EBERHARD KARLS
UNIVERSITÄT
TÜBINGEN

University of Tübingen
Working Papers in
Economics and Finance

No. 37

Do Better Capitalized Banks Lend Less?
Long-Run Panel Evidence from Germany

by

Claudia M. Buch & Esteban Prieto

Faculty of Economics and Social Sciences
www.wiwi.uni-tuebingen.de

Do Better Capitalized Banks Lend Less?

Long-Run Panel Evidence from Germany*

Claudia M. Buch (University of Tübingen, CESifo, and IAW)

Esteban Prieto (University of Tübingen)

May 2012

Abstract

Insufficient capital buffers of banks have been identified as one main cause for the large systemic effects of the recent financial crisis. Although higher capital is no panacea, it yet features prominently in proposals for regulatory reform. But how do increased capital requirements affect business loans? While there is widespread belief that the real costs of increased bank capital in terms of reduced loans could be substantial, there are good reasons to believe that the negative real sector implications need not be severe. In this paper, we take a long-run perspective by analyzing the link between the capitalization of the banking sector and bank loans using panel cointegration models. We study the evolution of the German economy for the past 60 years. We find no evidence for a negative impact of bank capital on business loans.

JEL-codes: G2, E5, C33

Keywords: Bank capital, business loans, cointegration

* Corresponding author: Claudia Buch, University of Tübingen, Department of Economics and Social Sciences, Mohlstrasse 36, 72074 Tübingen, Germany claudia.buch@uni-tuebingen.de, Esteban Prieto: esteban.prieto@wiwi.uni-tuebingen.de.

We would like to thank Jörg Breitung, Mathias Hoffmann, Jörn Kleinert, Lukas Menkhoff, Jörg Rocholl, and seminar participants at the universities of Zürich and Hannover and at the CESifo Area Conference on Macro, Money, and International Finance (March 2012) for most helpful comments and discussions. All errors and inconsistencies are solely in our own responsibility.

1 Motivation

Insufficient capital buffers of banks have been identified as one main cause for the large systemic effects of the recent financial crisis (see, e.g., Hellwig 2010). Asset prices declined, banks' capital buffers turned out to be insufficient, banks resorted to fire sales of assets, thus further depressing asset prices and causing a downward spiral of prices and markets. Although higher capital requirements are no panacea, they feature prominently in proposals for regulatory reform.[1]

But how do increased capital requirements affect bank loans? If the Modigliani-Miller theorem applies to banks, then the funding structure of banks would be irrelevant for the volume and structure of banks' activities (Miller 1995). Yet, there is widespread believe that bank assets and thus also loans decline in the short-run when banks need to hold more capital. But, taking a longer-term perspective, there are good reasons to believe that the negative real sector implications need not be severe (Admati et al. 2010, Kashyap et al. 2010). Facing increased capital requirements, banks can shrink their balance sheets, they can recapitalize and keep assets constant, or they can even expand their assets. In addition, they can change the structure of their assets by increasing or decreasing the share of business loans.

In this paper, we analyze the link between bank capital and bank loans in the long-run using panel evidence for German banking groups over the last 50 years (1960-2010). The German banking system provides an interesting case study. We have data for nine distinct banking groups, including the three main tiers, i.e. the private commercial banks, the savings banks, and the cooperative banks. This heterogeneity across banking groups can be used to identify the impact of capital on loans. Methodologically, we use a cointegrated panel error-correction model which allows modeling both, short-run fluctuations in bank loans as well as adjustment to departures from the long-run cointegration relationship. While the long-run cointegration relationship is assumed to be identical across different banking groups, the short-run dynamics of loans are allowed to vary across banks. The impact of changes in bank capital on the real economy is measured through changes in the structure and the volume of loans to private non-banks (business loans).

[1] Higher capital requirements are a core feature of the Basel III framework (Basel Committee on Banking Supervision 2011) and feature prominently in reform proposals such as the one proposed by the Independent Commission on Banking (2011) in the UK.

Testing the implications of bank capital regulation on bank loans and bank risk taking has a long tradition in empirical banking studies. Most studies focus on the short-run adjustment (see also Kashyap et al. 2010). Berrospide and Edge (2009, 2010) use quarterly data on 165 US bank holdings companies for the years 1992-2009. They model how differences between actual and targeted capital ratios affect growth in bank loans. They find that banks holding a capital buffer exhibit higher loan growth. Francis and Osborne (2009) analyze data for 200 UK banks for the period 1996-2007. Their data provide information on adjustments of banks to bank-specific regulatory capital requirements, and they find that higher capital requirements lower bank loans. The adjustment is completed after four years. Aiyar et al. (2012) use a policy experiment in the UK to identify the impact of increased capital requirements on bank lending, and they find a negative effect. Van den Heuvel (2007) uses US data and finds that capital adequacy regulation has welfare costs in terms of a permanent loss in consumption between 0.1 and 1 percent due to reduced liquidity creation. Gambacorta and Mistrulli (2003) show that a higher degree of capitalization lowers the procyclicality of bank loans.

Here, we extend the literature in several regards.

First, we analyze the short-run *and* the long-run response of bank loans to higher capital in an integrated framework. This is important because much of the current discussion focuses on short-term adjustment cost. With our approach, we are able to assess the speed of adjustment to a new equilibrium. We find that bank capital and business loans are cointegrated. Banks with higher equity capital also have higher loan volumes, i.e. they lend more to the private sector. The speed of adjustment differs across banks, with the largest German banks (the "Big Banks") adjusting fastest to a system-wide shock, and the *Landesbanken* adjusting slowest.

Second, we analyze the link between the levels of capital and loans, i.e. we focus on the adjustment of loan quantities rather than interest rates. Using information on levels of loan is important because much of the current policy discussion focuses on the adjustment of balance sheet *ratios*. In order to assess the impact of higher bank capital on the real economy, it is important to study the *level* effects as well (Greenlaw et al. 2011). This is because banks can comply with increased capital ratios by reducing the volume of their activities – and thus their loans – or by increasing the level of capital – at unchanged or even higher volumes of loans. We find that a long run increase in bank capital by one percent increases bank loans, *ceteris paribus,* by 0.22 percent. We also conduct a simulation of a situation in which banks increase bank capital and reduce bank deposits by the same amount. Such an increase in the capital-to-asset ratio is associated with a decline in bank loans only at levels of capitalization far outside the range of values observed in our data, namely at capital-to-asset ratios of more than 33 percent.

Third, we distinguish the adjustment of business loans, claims on the government, and loans to non-banks. While a higher level of bank capital has not clear long-run impact on the level of claims on the government or loans to banks, banks with higher capital supply more business loans (i.e. loans to private non-banks) in the long-run.

Fourth, the panel cointegration estimators have an important advantage compared to panel studies, in which the cross-section dominates, or compared to time series studies. Panel cointegration models can account for unobserved heterogeneity not only with regard to time-invariant factors (captured in cross-section-specific fixed effects) but also with regard to time-varying factors (captured in cross-section-specific trends) (Pedroni 2007). This allows using a fairly parsimonious specification which focuses on the adjustment of loan quantities in response to changes in capitalization.

In the following second part, we briefly motivate our analysis theoretically. In Part three, we describe our data and present descriptive statistics. In part four, we present our empirical model, panel unit root tests, panel cointegration tests, and estimates of the long-run cointegration vector. Part five concludes.

2 Theoretical Motivation

We are interested in analyzing the impact of bank capital and thus banks' funding structure on their loans or, more generally, on the structure of their assets. The main intuition of how funding affects bank loan choices can be illustrated with a simple banking model, which has been adapted from Khwaja and Mian (2008). Consider a representative bank *i* which gives out loans (*L*) and funds these through deposits (*D*) and capital (*C*):

$$L_{it} = D_{it} + C_{it}$$

where *t* denotes time. Deposits can be raised costlessly up to a limit $\overline{D}$, and raising equity is subject to some variable cost $\alpha^C > 0$. The return on loans is given by $\overline{r} - \alpha^L L_{it}$, i.e. marginal returns decrease as loan size increases due to operating costs or information asymmetries. The assumption that the supply of deposits is constrained implies that the bank's optimization problem reduces to finding the optimal volume of loans, which also determines the share of equity finding. The bank's first order condition determining the level of loans in the steady state is thus given by:

$$\alpha^C C_{it} = \overline{r} - \alpha^L L_{it} \tag{1}$$

where the left-hand-side gives the marginal costs of funds and the right-hand-side gives the marginal revenues per unit lend. Transforming equation (1) shows the optimal volume of loans in the steady state is a function of the banks' funding structure and their marginal costs and revenues:

$$L_{it}^{*} = \frac{1}{\alpha^{L}}\left(\bar{r} \quad \alpha^{C} C_{it}\right) \tag{1'}$$

Equation (1') is the long-run steady-state relationship between equity capital and loans that we want to estimate in this paper. It shows that banks increase their loans when the marginal costs of funds decrease and the marginal return on loans increases. In the empirical model, we will also allow for variations in the level of deposits *D*.

But we are also interested in estimating how banks adjust to exogenous shocks. For this purpose, the model can be extended by introducing shocks to the supply of bank deposits and to the demand for loans:

$$\overline{D}_{t+1} = \overline{D}_{t} + \overline{\delta} + \delta_{i} \tag{2a}$$

$$\bar{r} - \alpha^{L} L_{it+1} + \overline{\eta} + \eta_{ii} \tag{2b}$$

where $\overline{\delta}$ and $\overline{\eta}$ are macroeconomic shocks, and δ_i and η_i are bank-specific shocks. These shocks increase the volume of loanable funds and increase the return on loans, respectively.

The first order condition determining the optimal volume of loans in period $t + 1$ is then given by

$$\alpha^{C} C_{it+1} = \bar{r} - \alpha^{L} L_{it+1} + \overline{\eta} + \eta_{i}$$

Combining the two first order conditions yields the change in loans as a function of deposit supply and loan demand shocks as well as the variable costs of loans and equity:

$$\Delta L_{i} = \frac{\alpha^{C}}{\alpha^{L} + \alpha^{C}}\left(\overline{\delta} + \delta_{i}\right) + \frac{1}{\alpha^{L} + \alpha^{C}}\left(\overline{\eta} + \eta_{i}\right). \tag{3}$$

Both, in the long-run (1') and in the short-run (3), the relationship between bank loans and bank capital is a function of the bank's costs and thus of the bank's business model. We thus need an empirical model which flexibly accommodates to the fact that the short-run adjustment is heterogeneous across banks. The error-correction model that we will use for our empirical analysis has precisely that feature.

Obviously, the model by Khwaja and Mian (2008) makes a couple of highly stylized assumptions. Take the exogeneity of funding costs first. Several empirical studies show that the risk premium on bank capital is a function of banks' degree of leverage: the more deposit financing banks use to fund a certain volume of activities, the higher the potential losses to holders of equity capital, and thus the higher the risk premium on bank capital (Admati et al. 2010, Hanson et al. 2010). This implies that the marginal costs of raising capital are indexed with respect to time, which allows for the possibility that risk premia decline in the degree of leverage: $\alpha_t^C = \alpha_t^C(D_t/L_t)$, $\alpha_t^{C}{}' > 0$. Ceteris paribus, an increase in C thus has a smaller negative effect on L than in the baseline model.

The second restrictive assumption of the model is that banks hold only one asset. In reality, banks can invest into business loans, which are relatively illiquid assets, and other, more liquid assets. Bernanke and Gertler (1987), for instance, model banks in general equilibrium, and they distinguish liquid (interbank loans, government bonds) and illiquid assets (corporate loans). As in the model above, banks fund themselves with deposits and equity capital. Bernanke and Gertler derive the equilibrium demand for liquid and illiquid assets as a function of the banks' funding structure as well as the deep parameters of their model such as marginal evaluation and auditing costs or the discount factor.

Here, we do not estimate these models structurally. What is important for our analysis though is the result that estimating the relationship between bank loans and bank capital is not reminiscent of estimating a simple balance sheet constraint as given by equation (1). Instead, how banks adjust their loans in response to changes in their funding structure is a function of bank-specific parameters such as costs structures, business models, and exposure to bank-specific shocks.

3 Data and Descriptive Statistics

3.1 Data

We use panel data on the German banking system provided on the *Deutsche Bundesbank's* homepage.[2] The data give annual information on the asset and funding structure of banks from 1950 onward and allow distinguishing the following banking groups: Commercial Banks, Big Banks, Regional Banks, *Landesbanken*, Savings Banks, Regional Institutions of Credit Cooperatives (*Genossenschaftliche Zentralbanken*), Credit Cooperatives, Mortgage Banks (*Realkreditinstitute*), Special Purpose Banks (*Banken mit Sonderaufgaben*), branches of Foreign Banks, Foreign Banks, affiliates of Foreign Banks, and Home Loan Banks (*Bausparkassen*). For the last four banking groups, data start only in 1968, 1985 and 1999, respectively, and we work with a panel for nine

[2] The data can be downloaded from http://www.bundesbank.de/statistik/statistik_zeitreihen.php.

banking groups. Our panel dataset spans $T = 60$ years (1950-2009) and $N = 9$ banking groups.

From this dataset, we retrieve time series for each banking group on the level of capital, total deposits, business loans, loans to banks (interbank loans), and claims on the government. The data do not allow distinguishing whether banks hold capital in excess of the regulatory minimum, i.e. we cannot distinguish capital required by regulators and by the markets. Such an analysis requires bank-level data and detailed supervisory information as has been used, for instance, in Merkl and Stolz (2009).

When analyzing the effects of bank capitalization for Germany, it needs to be taken into consideration that German banks have hidden reserves on their balance sheets. According to Section 340f of the German Commercial Code (*Handelsgesetzbuch*), banks can build up hidden reserves by understating the value of certain assets (up to a threshold of 4% of the original asset value) (Bornemann et al. 2010). Because, by definition, hidden reserves are unobservable, this could lead to a mis-measurement of capital. Yet, we do not think that hidden reserves affect our results concerning the long-run effect of capital on loans for two reasons.

First, using micro-data for the period 1995-2009, Bornemann et al. (2010) show that German banks use hidden reserves mainly to cushion short-run shocks to income. Following this interpretation, the presence of hidden reserves would not affect the *long-run* relationship between bank capital and loans that we are interested in here because short-run dynamics have only second order effects on the estimated long-run relation. Second, as has been mentioned above, empirical panel cointegration models allow accounting for unobserved trend behavior of omitted factors such as hidden reserves. (Pedroni 2007).

More importantly, regulatory changes that have occurred in the 60 years that we study here might affect our results. In fact, several changes in the regulations pertaining to bank capital have stimulated research on the effects on bank behavior.[3] More specifically, the First Basel Accord of 1988 required banks to hold a minimum capital-to-asset ratio of 8%, the so-called Cooke ratio. Bank assets were calculated based on fixed risk weights, assigning lower risk weights to OECD than to non-OECD countries and to claims on the government than to business loans. In January 1993, the EU’s Capital Adequacy Directive has been implemented. The framework has later on been modified, inter alia by

[3] Kashyap et al. (2010), Berrospide and Edge (2009, 2010), and Francis and Osborne (2009) comprehensively survey the empirical literature; for an early review of the evidence following up on the 1st Basel Accord see Furfine et al. (1999).

allowing banks to use their internal risk models to calculate risk weights (Basel II). The new Basel II rules have been in force in the European Union (EU) since 2007. Banks not applying internal risk models can resort to the so-called standardized approach. Currently, the adoption of the new regulatory framework Basel III into EU legislation is under discussion. In contrast to the Basel II rules, the new framework foresees higher capital ratios, a stricter definition of core capital, liquidity rules, and procyclical capital buffers. The new regulations shall be phased in gradually until 2018. Other regulations have affected specific banking groups only, notably the withdrawal of state guarantees for *Sparkassen* and *Landesbanken* which has become effective in 2005.

Many of these changes may have been anticipated by the banks, and the effects may have been felt only with some lead or lag. Our data do not allow distinguishing changes in bank capital due to regulatory changes or mandated by the markets. Hence, we need a methodology which allows taking into account possible structural breaks in the relationships we are interested in without imposing a strict timing of the regulatory changes. For this purpose, we detect breakpoints by applying the sequential multiple breakpoint test of Bai and Perron (1998, 2003) to all series of the dataset prior to estimation, and we subtract the (possibly shifted) means from the series.

3.2 Descriptive Statistics

Before looking at the evolution of banks' funding structure and asset allocation in the post-war period that we study here, it is instructive to take a more long-term perspective. Figure 1 shows the evolution of German banks' capital-to-asset ratios since the late 19th century. Comparing the late 19th and early 20th century to the post-war evidence reveals an interesting pattern: historical capital ratios have been significantly higher than those observed in recent decades. In the late 19th century, banks held 35% of their assets in the form of equity capital, and this ratio fell to 5% of assets around 1920. Capital ratios spiked again in the late 1920s. Data for the war period are unavailable, but after the war, in 1950, German banks had low capital-to-asset ratios of about 2% of their (unweighted) assets. It could be argued that, due to war-related write-offs, this value has been below its steady state value. The post-war period would thus be characterized by a catching up process to a new steady state which differs from the adjustment process after normal business cycle fluctuations. Moreover, the structure of banking market has changed in this period because, for instance, Deutsche Bank was dissected into several regional credit institutions which were merged only in the late 1950s. For these reasons, our main empirical model will start in the year 1965.

The very high pre-war capital-to-asset ratios may seem exceptional compared to current numbers, but they match evidence from countries such as the United States and the United Kingdom (Berger et al. 1995, Haldane 2009). Haldane (2009) argues that the historic decline in the capitalization of banks was associated with a shift in risk from capital owners to the public sector in the early 20th century. The decline in banks' capital buffers coincides with the establishment of lender of last resort facilities and (public) deposit insurance systems. In Germany, no nation-wide deposit insurance system existed before the mid-1970s (Beck 2002). In response to the insolvency of the *Herstatt* bank in 1974, a new deposit insurance system has been set up which is organized along the demarcation lines between the three tiers of the German banking system. For privately-owned banks, the German Banking Association maintains a deposit insurance system, while the savings and the regional banks have their own regional and national insurance systems. A complementary explanation for the declining capitalization of banks in historic perspective could be an increase in the liquidity of banks' assets (Diamond and Rajan 2000).

Using the data in our regression sample, Figure 2a shows the evolution of banks' capital and business loans, Figure 2b has the respective ratios, and Figure 2c shows the composition of banks' assets in terms of shares of business loans, claims on the government, and loans to banks. For the ratios, we show the unweighted capital-to-asset ratio. Since the 1950s, the capitalization of German banks has increased continuously. Up until the mid-1990s, large banks and credit banks have had a consistently higher capital-to-asset ratio than the average German bank. The capitalization of the *Landesbanken* has been consistently below average. The capitalization of the savings banks has largely followed the trends for the German banking system as a whole.

The fact that smaller banks in Germany have relatively low capital-to-asset ratio may seem at odds with findings from the US where smaller banks are better capitalized than larger banks (Kashyap et al. 2010). It could reflect the fact that the German savings banks have relatively safe asset portfolios and/or that these banks more proportionally have hidden reserves on their balance sheets. Both factors would tend to lower their capitalization. We account for the structural differences across German banks concerning the use of hidden reserves by allowing for heterogeneous intercepts, trends, and short-run dynamics.

Since the late 1990s, capital-to-asset ratios have converged across banking groups, and German banks entered the crisis period in 2008/2009 with a capital-to-asset ratio of about 5%. The dispersion of capital ratios has increased in the crisis period, reflecting different exposures to shocks, different abilities of banks to raise external capital, and different needs for recapitalization through the government. At the end of 2010, the capitalization of German banks stood between 5.8% of total assets for the cooperative banks and 3.9% for the large banks.

During our sample period, capital-to-asset ratios of German banks have thus gradually increased. Has this induced the banks to reduce their loan volumes? Figure 2b also shows the evolution of the banks' loans-to-assets ratio over time. Generally, there has been a downward trend, reflecting the disintermediation of banking services. This trend has been less pronounced for the savings and the cooperative banks. Claims on the government had a fairly stable share of total assets while loans to banks have increased (Figure 2c).

4 Methodology

The descriptive statistics reported in Figure 2 suggest that loans and capital of German banks are negatively correlated. However, such a correlation might be spurious if the variables under study are non-stationary. In this case, the observed correlation could simply reflect a common stochastic trend.

The focus of our empirical model is on the long-run link between bank capital and bank loans. In the short-run, loans fluctuate around the long-run trends in response to different shocks. These shocks move loans away from their long-run trend and induce an error-correction mechanism back towards the steady state. We are interested in all three aspects – the long-run relationships, the short-run fluctuations, and the speed of adjustment to a new equilibrium once shocks have occurred. A convenient way to analyze these adjustment channels is an error-correction framework.

4.1 Panel Unit Root Tests

Before determining whether bank loans, capital, and deposits are cointegrated, we need to determine the unit root properties of the two series. We test for non-stationarity using Pesaran's (2007) panel unit root test. This second generation test allows for cross-sectionally dependence due to common stochastic trends or shocks.

The test starts from a regression of the change in each variable of interest ($\Delta y_{i,t}$) on its own lag ($y_{i,t-1}$) as in a standard Augmented Dickey Fuller (ADF) regression. Additionally, the cross-section averages of lagged levels ($\bar{y}_{t-1}$) and the first differences of the series ($\Delta\bar{y}_{t-1}$) are added to the equation in order to eliminate cross-sectional dependence. Pesaran (2007) thus suggests estimating the cross-sectionally augmented panel version of the Dickey-Fuller regression model:

$$\Delta y_{i,t} = \alpha_i + b_i y_{i,t-1} + c_i \bar{y}_{t-1} + d_i \Delta\bar{y}_{t-1} + \varepsilon_{it} \, .$$

The test is implemented by computing individual cross-sectionally augmented ADF statistics ($CADF_i$), which are then averaged to obtain the cross-sectionally augmented Im, Pesaran, Shin (2003) test, the so-called *CIPS*-statistic.

The test results are presented in Table 1. To allow for the adjustment process in the post-war period, our main regression sample starts in 1965. We present results including the crisis years (1965-2009) and excluding these years (1965-2006). We implement the test with individual specific constants, and we include or exclude trends. The lag length in each individual *CADF* regression is set according to the Akaike Information (AIC) criterion.

The results presented in Table 1 clearly indicate that the levels of capital, deposits, and loans should be considered non-stationary. The test never allows rejecting the null hypothesis of the presence of a unit root. We also show the test results for the first differenced series. In all cases, we reject the null of non-stationarity for the differenced series, providing further evidence that the level series are integrated of order 1. The finding of non-stationarity does not depend on the sample chosen (i.e. including or excluding the crisis years).

In Table 2, we also present the results for the banking-group-specific ADF regressions. Note that we do not require each individual series to be non-stationary because the panel unit root test is formulated against the alternative that a non-vanishing fraction of the series is stationary. The results indicate that we are not able to reject the hypothesis of a unit-root in the series in almost all cases: The hypothesis of a unit root is rejected in only two of the 27 series.

4.2 Specification of the Error-Correction Model

The result of the panel unit root test that the variables under study are non-stationary points to the possibility of a long-run cointegration relation between loans, capital, and deposits. Our main testing equation is a reduced-form error correction model, which relates changes in loans in each banking group i in year t (ΔL_{it}) to deviations from the long-run steady state relationship and to short-run fluctuations of endogenous and exogenous variables:

$$\Delta L_{i,t} = c_i + \alpha_{0,i}\beta' X_{it-1} + \sum_{j=1}^{M_i-1} \alpha_{1ij} \Delta X_{it-j} + \varepsilon_{it} \qquad (4)$$

where the vector X_{it-1} is a (3 x 1) vector containing the levels of bank loans, bank capital, and deposits. The scalar c_i represents banking group-specific deterministic constants. The (3 x r) vector β represents the matrix containing the cointegrating relationships between loans, capital, and deposit, with r referring to the cointegrating rank. The (1 x r) loading matrix $\alpha_{0,i}$ indicates the speed of adjustment to a new equilibrium. We will assume throughout that the cointegrating rank is equal to $r = 1$ i.e. that there exists only one equilibrium relation among the variables.[4] The lag length M_i is set according to the AIC criterion and is allowed to differ between banking groups.

Note that the error correction model in (4) looks similar to the partial adjustment models used by Berrospide and Edge (2009) or Francis and Osborne (2009). These authors estimate the following relationship:

$$\Delta L_{it} = \alpha_0 + \alpha_1 \left(\frac{C_{i,t} \text{ - } \hat{C}^*_{i,t}}{\hat{C}^*_{i,t}} \right) + \sum_{n+1}^{N} \gamma_0 \Delta L_{i,t \quad n} + \sum_{m+1}^{M} \gamma_1 \Delta \mathbf{X}_{i,t \quad m} + \varepsilon_{it}$$

where changes in loans in each period are a function of the difference between the actual and the targeted capital buffer $(C_{i,t} - \hat{C}^*_{i,t}) / \hat{C}^*_{i,t}$ and a set of controls **X**. The main difference between the two models is that the partial adjustment mechanism does not explicitly depend on the *level* of loans, hence the *long-run* relationship between loans and capital is not modeled. The error-correction specification as specified in equation in (4) instead dissects changes in loans in each period into the speed of adjustment to departures from the long-run cointegration relationship and short-run dynamics.

According to theory (Section 2), the cointegration vector β depends on the deep, structural parameters of the economy and is thus restricted to be identical across banks. The loading matrix $\alpha_{0,i}$ accommodated differences in the speed of adjustment to a new equilibrium across bank, and is allowed to vary across banking groups. These differences across banks in terms of adjusting to exogenous shocks can have different reasons. Banks may, for instance, differ in their degree of profitability and the use of hidden reserves (Bornemann et al. 2010). They may also differ in their degree of internationalization and the ability to smoothen domestic shocks by borrowing and lending internationally.

Compared to standard panel, cross-section, or time series estimates, the specification of our empirical model might seem very parsimonious. Yet, we use a panel cointegration framework which allows estimating the model allowing for banking group-specific trends and constant terms. Hence, we implicitly model omitted variables which show systematic trend behavior for each banking group (Pedroni 2007).

[4] We also formally test for the existence of a common cointegrating rank and the number of cointegration relationships using the “LR-bar” statistic proposed by Larsson et al. (2001). The results, which are available upon request, support our assumption of only one cointegration relationship among loans, capital, and deposits.

3.2.1 Cointegration Tests

To formally test for the existence of a cointegration relation between loans, capital, and deposits, we apply Westerlund (2007) tests for cointegration in panels. The tests proposed by Westerlund (2007) apply the time-series tests for cointegration by Banerjee, Dolado, and Mestre (1998) to a panel context. Rather than testing the unit root properties of the residuals of the structural equation of interest, the Westerlund (2007) tests refer to the significance of the error-correction parameter $\alpha_{0,i}$: If the null hypothesis that the error-correction term is insignificant can be rejected, the variables under study are cointegrated. One main advantage is that these tests do not need to impose a common factor structure on the residuals but rather allow for completely heterogeneous residual dynamics. Additionally, the tests are very flexible and allow for an almost complete heterogeneous specification of the long- and short-run coefficients of the error correction model.

To be more specific, we estimate the error-correction model given in (4), and we test whether deviations of loans from their long-run equilibrium lead to an error-correction mechanism. In equation (4), the speed of adjustment is given by $-2 < \alpha_{0i} < 0$. If $\alpha_{0i} < 0$, an error correction mechanism is operating, which implies that the variables are cointegrated. In contrast, if $\alpha_{0i} \geq 0$, there is no cointegration. The tests for cointegration are, therefore, based on testing the null hypothesis of $H_0 : \alpha_{0i} = 0$ against the alternative hypothesis $H_1 : \alpha_{0i} < 0$ (Westerlund 2007).

Westerlund (2007) proposes four tests, which differ with regard to the pooling assumptions and with regard to the formulation of the alternative hypothesis. For the pooled panel statistics, the cointegration vector is estimated on data pooled across cross-sections, and the alternative hypothesis is that there is cointegration for the panel as a whole. For the two group mean statistics, the model is estimated separately across panel units. The alternative is defined such that a rejection of the null should be taken as evidence in favor of cointegration for a sufficiently large fraction of the panel.[5]

3.2.2 Long-Run Cointegration Vector

The long-run cointegration vector β in the error-correction model (4) can be estimated using at least three different specifications (Breitung and Pesaran 2008): a fully modified OLS regression (FMOLS) (Pedroni 2000), a dynamic OLS regression (DOLS), and a Two-Step estimator (Breitung 2005). The fully modified model, in turn, can be estimated

[5] We refer to Westerlund (2007) for a more detailed presentation of the construction of the various test statistics.

as a pooled or a group mean model. All estimation procedures deal with the fact that OLS estimates in cointegrated systems are spurious, and they also account for possible regressor endogeneity. The FMOLS employs a semi-parametric correction to the OLS estimator in the spirit of Phillips and Hansen (1990). In the limit, the FMOLS estimator eliminates the bias introduced by the endogeneity of the regressors. The idea of the DOLS estimator is to correct for endogeneity and serial correlation by including leads and lags of the regressors in the cointegrating regression. The Two-Step estimator proposed by Breitung (2005) performs a correction for endogeneity at the second stage by using a two-step FMOLS procedure and estimating common factors from the residuals of an initial FMOLS estimation (Breitung and Pesaran 2005). We use this estimator here because of its superior small sample properties.

Using the two-step estimator, estimating equation (4) proceeds in two steps. In a first step, the matrix of the long-run cointegration vector (β) is estimated based on a consistent estimator of the short-run parameters α_i. Because there is only one cointegration relation among the variables, we use the Engle and Granger (1987) two-step estimator to obtain consistent estimators of the short-run parameters. At this stage, the restriction that the cointegration vectors are the same for each cross-section is ignored. In a second step, the cointegration matrix β can be estimated by running an OLS regression on the pooled data.

4.3 Results on Cointegration and the Cointegration Vector

The results of the cointegration tests and the estimated long-run cointegration coefficient β are presented in Tables 3a-3c. In Table 3a, we show results using the level of business loans, our baseline specification, as the dependent variable.[6] For this specification, we also check whether results are robust to including and excluding the crisis years 2007-2009. In both cases, the sample starts in 1965. We repeat the exercise also for claims on the government (Table 3b) and loans to banks (Table 3c). In each case, we show specifications with individual-specific constants and allowing for structural breaks in the means using the sequential multiple breakpoint test of Bai and Perron (2003). We distinguish specifications including and excluding a linear time trend.

For the level of business loans, we find a positive and significant elasticity of loans with respect to bank capital of 0.22-0.24 (Table 3a). Because both variables are specified in logs, these coefficients can be interpreted as elasticities: increasing the level of capital by

[6] The results for the Two-Step Cointegration tests are based on the Gauss program *pan2step.prg* available on Jörg Breitung's homepage (http://www.ect.uni-bonn.de/mitarbeiter/joerg-breitung/two-step-estim-panel-data/index), which we translated to Matlab for our purposes.

1% increases loans by about 0.23%. The elasticity of loans with respect to an increase in deposits is higher (0.61 for the full period, 0.47 when excluding the crisis period). Both coefficients are highly significant. There is strong evidence for cointegration in the model without a trend term for both sample periods (Columns 1 and 3). In either case, three out of the four cointegration tests reject the null hypothesis of no cointegration. Evidence for cointegration is weaker when the trend is included. These results indicate that an increase in the level of equity capital *ceteris paribus* increases loans.

In Panels 3b and 3c, we repeat the same exercise for claims on the government and loans to banks. The idea is to check whether the capitalization of banks has an impact on the structure of banks' assets. Table 3b shows that equity capital has no clear-cut impact on claims on the government – the point estimate is either insignificant or there is no evidence for cointegration. There is no specification in which we find both, a significant impact *and* evidence for cointegration.

Table 3c provides a somewhat inconclusive picture for loans to banks as well. Higher bank capital is associated with a higher level of loans to banks. The elasticity is comparable to that for loans to non-banks (0.22). Yet, we obtain this result only when no time trend is included. When accounting for a trend, the significant link between bank capital and loans to banks disappears. This could indicate that the model without the trend is mis-specified.

Results presented so far inform about the elasticities of bank loans with regard to capital and deposits separately. Yet, much of the public discussion about bank capitalization focuses on the effects of changes in the capital-to-asset ratio on bank loans. To let our results speak to this debate, we calculate the effect on loans of substituting deposit funding with funding through bank capital. That is, we conduct the following thought experiment: Given the long-run structural relationship between loans, capital, and deposits, how do bank loans change if we simultaneously *increase* bank equity capital by 1% and *reduce* bank deposits by an amount such that the overall balance sheet size remains constant (i.e. we reduce deposit funding by the same nominal amount as we increase equity capital: $-dD_t = dC_t$)?

In order to illustrate our approach, consider the long-run relationship between bank loans, capital, and deposits that we have estimated: $log\, L_t = \hat{\beta}_1 \, log\, C_t + \hat{\beta}_2 \, log\, D_t$, where $\hat{\beta}_1$ and $\hat{\beta}_2$ are estimates of the long-run cointegration relationships. Totally differentiating this equation gives:

$$d\, log\, L_t = \hat{\beta}_1 \frac{dC_t}{C_t} + \hat{\beta}_2 \frac{dD_t}{D_t}$$

If the increase in bank capital is compensated by a *reduction* in deposit funding by the same magnitude, we can rewrite the above equation as

$$d\log L_t = \beta_1 \frac{dC_t}{C_t} - \beta_2 \frac{dC_t}{D_t}.$$

This equation shows that the effect of an increase in bank capital, which increases the capital-to-asset ratio, depends on two factors. The first are the magnitudes of the estimated long-run elasticities $\hat{\beta}_1$ and $\hat{\beta}_2$. The second is the relative importance of the two different funding sources. For a very small share of capital relative to total assets (which is equal to $C_t + D_t$), increasing the bank capital by one percent, corresponds to a small percentage reduction in the level of deposit funding. Consequently, the negative effect of reducing deposit funding ($-\hat{\beta}_2[dC_t/D_t]$) is negligible, and the overall effect on loans is dominated by the positive effect of increasing capital ($+\hat{\beta}_1[dC_t/C_t]$).

Figure 3 depicts this relationship. We plot the change in the log volume of loans as a result of increasing the level of bank capital by one percent, for different values of bank capitalization. The Figure is based on the estimates of the cointegration vector presented in Table 3, Column 3, i.e. using the sample that ends in 2006 and that has no trend. It shows a positive response of loans to an increase in bank capital for ranges of the capital-to-asset ratio above 0.33, and a negative response above that value. Hence, for capital-to-asset ratios below 0.33, the positive effect of raising more capital dominates the negative effect of shrinking deposits.[7] This threshold is high considering that, on average, the capital-asset-ratio has been in the range of less than 0.10 for all banking groups during the period under study (Figure 2b). Given the range of capital-asset-ratios that we have observed in the past 60 years, the new regulatory ratios, and given estimates of bank capital required also to buffer large shocks,[8] a negative impact of an increased capital-to-asset ratio on bank loans is, given our estimates, highly unlikely. In this sense, our results complement the findings in Kashayp et al. (2010) who find the impact of increase capital requirements on bank loan rates to be rather modest.

These finding are confirmed by unreported regressions using balance sheet ratios (which are, to be fair, more sensitive to the model specification).[9] Our preferred model

---

[7] Based on the estimates from the sample including the crisis years the effect of increasing bank capital becomes negative for capital-to-asset ratios above 0.26.

[8] The level of "optimal" bank capital needed to buffer large shocks calculated by Marcheggiano et al. (2012) is 20% of risk weighted assets or, assuming that risk-weighted assets account for 30-50% of total assets, capital ratios of 7-10% of total assets.

[9] The results of the entire exercise (i.e. unit root tests, cointegration tests and estimates of the long run coefficient) using balance sheet ratios are available on request.

specification (including a constant and a trend) suggests a long-run relationship between the ratio of business loans to total asset and the capital-to-asset ratio, as well as between the ratio of loans to banks over total assets and the capital-to-asset ratio. The long-run cointegrating parameter is positive in the regression using business loans and negative in the regression using loans to the banking sector as dependent variable. This is in line with the results from the level specifications in that increasing bank capital has an effect on loans to non-banks.

4.4 Persistence

So far, our analysis has focused on the long-run adjustment of bank loans to changes in bank capital. An important question is though how long it takes the banks to return to their equilibrium once being hit by a negative shock.

In Figure 4, we present the bootstrap median estimates of persistence profiles, along with one standard deviation bootstrap bounds, implied by the common long-run cointegrating relations and the heterogeneous short-run adjustment parameters.[10] Persistence profiles show the effects of system-wide shocks to the cointegrating relationship and allow examining the speed by which the long-run relationship converges back to the equilibrium (Pesaran and Shin 1996). The impact value of the persistence profiles is normalized at unity, and the profile converges to zero at longer horizons only if the relation under investigation is indeed a cointegrating vector.

The median estimates in Figure 4 clearly show that the persistence profiles of the relation between business loans and bank funding. This convergence provides additional evidence in support of the hypothesis that a long-run cointegrating relationship between bank funding and bank loans exists. The profile plots also show heterogeneity in the way the different banking groups adjust to shocks. For the group of Big Banks, for instance, nearly 98% of the adjustments are made within the first three years (based on the median estimates). In contrast, for Regional Banks, *Landesbanken*, and Mortgage Banks, shocks have sizeable effects on loans even after ten years. For these banks, 5.8%, 15.9%, and 21.26%, respectively, of the effects of shocks are still present after this period. This supports the point made by Kashyap et al. (2010) who argue that, because of the flow

[10] We apply the following bootstrap procedure: after having estimated the model in equation (4) using the method described in Section 4.2, we construct bootstrap residuals as usual. Next, we construct bootstrap time series recursively using the levels representation of the model in (4) for each banking group. From the generated bootstrap time series, we re-estimate all banking-group-specific short-run parameters using the error correction representation given in (4), while keeping the estimated long run parameters β fixed at the two-step estimate over all replications. (See Dees et al. (2007) for a similar procedure in the GVAR context.)

cost of adjusting banks' balance sheets, higher capital requirements should be phased in gradually in order to minimize the effect on lending. Incidentally, a period of almost 10 years is also the period that has been chosen for a phasing in of the new Basel III requirements.

For the *Landesbanken* and Mortgage Banks, but also for Savings Banks, we observe an 'overshooting' of the relation between loans and funding in the sense that the deviation of the long-run relation from its equilibrium value gets amplified in the first couple of year.

Interpreting these adjustments is difficult because we cannot link them in a structural way to characteristics of the respective banking groups. The overshooting result for some banking groups could imply that these banks cannot quickly move out of existing contracts because of tight informational or contractual customer relationships. It is also interesting to note that the banks with the highest degree of international exposures, i.e. the Big Banks, adjust fastest to shocks. This could indicate that international activities and the associated diversification of assets and liabilities ease the adjustment to shocks.

5 Conclusions

Significantly higher capital requirements for commercial banks can help mitigating the cost of future financial crisis. Higher bank capital should lower incentives for risk-taking; bank capital functions as a shock absorber before losses are covered through explicit or implicit deposit guarantee schemes; and higher bank capital weakens the deleveraging and multiplier effects that can lead to systemic financial crisis (Hellwig 2010). The main argument that is typically brought forward against higher capital requirements is that banks which have to comply with higher capital requirements are likely to reduce (business) loans.

The purpose of this paper has been to shed light on the effects that higher bank capital has on business loans. We make three contributions to the literature: (i) we use long-run evidence for German banks, covering a period of almost 60 years, (ii) we account for heterogeneity across German banking groups with regard to short-term dynamics and trends, and (iii) we establish the long-run relationship between bank capital and loans using panel cointegration techniques. Hence, omitted variables and endogeneity issues are not prevalent as in time series studies or studies using panels with a relatively short time series dimension. Our findings are as follows:

First, the levels of bank capital, deposits, and loans exhibit non-stationary behavior. Assessing the impact of capital on business loans in the long-run thus requires an empirical model which takes this non-stationarity in the data into account. Otherwise, results suffer from a spurious regression problem.

Second, bank capital and business loans are cointegrated around a long-term trend.

Third, the long-run impact of bank capital on loans is positive. A one percent increase in the level of bank capital increases bank loans by about 0.22 percent. We find a negative response of bank loans to an increase in bank capital only at levels of the capital-to-asset ratio of 35 percent, i.e. at ratios far outside the range of values observed in the sample period or proposed in the current regulatory debates.

Fourth, short-run adjustment differs across banking groups. The group of banks which returns fastest to their long-run steady state are the large and thus more internationally active banks.

As regards the applicability of our research to the current policy debate, there are, of course, many limitations. We can, first of all, not distinguish the impact of regulatory capital requirements from capital requirements mandated by market forces because we have no information about regulatory capital requirements. Second, we have focused on the adjustment of bank loans rather than prices. Some of the adjustment of banks to higher capital (requirements) also runs through prices loans rates and returns on equity capital. Third, firms can respond to reduced availability of bank loans by shifting to other sources of finance such as bond finance, equity finance, or trade credits. Because we focus on bank loans, we cannot assess the importance of these substitution effects which would, in any case, imply that we overestimate the impact of bank capital on financial sources available to firms. We leave these issues for future.

6 References

Admati A. R., DeMarzo P. M., Hellwig M., and P. Pfleiderer P. (2011). Fallacies, Irrelevant Facts, and Myths in the Discussion of Capital Regulation: Why Bank Equity is Not Expensive. Stanford University and Max-Planck Institute Bonn.

Aiyar, S., C.W. Calomoris, and T. Wieladek (2012). Does Macro-Pru Leak? Evidence from a UK Policy Experiment. National Bureau of Economic Research. NBER Working Paper 17822. Cambridge MA.

Allen, F. and D. Gale (2000). Financial Contagion. *Journal of Political Economy* 108(1): 1-33.

Bai J., and P. Perron (1998). Estimating and testing linear models with multiple structural changes. *Econometrica* 66: 47–78.

Bai J., and P. Perron (2003). Computation and Analysis of Multiple Structural Change Models. *Journal of Applied Econometrics* 18: 1-22.

Banerjee, A., Dolado, J.J., and R. Mestre (1998). Error-correction mechanism tests for cointegration in a single-equation framework. *Journal of Time Series Analysis* 19: 267-283.

Basel Committee on Banking Supervision (2011). Basel III: A global regulatory framework for more resilient banks and banking systems. Bank for International Settlements. June. Basel.

Beck, T. (2002). Deposit insurance as private club: is Germany a model? *The Quarterly Review of Economics and Finance* 42(4): 701-719.

Berger, A.N., R.J. Herring, and G.P. Szego (1995). The role of capital in financial institutions. *Journal of Banking and Finance* 19(3-4): 393-430.

Bernanke, B., and M. Gertler (1987). Banking in General Equilibrium. *New Approaches to Monetary Economics*, ed. W. Barnett and K. Singleton, New York: Cambridge University Press, Cambridge.

Berrospide, J.M., and R.M. Edge (2009). Linkages between the Financial and Real Sectors: Bank Credit and Capital over the Crisis. Federal Reserve Board. Mimeo.

Berrospide, J.M., and R.M. Edge (2010). The Effects of Bank Capital on Lending: What Do We Know, and What Does It Mean? *International Journal of Central Banking* 6(34): 187-204.

Bornemann, S., S. Homölle, C. Hubensack, T. Kick, and A. Pfingsten (2009). Determinants for Using Visible Reserves in German Banks – An Empirical Study. Deutsche Bundesbank. Discussion Paper Series 2: Banking and Financial Studies. 11/2009. Frankfurt a.M.

Bornemann, S., T. Kick, C. Memmel, and A. Pfingsten (2010). Are banks using hidden reserves to beat earnings benchmarks? Evidence from Germany. Deutsche Bundesbank. Discussion Paper Series 2: Banking and Financial Studies. 13/2010. Frankfurt a.M.

Breitung, J. (2005). A parametric approach to the estimation of cointegration vectors in panel data. *Econometric Reviews* 24: 151-173.

Breitung, J., and M.H. Pesaran (2008). Unit Roots and Cointegration in Panels. In: L. Matyas and P. Sevestre (eds.). *The Econometrics of Panel Data: Fundamentals and Recent Developments in Theory and Practice*, Kluwer Academic Publishers, Chap. 9: 279-322

Dees, S., S. Holly, M. H. Pesaran, and L. V. Smith (2007). Long Run Macroeconomic Relations in the Global Economy. *Economics: The Open-Access, Open-Assessment E-Journal* 1: 2007–3.

Diamond, D., and R. Rajan (2000). A Theory of Bank Capital. *Journal of Finance* 6: 2431-2465.

Francis, W., and M. Osborne (2009). Bank regulation, capital and credit supply: Measuring the impact of Prudential Standards. Financial Services Authority. Occasional Paper Series 36. London.

Furfine, C., G. Hans, D. Hancock, D. Jes, W. Perraudin, L. Radecki, and M. Yoneyama (1999). Capital Requirements and Bank Behavior: The Impact of the Basel Accord. Basle Committee on Banking Supervision. Working Papers 1. Basle.

Gambarcorta, L., and P.E. Mistrulli (2003). Bank capital and lending behavior: empirical evidence for Italy. Banca D'Italia. Temi di discussione del Servizio Studi 486. Rome.

Greenlaw, D., A.K. Kashyap, K. Schoenholtz, and H.S. Shin (2011). Stressed Out: Macroprudential Principles for Stress Testing. Prepared for the U.S. Monetary Policy Forum

Haldane, A. (2009). Banking on the State. Bank of England. http://www.bis.org/review/r091111e.pdf

Hellwig, M. (2010). Capital Regulation after the Crisis: Business as Usual? Max Planck Institute for Research on Collective Goods. Bonn.

Holtfrerich, C.-L. (1981). Die Eigenkapitalausstattung deutscher Kreditinstitute 1871-1945. Das Eigenkapital der Kreditinstitute als historisches und aktuelles Problem. *Bankhistorisches Archiv* 5. Beiheft.

Im, K.S., M.H. Pesaran, and Y. Shin (2003). Testing for Unit Roots in Heterogeneous Panels. *Journal of Econometrics* 115: 53-74.

Independent Commission on Banking (2011). Interim Report -- Consultation on Reform Options. April. London.

Ioannidis, C., D.A. Peel, and M.J. Peel (2003). The Time Series Properties of Financial Ratios: Lev Revisited. *Journal of Business Finance and Accounting* 30(5): 699–714.

Kashyap, A.K., J.C. Stein, and S. Hanson (2010). An Analysis of the Impact of “Substantially Heightened” Capital Requirements on Large Financial Institutions. University of Chicago, Harvard University. Mimeo.

Khwaja, A.I., and A. Mian (2008). Tracing the Impact of Bank Liquidity Shocks: Evidence from an Emerging Market. *American Economic Review* 98(4): 1413–42.

Kishan, R.P., and T.P. Opiela (2000). Bank Size, Bank Capital, and the Bank Lending Channel. *Journal of Money, Credit, and Banking* 32(1): 121-141.

Larsson, R., J. Lyhagen, and M. Löthgren (2001). Likelihood-based cointegration tests in heterogeneous panel. *The Econometrics Journal* 4(1): 119-142.

Levin, A., C. Lin, and C. Chu (2002). Unit Root Tests in Panel Data: Asymptotic and Finite Sample Properties. *Journal of Econometrics* 108: 1-24.

Marcheggiano, G., D. Miles and J. Yang (2012). Optimal Bank Capital. *Economic Journal* (forthcoming)

Merkl, C., and S. Stolz (2009). Banks' regulatory buffers, liquidity networks and monetary policy transmission. *Applied Economics* 41(16): 2013-2024.

Miller, M.H. (1995). Do the M&M propositions apply to banks? *Journal of Banking and Finance* 19: 483-489.

Pedroni, P. (2000). Fully-Modified OLS for Heterogeneous Cointegrated Panels. *Advances in Econometrics* 15: 93-130.

Pedroni, P. (2007). Social Capital, Barriers to Production and Capital Shares; Implications for the Importance of Parameter Heterogeneity from a Nonstationary Panel Approach. *Journal of Applied Econometrics* 22: 429-51.

Pesaran, M.H. (2007). A simple panel unit root test in the presence of cross-section dependence. *Journal of Applied Econometrics* 22(2): 265-312.

Pesaran, M.H., and R. Smith (1995). Estimating long-run relationships from dynamic heterogenous panels. *Journal of Econometrics* 68: 79-113.

Pesaran, M.H., and Y. Shin (1996). Cointegration and speed of convergence to equilibrium. *Journal of Econometrics* 71(1-2): 117-143.

Phillips, P., and B. Hansen (1990). Statistical Inference in Instrumental Variables Regression with I(1) Processes. *Review of Economic Studies* 57: 99–125.

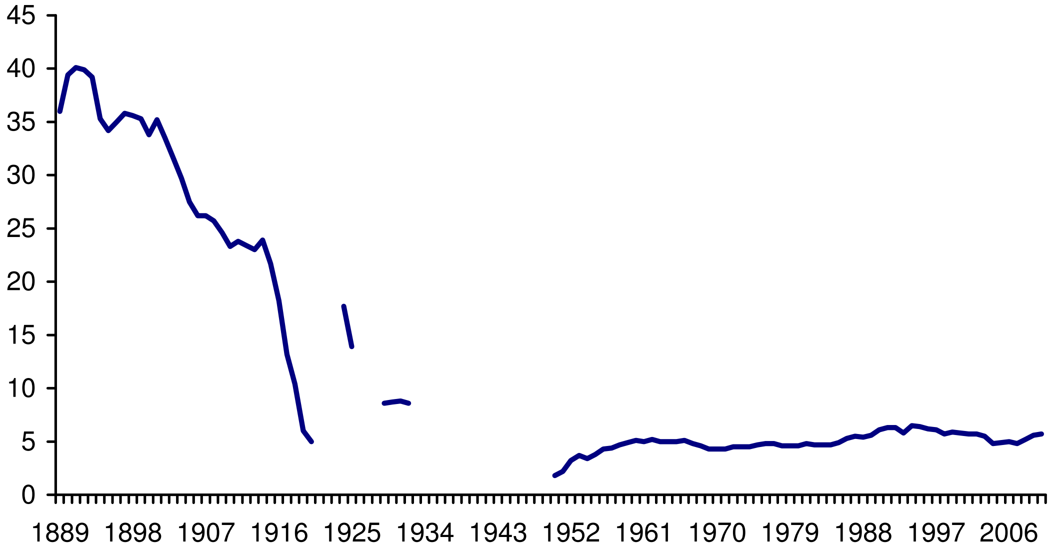
Van den Heuvel, S.J. (2007). The Welfare Cost of Bank Capital Requirements. The Wharton School. Mimeo.

Westerlund, J. (2007). Testing for Error Correction in Panel Data. *Oxford Bulletin of Economics and Statistics* 69(6): 709-747.

Whittington, G., and M. Tippett (2003). The Components of Accounting Ratios as Co-integrated Variables. *Journal of Business Finance and Accounting* 26(9) & (10): 1245–1273.

Figure 1: Capitalization of German Banks 1983-2010

This Figure shows the evolution of the (unweighted) capital-to-assets ratio of German banks. Data before 1950 are taken from Holtfrerich (1981), data after 1950 from the Bundesbank's time series database. Gaps and spikes in the data for the 1920s and 1930s come from the original statistics.

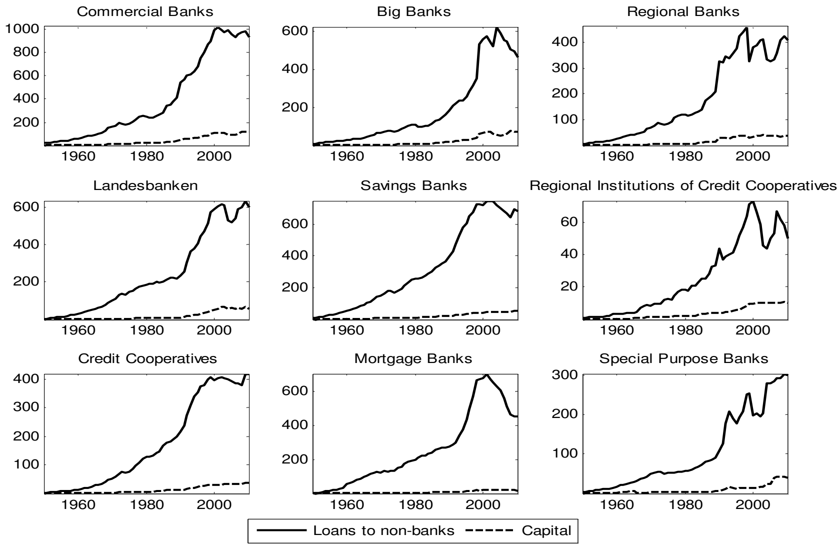


Sources: Holtfrerich (1981), time series database *Deutsche Bundesbank*, own calculations.

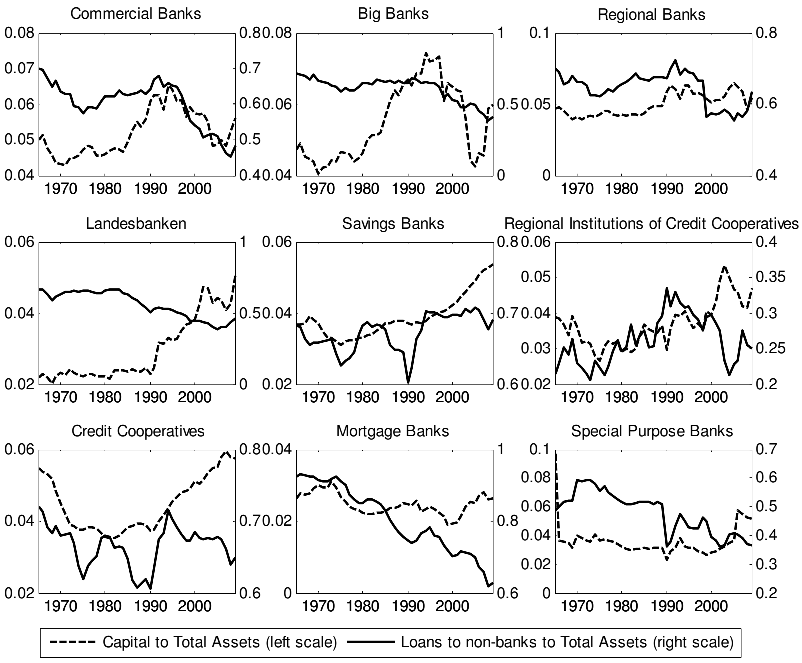
Figure 2: Capital-to-Assets and Loans-to-Assets Ratios of German Banks

Grossbanken = Large banks, *Regionalbanken* = small regional banks, *Sparkassen* = savings banks, *Kreditgenossenschaften* = cooperative banks, *Genossenschaftliche Zentralbanken* = cooperative central banks, *Realkreditinstitute* = public and private real estate banks, *Banken mit Sonderaufgaben* = special purpose banks.

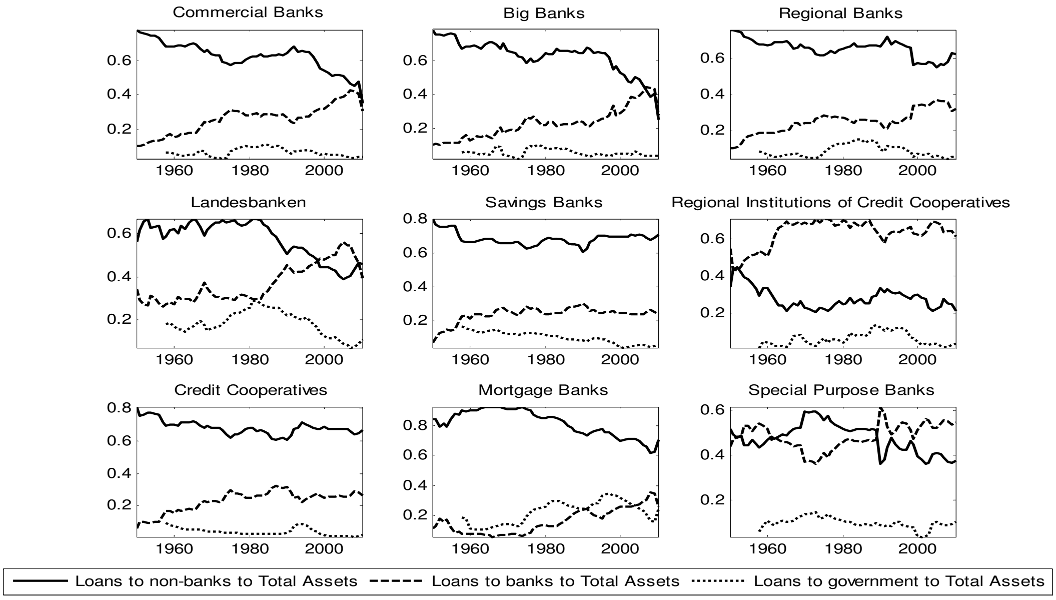
(a) Levels (Billion Real €)



(b) Ratios (% of Total Assets)



(c) Structure of Assets (% of Total Assets)



Sources: Time series database *Deutsche Bundesbank*, own calculations.

Figure 3: Long-Run Effect of Increasing the Capital-to-Asset Ratio

This figure is based on the estimates of the long-run cointegration vector presented in Column 3 of Table 3, and they give the change in log loans for an increase in bank capital that is compensated by a decline in deposit funding: $d\log L_t = \beta_1\, dC_t/C_t + \beta_2\, dD_t/D_t$. See the main text for details.

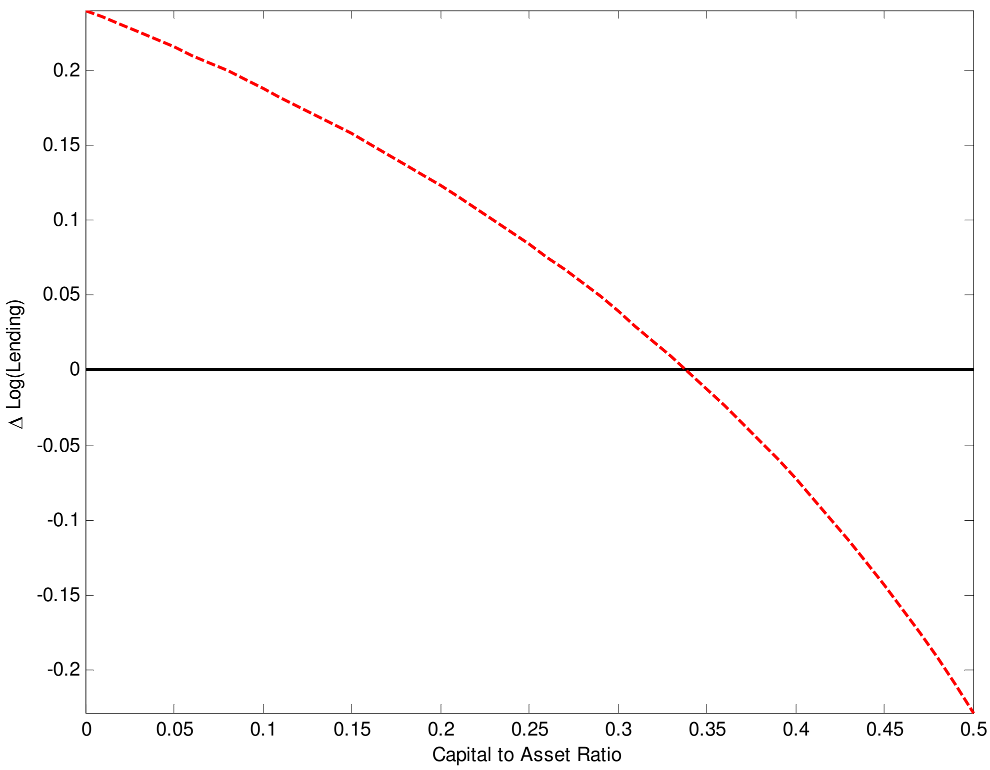


Figure 4: Persistence Profiles

This figure shows bootstrap median estimates persistence profiles together with one standard deviation bootstrap bounds. The persistence profiles have been calculated using the method proposed by Pesaran and Shin (1996). They show the effects of system-wide shocks on the error-correction mechanism and allow analyzing the speed of convergence to the steady state. The impact of the value of the persistence profile is normalized at unity, and the profile converges to zero if there is indeed a valid cointegration vector. The unit of the horizontal axis are years.

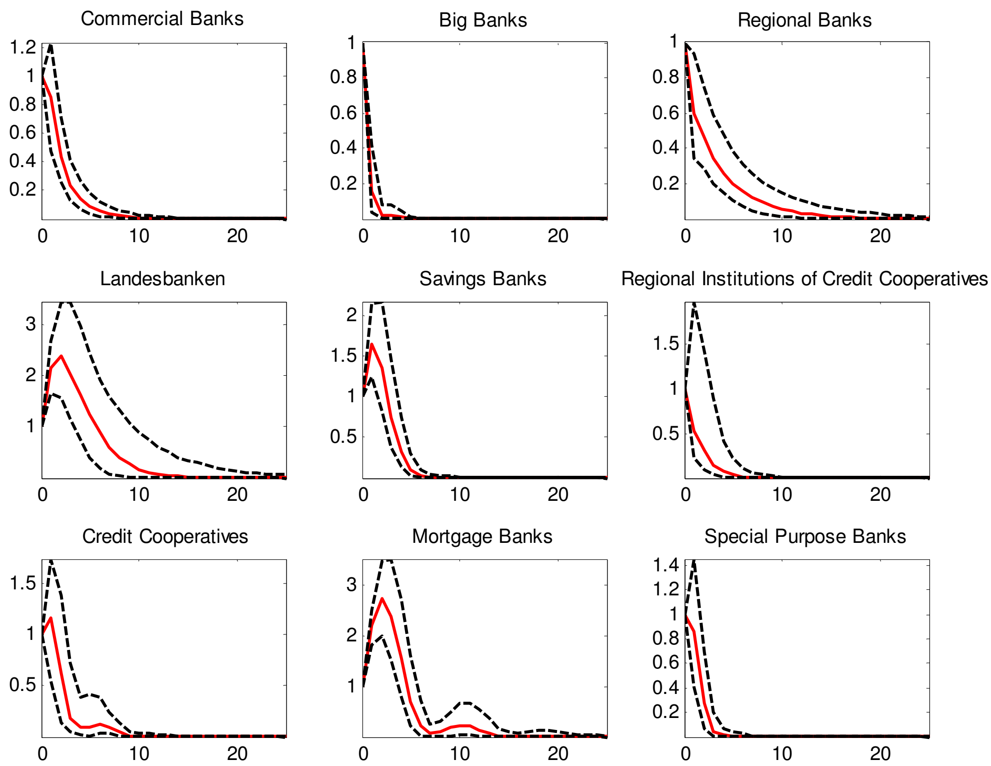


Table 1: Panel Unit Root Tests

This Table reports $\bar{t}$ statistics from the unit root test proposed by Pesaran (2007) accounting for cross-sectional dependence of the variables under study, i.e. the CPIS statistic. Business loans, capital, and deposits are in logs. The Null hypothesis is that the variable contains a unit root. *, **, *** = significant at the 10%, 5%, 1%-level.

(a) 1965-2009

	Constant and trend		No trend	
	CIPS-Statistic	*p*-value	*CIPS*-Statistic	*p*-value
Levels				
Business loans	-2.134	0.73	-2.001	0.26
Capital	-2.323	0.50	-2.181	0.12
Deposits	-1.995	0.86	-1.852	0.41
First differences				
Business loans	-4.954**	0.01	-4.957**	0.01
Capital	-5.456**	0.01	-5.520**	0.01
Deposits	-3.897**	0.01	-5.026**	0.01

(b) 1965-2006

	Constant and trend		No trend	
	CIPS-Statistic	*p*-value	*CIPS*-Statistic	*p*-value
Levels				
Business loans	-1.778	0.96	-1.429	0.84
Capital	-2.388	0.42	-1.949	0.31
Deposits	-1.614	0.99	-1.518	0.77
First differences				
Business loans	-5.055**	0.01	-4.919**	0.01
Capital	-5.469**	0.01	-5.425**	0.01
Deposits	-3.814**	0.01	-5.039**	0.01

Table 2: Banking-Group-Specific Unit Root Tests

This Table reports results from the unit root test proposed by Pesaran (2007) for each individual banking group in the panel. The test accounts for cross-sectional dependence. The Null hypothesis is that the variable contains a unit. The sample period is 1965-2009.

	Constant and trend		No trend	
	CIPS-Statistic	*p*-value	*CIPS*-Statistic	*p*-value
		Business loans		
Commercial banks	-2.95	0.23	-2.32	0.28
Big banks	-1.73	0.76	-1.96	0.42
Regional and other commercial banks	-1.22	0.91	-1.54	0.61
Landesbanken	-3.30	0.14	-3.35*	0.05
Savings banks	-1.58	0.81	-1.49	0.63
Regional institutions of credit cooperatives	-1.99	0.65	-1.34	0.69
Credit cooperatives	-1.13	0.92	-1.04	0.79
Mortgage banks	-2.43	0.45	-2.61	0.18
Special purpose banks	-2.88	0.25	-2.36	0.26
		Capital		
Commercial banks	-3.07	0.19	-2.74	0.15
Big banks	-3.46	0.10	-2.93	0.11
Regional and other commercial banks	-2.06	0.62	-2.02	0.39
Landesbanken	-1.32	0.89	-1.71	0.54
Savings banks	-2.65	0.35	-2.57	0.19
Regional institutions of credit cooperatives	-3.80*	0.06	-3.81**	0.02
Credit cooperatives	-0.80	0.96	-0.46	0.92
Mortgage banks	-2.33	0.50	-2.08	0.37
Special purpose banks	-1.41	0.86	-1.32	0.70
		Deposits		
Commercial banks	-1.70	0.77	-1.73	0.53
Big banks	-1.32	0.89	-1.39	0.67
Regional and other commercial banks	-2.40	0.46	-2.82	0.13
Landesbanken	-1.77	0.74	-1.80	0.49
Savings banks	-2.41	0.46	-2.33	0.27
Regional institutions of credit cooperatives	-2.28	0.52	-2.13	0.35
Credit cooperatives	-1.92	0.68	-1.78	0.50
Mortgage banks	-2.95	0.23	-1.54	0.61
Special purpose banks	-1.20	0.91	-1.16	0.76

Table 3: Error-Correction Estimates and Panel Cointegration Tests

These tables present estimates for the long-run cointegration parameters using the Two-Step estimator (Breitung 2005). The dependent variable is the level of business loans (in logs) in panel (a), the ratio of business loans to total assets in Panel (b), claims on the government in Panel (c), and loans to banks in Panel (d). The explanatory variable is the log of capital and deposits and the ratio of bank capital to assets, respectively. The columns present different specifications using specifications with and without a linear trend. Estimates in bold indicate significance at the 5% level. The results for the Two-Step Cointegration tests are based on the Gauss program *pan2step.prg* available on Jörg Breitung's homepage (http://www.ect.uni-bonn.de/mitarbeiter/joerg-breitung/two-step-estim-panel-data/index), which we translated to Matlab for our purpose. The panel cointegration statistics follow Westerlund (2007). The Null hypothesis is that the variables under study are not cointegrated. Breakpoint tests suggested by Bai and Perron (1998, 2003) have been applied in all models.

(a) Dependent Variable: Log Business Loans

	1965-2009				1965-2006			
	(1)		(2)		(3)		(4)	
Log capital	**0.22**		**0.33**		**0.24**		**0.21**	
t-statistic	*7.40*		*5.20*		*4.15*		*1.98*	
p-value	*0.00*		*0.00*		*0.00*		*0.05*	
Log deposits	**0.61**		**0.57**		**0.47**		**0.46**	
t-statistic	*20.53*		*9.02*		*7.66*		*5.02*	
p-value	*0.00*		*0.00*		*0.00*		*0.00*	
Westerlund Cointegration Tests								
	Value	*p*-value	Value	*p*-value	Value	*p*-value	Value	*p*-value
G_t	**-2.60**	0.03	-3.02	0.04	-2.23	0.27	-2.76	0.21
G_a	**-16.56**	0.00	**-20.09**	0.00	**-14.16**	0.01	-15.20	0.26
P_t	-6.43	0.11	-6.33	0.72	**-6.64**	0.07	-6.56	0.63
P_a	**-11.39**	0.00	-10.54	0.49	**-12.67**	0.00	**-14.17**	0.05
Constant	yes		yes		yes		yes	
Trend	no		yes		no		yes	
Breakpoint tests	yes		yes		yes		yes	

(b) Dependent Variable: Claims on Government (1965-2009)

	Log claims on the government			
	(1)		(2)	
Log capital	0.03		**0.29**	
t-statistic	*0.31*		*1.72*	
p-value	*0.76*		*0.09*	
Log deposits	**0.39**		**0.33**	
t-statistic	*4.11*		*1.94*	
p-value	*0.00*		*0.05*	
Westerlund Cointegration Tests				
	Value	*p*-value	Value	*p*-value
G_t	**-2.57**	0.04	-2.35	0.74
G_a	**-13.68**	0.02	-12.33	0.70
P_t	**-8.11**	0.00	-7.18	0.37
P_a	**-10.67**	0.01	-10.00	0.59
Constant	yes		yes	
Trend	no		yes	
Breakpoint tests	yes		yes	

(d) Dependent Variable: Loans to Banks (1965-2009)

	Log loans to banks			
	(1)		(2)	
Log capital	**0.20**		-0.09	
t-statistic	*2.49*		*-0.99*	
p-value	*0.01*		*0.32*	
Log deposits	**0.55**		**0.29**	
t-statistic	*7.10*		*2.89*	
p-value	*0.00*		*0.00*	
Westerlund Cointegration Tests				
	Value	*p*-value	Value	*p*-value
G_t	**-2.62**	0.03	-2.51	0.53
G_a	**-17.04**	0.00	-15.03	0.28
P_t	**-8.78**	0.00	**-9.04**	0.01
P_a	**-13.49**	0.00	**-14.19**	0.05
Constant	yes		yes	
Trend	no		yes	
Breakpoint tests	yes		yes	