indicator, the three components (bank-level PDs, credit spread, growth rate of the “Prime Banks Performance Index”) are first (0,1) – standardized and aggregated to form an institution-level metric which will then be used in our empirical analysis.<sup>18</sup> This indicator at the institutional level is also called basket indicator. To be reported for the entire banking system and for graphical purpose (see Appendix II), the institution-level indicators are subsequently weighted with the respective institution’s total assets.<sup>19</sup> The indicator for the entire banking system is also called composite indicator. The standardized PDs and the credit spread are entered reciprocally in order to ensure that all components of the indicator point in the same direction. A considerable advantage of our stability indicator is that it can be reported for the entire banking system as well as for individual institutions.

It should be noted that all three components of the indicator are regarded as forward-looking. Unlike other indicators of risk-bearing capacity, based on metrics and bank balance sheet data, this indicator therefore reflects the current and future development of the German banking system. Furthermore, the stability indicator measures contagion effects indirectly as for individual financial institutions, two banking-system wide components are added: First, if the PD for bank  $i$  in period  $t$  is low but, for example, the credit spread implies an increased bank risk premium, the stability indicator for that particular bank  $i$  is also higher in that period. Second, PDs for large institutions also comprise “contagion components” (i.e. they include the risk of spillover effects from the default of other major players in the banking market).<sup>20</sup> The basket indicator is much broader than standard market-based banking stability indicators (such as CDS spreads, or stock returns) and covers all institutions of the German banking system. In particular, the basket indicator includes savings banks, cooperative banks, and small private banks; these institutions control a sizeable share of the German market and play a central role in regional credit supply.

---

<sup>18</sup> The standardized indicators are entered into the calculation of the metric at their respective weight (see III.2.).

<sup>19</sup> See e.g. Illing and Liu (2006), Puddu (2008) or Hanschel and Monnin (2005) for similar proceeding.

<sup>20</sup> In particular, during the financial crisis it could be observed that the whole banking sector (and not only banks which were close-to-default) faced severe rating downgrades.

## 2. Assigning Weights to Stability Indicator Components

To evaluate possible weights allocated to the individual indicator components, we provide a novel weighting procedure. The literature provides no convincing methodology for assigning adequate weights to the components of a composite stability indicator. Even when theory suggests that a certain set of variables should be included, it still remains unclear how these components should be weighted.<sup>21</sup> Techniques include the commonly applied variance-equal weight method, factor analysis or weighting schemes based on market shares of respective components. The latter two follow the idea that a main driver of financial instability can be identified. But, as Illing and Liu (2006) point out, the major difficulty lies in the lack of a benchmark against which adequate weights can be verified. However, the authors argue that their results remain qualitatively similar regardless of the method chosen. Similar, Hanschel and Monnin (2005) justify the variance-equal weight method as other methodologies would not yield meaningful results for the Swiss case. In our view this does not solve the initial problem of verifying the indicator's reliability.

Therefore, selecting a benchmark as target for the final choice on assigning weights should overcome above named shortcomings. We propose a unique methodology in accordance with the supervisory risk profile assessment which comprises an evaluation of all of an institution's risks, its organization and internal control procedures and its risk-bearing capacity. The grading is done in four categories (A, B, C, D), where A means an excellent grading, while D denotes a "problem bank". The assessment is made by the Bundesbank at least once a year and passed on to BaFin for approval and any further regulatory decision-making.

Based on three components: (i) standardized PDs for an individual institution, (ii) the credit spread, and (iii) the stock market index, we calculate 36 basket stability indicators with weightings ranging from "10%-10%-80%" to "80%-10%-10%." Furthermore, we base the choice of the final stability indicator on the supervisory risk profile assessment.<sup>22</sup> As we are interested in a one-size-fits-all approach, weights are not allowed to vary by category of banks or size. We specify the following partial proportional odds model,

$$P(RP_{i,t} > j) = \frac{e^{\alpha_j + \beta_j SI_{i,t} + \eta_j X_{i,t} + \pi_j BG_i}}{1 + e^{\alpha_j + \beta_j SI_{i,t} + \eta_j X_{i,t} + \pi_j BG_i}} \quad (2)$$

in which  $SI_{i,t}$  is the respective basket stability indicator,  $X_{i,t}$  is a set of controls for the relevant qualitative risk factors (i.e., internal governance, internal capital adequacy

---

<sup>21</sup> As theoretical evidence on appropriate indicator components that proxy the term banking system stability is rather scarce, selected indicators are primary based on existing definitions of banking system stability, empirical evidence and for practical purposes.

<sup>22</sup> See Deutsche Bundesbank and BaFin (2008). For a comprehensive discussion of the concept of supervisory risk profiles and the partial proportional odds model see also Kick and Pfingsten (2011).

assessment process (ICAAP), and other qualitative risk factors)<sup>23</sup> which are by definition not included in the stability indicator, but in the supervisory risk profile.  $BG_i$  are banking group dummies (savings banks and cooperative banks; private banks are the reference group), and  $\alpha$ ,  $\beta$ ,  $\eta$ , and  $\pi$  are the parameters to be estimated.

For the final indicator selection we apply Wald tests with the hypothesis “ $H_0$ : Coefficients on the respective stability indicator for the worst supervisory risk profile categories C and D jointly zero” in 36 regression models.<sup>24</sup> By assigning weights to the three indicator components, we aim to identify the stability indicator for the banking system with the maximum fit to the supervisory risk profile assessment. The Wald statistic shows a maximum for the following basket stability indicator: 70% standardized PDs (Moody’s Bank Financial Strength Rating and bank rating model for small private, savings and cooperative banks), 20% credit spread and 10% “Prime Banks Performance Index”. In a robustness check, we examine the impact of other weights on our regression results. The second and third best fit according to the supervisory risk profile assessment yield to weights that are similar in magnitude, with 70-10-20 and 80-10-10 weights for the standardized PDs, credit spread and “Prime Banks Performance Index”, respectively. As these weights do not significantly alter the statistical and economic significance of estimated standardized beta coefficients, but lead to a decline in the within-R-squared for the third best fit, we apply the first-best weights to all further banking system stability analyses in this paper.

Two arguments limit the scope of our novel weighting procedure. First, as the supervisory risk profile assessment focuses on idiosyncratic risk rather than systemic risk, this might bias our results towards a higher weight of the PD. Second, e.g. Krainer and Lopez (2008) show that stock and bond markets may yield further information not included in the current supervisory ratings which might also cause a similar bias towards higher weights associated with the idiosyncratic PDs. Related to the first issue, as we consider the individual institution’s score as main component of the stability indicator according to our definition of banking system stability we justify to assign a higher weight to the idiosyncratic indicator component. Furthermore, information content in stock and bond markets at least constitutes 30% of the stability indicator. In sum, we believe that despite above named drawbacks we are able to present a useful benchmark approach on which appropriate weights can be derived and which should in any case be superior to e.g. variance-equal weighting that lacks any benchmark justification.

---

<sup>23</sup> For each qualitative risk factor C and D grades are coded as individual variables where the categories A and B constitute the reference group.

<sup>24</sup> C and D indicate problematic and outstanding problem banks which represent a potential threat to the stability of the German banking system.

### *3. Evolution of the Stability Indicator*

We show the composite indicator in an aggregated form for the entire banking system in Appendix II. Over time, it was already on the decline in 2007 and entered negative territory in 2008. The expected recovery occurs in 2010 for most banking groups—Landesbanks excepted. For 2011, the indicator shows that the credit spread and the stock market index for the banking sector components contribute to a renewed deterioration of banking system stability. This trend largely reflects uncertainty surrounding the prospect of default (or debt rescheduling) in some euro-area peripheral countries. The elevated stress in the markets also affects the Landesbanks, for which Moody's BFSR deteriorated slightly further in 2011. At the current end, the small banks (savings banks, cooperative banks, and small private banks) are continuing to gain in stability, which is likely to be due both to their business model and their preparation for stricter capital rules (Basel III) from 2013 onwards. Although the evolution of the credit spread is for some periods quite similar to the time series pattern of the composite stability indicator, we argue our indicator to be a more comprehensive proxy for overall banking system stability as it is also available at institutional level. The former is intended to indicate the overall condition of the banking system, whereas the bank-level stability indicators are used for empirical analysis. Overall, the stability indicator shows deterioration in 2011 compared to 2010; however, it is still well above its level in 2009, the low point of the financial and economic crisis.

## **IV Macroeprudential Leading Indicators for the German Banking System**

Based on theoretical considerations and empirical evidence, we select macroprudential leading indicators that may explain banking system stability at different lag operators and, as it is usually done in the literature, classify them into macroeconomic, financial and structural variables, see Appendix III. Particular interest is devoted to country-specific variables that help supervisors in identifying imminent threats to the German banking system. In accordance with Fichtner et al. (2009), who argue that increased globalization has to be taken into account in empirical analysis by using extended leading indicators for the prediction of economic activity, we test both national and international adjusted leading indicators to control for increased internationalization of the German banking system.

### *1. Macroeconomic Variables*

According to economic theory, higher asset and property price growth is associated with the boom phase in the business cycle that might imply a buildup of financial

imbalances and has the potential to result in banking system instability.<sup>25</sup> For asset price indicators, it is important to distinguish between property and equity prices, as they reflect different transmission channels of exogenous shocks to the real economy.<sup>26</sup> Although real estate price indices did not reflect overheating in the German housing market indicating upcoming risk prior to the financial crisis of 2008/2009, Koetter and Poghosyan (2008) show that price-to-rent ratios may be important determinants for instability in the German banking system. In our empirical analysis we test the German real estate price index provided by Bulwien AG which is an indicator of asset price trends in national real estate markets. We also include asset price indicators for internationally important real estate markets as they played an important role in the financial crisis 2008/2009.

An important leading indicator for economic outlook in Germany is the ifo business cycle index. The indicator captures expectations of real economic development and indicates positive or negative shocks affecting the real economy. Expectations of economic upturn are contemporaneously expected to induce higher predicted banking system stability whereas, in the event of an expected economic downturn, future banking system stability should be negatively affected (e.g., via increasing defaults of borrowers). As e.g. Lorenzoni (2008) theoretically shows, high gross fixed investments are also expected to precede economic up/downturns reflecting real economic demand. Again, large positive growth rates are anticipated to signal market overheating with the potential of subsequent banking system instability.

## *2. Financial Variables*

Turning to financial variables, we look at indicators for lending to the private sector, financial market indicators and monetary indicators. According to economic theory, lending booms may precede banking system instability as they imply increased risk-taking in the financial system that has the potential to result in financial turmoil if the economy is hit by a negative, adverse shock. We therefore include the national private credit-to-GDP ratio in our analysis.<sup>27</sup>

With respect to financial market indicators, we take into account the role of the interbank market, which has become especially important during the financial crisis of 2008/2009. To separate the effects of distress on the interbank market and monetary policy, we include the 3-month Libor over 3-month Bubill similar to a TED Spread for

---

<sup>25</sup> Borio and Drehmann (2009) refer to financial imbalances as “growing fragility of private sector balance sheets during benign economic conditions”, BIS Quarterly Review, March 2009, p. 30.

<sup>26</sup> See Borio and Lowe (2002) for detailed argument. The authors argue that property prices have been more important in predicting banking crises than equity prices.

<sup>27</sup> Concerning equity market indices, we do not include indicators such as the DAX 30/Euro Stoxx 50 Index or the Euro Stoxx Banks as stock market indicators for the European banking sector since we are interested in drivers of banking system stability apart from related stability indicator’s individual components.

the former and the 3-month Bublick reflecting key ECB interest rate cycles for the latter. We expect loose monetary policy and an increased Libor spread to precede banking system instability: If financial market confidence is low, making banks wary of lending in the interbank market, the 3-month Libor is high and predicted instability in the banking system is expected to increase. With regard to monetary expansion, we also look at M2-to-GDP indicating excessive liquidity in the financial market which possibly precedes a lending boom.<sup>28</sup>

### *3. Structural Variables and Regional Spillover Effects*

Regarding spillover effects, we first control for international spillover effects in the regression model. The dependence of the German banking system on international exposures steadily increased between 1995 and 2010 which will be described in more detail in the next section. We take this structural change in national banks' balance sheet exposures into account as the observed period of predicted banking system instability in 2008/2009 can partly be explained by the revaluation of large foreign exposures. We are unable to calculate an indicator reflecting foreign lending and securities in terms of balance sheet total at fair value due to lack of adequate data. However, we include the respective indicator based on book values in our analysis which, for financial institutions, should be a suitable proxy. Similar, Borio and Drehmann (2009) provide first evidence on the role of cross-border exposures in determining banking system crises.<sup>29</sup> In addition, we test the forward-looking VIX index based on S&P stock market index options as a proxy for international risk aversion and expected implied volatility in international financial markets, with higher values indicating less expected banking system stability and vice versa.<sup>30</sup>

Second, we analyze spillover effects between financial intermediaries. The literature has studied the effects of bank's failures on the equity returns of other banks and finds evidence for the existence of spillovers, which can largely be attributed to fundamentals rather than to irrational investor behavior; see e.g. Aharony and Swary (1983). We already discussed the TED spread which is an indicator for interbank stress. In addition, we analyze spillover effects in regional banking markets. For this purpose, we divide Germany into its respective area (county) levels  $l$  and measure the regional spillover effect for bank  $i$  by calculating the balance sheet total-weighted standardized PD of all financial institutions in  $l$  (except  $i$ ), lagged by one period,

---

<sup>28</sup> See von Hagen and Ho (2003) for a detailed discussion of M2 in preceding banking crises, pp. 9-10.

<sup>29</sup> In the context of their applied methodology, the authors construct an indicator that weighs signals issued by underlying macroprudential indicators in those countries to which the domestic banking sector is exposed. They confirm that signals resulting from cross-border exposures have especially been important for Germany and the Netherlands during the financial crisis of 2008/2009.

<sup>30</sup> See e.g. Bekaert et al. (2010) for a discussion of the VIX as a proxy for risk aversion and uncertainty in financial markets.

which is included as an additional covariate in the regression model. That is, we test the explanatory effect of weighted standardized PDs of geographically surrounding financial institutions on the stability indicator for bank  $i$  after one year.

## V Empirical Analysis

### 1. Data and Descriptive Statistics

Our study analyzes banking system stability with respect to macroprudential determinants at the institutional level, examining between 3,330 banks (in 1995) and 1,685 banks (in 2010) and including all German banks. During the 16-year period, the number of banks in the sample exceeds the number of effectively existing institutions in the German banking system caused by the technical treatment of mergers.<sup>31</sup> The stability indicator for the banking system—which is the dependent variable in our regression analysis—can be calculated for 37,151 bank-year observations, reflecting a panel of 70% cooperative banks (the vast majority), 22.5% savings banks and 7.5% commercial banks. It adequately represents the existing distribution of financial institutions in the German three-pillar system. In the following, we highlight some interesting developments of the leading indicators which enter the empirical model as regressors.

With regard to our set of macroeconomic variables, the national commercial real estate variable is suited to indicate increased real estate prices prior to two observed periods of predicted banking system instability in Germany in 2002/2003 and 2008/2009. The ifo index contemporaneously well captures exogenous shocks to the real economy. Within our observation period, several shocks can be identified, e.g. in 2001/2002 and 2008 that were accompanied by significant adverse effects. Also, periods of higher expected banking system stability have been accompanied by an increasing ifo index, especially during the period of economic upturn between 2004 and 2007.

Among our set of financial variables, we expect the 3-month Libor over 3-month Bubill to be statistically relevant in explaining the stability indicator for the banking system. The index precedes observed periods of predicted banking system instability in 2002/2003 and 2008/2009 by a sharp reversal of its growth rate. Interestingly, in contrast to e.g. the US financial sector and other euro-area countries that experienced huge national private credit-to-GDP ratios prior to the financial crisis 2008/2009, Germany did not experience any major expansionary phase between 1995 and 2010. The indicator even declined prior to the financial crisis of 2008/2009 and thus did not issue any signals for future banking system instability. According to economic theory,

---

<sup>31</sup> At the time of the merger a new (third) bank is artificially constructed in the data set. This procedure is important in order not to distort the empirical results as, for example, a fixed effect is included in the regression model.

this evolvement over time suggests the national private credit-to-GDP ratio or real domestic credit growth to be less important in explaining observed periods of national banking system instability, although these variables repeatedly proved to be among the best-performing indicators in predicting banking system crises and -instability in industrial and emerging market economies.

Instead, we observe increased dependence of the national banking system on international exposures between 1999 and 2010.<sup>32</sup> Foreign lending and securities doubled in terms of balance sheet total from 14.3% in 1999 to 28.5% in 2009 with a slight decline to 27.2% in 2010 for all banks. During that time, holdings of foreign stocks and bonds nearly tripled from 3.4% in 1999 to 8.3% in 2009.<sup>33</sup> Especially commercial banks and Landesbanks invested heavily in international markets and securities. The latter can be explained in part by the abolition of state guarantees (“Gewährträgerhaftung” and “Anstaltslast” in German) in 2004/2005, forcing affected banks to find new investment opportunities according to altered business models and refinancing conditions that partly replaced public sector with business investments. This crowding out reveals clear structural changes in the composition of banks’ balance sheet exposures towards a strengthened dependence on international developments and will be considered in the empirical analysis by including the VIX index, indicating to increased international risk aversion of financial market participants, e.g. in 2001/2002 and 2007 to 2009.

For descriptive statistics of the original and rescaled time series, see Appendix V.

## 2. Panel Regression Model

In the empirical analysis, we explain the stability indicator for the banking system across Germany’s three-pillar structure and over a total of 37,151 bank-year observations, which allows us to take into account unobserved time-invariant individual heterogeneity. The data-generating process of the stability indicator is dynamic as the indicator  $y_{i,t}$  follows an AR(1) process. Using lag operators to identify determinants of future banking system stability may imply predetermined or endogenous explanatory variables.

Thus, we consider an autoregressive distributed lag (1, p, q) model in panel version of the following form:<sup>34</sup>

$$y_{i,t} = \alpha y_{i,t-1} + \sum_{j=1}^J \beta_j X_{j,t-p} + \sum_{k=1}^K \beta_k Z_{i,k,t-q} + \mu_i + v_{i,t}. \quad (3)$$

<sup>32</sup> See Appendix IV.

<sup>33</sup> For credit cooperatives (savings banks), foreign lending and securities in terms of balance sheet total increased from 1.6% (1.8%) in 1999 to 8.2% (4.0%) in 2010. Source: Deutsche Bundesbank.

<sup>34</sup> See Wooldridge (2010) for a detailed discussion of ARDL (1, p, q) models in panel version.

The dependent variable is the stability indicator for the banking system at the institutional level  $i$  at time  $t$  and is denoted by  $y_{i,t}$ , and its lagged value is denoted accordingly. As we are not interested in the evolution of the explanatory variables over time but in their most significant lagged values,  $X_{j,t-p}$  and  $Z_{i,k,t-q}$  contain only lag  $t - p$  respective  $t - q$  of the explanatory variables. The lags are thus allowed to differ across explanatory variables. Hereby,  $X_{j,t-p}$  denote macroprudential variables and  $Z_{i,k,t-q}$  denote bank-specific control variables. The coefficients  $\beta_j$  and  $\beta_k$  describe the effect of  $X_{j,t-p}$  and  $Z_{i,k,t-q}$  on  $y_{i,t}$  and are constant across entities and time. The fixed effect is described by  $\mu_i$  and the idiosyncratic error term by  $v_{it}$ . The bank specific control variables capture the cross-sectional (bank-level) variation in the risk indicator over time. However, our focus is on the time series variation of the indicator for each bank explained by macroprudential leading indicators. As such these are intended to explain the aggregate (average) risk level in the banking system. Since we use bank-level data to carry out the empirical analysis, the boost in observations will lead to much lower standard errors. We therefore concentrate on the economic rather than on the statistical significance of our results.<sup>35</sup>

When using dynamic panel data models, two problems which lead to inconsistent OLS estimation usually arise. The first is associated with the “Nickell Bias” or “Dynamic Panel Bias” as the regressor  $y_{i,t-1}$  is correlated with the error term  $\mu_i$  which is, by definition, independent of time in the regression model.<sup>36</sup> The second problem appears when removing the individual heterogeneity term  $\mu_i$  by first differencing the estimation equation.<sup>37</sup>

To control for the above named problems, a two-step Arellano-Bond (1991) difference GMM estimation procedure is appropriate. However, as instrumenting is technically difficult in the Arellano-Bond model due to highly unbalanced panel data, we also apply a standard fixed-effects model including the lagged dependent variable as an additional regressor. Again, we have to ensure reliable OLS estimates. The first problem of “dynamic panel bias” is addressed by within-transformation of the estimation equation; the second problem of endogeneity remains as the lagged dependent variable is not instrumented in our fixed-effects model. We argue that our estimation results are, however, asymptotically valid for two reasons. First, the coefficient  $\alpha$  is approximately estimated at 0.36 in both the Arellano-Bond and fixed-effects estimations which is quite robust and suggests the bias to be small.<sup>38</sup> Second, as Mehrhoff (2009) finds, the “Nickell Bias” decreases with increasing  $T$  and decreasing  $\alpha$ ; it should be in an acceptable range in our sample as  $T$  is at least 16 and increasing

---

<sup>35</sup> We might also relate our macroprudential indicators to bank-specific variables. However, as this proceeding does not relate to our core research question, we leave it to future research.

<sup>36</sup> See Nickell (1981).

<sup>37</sup> This leads to an endogeneity problem by definition because  $(y_{i,t-1} - y_{i,t-2})$  is correlated with  $(v_{it} - v_{i,t-1})$ . Instrumental variables can be applied and lead to consistent estimates if corresponding assumptions are fulfilled.

<sup>38</sup> Regression results for the Arellano Bond model are not reported and are available upon request.

and  $\alpha$  is low. We therefore rely on the results from the fixed effects model specification.<sup>39</sup>

We start our empirical analysis for all banks without any other regressor except the control variable as a benchmark model.<sup>40</sup> Successively, we include additional explanatory variables with respect to our classification scheme of macroeconomic, financial and structural indicators and test theoretical evidence on separate lag operators of explanatory variables.<sup>41</sup> To achieve interpretable results, growth rates of explanatory variables are specified in the estimation equation except for the bank specific control variable. The choice of an optimal model is based on a separately calculated AIC criterion.<sup>42</sup>

We find evidence that our data is correlated along two dimensions. The observations of macroprudential indicators are correlated within year as they capture effects of economic up(down)swings. In addition, observations of macroprudential indicators are correlated along the panel identifier as they are identical for each bank  $i$  in year  $t$ . To control for standard errors that are not identical and independently distributed (i.i.d.) and subject to problems of heteroskedastic and autocorrelated patterns in idiosyncratic error terms, we apply clustered standard errors following Cameron et al. (2006). Most of the serial correlation in idiosyncratic error terms is eliminated by first differencing of logarithmic explanatory variables except for the control variables and avoids biased t-statistics and confidence intervals due to non-stationary explanatory variables.

Estimation results can be found in tables (1) – (3) in Appendix VIa - VIb. Whereas the first model (1) reports an international estimation specification, the second model (2) refers to a national model. The overall model specification is given in column (3).

## VI Results

Our main results reveal that macroprudential early warning indicators commonly used to predict banking system crises and –instability in both developing and developed countries are only to some extent useful leading indicators for Germany in our observational period. We present our findings not only for the whole banking system,

---

<sup>39</sup> The Hausmann test reveals a fixed effects specification to be appropriate.

<sup>40</sup> We also tested other control variables, e.g. the value of total assets itself and (core) deposits in terms of total assets, the latter reflecting different business models, but found no significant improvement.

<sup>41</sup> In line with e.g. Hanschel and Monnin (2005) or Borio and Drehmann (2009) we consider four and more lags to constitute an irrelevant long time horizon in preceding banking system stability or – crises. As the business cycle is usually characterized by a time horizon of eight years, it suggests the appliance of more than four lags either indicating a boom or a bust phase to be inappropriate. In a robustness check, we also identify the individual optimal lag structure of our set of macroprudential indicators based on AIC criterion by including them separately into our benchmark model. As this proceeding leads to identical lag structures, we only report the same lag choice for different model specifications.

<sup>42</sup> In a robustness check, we also implemented the gap approach suggested by Borio and Lowe (2002). However, including the explanatory variables in deviation from their one-sided HP-trend did not lead to superior results but less explanatory power of the overall model specification.

but also for different banking sectors. Regarding our set of macroeconomic, financial and structural explanatory variables, we identify indicators that prove explanatory power and a constant optimal lag structure among various specifications according to AIC criterion.<sup>43</sup> These indicators will be subsequently presented in detail. As argued in the previous section, there is no serious “dynamic panel bias” problem in our data, and our findings are robust throughout different regression techniques. Therefore, we report and discuss results derived from a fixed-effects regression model.

Overall, the explanatory power of several estimated fixed-effects models for all banks is good, as the within-R-squared varies around 29% except for commercial banks for whom the within-R-squared is higher. The estimated coefficient of the dynamic term  $y_{t-1}$  is significant and robust among several specifications, and is close to the estimated coefficients from the Arellano-Bond GMM regression model.

### *1. Macprudential Indicators*

Among our set of macroeconomic variables, we begin with asset price indicators, of which the national commercial real estate price index shows explanatory power in preceding the banking system stability indicator with a lag of one period. The sign of the estimated standardized beta coefficient is negative and robust among various specifications and explains about 25% of the standard deviation of  $y$ . Higher growth rates of the commercial real estate price index thus indicate a boom phase in the business cycle and imply less banking system stability in the subsequent period. We conclude that property prices are relevant predictors for banking system stability, reflecting their importance in the transmission channel of capital costs, as has been shown in studies examining banking system crises in panels of developed countries, e.g. by Borio and Drehmann (2009).

Concerning leading indicators for economic outlook and the business cycle, the ifo index is significant and robust among various estimation specifications. Due to its positive sign, a positive growth rate of the ifo index indicates positive economic expectations and contemporaneously leads to more banking system stability. The estimated beta coefficient explains about 18% of the standard deviation of  $y$ . Although theoretical evidence suggests gross fixed investments to be a promising leading indicator of the economic outlook and driver of banking system stability, the indicator proved to have little explanatory power. Likewise, Hanschel and Monnin (2005) do not find investments to be a robust leading indicator of the stability of the Swiss banking sector but instead European real GDP, which shows the country to be less nationally dependent and more internationally open.

---

<sup>43</sup> Whereas some indicators reveal a clear lead time, others coincidentally explain the stability indicator. We argue that the latter are however useful early warning indicators as they can be monitored at least on a monthly basis and for those commonly used forecasts on annual basis are available.

As for the set of financial indicators, the 3-month Libor over 3-month Bubill – Spread (TED spread) is robust among several estimation equations coincidentally explaining the stability indicator for the banking system according to AIC criterion, accounting for about 7% of the standard deviation of  $y$ . Due to its negative sign, as higher interbank interest rates are associated with less confidence in the interbank market and funding that gets more expensive, large positive growth rates of the spread lead to less anticipated banking system stability, which supports the importance of the interbank market in determining coincidentally the stability of the banking system. With respect to monetary expansion, the ratio of national M2-to-GDP shows less explanatory power and is not robust among various estimation specifications. Instead, the 3-month Bubill reflecting the cycle of key ECB interest rates precedes the stability indicator with one lag, explaining about 16% of the standard deviation of  $y$ . Due to its positive sign, we can empirically support recent evidence from the financial crisis suggesting loose monetary policy to precede banking system instability. We conclude that monetary policy rather affects national banking system stability via the transmission channel of key ECB interest rates than via the money supply given by M2.

The most prominent leading indicators of banking system crises and - instability in the existing literature are the credit-to-GDP ratio and the credit growth variable. Our results, however, do not confirm an overall outstanding explanatory power of these indicators for Germany. We find, however, evidence for the relevance of the national private credit-to-GDP ratio at the banking sector level, which will be discussed below. This is important, as it reveals evidence that the indicators might be among the best predictors of banking system crises and -instability in various panels of emerging and industrial countries<sup>44</sup>, but they do not prove similar explanatory power for the whole German banking system.

Turning to the set of structural variables, we discuss the relevance of international and regional spillover effects. For the identification of a macroprudential indicator which explains international spillover effects, we find that the VIX index significantly captures current international risk aversion of financial market participants and explains about 11% of the standard deviation of  $y$ . The inclusion of the variable improves explanatory power of the overall model from around 26% throughout various estimation specifications to about 30% which is stated, not reported. It coincidentally explains the stability indicator for the banking system. This implies that a higher growth rate of the VIX index induces less banking system stability, as increased fluctuations in financial markets, which have adverse impacts on national banking system stability, are expected. According to the overall model, this variable accurately reflects international spillover effects and seems to have a higher impact on banking system stability than regional effects, as estimated standardized beta coefficients are notably higher. However, our indicator of counterparty exposures in terms of balance

---

<sup>44</sup> See, for example, Borio and Lowe (2002), Borio and Drehmann (2009).

sheet total at the banking group level turned out to be insignificant in the empirical analysis. We do believe that this owes to difficulties in constructing the variable using exposures at book-market values only instead of market-based prices which is due to lack of adequate data. The construction of indicators which adequately reflect cross-country exposures has undoubtedly become important against the background of the 2008/2009 financial crisis and is left to future research.<sup>45</sup>

## *2. Analyses by Banking Sector*

Concerning analyses by different sectors of the German banking system, banking sector specific early warning models turn out to be relevant. With respect to regression models for separate banking sectors, we find that the overall explanatory power reflected by within-R-squared remains approximately in the same interval as for the overall model, except for the rising explanatory power of the estimated models for commercial banks because the estimated standardized beta coefficients of the lagged dependent variable are significantly higher. This implies that commercial banks seem to be less driven by macroprudential indicators, depending more on their lagged stability indicator. This finding is supported by the fact that commercial banks are highly complex and intertwined with international financial markets due to their business models; other supervisory tools that examine, for example, liquidity or contagion effects should therefore complement the monitoring of real economic and financial developments. All other leading indicators remain predominantly robust and significant with approximately the same estimated beta coefficient among various specifications, supporting their fundamental relevance across all banking sectors.

Interestingly, whereas the private credit-to-GDP ratio indicates some explanatory power throughout various specifications for all banks, the variable becomes strongly significant for cooperative banks, but remains insignificant for commercial banks. The results are mixed for savings banks. We conclude that national private credit-to-GDP is a relevant predictor for regionally focused banks in determining banking system stability, but it is less important for internationally oriented banks. This suggests that nuanced indicators are relevant for the financial analysis of the German banking system. International asset price indicators indeed show some explanatory power for commercial banks with a lag of one period but are not robust among several specifications.<sup>46</sup>

---

<sup>45</sup> The approach by Borio/Drehmann (2009) offers a first step in the right direction but should, in the future, also include exposures to a foreign country rather than exclusively focus on lending by institutions located in a given country. See footnote 20 on p. 42.

<sup>46</sup> Estimation results are not reported and are available upon request.

### 3. *International and Regional Spillover Effects*

Turning to international and regional effects across banking sectors, we again observe heterogeneous determinants of banking system stability that require us to take a different view in our analysis of the stability of the German banking system. In the empirical analysis of commercial banks, regional effects become irrelevant in determining stability in the German system. Instead, the 3-month Libor over 3-month Bubill spread and the VIX index capture international effects accurately throughout various estimation equations. The former variable forfeits some of its statistical significance, which might be explained either by the fact that we include the 3-month Euro-Libor in empirical analysis, whereas commercial banks also obtain funding in US-Dollar on international financial markets, or by an offsetting effect through emergency funding of central banks in times of financial stress. Due to the fact that these institutions are internationally oriented, they are highly dependent on international developments, whereas regional factors only play a minor role.

However, regional spillover effects become a significant determinant for banking system stability in particular for small cooperative banks, whereas results for savings banks are ambiguous. We employ a regional spillover variable in the regression model in order to measure the effect of the one-year lagged asset-weighted standardized PD calculated for financial institutions of region  $l$  on institution  $i$  located in the same area level and thus the impact of banking distress in surrounding financial institutions on institution  $i$ . As the estimated standardized beta coefficient is significant with positive sign, increased banking distress in surrounding financial institutions transmit to increased banking distress for bank  $i$  one subsequent period. Under the assumption that the –in most model specification insignificant– control variable regional per-capita GDP growth is an appropriate proxy for regional real economic stress, we are able to rule out that the real economy, e.g. insolvency of local companies, is in effect driving regional banking stability and this finally limits the channel for regional banking stress to the regional spillover effects we observe. We conclude that, as cooperative banks and savings banks predominantly obtain funding through regional deposits, they are thus less dependent on international financial markets and at least predominantly regionally focused. However, the VIX index is statistically significant across both banking sectors, reflecting the fact that credit cooperatives and savings banks likewise start participating in international financial markets.

In summary, we conclude that our empirical results give rise to banking sector specific early warning models which allow for heterogeneous determinants of the stability of the German banking system. Whereas the commercial real estate price index, the ifo index, the 3-month Libor over 3-month Bubill, the 3-month Bubill and the VIX seem to be useful macroprudential leading indicators in all models, regional spillover effects and the credit-to-GDP ratio play a significant role for cooperative banks, but are less important for commercial banks. These heterogeneous determinants of banking system

stability indicate a diversification effect of the German three-pillar banking system (according to which each banking sector is affected by different shocks in different ways) that in this way may contribute to the stability of the banking system as a whole.

## **VII Concluding Remarks**

Over the past two decades, Germany experienced several periods of banking system instability rather than full-blown banking system crises. We introduce a continuous and forward-looking stability indicator for the German banking system which is used to identify macroprudential early warning indicators and both international and regional spillover effects. It comprises not only major systemically relevant institutions, but also small private, savings, and cooperative banks, which are in particular relevant for regional credit supply. Our measure is meant to provide a macroprudential analysis tool for banking supervisors and policy makers.

The stability indicator encompasses three components: an institution's probability of default, a credit spread, and a stock market index for the banking sector. The probabilities of default (PDs) are derived from the Bundesbank's hazard rate model for small banks; for large institutions, Moody's Bank Financial Strength Ratings are used. We apply the supervisory risk profile assessment as a benchmark for assigning weights to indicator components. Despite a slight recovery of our stability indicator for the overall banking system in 2010, major German banks, in particular, are still suffering from increased stress in financial markets caused by the European sovereign debt crisis. Therefore, the importance of our study remains elevated.

The empirical study is based on confidential supervisory reporting data provided by the Deutsche Bundesbank which consists of up to 3,330 institutions over the period 1995 to 2010. We apply panel regression techniques and find that asset price indicators, leading indicators for the business cycle and monetary indicators are reliable early warning indicators. This stresses the necessity of monitoring macroprudential indicators in banking supervision and supports regulators developing regulatory requirements incorporating the business cycle. In addition, international spillover effects play a significant role for banking system stability across all banking sectors, whereas regional spillover effects and the national credit-to-GDP ratio significantly affect credit cooperatives, but are less important for commercial banks. These findings imply heterogeneous determinants of banking system stability which indicate that the German three-pillar banking system features a diversification effect according to which each banking sector is affected by different shocks in different ways. This might contribute to the stability of the banking system as a whole.

Our results also feed into the ongoing debate on the choice of a suitable conditioning variable on which countercyclical capital buffers should be based, e.g. regarding the ifo index or our suggested short-term monetary indicators. Beyond the scope of this

paper, further research is needed to develop indicators that adequately map increased cross-border exposures of financial institutions. We regard the approach by Borio and Drehmann (2009) to offer a first step in the right direction. This became especially important with respect to international spillover effects during the financial crisis of 2008/2009 and the subsequent European sovereign debt crisis.

## References

- Aharony, Joseph and Itzhak Swary (1983). “*Effects of bank failures: Evidence from capital markets.*” *Journal of Business*, Vol. 56 (3), 305-322.
- Arellano, Manuel and Stephen Bond (1991). “*Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations.*” *Review of Economic Studies*, Vol. 58, Issue 2, 277-297.
- Behr, Andreas, Kamp, Andreas, Memmel, Christoph and Andreas Pfingsten (2007). “*Diversification and the banks’ risk-return-characteristics—evidence from loan portfolios of German banks.*” Deutsche Bundesbank, Discussion Paper, Series 2, No. 05.
- Bekaert, Geert, Hoerova, Marie and Marco Lo Duca (2010). “*Risk, Uncertainty and Monetary Policy.*” NBER Working Paper, No. 16397.
- Bernanke, Ben, Gertler, Mark and Simon Gilchrist (1996). “*The Financial Accelerator and the Flight to Quality.*” *The Review of Economics and Statistics*, Vol. 78, No. 1, 1-15.
- Bordo, Michael D., Dueker, Michael J. and David C. Wheelock (2001). “*Aggregate Price Shocks and Financial Instability: A Historical Analysis.*” The Federal Reserve Bank of St. Louis, Working Paper, No. 2000-005B.
- Borio, Claudio and Mathias Drehmann (2009). “*Assessing the risk of banking crises—revisited.*” *BIS Quarterly Review*, March.
- Borio, Claudio and Philip Lowe (2002). “*Assessing the risk of banking crises.*” *BIS Quarterly Review*, December.
- Cameron, Colin A., Gelbach, Jonah B. and Douglas L. Miller (2006). “*Robust Inference with Multi-way Clustering.*” NBER Working Paper, No. 327.
- De Graeve, Ferre, Thomas Kick and Michael Koetter (2008). “*Monetary policy and financial (in)stability: An integrated micro-macro approach.*” *Journal of Financial Stability*, Vol. 4, 205-231.
- De Jonghe, Oliver (2007). “*The impact of revenue diversity on banking system stability.*” Ghent University, Mimeo.
- Demirgüç-Kunt, Asli and Enrica Detragiache (1998). “*The Determinants of Banking Crises in Developing and Developed Countries.*” *IMF Staff Papers*, Vol. 45, No. 1.
- Demirgüç-Kunt, Asli and Enrica Detragiache (2005). “*Cross-Country Empirical Studies of Systemic Bank Distress: A Survey.*” *IMF Working Paper*, No. 05/96.
- Deutsche Bundesbank and BaFin (2008). “*Guideline on carrying out and ensuring the quality of the ongoing monitoring of credit and financial services institutions by the Deutsche Bundesbank of 21 February 2008.*” Frankfurt a. M./Bonn: Deutsche Bundesbank and BaFin.

- Deutsche Bundesbank (2003). *“Report on the stability of the German financial system.”* Monthly Report, December.
- ECB (2010). *“Financial Stability Review.”* December. Available online at [www.ecb.org](http://www.ecb.org).
- Fichtner, Ferdinand, Ruffer, Rasmus and Bernd Schnatz (2009). *“Leading Indicators in a globalised world.”* ECB Working Paper, No. 1125.
- Gertler, Mark and Nobuhiro Kiyotaki (2010). *“Financial Intermediation and Credit Policy in Business Cycle Analysis.”* Handbook of Monetary Economics, Vol. 3, 547-599.
- Hanschel, Elke and Pierre Monnin (2005). *“Measuring and forecasting stress in the banking sector: evidence from Switzerland.”* BIS Papers, No. 22.
- Hardy, Daniel C. and Ceyla Pazarbasioglu (1999). *“Determinants and Leading Indicators of Banking Crises: Further Evidence.”* IMF Staff Papers, Vol. 46, No.3.
- Hosmer, David W. and Stanley Lemshow (2000). *Applied Logistic Regression (2nd ed.)*. New York: Wiley.
- Illing, Mark and Ying Liu (2006). *“Measuring financial stress in a developed country: An application to Canada.”* Journal of Financial Stability, Vol. 2, 243-265.
- IMF (2003). *“Managing Systemic Banking Crises.”* IMF Occasional Paper, No. 224.
- Kick, Thomas and Michael Koetter (2007). *“Slippery Slopes of Stress: Ordered Failure Events in German Banking.”* Journal of Financial Stability, Vol. 3, Issue 2, 132-148.
- Kick, Thomas and Andreas Pfingsten (2011). *“The importance of qualitative risk assessment in banking supervision before and during the crisis.”* Deutsche Bundesbank, Discussion Paper, Series 2, No. 09.
- Koetter, Michael and Tigran Poghosyan (2008). *“Real estate markets and bank distress.”* Deutsche Bundesbank, Discussion Paper, Series 2, No. 18.
- Krainer, John, and Jose A. Lopez (2008). *“Using Securities Market Information for Bank Supervisory Monitoring.”* International Journal of Central Banking, 125-165.
- Lorenzoni, G. (2008). *“Inefficient Credit Booms.”* Review of Economic Studies, Vol. 75, Issue 3, 809-833.
- Mehrhoff, Jens (2009). *“A solution to the problem of too many instruments in dynamic panel data GMM.”* Deutsche Bundesbank, Discussion Paper, Series 1, No. 31.
- Misina, Miroslav and Greg Tkacz (2008). *“Credit, Asset Prices, and Financial Stress in Canada.”* Bank of Canada, Working Paper, No. 2008-10.
- Nickell, Stephen (1981). *“Biases in dynamic models with fixed effects.”* Econometrica, Vol. 49, No. 6, 1417-1426.

- Porath, Daniel (2004). “*Estimating probabilities of default for German savings banks and credit cooperatives.*” Deutsche Bundesbank, Discussion Paper, Series 2, No. 06.
- Puddu, Stefano (2008). “*Optimal Weights and Stress Banking Indexes.*” HEC-Université de Lausanne.
- Segoviano, Miguel A. and Charles Goodhart (2009). “Banking Stability Measures.” IMF Working Paper, WP/09/4.
- von Hagen, Jürgen and Tai-Kuang Ho (2003). “*Money Market Pressure and the Determinants of Banking Crises.*” ZEI b, Center for European Integration Studies, University of Bonn.
- Wooldridge, Jefferey M. (2010). *Econometric analysis of cross-section and panel data*. 2<sup>nd</sup> edition, MIT press, Cambridge, Mass. (et al.).

## Appendix

### Appendix I: Regression Statistics “Bundesbank Hazard Rate Model” for Savings, Cooperative, and Small Private Banks.

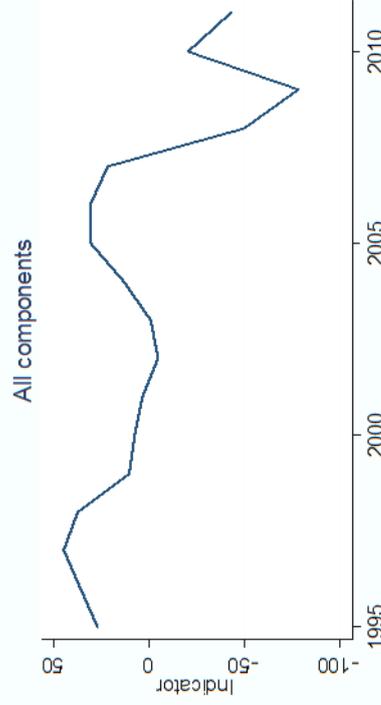
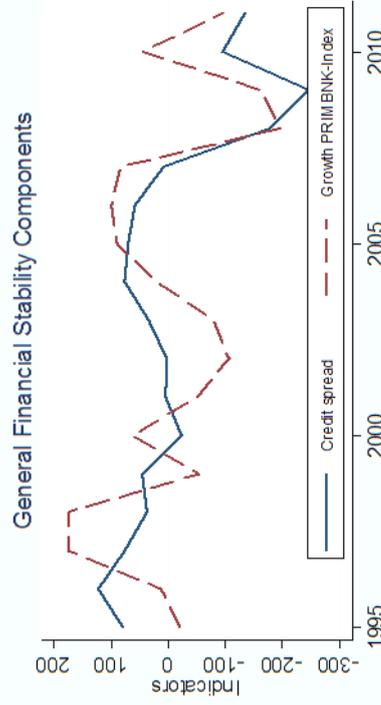
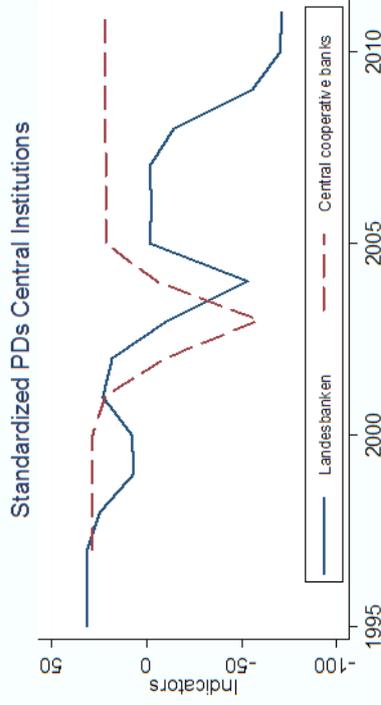
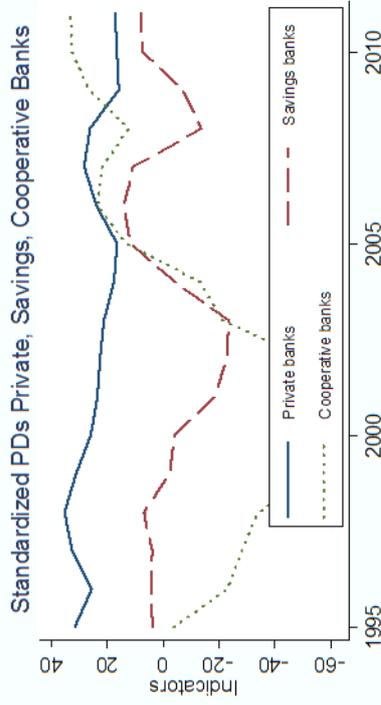
This table shows regression statistics from a bank rating model that is based on the logistic link function which transforms a set of bank-specific covariates and a macroeconomic variable observed in year t-1 into the probability of default (PD) of a bank in year t. The right-hand side of the regression equation is based on the CAMELS taxonomy. On the left-hand side of our logistic regression we use a unique data set of bank distress events collected by the Deutsche Bundesbank over the time period 1994 to 2006 which is only available for small banks. Along with PDs from Moody’s Bank Financial Strength Ratings, the PDs from this rating model constitute the main component of the financial stability indicator.

Variable	
Tier 1 capital ratio	-0.04691*** (-3.039)
Total bank reserves	-1.69905*** (-13.410)
Reserves reduction	0.54120*** (6.487)
Share of customer loans	0.00815** (2.265)
Sector HHI	-0.00845** (-2.272)
Hidden liabilities	0.62935*** (6.977)
Share of fee income	0.02784*** (3.518)
RoE	-0.05372*** (-15.729)
Branches HHI	0.00069*** (4.102)
Yield curve	0.11602** (2.288)
Dummy savings banks	-0.30262 (-1.332)
Dummy cooperative banks	0.06767 (0.426)
Constant	-2.46671*** (-6.383)
Observations	29,991
Number of banks	4,682
AUC	0.877

**Tier 1 ratio** = Tier 1 capital to risk-weighted assets. **Total bank reserves** = Total bank reserves (according to sections 340f and 340g of the German Commercial Code) to total assets. **Reserves reduction** = Dummy takes one if total bank reserves are used. **Share of customer loans** = Customer loans to total assets. **Sector HHI** = Herfindahl-Hirschman Index over 23 industry sectors (i.e., larger values indicate higher concentration in the loan portfolio). **Hidden liabilities** = Dummy indicates avoided write-offs on the bank’s assets. **Share of fee income** = Fee income to total income. **ROE** = Operating results to equity. **Branches HHI** = Herfindahl-Hirschman Index over bank branches per state (i.e., larger values indicate higher branch concentration in the respective “Bundesland” banking market). **Yield curve** = Interest rate on 10-year minus 1-year German government bond. **Dummy savings banks** = Dummy takes one for savings banks. **Dummy cooperative banks** = Dummy takes one for cooperative banks. All ratios in percent; t-statistics in parentheses; \*\*\* p<0.01, \*\* p<0.05, \* p<0.1.

**Appendix II: Stability Indicators for the German Banking System.**

## Stability Indicators for the German Banking System



### Appendix III: Set of Explanatory Variables, Variable Code and Data Source.

	Type	Variable	Code	Source
<b>Macroeconomic Variables</b>	<b>Asset price indicators</b>	National real estate price index (commercial)	<i>REALEST_PRICE</i>	Bulwien AG
	<b>Leading indicators for business cycle</b>	Ifo business cycle expectations	<i>IFO_INDEX</i>	Ifo-Institute
		Gross fixed investments	<i>GR_FIXED_INV</i>	German Federal Statistical Office
<b>Financial Variables</b>	<b>Lending</b>	National private credit to GDP	<i>CRED_TO_GDP</i>	Deutsche Bundesbank
	<b>Monetary indicators</b>	Libor (3-month)	<i>LIBOR_3M</i>	British Bankers' Association
		Bubill (3-month) M2-to-GDP	<i>3MBUBILL</i> <i>M2_TO_GDP</i>	Bloomberg Deutsche Bundesbank
<b>Structural Variables</b>	<b>Regional spillovers</b>	Asset-weighted probability of default for institutions in the same county, excluding the respective bank	<i>COUNTY_PD</i>	Deutsche Bundesbank
		Regional GDP (percentage change)	<i>COUNTY_GDP</i>	German Federal Statistical Office
	<b>Counterparty exposures</b>	International exposures in terms of balance sheet total (at banking group level)	<i>INT_EXP</i>	Deutsche Bundesbank
	<b>Risk aversion</b>	Indicator for risk appetite	<i>VIX_INDEX</i>	Chicago Board Options Exchange
	<b>Bank size</b>	Logarithm of GDP-deflated total assets	<i>LN_ASSETS</i>	Deutsche Bundesbank

Source: Various. Note: We also included further indicators (e.g. real GDP, residential house price index) at national and European level that turned out not to be significant and are available upon request.

**Appendix IV: Selected Balance Sheet Items in € Billion, All Banks.**

	1999	2004	2007	2009	2010
Stocks and bonds from foreign issuers	195.9	382.5	675.0	639.0	592.1
In % of balance sheet total	3.41	5.74	9.09	8.27	7.75
Foreign lending (bonds included)	823.2	1519.0	2245.3	2199.9	2074.2
In % of balance sheet total	14.34	22.79	30.22	28.48	27.15
<i>Of which</i>					
Lending to foreign banks (bonds and money market securities included)	427.1	889.4	1379.0	1332.4	1255.2
In % of balance sheet total	7.44	13.35	18.56	17.25	16.43
Lending to foreign non-banks (bonds included)	396.1	629.5	866.3	867.5	819.0
In % of balance sheet total	6.90	9.45	11.66	11.23	10.72
Deposits and borrowing from foreign banks	483.6	603.3	745.5	696.1	749.8
In % of balance sheet total	8.42	9.05	10.03	9.01	9.82
Deposits and borrowing from foreign non-banks	284.4	311.2	318.3	254.9	254.6
In % of balance sheet total	4.95	4.67	4.28	3.3	3.3

Source: Deutsche Bundesbank.

**Appendix V: Descriptive Statistics.**

Variable	Mean	Std. Dev.	Skewness	Kurtosis	P5	P95
BASKET_SI_INST <sub>i,t</sub>	4.37	74.51	-4.09	28.48	-118.50	59.19
LN_ASSETS	19.43	1.44	0.44	2.98	17.26	21.91
COUNTY_PD	-0.24	65.31	-5.18	55.03	-108.97	46.99
COUNTY_GDP	1.35	3.46	0.16	6.79	-5.60	6.35
REALEST_PRICE	98.35	4.39	1.29	4.14	93.55	109.59
IFO_INDEX	100.16	3.83	-0.08	2.57	93.38	105.82
GR_FIXED_INV	93.97	5.10	0.62	2.14	88.26	102.55
CRED_TO_GDP	1.55	0.14	-1.01	2.64	1.25	1.68
TED_SPREAD	-0.96	1.84	-0.70	1.80	-4.38	0.62
3MBUBILL	2.79	1.20	-0.45	3.24	0.31	5.15
VIX_INDEX	21.27	5.99	0.02	2.05	12.42	31.48

Note: Original and rescaled time series. Various sources; see appendix III.

## Appendix VIa: Empirical Results for Fixed Effects Estimation, All Banks & Commercial Banks.

This table shows regression statistics from a standard fixed-effects model with clustered standard errors. On the left-hand side of our estimation equation we use a basket banking stability indicator at the institutional level over the time period 1995 to 2010. The Indicator is based on the institutions' individual standardized probabilities of default, a credit spread (i.e., the average bank risk premium) and a stock market index for the banking sector ("Prime Banks Performance Index"). The right-hand side of the regression equation is based on various macroprudential variables included with different lags.

	All Banks			Commercial Banks		
BASKET_SI	(1)	(2)	(3)	(1)	(2)	(3)
L1.BASKET_SI	0.355*** (11.480)	0.335*** (14.672)	0.354*** (12.874)	0.443*** (16.026)	0.424*** (14.792)	0.446*** (15.084)
<b>Control Variable</b>						
L0.LN_ASSETS	-0.313*** (-3.410)	-0.332*** (-4.217)	-0.322*** (-5.847)	-0.050 (-0.998)	-0.053 (-1.059)	-0.049 (-1.007)
<b>Regional Variables</b>						
L1.COUNTY_PD	0.041*** (3.678)	0.023* (1.992)	0.029** (2.932)	0.008 (0.430)	-0.002 (-0.130)	0.010 (0.544)
L0.COUNTY_GDP	0.002 (0.131)	-0.005 (-0.267)	-0.006 (-0.374)	0.004 (0.188)	-0.002 (-0.087)	-0.011 (-0.715)
<b>Macro Variables</b>						
L1.REALEST_PRICE	-0.211*** (-4.785)	-0.236*** (-3.297)	-0.330*** (-6.408)	-0.222*** (-5.385)	-0.209** (-2.562)	-0.306*** (-5.960)
L0.IFO_INDEX	0.137** (2.709)	0.203*** (4.019)	0.192*** (3.771)	0.180*** (4.970)	0.216*** (5.373)	0.213*** (5.351)
L2.GR_FIXED_INV		0.017 (0.303)	0.142* (2.009)		-0.011 (-0.185)	0.134* (2.024)
L1.CRED_TO_GDP		-0.087 (-1.659)	-0.131** (-2.465)		0.015 (0.301)	-0.042 (-0.819)
<b>Financial Variables</b>						
L0.TED_SPREAD	-0.071* (-2.108)	-0.063** (-2.807)	-0.084*** (-4.799)	-0.042 (-1.626)	-0.038 (-1.712)	-0.054** (-2.870)
L1.3MBUBILL	0.129*** (3.031)	0.145*** (4.779)	0.202*** (5.724)	0.205*** (6.025)	0.204*** (6.116)	0.269*** (9.065)
<b>International Variable</b>						
L0.VIX	-0.070 (-1.514)		-0.148** (-2.564)	-0.081* (-1.939)		-0.160*** (-3.081)
Observations	32,107	32,107	32,107	2,368	2,368	2,368
Number of times	16	16	16	16	16	16
F statistic	34.28	135.2	118.2	340.9	181.0	330.5
Within-R2	0.287	0.289	0.300	0.473	0.465	0.480

## Appendix VIb: Empirical Results for Fixed Effects Estimation, Cooperative Banks & Savings Banks.

This table shows regression statistics from a standard fixed-effects model with clustered standard errors. On the left-hand side of our estimation equation we use a basket banking stability indicator at the institutional level over the time period 1995 to 2010. The Indicator is based on the institutions' individual standardized probabilities of default, a credit spread (i.e., the average bank risk premium) and a stock market index for the banking sector ("Prime Banks Performance Index"). The right-hand side of the regression equation is based on various macroprudential variables included with different lags.

	Credit Cooperatives			Savings Banks		
BASKET_SI	(1)	(2)	(3)	(1)	(2)	(3)
L1.BASKET_SI	0.344*** (8.138)	0.315*** (9.971)	0.333*** (9.296)	0.348*** (7.164)	0.333*** (7.198)	0.351*** (7.110)
<b>Control Variable</b>						
L0.LN_ASSETS	-0.683*** (-3.536)	-0.720*** (-4.257)	-0.689*** (-5.397)	-0.665*** (-2.996)	-0.498* (-2.107)	-0.565*** (-3.033)
<b>Regional Variables</b>						
L1.COUNTY_PD	0.053*** (4.062)	0.030** (2.450)	0.035*** (3.419)	0.028* (2.001)	0.016 (1.179)	0.023* (1.779)
L0.COUNTY_GDP	0.002 (0.097)	-0.003 (-0.152)	-0.004 (-0.195)	0.007 (0.361)	-0.001 (-0.047)	-0.001 (-0.051)
<b>Macro Variables</b>						
L1.REALEST_PRICE	-0.183*** (-3.732)	-0.222*** (-3.262)	-0.308*** (-6.052)	-0.199*** (-5.047)	-0.192** (-2.568)	-0.292*** (-6.235)
L0.IFO_INDEX	0.131** (2.318)	0.207*** (3.645)	0.196*** (3.472)	0.137*** (3.113)	0.186*** (4.279)	0.172*** (3.958)
L2.GR_FIXED_INV		0.019 (0.358)	0.131* (1.762)		-0.017 (-0.326)	0.127* (2.025)
L1.CRED_TO_GDP		-0.136** (-2.598)	-0.173*** (-3.185)		-0.013 (-0.263)	-0.067 (-1.503)
<b>Financial Variables</b>						
L0.TED_SPREAD	-0.088** (-2.337)	-0.079*** (-3.467)	-0.100*** (-5.101)	-0.046* (-2.130)	-0.037* (-1.836)	-0.057*** (-3.596)
L1.3MBUBILL	0.108** (2.242)	0.129*** (3.933)	0.180*** (4.671)	0.143*** (3.746)	0.139*** (4.276)	0.202*** (5.810)
<b>International Variable</b>						
L0.VIX	-0.067 (-1.388)		-0.134** (-2.268)	-0.094** (-2.200)		-0.166*** (-2.993)
Observations	22,202	22,202	22,202	7,373	7,373	7,373
Number of times	16	16	16	16	16	16
F statistic	23.45	63.51	63.70	61.57	111.3	64.38
Within-R2	0.274	0.286	0.296	0.288	0.281	0.293

## **The following Discussion Papers have been published since 2012:**

01	2012	A user cost approach to capital measurement in aggregate production functions	Thomas A. Knetsch
02	2012	Assessing macro-financial linkages: a model comparison exercise	Gerke, Jonsson, Kliem Kolasa, Lafourcade, Locarno Makarski, McAdam
03	2012	Executive board composition and bank risk taking	A. N. Berger T. Kick, K. Schaeck
04	2012	Stress testing German banks against a global cost-of-capital shock	Klaus Duellmann Thomas Kick
05	2012	Regulation, credit risk transfer with CDS, and bank lending	Thilo Pausch Peter Welzel
06	2012	Maturity shortening and market failure	Felix Thierfelder
07	2012	Towards an explanation of cross-country asymmetries in monetary transmission	Georgios Georgiadis
08	2012	Does Wagner's law ruin the sustainability of German public finances?	Christoph Priesmeier Gerrit B. Koester
09	2012	Bank regulation and stability: an examination of the Basel market risk framework	Gordon J. Alexander Alexandre M. Baptista Shu Yan
10	2012	Capital regulation, liquidity requirements and taxation in a dynamic model of banking	Gianni De Nicolò Andrea Gamba Marcella Lucchetta
11	2012	Credit portfolio modelling and its effect on capital requirements	Dilek Bülbül Claudia Lambert

12	2012	Trend growth expectations and U.S. house prices before and after the crisis	Mathias Hoffmann Michael U. Krause Thomas Laubach
13	2012	The PHF: a comprehensive panel survey on household finances and wealth in Germany	Ulf von Kalckreuth Martin Eisele, Julia Le Blanc Tobias Schmidt, Junyi Zhu
14	2012	The effectiveness of monetary policy in steering money market rates during the financial crisis	Puriya Abbassi Tobias Linzert
15	2012	Cyclical adjustment in fiscal rules: some evidence on real-time bias for EU-15 countries	Gerhard Kempkes
16	2012	Credit risk connectivity in the financial industry and stabilization effects of government bailouts	Jakob Bosma Micheal Koetter Michael Wedow
17	2012	Determinants of bank interest margins: impact of maturity transformation	O. Entrop, C. Memmel B. Ruprecht, M. Wilkens
18	2012	Tax incentives and capital structure choice: evidence from Germany	Thomas Hartmann-Wendels Ingrid Stein, Alwin Stöter
19	2012	Competition for internal funds within multinational banks: foreign affiliate lending in the crisis	Cornelia Düwel Rainer Frey
20	2012	Fiscal deficits, financial fragility, and the effectiveness of government policies	Markus Kirchner Sweder van Wijnbergen
21	2012	Saving and learning: theory and evidence from saving for child's college	Junyi Zhu

22	2012	Relationship lending in the interbank market and the price of liquidity	Falk Bräuning Falko Fecht
23	2012	Estimating dynamic tax revenue elasticities for Germany	Gerrit B. Koester Christoph Priesmeier
24	2012	Identifying time variability in stock and interest rate dependence	Michael Stein, Mevlud Islami Jens Lindemann
25	2012	An affine multifactor model with macro factors for the German term structure: changing results during the recent crises	Arne Halberstadt Jelena Stapf
26	2012	Determinants of the interest rate pass-through of banks – evidence from German loan products	Tobias Schlüter, Ramona Busch Thomas Hartmann-Wendels Sönke Sievers
27	2012	Early warning indicators for the German banking system: a macroprudential analysis	Nadya Jahn Thomas Kick

**The following Discussion Papers have been published since 2011:**

**Series 1: Economic Studies**

01	2011	Long-run growth expectations and “global imbalances”	M. Hoffmann M. Krause, T. Laubach
02	2011	Robust monetary policy in a New Keynesian model with imperfect interest rate pass-through	Rafael Gerke Felix Hammermann
03	2011	The impact of fiscal policy on economic activity over the business cycle – evidence from a threshold VAR analysis	Anja Baum Gerrit B. Koester

04	2011	Classical time-varying FAVAR models – estimation, forecasting and structural analysis	S. Eickmeier W. Lemke, M. Marcellino
05	2011	The changing international transmission of financial shocks: evidence from a classical time-varying FAVAR	Sandra Eickmeier Wolfgang Lemke Massimiliano Marcellino
06	2011	FiMod – a DSGE model for fiscal policy simulations	Nikolai Stähler Carlos Thomas
07	2011	Portfolio holdings in the euro area – home bias and the role of international, domestic and sector-specific factors	Axel Jochem Ute Volz
08	2011	Seasonality in house prices	F. Kajuth, T. Schmidt
09	2011	The third pillar in Europe: institutional factors and individual decisions	Julia Le Blanc
10	2011	In search for yield? Survey-based evidence on bank risk taking	C. M. Buch S. Eickmeier, E. Prieto
11	2011	Fatigue in payment diaries – empirical evidence from Germany	Tobias Schmidt
12	2011	Currency blocs in the 21 <sup>st</sup> century	Christoph Fischer
13	2011	How informative are central bank assessments of macroeconomic risks?	Malte Knüppel Guido Schulte frankenfeld
14	2011	Evaluating macroeconomic risk forecasts	Malte Knüppel Guido Schulte frankenfeld
15	2011	Crises, rescues, and policy transmission through international banks	Claudia M. Buch Cathérine Tahmee Koch Michael Koetter

16	2011	Substitution between net and gross settlement systems – A concern for financial stability?	Ben Craig Falko Fecht
17	2011	Recent developments in quantitative models of sovereign default	Nikolai Stähler
18	2011	Exchange rate dynamics, expectations, and monetary policy	Qianying Chen
19	2011	An information economics perspective on main bank relationships and firm R&D	D. Hoewer T. Schmidt, W. Sofka
20	2011	Foreign demand for euro banknotes issued in Germany: estimation using direct approaches	Nikolaus Bartzsch Gerhard Rösl Franz Seitz
21	2011	Foreign demand for euro banknotes issued in Germany: estimation using indirect approaches	Nikolaus Bartzsch Gerhard Rösl Franz Seitz
22	2011	Using cash to monitor liquidity – implications for payments, currency demand and withdrawal behavior	Ulf von Kalckreuth Tobias Schmidt Helmut Stix
23	2011	Home-field advantage or a matter of ambiguity aversion? Local bias among German individual investors	Markus Baltzer Oscar Stolper Andreas Walter
24	2011	Monetary transmission right from the start: on the information content of the eurosystem's main refinancing operations	Puriya Abbassi Dieter Nautz
25	2011	Output sensitivity of inflation in the euro area: indirect evidence from disaggregated consumer prices	Annette Fröhling Kirsten Lommatzsch

26	2011	Detecting multiple breaks in long memory: the case of U.S. inflation	Uwe Hassler Barbara Meller
27	2011	How do credit supply shocks propagate internationally? A GVAR approach	Sandra Eickmeier Tim Ng
28	2011	Reforming the labor market and improving competitiveness: an analysis for Spain using FiMod	Tim Schwarzmüller Nikolai Stähler
29	2011	Cross-border bank lending, risk aversion and the financial crisis	Cornelia Düwel, Rainer Frey Alexander Lipponer
30	2011	The use of tax havens in exemption regimes	Anna Gumpert James R. Hines, Jr. Monika Schnitzer
31	2011	Bank-related loan supply factors during the crisis: an analysis based on the German bank lending survey	Barno Blaes
32	2011	Evaluating the calibration of multi-step-ahead density forecasts using raw moments	Malte Knüppel
33	2011	Optimal savings for retirement: the role of individual accounts and disaster expectations	Julia Le Blanc Almuth Scholl
34	2011	Transitions in the German labor market: structure and crisis	Michael U. Krause Harald Uhlig
35	2011	U-MIDAS: MIDAS regressions with unrestricted lag polynomials	C. Forni M. Marcellino, C. Schumacher

## Series 2: Banking and Financial Studies

01	2011	Contingent capital to strengthen the private safety net for financial institutions: Cocos to the rescue?	George M. von Furstenberg
02	2011	Gauging the impact of a low-interest rate environment on German life insurers	Anke Kablau Michael Wedow
03	2011	Do capital buffers mitigate volatility of bank lending? A simulation study	Frank Heid Ulrich Krüger
04	2011	The price impact of lending relationships	Ingrid Stein
05	2011	Does modeling framework matter? A comparative study of structural and reduced-form models	Yalin Gündüz Marliese Uhrig-Homburg
06	2011	Contagion at the interbank market with stochastic LGD	Christoph Memmel Angelika Sachs, Ingrid Stein
07	2011	The two-sided effect of financial globalization on output volatility	Barbara Meller
08	2011	Systemic risk contributions: a credit portfolio approach	Klaus Düllmann Natalia Puzanova
09	2011	The importance of qualitative risk assessment in banking supervision before and during the crisis	Thomas Kick Andreas Pfingsten
10	2011	Bank bailouts, interventions, and moral hazard	Lammertjan Dam Michael Koetter
11	2011	Improvements in rating models for the German corporate sector	Till Förstemann

12	2011	The effect of the interbank network structure on contagion and common shocks	Co-Pierre Georg
13	2011	Banks' management of the net interest margin: evidence from Germany	Christoph Memmel Andrea Schertler
14	2011	A hierarchical Archimedean copula for portfolio credit risk modelling	Natalia Puzanova
15	2011	Credit contagion between financial systems	Natalia Podlich Michael Wedow
16	2011	A hierarchical model of tail dependent asset returns for assessing portfolio credit risk	Natalia Puzanova
17	2011	Contagion in the interbank market and its determinants	Christoph Memmel Angelika Sachs
18	2011	Does it pay to have friends? Social ties and executive appointments in banking	A. N. Berger, T. Kick M. Koetter, K. Schaeck



## **Visiting researcher at the Deutsche Bundesbank**

The Deutsche Bundesbank in Frankfurt is looking for a visiting researcher. Among others under certain conditions visiting researchers have access to a wide range of data in the Bundesbank. They include micro data on firms and banks not available in the public. Visitors should prepare a research project during their stay at the Bundesbank. Candidates must hold a PhD and be engaged in the field of either macroeconomics and monetary economics, financial markets or international economics. Proposed research projects should be from these fields. The visiting term will be from 3 to 6 months. Salary is commensurate with experience.

Applicants are requested to send a CV, copies of recent papers, letters of reference and a proposal for a research project to:

Deutsche Bundesbank  
Personalabteilung  
Wilhelm-Epstein-Str. 14

60431 Frankfurt  
GERMANY

