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Which banks are more risky? The impact of loan growth and business model on bank risk-taking

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Abstract

In this paper, we analyze the impact of loan growth and business model on bank risk in 15 EU countries. In contrast to the literature, we include a large number of unlisted banks in our sample which represent the majority of banks in the EU. We show that banks with high rates of loan growth are more risky. Moreover, we find that banks will become more stable if they increase their non-interest income share due to a better diversification of income sources. The effect, however, decreases with bank size possibly because large banks are more active in volatile trading and off-balance sheet activities such as securitization that allow them to increase their leverage. Our results further indicate that banks become more risky if aggregate credit growth is excessive. This even affects those banks that do not exhibit high rates of individual loan growth compared to their competitors. Overall, our results indicate that differences in the lending activities and business models of banks help to identify risks, which would only materialize in the long-term or in the event of a shock.

JEL-Classification: G20, G21, G 28

Keywords: Banks, risk-taking, business model, loan growth

Non-technical Summary

In this paper, we analyze the impact of lending growth and business model on bank risk in 15 EU countries. In contrast to the literature on this issue which mainly focuses on large and listed banks, we include a large number of smaller unlisted banks in our sample which represent the majority of banks in the EU. We think that this is important for the broader applicability of the results. We also think that our sample should better allow us to identify the effects of loan growth and banks' business models on bank risk, since unlisted differ markedly in their lending behavior and business model from listed banks.

Controlling for endogeneity, bank-, year- and country-specific effects we find that it is important to enlarge the number of banks and bank types to come to general conclusions about the effect of banks' business model on risk-taking in the EU banking sector. While the previous studies suggest that it may be beneficial for banks to reduce their share of non-interest income, our results indicate the opposite. This finding is consistent with the common view that European banks are better able to exploit the diversification potential of fee-based activities due to their experience with universal banking models than US banks. The diversification effect of a higher share on non-interest income, however, decreases with bank size possibly because larger banks are more likely to be active in volatile and risky trading and off-balance sheet activities such as securitization that allows them to employ a higher financial leverage than small banks.

Finally, our paper indicates that supervisors should carefully monitor loan growth on the individual level, since high rates of loan growth are associated with of bank risk-taking. Moreover, they should be aware of the development of aggregate credit growth, since our results show that banks reduce their lending standards and become more risky during periods of excessive lending growth at the country level. This even affects those banks that do not exhibit high rates of individual loan growth compared to their competitors. With respect to aggregate credit growth our paper, therefore, provides support for the introduction of countercyclical capital buffers which should reduce credit growth and the build-up of systemic risk during booms.

Nichttechnische Zusammenfassung

In der vorliegenden Arbeit untersuchen wir den Einfluss von Kreditwachstum und Geschäftsmodell auf das Risiko von Banken in 15 EU-Staaten. Im Gegensatz zur bestehenden Literatur zu diesem Thema konzentrieren wir uns nicht nur auf große, börsennotierte Banken, sondern beziehen auch eine Vielzahl kleinerer Banken, die nicht an der Börse notiert sind, in unsere Analyse ein. Da diese Institute die Mehrheit der Banken in Europa repräsentieren, ermöglicht unsere Arbeit allgemeinere Aussagen zum Einfluss des Geschäftsmodells auf das Risiko, das eine Bank eingeht.

Während die bisherigen Studien für börsennotierte Banken darauf hindeuten, dass Banken weniger Risiken eingehen, wenn sie ihren Anteil des Nichtzinseinkommens am gesamten operativen Einkommen reduzieren, deuten unsere Ergebnisse auf das Gegenteil hin. Sie stimmen mit der allgemeinen Einschätzung überein, dass europäische Banken die Diversifikationsvorteile, die die Expansion ins Nichtzinsgeschäft bieten, auf Grund ihrer Erfahrungen mit Universalbankenmodellen besser ausnutzen können als US-amerikanische Banken. Der Diversifikationseffekt nimmt jedoch mit zunehmender Größe des Kreditinstituts ab. Ein Grund hierfür könnte sein, dass große Banken stärker im volatilen und riskanten Eigenhandel tätig sind und außerbilanzielle Geschäfte wie Verbriefungen durchführen, die es ihnen erlauben, ihren finanziellen Hebel zu erhöhen.

Darüber hinaus zeigen unserer Ergebnisse, dass Bankaufseher das Kreditwachstum von Banken intensiv beobachten sollten, da Banken mit einem hohen Kreditwachstum riskanter sind. Außerdem sollten Aufseher auch die Entwicklung des aggregierten Kreditwachstums im Auge behalten, da die Ergebnisse unserer Studie darauf hindeuten, dass Banken während Phasen exzessiven Kreditwachstums riskanter werden. Das betrifft auch die Banken, die niedrige Kreditwachstumsraten im Vergleich zu ihren Wettbewerbern aufweisen. Insgesamt stützen unsere Ergebnisse somit die Einführung antizyklischer Kapitalpuffer, die das Kreditwachstum und den Aufbau systemischer Risiken in Aufschwungphasen reduzieren sollen.

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Which banks are more risky? The impact of loan growth and business model on bank risk-taking[1]

1. Introduction

The financial crisis of 2007/2008 has led to significant losses of banks. However, not all banks were affected equally. In particular, large-complex banking groups with a focus on investment banking recorded large losses (ECB, 2010). Due to their systemic importance their risk-taking behavior has been analyzed frequently in the literature (e.g. Altunbas et al., 2011, Beltratti and Stulz, 2012, Demirgüc-Kunt and Huizinga, 2010 and Laeven and Levine, 2009).

Banks with a more traditional banking model, however, suffered large losses as well. In particular, banks with high rates of loan growth reported a significant drop in their performance during the crisis as indicated Figure 1. For example, while the return-on-equity (ROE) of EU banks with the highest average rate of loan growth between 2003 and 2006 decreased, on average, from 13.34% in 2006 to 6.77% in 2008, the ROE of banks with the lowest loan growth rates declined less steeply from 10.46% to 5.65%. Interestingly, while the profitability of the first group of banks dropped further in 2009, the ROE of banks with the lowest rates of loan growth increased. Furthermore, for the first time since 2002 the ROE of banks with the lowest rates of loan growth was higher than the ROE of banks with the highest rates of lending growth.

If we consider the drop-off in performance during the crisis as indicator of risk-taking, banks with high loan growth rates seem to have incurred greater risks than banks with low rates of loan growth. In the pre-crisis period, this resulted in a higher profitability of these banks, but in a large decrease in profits in 2008. The further decline in bank profitability in 2009 suggests that not all of these risks materialized in 2008, but also in 2009 due to the economic downturn that followed. Since economic growth is still weak and unemployment high, many banks with previously high rates of loan growth continue to report low profitability up to day. Due to pressure from investors and regulators these banks are among those that have to deleverage and change their business model most. Banks with high non-interest income also have to rethink their business model, since non-interest income is highly volatile and led to large losses during the crisis (Liikanen, 2012). This may particularly concern large banks with

[1] Deutsche Bundesbank, Wilhelm-Epstein-Straße 14, 60431 Frankfurt am Main, Germany. E-Mail: matthias.koehler@bundesbank.de. The author would like to thank Tobias Michalak, Nora Srzentic, Christoph Memmel, Heinz Herrmann and the participants at the Bundesbank seminar and the Conference on the "Stability of the European Financial System and the Real Economy in the Shadow of the Crisis" in Dresden for helpful comments and suggestions. The paper represents the author's personal opinions and does not necessarily reflect the views of the Deutsche Bundesbank or its staff.

substantial trading activities (Liikanen, 2012). Smaller banks with a large share of interest income, in contrast, may benefit from higher non-interest income as it may help them to diversify their income sources which should make them less dependent on overall business conditions and more stable.

In this paper, we analyze the impact of loan growth and business model on bank risk in 15 EU countries. In contrast to the previous literature that analyzes the impact of bank's business model on risk-taking based on a sample of listed banks, we include a large number of unlisted institutions which represent the majority of banks in the EU. Our results indicate considerable heterogeneity in risk-taking across banks and countries. We show that banks with high rates of loan growth are more risky. We further find evidence that banks will become more stable if they increase their non-interest income share due to a better diversification of income sources. The effect, however, decreases with bank size. This indicates that it is important to enlarge the sample of banks to come to general conclusions about the effect of banks' business model on risk. Our results further show that banks become more risky if aggregate credit growth is excessive. This even affects those banks that do not exhibit high rates of individual loan growth compared to their competitors. Overall, our results indicate that differences in the lending activities and the business models of banks help to identify risks, which would only materialize in the long-term or in the event of a shock.

While the literature consistently finds that excessive rates of loan growth lead to greater risk-taking (see e.g. Foos et al., 2010 and Jimenez and Saurina, 2007), there is less consensus among academics about the impact of a bank's business mix on bank risk. For example, while some argue that an increase in non-interest activities such as investment banking provides banks with additional sources of revenue and can therefore provide a diversification in their overall income which should make them more stable, others argue that banks may also become less stable if they diversify into non-lending activities due to the higher volatility of non-interest income.[2] Evidence from the recent crisis provides support for the latter hypothesis.

Altunbas et al. (2011), for example, show that banks with high non-interest income are more risky. Larger banks and those with more aggressive loan growth are less stable as well, while banks with less risk-taking are characterized by a strong deposit base. Demirgüc-Kunt and Huizinga (2010) obtain similar results. They show that banks with a high level of fee and trading income are more risky. Banks that heavily rely on wholesale funding are more risky as well, while Demirgüc-Kunt and Huizinga (2010) find no evidence that high rates of asset growth result into greater risk-taking. Common to both studies is that the impact of a bank's business model on risk is analyzed for a sample of listed banks which are usually larger and more active in non-lending activities than banks not listed such as savings and cooperative banks.

[2] Saunders and Walter, (1994), De Young and Roland (2001) and Stiroh (2004) provide detailed literature reviews. For Germany, Busch and Kick (2009) show that the volatility of commercial banks' returns significantly increases if they are involved in fee business. There is, however, no evidence that the returns of German savings and cooperative banks become more volatile.

We contribute to these papers in three important ways. First of all, in addition to listed banks our dataset includes a large number of unlisted banks. This should give a more representative picture about the European banking sector as unlisted banks represent the majority of banks in the EU. We think this is important for the broader applicability of the results. We also think that our sample should better allow us to identify the effects of loan growth and banks' business models on the level of risk-taking, since unlisted banks are usually smaller and have a more traditional business model with a greater focus on lending activities than listed banks. Including unlisted banks also enlarges the number of bank types, since savings and cooperative banks are usually not listed. For example, among the unlisted banks in our sample more than 70% are savings and cooperative banks. The latter do not only have different business models, but also differ in terms of their business objective and ownership structure from commercial banks (Hesse and Cihak, 2007 and Beck et al., 2009).

Second, estimations on the determinants of bank risk are impeded by the problem of endogeneity between the variables used to describe a bank's business model and bank risk. We solve this problem by choosing an econometric approach that instruments endogenous variables with their own lags. Furthermore, we allow the risk-taking behavior of banks to be dynamic as bank risk may be persistent over time due to inter-temporal risk smoothing, competition, banking regulations or relationship banking with risky customers (Delis and Kourtas, 2011).

Third, even though there are several theoretical papers that show that banks lower their lending standards and collateral requirements during booms (Ruckes, 2004 and Dell Ariccia and Marquez, 2006), the empirical evidence on the impact of lending booms on individual bank risk-taking is limited. Using two different indicators to characterize periods of excessive lending growth, we analyze whether high rates of aggregate credit growth led to an increase in individual bank risk.

We follow Altunbas et al. (2011) and Demirgüc-Kunt and Huizinga (2010) and measure bank risk-taking using the Z-Score, defined as the number of standard deviations that a bank's return on asset has to fall for the bank to become insolvent.[3] Our sample shows considerable heterogeneity in risk-taking across banks and countries. We explain this by differences in loan growth and the business model of banks as well as the development of aggregate credit growth.

Our results show that loan growth is an important determinant of bank risk. We find evidence that banks with high rates of loan growth are more risky. This may indicate that banks lower their lending standards and collateral requirements to increase loan growth. Furthermore, banks that exhibit significantly higher rates of loan growth than their competitors may attract customers which have not been given a loan by other banks because they asked for too low loan rates or provided not sufficient collateral relative to their credit quality (Foos et al., 2010).

[3] Other studies that use the Z-Score to measure bank risk-taking are Laeven and Levine (2009) and Foos et al. (2010).

Banks' business mix also matters. In contrast to Altunbas et al. (2011) and Demirgüc-Kunt and Huizinga (2010), we show that banks become more stable if they generate a larger fraction of their income from non-interest activities.[4] This effect depends on bank size, however. While smaller banks benefit from the income diversifying effects of a higher non-interest income share, we find the opposite for large banks. We think that this reflects the different sets of non-interest income activities of small and large banks. While large banks are more active in volatile trading activities, smaller banks usually derive a higher share of their income from provisions which are more stable and often linked to interest income due to cross-selling activities (see also Stiroh, 2004). Larger banks may also be more likely to engage in more risky off-balance sheet activities such as securitization which allows them to employ a higher financial leverage than small banks. This is also reflected by our sample which shows a strong negative relationship between bank size, non-interest income share and a bank's capital ratio. Together this may offset the positive effect of a higher non-interest income share and a larger size on bank stability and may ultimately result in greater risk-taking by large credit institutions.

Furthermore and in contrast to Altunbas et al. (2011) and Demirgüc-Kunt and Huizinga (2010), we find no evidence that banks that rely on wholesale funding are more risky than banks that primarily fund their activities by customer deposits. The latter are usually considered as a more stable source of funding (Song and Thakor, 2007 and Shleifer and Vishny, 2010). We think that our results are driven by the large number of unlisted banks included in our sample which primarily fund their loans by customer deposits as indicated by relatively low average loan-to-deposit ratios. Moreover, we have no investment banks included. Hence, the risks stemming from the excessive reliance on wholesale funding as, for example, described by Huang and Ratnovksi (2008) should be significantly lower for most of the banks included in our sample. Altunbas et al. (2011) and Demirgüc-Kunt and Huizinga (2010), in contrast, focus on large and listed banks that primarily depend on wholesale funding.

Bank risk also significantly differs across countries. We find evidence that aggregate credit growth is an important determinant of bank risk at the country level. This is consistent with the literature that shows that banks reduce their lending standards and collateral requirements during booms due to improved borrows' income prospects, rising collateral values (Ruckes, 2004) and a reduction in information asymmetries (Dell'Arrica and Marquez, 2006). In contrast to idiosyncratic risk that arises if single institutions reduce their lending standards, a general reduction of lending standards leads to the build-up of systemic risk in the banking sector that once it materializes affects all banks. Taking into account GDP growth, the level of interest rates as well as the size and the level of competition in the banking sector do not change our results.

[4] Non-interest income includes activities such as income from trading and securitization, investment banking and advisory fees, brokerage commissions, venture capital, and fiduciary income, and gains on non-hedging derivatives.

Our findings are robust to bank-specific effects that control for differences in corporate governance mechanisms (Laeven and Levine, 2009 and Beltratti and Stulz, 2012) and managerial performance (Altunbas et al, 2011) across banks. In addition, we include country-fixed effects to control for differences in banking regulations and other time-invariant characteristics across countries that may have an impact on bank risk (Laeven and Levine, 2009 and Beltratti and Stulz, 2012).

Our paper has several important implications. First, our results suggest that supervisors should carefully monitor loan growth on the individual and aggregate level, since high rates of lending growth are associated with greater risk-taking. Second, non-interest income helps banks to diversify their income sources and to generate higher returns. This effect depends on bank size, however. While smaller banks should become more stable, we find evidence that larger banks may become less stable if they increase their share of non-interest income possibly because they are more active in volatile trading activities and off-balance sheet activities such as securitization that allow them to increase their leverage. Overall, our results suggest that the results of previous studies should not be generalized for all banks. Our results further indicate that it is important for supervisors not only to look at bank capital and loan growth, but also to understand banks' business models, since this should help them to identify risks, which would only materialize in the long-term or in the event of a shock. Finally, our results show that supervisors should be aware of the development of aggregate credit growth as bank stability significantly decreases if aggregate lending growth is excessive. This even affects those banks that do not exhibit high rates of individual loan growth compared to their competitors.

The paper is structured as follows. In the next section, we present the dataset. In Section 3, we take a first look at the development of bank risk-taking across time and show that bank risk significantly differs across bank types and business models. In addition, we relate bank risk to the development of aggregate credit growth. The empirical model is presented in Section 4 and the results in Section 5. In Section 6, we analyze whether the effect of a bank's business mix differs according to bank size and *vice versa*. Alternative indicators of bank risk are considered in Section 7. Section 8 summarizes our main findings and concludes.

2. Data

We use bank balance sheet data from Bankscope (2011). The panel includes commercial banks, cooperative banks and savings banks in 15 EU countries. We do not include bank holding companies, investment banks and non-bank credit institutions, since our focus is on banks with lending activities. The original database includes 23,699 observations for the period between 2002 and 2009. We include 2009, since not all of the risks banks incurred in the pre-crisis period might have materialized in 2008, but also in 2009. We drop all banks that do not report balance sheet data between 2003 and 2006 to assure that we have a sufficient number of observations to analyze bank risk-taking in the pre-crisis period and also include those banks that became insolvent during the crisis. This leaves us with 19,231 observations

and 2,966 banks. The distribution of observations and banks across countries is reported in Table 1. In terms of assets, our sample covers almost 90% of the commercial, savings and cooperative banks' assets in the EU 15.

In contrast to the literature which usually examines listed banks (e. g. Altunbas et al., 2011 and Demirgüc-Kunt and Huizinga, 2010, Laeven and Levine, 2009), we include unlisted banks. This is important as unlisted banks represent the majority of banks in the EU. For example, among the banks included in our sample more than 95% are not listed. We think this is important for the broader applicability of the results. We also think that our sample should better allows us to identify the effects of loan growth and banks' business models on the level of risk-taking, since unlisted banks are usually smaller and have a different business model than listed banks as we will show later. Due to their focus on lending activities they are primarily exposed to credit risk. Listed banks, in contrast, are usually larger and more active in non-lending activities. Focusing on listed banks may, hence, underestimate the risk banks incur through their lending activities and overstate the risk of non-lending activities. Furthermore, larger banks benefit from sophisticated risk management systems that may mitigate adverse effects from loan growth on bank stability (Laeven and Majnoni, 2003 and Foos et al., 2010).

Including unlisted banks also enlarges the number of bank types, since savings and cooperative banks are usually not listed. For example, among the unlisted banks in our sample more than 70% are savings and cooperative banks. The latter do not only have different business models than commercial banks, but also differ in terms of their business objective and ownership structure from commercial banks (Hesse and Cihak, 2007 and Beck et al., 2009). While the latter are owned by their shareholders and aim at maximizing profits, savings and cooperative banks are owned by their stakeholders and primarily created to provide financial services to specific sectors or to improve financial access in selected geographical areas. This suggests that cooperative and savings banks have a different risk-taking behavior than commercial banks.

3. Bank Risk Taking

We follow the literature and measure bank risk using the Z-Score (see e. g. Boyd and De Nicolo, 2005). The Z-Score has frequently been used to analyze the determinants of bank risk-taking in the pre-crisis period (Laeven and Levine, 2009, Foos et al., 2009, Altunbas et al., 2011 and Demirgüc-Kunt and Huizinga, 2010). It is defined as the ratio of the return on assets plus the capital ratio divided by the standard deviation of the return on assets over the period between 2003 to 2009:[5]

$$Z - Score_{it} = \frac{ROA_{it} + CAR_{it}}{SDROA_i} \quad (1)$$

[5] Like all other bank variables, the capital-asset ratio (CAR) and the return-on-asset (ROA) are winsorized at the 1%- and 99%-level to eliminate outliers.

where ROA is the return on assets and CAR the ratio of total equity over total assets of bank *i* in year *t*. $SDROA$ is each bank's standard deviation of the ROA. It is calculated over the whole sample period. The Z-Score is the inverse of the probability of insolvency, i. e. a higher Z-Score indicates that a bank incurs fewer risks and is more stable. More specifically, it indicates the number of standard deviations below the expected value of a bank's return on assets at which equity is depleted and the bank is insolvent (Boyd et al., 1993). Because the Z-Score is highly skewed, we use the natural logarithm of the Z-Score in our empirical analysis.[6]

Table 2 shows descriptive statistics for the Z-Score and its components. The average Z-Score over all banks is 36.26. The mean values significantly differ across bank types. For example, while unlisted have an average Z-Score of 36.66, listed banks report a significantly lower mean Z-Score of 26.74. This indicates that listed banks are less stable than banks not listed. Risk-taking also significantly differs between commercial banks, savings banks and cooperative banks. Comparing their average Z-Score, we find that cooperative banks (41.99) have the highest Z-Score, followed by savings banks (37.15) and commercial banks (24.75). This suggests that commercial banks are significantly more risky than savings and cooperative banks. Differences in the Z-Score across bank types are primarily driven by a lower volatility of returns (SDROA) rather than by differences in the level of capitalization (CAR) and profitability (ROA) across bank types.[7] For instance, even though unlisted banks have a lower average level of capitalization and profitability than listed banks, they are significantly more stable than the latter group of banks due to a lower standard deviation of returns (SDROA).

Bank risk may not only be related to bank type. It may also differ due to differences in the lending behavior of banks. This is reflected in Figure 2 which shows the development of the average Z-Score of the banks in the bottom and top quartile of the distribution of average loan growth between 2003 and 2006. While the banks with the lowest rates of loan growth became, on average, more stable, banks with the highest rates of loan growth became less stable. This suggests that the banks with the highest rates of loan growth increased their profitability in the pre-crisis period by incurring greater risks (see Figure 1). Overall, there is considerably heterogeneity in risk-taking across banks and bank types. Hence, it is important to enlarge the set of banks analyzed to better identify the effects of loan growth and business models on the level of bank risk.

[6] As alternative indicators of bank risk, we later also consider the two components of the Z-Score which measure banks' exposure to portfolio and leverage risk. We do not use loan loss provisions or non-performing loans to measure bank risk, since they are traditionally backward looking and highly procyclical (Laeven and Majnoni, 2003 and Bikker and Metzemakers, 2005). Furthermore, loan loss provisions only measure credit risk, while the Z-Score is an overall measure of bank risk capturing not only credit, but also liquidity and market risk that primarily arises from non-lending activities.

[7] Please note that in Germany the standard deviation of returns might be low due to the use of hidden reserves which are allowed to be buildt by banks according to section 340f of the German Banking Code ("340f reserves") to smooth profits over time (also see Bornemann et al., 2012).

3a. Bank Characteristics

We now turn the variables used in the regression analysis to characterize banks' lending activity and business model. The latter is described on the asset side according to banks' business mix and on the liability side based on banks' funding structure. More specifically, we use the following variables:

(1) Lending Activity

To measure banks lending activity, we include a bank's abnormal loan growth rate (LOANGR) which is defined similarly to Foos et al. (2010) as the difference between a bank's loan growth rate and the median loan growth rate of all banks from the same country and year.[8] LOANGR compares a bank's loan growth rate with those of the other banks in our sample. This takes account of the fact that high rates of loan growth not necessarily reflect excessive risk-taking if all other banks have similarly high growth rates. If banks raise lending by lowering their lending standards, relaxing collateral requirements or a combination of both, higher rates of loan growth are associated with greater risk (Foos et al., 2010). Furthermore, banks which exhibit significantly higher loan growth rates than their competitors may attract customers which have not been given a loan by other banks because they asked for too low loan rates or provided not sufficient collateral relative to their credit quality (Foos et al., 2010). Loan growth is clearly endogenous, since banks may decide to reduce lending if risk is high.

(2) Business Mix

Our main indicator of a bank's business mix is the share of non-interest income to total income (NNINC) as bank's income streams best reflects its business strategy. The effect of non-interest income on bank risk is not clear a *priori*. On the one hand, a higher share of non-interest income should make banks less dependent on interest income and improve risk diversification. This should make them more stable (Boyd et al., 1980). On the other hand, a large share of non-interest income may destabilize banks, since it is usually more volatile than interest income, because it is more difficult for borrowers to switch their lending relationship due to information costs (DeYoung and Roland, 2001). Earnings volatility may also increase due to greater operational leverage, since expanding into non-interest income may imply a rise in fixed costs (DeYoung and Roland, 2001). Furthermore, because regulators require banks to hold less capital against non-interest income activities, financial leverage may be larger which may raise earnings volatility further (DeYoung and Roland, 2001). This suggests that banks with a high non-interest income share may also be less stable than banks that mainly supply loans.

[8] We obtain similar results when we use the deviation from the average loan growth rate of all banks from the same country and year as suggested by Altunbas et al. (2011). Since the mean is sensitive to outliers, we choose to report the results with the difference from the median.

In addition to NNINC, we use the ratio of loans to total bank assets (LOANS) as alternative indicator of banks' business mix. Banks with a higher share of customer loans to total assets are more active in lending. These banks should have a smaller portfolio of securitized assets that turned out to be risky during the crisis. However, banks with a larger portfolio of loans may also be more risky, since banks specializing in granting customer loans are more exposed to credit risk (Maudos and de Guevara, 2004). Hence, the effect of LOANS is not clear either. Since banks may adjust their business mix to the level of bank risk, LOANS and NNINC are endogenous as well.

(3) Funding Structure

Banks' business models may not only differ on the asset side in terms of their business mix, but also on the liability side in terms of their funding structure. Hence, we include the ratio of customer loans to customer deposits (LOANDEP) as additional control variable. A higher ratio suggests that banks are more dependent on wholesale funding to finance their loans. Huang and Ratnovski (2008) argue that wholesale funding may reduce risk-taking through a better monitoring of banks by sophisticated financiers. Furthermore, banks with a higher share of wholesale funds are less dependent from deposit funding which should improve the diversification of funding sources and make banks more stable. However, they also show that the latter have the incentive to prematurely withdraw their funds based on a noisy public signal on bank quality forcing it to inefficiently liquidate assets. Deposit funding, in contrast, is more stable, since customer deposits are usually protected by deposit insurance (Shleifer and Vishny, 2010) and held for liquidity services (Song and Thakor, 2007). LOANDEP is endogenous, since banks may reduce their reliance on wholesale funding if the level of bank risk is high.

In addition to the variables outlined above, we include additional control variables such as the ratio of liquid assets to total assets (LIQUID) to measure bank liquidity, the logarithm of bank assets (SIZE) to control for bank size and the net interest margin (NIM) to measure bank profitability. Since endogeneity can neither be excluded for these variables nor for the main variables of interest, we instrument them in the subsequent empirical section with their own lags. To eliminate outliers, all bank variables are winsorized at the 1%- and 99%-level.

3b. Comparison of Bank Characteristics for Different Bank Types

In this section, we compare the business model of different bank types in our sample. Table 3 shows considerable heterogeneity among bank types. First, listed banks and commercial banks are larger than unlisted banks, savings and cooperative banks. Savings banks and cooperative banks also differ in their business mix from commercial banks. While the latter are more active in non-lending activities, savings and cooperative banks mainly focus on lending. For example, while the latter report a loan-to-asset ratio (LOANS) of more than 60%, the share of customer loans in total bank assets is significantly smaller for commercial banks (less than 50%). The importance of lending activities for savings and cooperative banks is

even higher if we consider the share of net non-interest income to total income (NNINC) which is 26% for savings and cooperative banks compared to 41% for commercial banks. Listed banks report a significantly higher proportion of non-interest income than unlisted banks as well.

Savings banks and commercial banks also differ with respect to their funding structure from commercial banks. While the latter use wholesale funds to finance their loans, savings and cooperative banks primarily use customer deposits as source of funding as indicated by the significantly higher ratio of loans to deposits (LOANDEP) for commercial banks. Interestingly, savings banks report a loan-to-deposit ratio of less than one indicating that they do not channel through all funds from depositors to borrowers. Listed banks also show a greater dependence on wholesale funds than banks not listed. Overall, however, the average loan-to-deposit ratio is relatively small for all types of banks in our sample. This is because we have no bank holding companies, investment banks and non-bank credit institutions included in our sample.

Commercial banks are also more liquid than savings and commercial banks as indicated by the significantly higher share of liquid assets to total assets (LIQUID). Since they are more dependent on wholesale funds, commercial banks might hold a large stock of liquid assets as buffer against liquidity shocks. Savings and cooperative banks, in contrast, primarily fund their loans by customer deposits which are usually stickier and premature deposit withdrawals unlikely.[9] Finally, we see that commercial banks report significantly higher rates of abnormal loan growth (LOANGR) than savings and cooperative banks. This suggests that commercial banks incur greater credit risks than the latter. This does not seem to translate into a higher net interest margin (NIM), however. In contrast, while commercial banks report an average net interest margin of 2.22%, savings and cooperative banks have a net interest margin that is, on average, 2.61% and 2.82%, respectively. Interestingly, net interest margins and customer loan growth rates do not significantly differ between listed and unlisted banks.

Overall, the descriptive analysis indicates that there are important differences in lending activity and business models across bank types. For this reason, it is important not only to look at listed banks, but also to consider other types of banks in order to identify the effects of loan growth and banks' business models on the level of risk-taking in the EU banking sector.

3c. Country Characteristics

We will now turn to the variables that may explain differences in bank risk across countries. Dell'Arrica et al. (2012) note that an important determinant for the stability of banks at the country level is the development of aggregate credit, since excessive credit growth is a good predictor of a financial crisis (Borio and Lowe, 2002, Borio and Drehmann, 2009 and Drehmann et al., 2010 and Mendoza and Terrones, 2008). Risk-taking is particularly high during lending booms, since banks typically lower their lending standards and collateral re-

[9] Liquid assets are trading assets and loans and advances with a maturity of less than three months (Bankscope, 2011).

quirements during this phase of the financial cycle.[10] In contrast to idiosyncratic risk that arises if single institutions reduce their lending standards, a general reduction of bank lending standards leads to the build-up of systemic risk in the banking sector that once it materializes affects all banks.

Reasons for the loosening of lending standards during lending booms are a general reduction in banks' risk perception and increased risk tolerance of banks due to improved borrowers' income prospects, rising collateral values (Ruckes, 2004) and a reduction in information asymmetries that lower adverse selection costs (Dell'Arrica and Marquez, 2006).[11] This leads to an increase in bank risk if lending standards decline more than justified by economic fundamentals as, for example, shown by Dell'Arrica et al. (2008) and Jimenez and Saurina (2006). Together with ample liquidity and a larger demand for loans during booms this leads to an increase in aggregate credit growth that is more than commensurate to the increase in demand as typically indicated by high rates of credit-to-GDP growth (Borio and Lowe, 2002, Borio and Drehmann, 2009 and Drehmann et al., 2010, Dell'Arrica et al., 2012). Banks usually do not take account of the risks incurred during the economic upturn, but rather when credit losses started to materialize (Borio et al., 2001).[12] To make matters worse, while banks underestimate risks during booms, they overstate risks during recessions (Repullo and Saurina, 2011). This often leads to protracted credit crunches which can bring about or exacerbate the economic downturn of the real economy and further destabilize the banking sector.

We use the annual growth rate of the private credit-to-GDP ratio (CREDIT GROWTH) to measure whether aggregate credit growth is excessive. For the reasons mentioned above, we would expect banks to be more risky if aggregate credit growth exceeds economic growth. This is reflected in Figure 3 which shows a negative relationship between a country's average Z-Score and the credit-to-GDP ratio, i. e. banks are less stable if the growth rate of private credit exceeds GDP growth. Since CREDIT GROWTH not necessarily indicates excessive risk-taking if high rates of credit-to-GDP growth reflect a long-term trend, for example, due to financial deepening (Drehmann et al., 2010), we use the deviation of credit-to-GDP growth from its long-term trend (CREDIT GAP) as alternative indicator for excessive credit growth at the aggregate level. The idea behind this indicator is that when credit-to-GDP growth is sufficiently above its long-term trend, financial imbalances emerge that signal the risk of future distress (Borio and Lowe, 2002). The long-term trend is obtained using the Hodrick-Prescott (1981) filter, a method frequently used in the literature to determine credit growth is excessive (Borio and Lowe, 2002, Borio and Drehmann, 2009 and Drehmann et al., 2010).[13] A similar approach is proposed by the Basel Committee on Banking Supervision

[10] This is also reflected by the Euro Area Bank Lending Survey that shows a loosening of lending standards up until 2008 and a considerable tightening thereafter. In line with that Maddalloni and Peydro (2011) show that Euro area banks reduced their lending standards over and above an improvement in the quality of borrower's industry and collateral which significantly increased bank risk between 2003 and 2008.

[11] A further mechanism is provided by Rajan (2004). He argues that bank managers reduce lending standards to hide losses and protect their own reputation when most borrowers are performing well, In contrast, when a common negative shock hits a sector, reputational concerns diminish and bank managers tighten credit standards and take fewer risks.

[12] For example, there are several studies that show that bank provision is highly pro-cyclical. and lead banks to lower their collateral requirement as, for instance, shown by Jimenez and Saurina (2006) for Spanish banks

[13] We use a smoothing parameter of 6.25 as recommended by Hodrick and Prescott (1997) for annual data and calculate the long-term trend for each country based on data on private credit-to-GDP growth for the period between 1960 and 2009. There

(BCBS, 2010a) to identify periods of excessive credit growth and to calculate countercyclical capital charges for banks as envisaged under Basel III.

Figure 4 shows large differences in the development of the CREDIT GAP across countries. While there does not seem to be excessive credit growth in Germany, there is a strong increase in the credit gap in Ireland and Spain between 2004 and 2006. Both is consistent with the general observation of a housing and lending boom in these countries in the mid 2000s that has led to an increase in bank risk-taking in these countries. In the United Kingdom, private credit-to-GDP growth was above its long-term trend in 2005 and from 2007 onwards as well. Deviations from the trend are, however, smaller. This suggests that the development of private credit-to-GDP growth was much more in line with its long-term trend than in Ireland and Spain. Overall, the comparison indicates that it is important to control for aggregate credit growth in the following empirical section. In addition, we include variables to control for real GDP growth (GDPGR), the size and the level of concentration in the banking sector (PCRDBGDP and CONC) and the level of long-term interest rates (INTEREST RATES).

4. Empirical Model

To identify the determinants of bank risk-taking, we estimate the following dynamic regression model for panel data:

$$Z - Score_{ict} = \sum_{l=1}^{2} Z - Score_{ict-l}\,\beta_l + B_{ict}\beta_3 + C_{ct}\beta_4 + BANK\ TYPE_i\,\beta_5 + \alpha_i + \delta_c + \gamma_t + \varepsilon_{ict}$$

where $Z - Score_{ict}$ is the logarithm of the Z-Score of bank *i* in country *c* and year *t*. B is a matrix of the bank variables described above and C a matrix of country-specific variables. Dummy variables for savings banks (SAVINGS), cooperative banks (COOPERATIVE) and listed banks (LIST) are included in the matrix $BANK\ TYPE$. ε_{ict} is the error term and $\beta_1, \beta_2, \beta_3, \beta_4$ and β_5 are coefficient vectors. In contrast to Altunbas et al. (2011) and Demirgüc-Kunt and Huizinga (2010), we model bank risk-taking as dynamic by including the first and second lag of the Z-Score.[14] Bank risk may be persistent over time due to intertemporal risk smoothing, competition, regulations or relationship banking with risky customers (Delis and Kourtas, 2010).

There are several other variables that affect bank risk. Laeven and Levine (2009), for example, find that banks with concentrated ownership structures incur greater risks, while Beltratti and Stulz (2012) show that banks with more shareholder-friendly boards are more risky. Since the focus of our paper is not on the corporate governance of banks, we include bank-

is a small number of gaps in the private credit-to-GDP time series. To close these gaps, we use the predicted values of a regression of private credit-to-GDP on country dummies and country-specific trends. The adjusted R^2 of this regression is 0.66. We test whether our results change if we use smoothing parameter of 100 and 150 and obtain similar results. Drehmann et al. (2010) argue that higher smoothing parameters should be used for private credit-to-GDP, since the duration of credit cycles is larger than that of business cycles.

[14] We include the second lag, since test statistics indicate second autocorrelation in the error terms in the model including only the first lag of bank risk. Please note that the transformed error terms are serially correlated of order one by construction.

specific effects α_i to control for the ownership and board structure of banks and differences in managerial attitude (Altunbas et al., 2011). Furthermore, we include country fixed effects δ_c to control for differences in institutions and banking regulations across countries (Laeven and Levine, 2009) as well as several other time-invariant country characteristics that affect bank risk. Year dummies γ_t capture time-specific effects such as trends in the regulatory stance and control for common shocks such as the advance of the financial crisis in 2007/2008.

The model is estimated with two-step System GMM as proposed by Arellano and Bover (1998) and Blundell and Bond (1998) with Windmeijer's (2005) finite sample correction. This estimation technique is particularly suitable for small T and large N samples such as ours. Using System GMM is appropriate for at least two reasons. First, the variables used to describe a bank's business model are potentially endogenous as outlined above. Second, first differencing the regression equation to eliminate the bank-specific effects would lead to a correlation between the lagged dependent variable and the error term. System GMM solves these problems by instrumenting the predetermined and endogenous variables with their own lags. Since estimates are biased in the presence of too many instruments, we instrument the lagged endogenous variable with its first and the bank-specific variables with their second lag as remote lags are unlikely to be informative instruments (Bond and Maghir, 1994).[15] Because lagged levels provide only weak instruments for first differences when the time series are persistent, we use System GMM instead of the Arellano Bond GMM estimator (Blundell and Bond, 2000). The country variables are treated as exogenous. The validity of the instruments is tested using the Hansen's J test statistic of overidentifying restrictions. In all cases, the test statistic accepts the null hypothesis that the instruments are exogenous. Furthermore, we employ the Arellano-Bond test to control for serial correlation in the residuals. The null hypothesis is not rejected in all cases indicating that there is no second and third order correlation in the first difference regression. All test statistics are reported at the bottom of each regression table.

5. Results

The regression analysis proceeds as follows. We first estimate a model that includes bank variables only. We call this our baseline model. In the second step, we include several country variables to identify the effect of economic growth and banking market structure and competition on risk. Finally, we control for aggregate credit growth. All regressions include year and country fixed effects which are not reported for the sake of brevity. For a list of variables included in the regression analysis see Table 4. Descriptive statistics are presented in Table 5.

[15] Moreover, we combine the columns of the optimal instrument matrix by addition, and, hence, use only one instrument for each variable rather than one for each period.

5a. Bank Characteristics and Risk-Taking

The results for our baseline model are reported in column (3) of Table 6. For comparison, we report the OLS and Fixed Effects estimates in columns (1) and (2).

First, bank risk-taking seems to be highly persistent as indicated by the large and significantly positive coefficient for the first and second lag of bank risk (L.Z-Score and L2.Z-Score).[16] This suggests that it is important to control for dynamics in bank risk-taking in order to derive consistent estimates. The coefficient for the lagged dependent variable further supports the validity of our model, since the coefficients for the first and second lag of bank risk lie in between those of the OLS and the Fixed Effects model. We would expect this in the presence of endogeneity, because the OLS estimate should be upward and the Fixed Effects estimate downward biased if the lagged dependent variables are correlated with the error term (Roodman, 2009). Overall, hence, we are confident that our model is appropriately specified.

Our results suggest that banks' loan growth is an important determinant of risk-taking in the EU banking sector. In line with Altunbas et al. (2011) and Foos et al. (2010) we find that banks with higher rates of abnormal loan growth (LOANGR) are more risky. This indicates that banks might have lowered their lending standards to increase lending and to undercut their competitors. Furthermore, banks which exhibit significantly higher loan growth rates than their competitors may attract risky customers which have not been given a loan by other banks (Foos et al., 2010). In column (4), we use the difference between bank's loan growth rate and the median loan growth rate of all other banks of the particular bank type instead of LOANGR and confirm our findings. Since we want to analyze whether banks become more risky if they have higher rates of loan growth relative to *all other* banks, we continue to report the results for LOANGR.

Banks with a high share of non-interest income to total income are more stable as well as reflected by the significantly positive coefficient for NNINC in our baseline model. This is consistent with the view that non-interest income improves income diversification and makes a bank less dependent on overall business conditions (Stiroh, 2004). Furthermore, expanded product lines and cross-selling opportunities associated with greater non-interest income may allow banks to improve their risk-return trade-off (Stiroh, 2004). Our findings might also reflect that European banks are better able to exploit the diversification potential of fee-based activities due to their experience with universal banking models compared to US banks as, for example, argued by De Young and Rice (2004). Overall, our results contrast with Altunbas et al. (2011) and Demirgüc-Kunt and Huizinga (2010) who find that banks with a higher share of non-interest income to total income are less stable. We think that this is a reflection of the fact that they focus on listed banks which are usually larger and more active in volatile trading activities than small banks. Larger banks are also usually more engaged in off-balance sheet activities that allow them to increase their financial leverage. Both may off-

[16] We also experimented with a higher order of lags for the dependent variables, but found no persistence beyond the first and second year.

set the positive effects of better income diversification. We confirm this hypothesis later when we analyze whether the effect of a bank's non-interest income share on bank stability is different for large banks.

We also find no evidence that banks with a higher ratio of customer loans to total assets are more risky as indicated by the insignificant coefficient for LOANS. There is also no evidence that banks with a higher ratio of loans to deposits are more risky as indicated by the insignificant coefficient for LOANDEP. This suggests that banks that more heavily rely on wholesale funding to finance their loans do not incur greater risks than banks that primarily fund their loans by customer deposits which are a more stable source of funding (Song and Thakor, 2007 and Shleifer and Vishny, 2010). This contrasts with evidence for listed banks (Altunbas et al., 2011 and Demirgüc-Kunt and Huizinga, 2010). We think that this is again the result of the unlisted banks included in our sample. While Altunbas et al. (2011) and Demirgüc-Kunt and Huizinga (2010) focus on listed banks which also include investment banks that primarily depend on wholesale funding, our sample includes a large number of unlisted banks, savings banks and cooperative banks which primarily fund their loans by deposits. This is also reflected in Table 3 which shows that the average loan-to-deposit ratio is relatively low for the whole sample. Hence, the risks stemming from the reliance on wholesale funding as described in Huang and Ratnovski (2008) should be significantly lower for most of the banks included in our sample which may explain why LOANDEP turns out to be insignificant in our regressions.[17]

Bank stability depends on other bank characteristics as well. We find evidence that banks with a larger share of liquid assets to total assets are more stable as indicated by the significant and positive coefficient for LIQUID. This is consistent with the hypothesis that liquid banks are less risky, since liquid assets are a buffer against liquidity shocks. Bank size, in contrast, does not matter as indicated by the insignificant coefficient for SIZE. *A priori*, we did expect large banks to be more stable, because they are better able to diversify than small banks (Demsetz and Strahan, 1997 and Stiroh, 2006). Larger banks may also have more sophisticated risk management systems than small banks that may reduce bank risk (Laeven and Majnoni, 2003 and Foos et al., 2010). As argued by Demsetz and Strahan (1997) and DeYoung and Roland (2001) these benefits might be outweighed, however, if large banks increasingly rely on non-interest income and engage in more risky off-balance sheet activities that allow them to employ a higher leverage. We explore this hypothesis later when we analyze whether the effect of bank size on stability is different for banks with a high and low non-interest income share.

Banks that report higher net interest margins are more stable as well as indicated by the positive and significant coefficient for NIM. This is consistent with the hypothesis that banks have less need to increase risk-taking to achieve their target rate of return if their net interest margin is high. The significant coefficient for the first lag of a bank's net interest margin (L.NIM)

[17] Alternatively, we include the ratio of customer deposits to liabilities and the ratio of short-term funding to liabilities instead of the loan-to-deposit and confirm our results.

indicates that the effect is dynamic, however. The negative coefficient suggests that a higher net interest margin in the previous year leads to an increase in the current level of bank risk-taking. This suggests that at least part of the higher net interest margin can be attributed to greater risk-taking which materializes with a lag. Ho and Saunders (1997) and Angabzo (1997), for example, show that banks charge higher interest margins if credit risk increases, a finding also made by Maudos and de Guevara (2004) and Lepetit et al. (2008) for European banks. The long-term effect of a bank's net interest margin on bank stability is, however, positive.

There are also important differences in risk-taking across bank types. For example, cooperative and savings banks are significantly more stable than commercial banks (the omitted category) as COOPERATIVE and SAVINGS turned out to be significantly positive in most regressions. LIST, in contrast, is mostly insignificant indicating that listed banks are not more risky than unlisted banks.

5b. Country Characteristics and Risk-Taking

We now turn to the characteristics that explain differences in risk-taking across countries. In contrast to the bank-specific variables which are clearly endogenous, we treat the country-variables as exogenous, since individual bank risk should be uncorrelated with developments at the country level. This is supported by Hansen's J test statistic which indicates that our instruments are still valid. In addition, we report the result of the Difference-in-Hansen tests which test whether the IV instruments are exogenous. The results are reported in Table 7.

The first country variable included is real GDP growth (GDPGR). *A priori*, we would expect bank risk to be lower, since unemployment and insolvency rates should be lower in an economic upswing. This should reduce credit risk and make a bank's loan portfolio less risky. Furthermore, better economic conditions increase the number of projects becoming profitable in terms of expected net present value thereby reducing the overall credit risk of the bank further (Kashyap et al., 1993). However, banks may also become more risky if they reduce their screening activity and lending standards during expansions (Ruckes, 2004). Overall, we find evidence for neither of these hypotheses as GDPGR turns out to be insignificant in all regressions. [18]

We also find no evidence that the size of the banking sector (PCRDBGDP) has an impact on bank risk. The level of banking sector concentration (CONC) which is measured by the Herfindahl Index and included to capture the level of competition does not matter either. The level of long-term interest rates, in contrast, does. The positive coefficient for INTEREST RATES suggests that bank become more stable if the level of interest rates is high. This is in line with the literature on the risk-taking channel of monetary policy which argues that banks have less need to increase their level of risk to generate their target rate of return if the level

[18] We also include lagged real GDP growth. Since it turned out to be insignificant, the results are not reported for the sake of brevity.

of interest rates is high (Jimenéz et al., 2008, Delis and Kouretas, 2011 and Maddalloni and Peydro, 2011).

Finally, we use two variables to measure whether aggregate credit growth is excessive. The first variable is the growth rate of private credit-to-GDP (CREDIT GROWTH). In addition, we include the deviation of credit-to-GDP growth from its long-term trend (CREDIT GAP). Since the risks that arise from high rates of aggregate credit growth may not materialize immediately, but with a lag, we also additionally include their first lags (L.CREDIT GROWTH and L.CREDIT GAP). For the reasons outlined above, we would expect banks to be more risky if credit-to-GDP growth is high and above its long-term trend. The results are presented in columns (3) and (4) of Table 7. While the contemporaneous effect of CREDIT GROWTH and CREDIT GAP is significantly positive, the lagged variables are significantly negative. This suggests that excessive rates of credit growth first have a positive effect on bank stability possibly due to higher profits during booms that make banks more stable. Later, the risks incurred during such booms reduce bank stability, however. Importantly, the negative effect of lagged credit growth is larger than the positive contemporaneous effect which suggests that the aggregate effect of excessive credit growth on bank stability is negative in the long-term.

Our results are consistent with Ruckes (2004), Dell'Ariccia and Marquez (2006) and Gorton and He (2008). They show that there is a general loosening of lending standards during periods of excessive credit growth. To the extent that lending standards decline more than justified by economic fundamentals, this leads to an increase in bank risk as, for example, shown by Dell'Arrica et al. (2008) and Jimenez and Saurina (2006). This not only destabilizes banks with high rates of individual loan growth, but also those that do not exhibit high rates of loan growth compared to their competitors. Furthermore, high rates of aggregate credit growth not only increase idiosyncratic, but also systemic risk that once it materializes affects all banks.

More importantly, the results of the main variables of interest remain unchanged. Banks with a higher rate of abnormal loan growth (LOANGR) continue to be less stable, while a higher level of wholesale funding (LOANDEP) still does not seem to matter. NNINC keeps its positive sign, but becomes insignificant in some regressions. This, however, changes significantly if we analyze whether the effect of banks' non-interest income differs with bank size as we will do next.

5c. Business Mix and Bank Size

In this section, we analyze whether the effect of banks' business mix differs with bank size and *vice versa*. As a starting point, we plot the average non-interest income share for each of 20 groups of observations, each containing 5% of total observations in increasing order. Figure 5 shows that banks are more active in non-interest business if they are larger possibly due to the high fixed costs involved with investment banking and trading activities which only large banks are able to afford. Demsetz and Strahan (1997) and DeYoung and Roland (2001) argue that the increasing reliance of large banks on non-interest income may out-

weigh the benefits that arise from a larger size such as better risk diversification if the shift toward non-interest based activities is associated with higher revenue volatility. Hence, to find out if the effect of non-interest income differs according to bank size, we include an interaction term between NNINC and SIZE (NNINC*SIZE) and re-run our regressions. The results are reported in Table 8.

They confirm our hypothesis. While NNINC and SIZE are significant and positive, the interaction term between both turns out to be significantly negative. This indicates that the benefits of a larger bank size decrease if banks become more active in non-interest income activities and *vice versa*. These results hold if we exclude the smallest and largest banks from the sample as illustrated in column (5) and (6) of Table 8.[19] One potential explanation for the negative relationship between size and the non-interest income share is that diminishing returns to diversification may set if banks become larger due to increased complexity, difficulty of oversight and risk management, or greater scope for agency problems that lead to excessive risk-taking by large banks. An alternative explanation is that larger banks are engaging in a different set of non-interest income activities such as more volatile and risky trading activities, while smaller banks derive a higher share of their non-interest income from provisions which are usually more stable and linked to interest income due to cross-selling activities (see also Stiroh, 2004). In line with that Stiroh (2004) shows that a greater reliance on non-interest income, in particular trading income, is associated with higher risk across commercial banks. Larger banks may also be more likely to engage in more risky off-balance sheet activities such as securitization than small banks. Because these activities require little or low regulatory capital, they can employ a higher financial leverage than small banks. This is consistent with the general observation that larger banks usually tend to hold less capital and are more leveraged than small banks. This is also reflected in Figure 5 which shows a negative relationship between bank's size, non-interest income share and the ratio of total equity over total assets.

Overall, our results indicate that the risk diversifying effects of a higher non-interest income share depend on bank size. While smaller banks should become more stable if they generate a higher share of income from non-interest activities as their income structure becomes more diversified, large banks might become less stable due to their greater exposure to volatile trading and off-balance sheet activities. The results of previous studies should, hence, not be generalized for all banks. This confirms our hypothesis from the beginning that a broader sample of banks is necessary to come to general conclusions about the effect of banks' business model on risk-taking.

[19] The smallest banks comprise all banks with total assets less than the 5%-quantile of the distribution of bank assets and the largest banks are all banks with assets larger than the 95%-quantile.

6. Extensions and Robustness Tests

In this section, we decompose the Z-Score into its two additive components to further check the robustness of our results and to get additional insights into the driving forces of bank risk-taking:[20]

$$PortfolioRisk_{it} = \frac{ROA_{it}}{SDROA_i} \quad (2)$$

$$LeverageRisk_{it} = \frac{CAR_{it}}{SDROA_i} \quad (3)$$

The first component is the return-on-asset (ROA) of bank *i* in year *t* divided by the standard deviation of the return on asset (SDROA). It is can be thought of as bank's risk-adjusted return and in this sense by interpreted as a measure of portfolio risk.[21] The second component is each bank's ratio of bank's equity to total assets (CAR) divided by SDROA. It reflects bank's leverage risk. In both cases, higher values indicate that banks are more stable. The results with our two alternative indicators of bank risk are presented in Table 9. To find out whether the effect of bank size on non-interest income derives from greater portfolio or leverage risk, we report the results for our full model including the interaction term between NNINC and SIZE.

The results reveal some interesting findings about the drivers of bank risk. First, the results for NNINC remain significantly positive for all measures of bank risk indicating that a higher share of non-interest income not only improves banks' risk-adjusted return, but also helps them to reduce leverage risk. The latter effect, however, decreases with bank size. This is consistent with our previous findings that larger banks are more likely to engage in more risky off-balance sheet activities that increase leverage. Overall, this suggests that large banks were too highly leveraged relative to the risk they were taking. Bank size (SIZE) remains significant and positive for leverage risk as well which indicates that the risk diversification effects of a larger bank size primarily reduces bank's exposure to leverage risk, while there is no improvement in portfolio risk. The same holds for abnormal lending growth. In line with the descriptive analysis, we find, however, no evidence that higher rates of lending growth result into higher returns, as indicated by the positive, but insignificant coefficient for LOANGR in the regression for portfolio risk. The results for the other bank controls are consistent with our previous results.

The results for the country controls are similar to our previous results as well. While the contemporaneous effect of aggregate credit growth is positive, the lagged impact is negative and

[20] See Stiroh and Rumble (2006), Demirgüc-Kunt and Huizinga (2010), Lepetit et al., 2008 and Barry et al. (2011) for a similar or the same decomposition of a bank's Z-Score.

[21] This is similar to a market-derived Sharpe-Ratio, which is defined as the ratio of expected returns (less the risk-free rate) divided by the standard deviation of returns.

primarily comes through greater leverage risk. The level of long-term interest rates also matters. However, while a higher level of interest rates seems to reduce bank's exposure to leverage risk, we find that it increases the level of portfolio risk. This suggests that the positive impact of higher interest rates on bank stability as measured by the Z-Score mainly comes through lower leverage risk.

7. Conclusions

In this paper, we analyze the impact of lending growth and business model on bank risk in 15 EU countries. In contrast to the literature that mainly focuses on listed banks, we include unlisted banks in our sample which represent the majority of banks in the EU. We think that this is important for the broader applicability of the results. We also think that our sample should better allow us to identify the effects of loan growth and banks' business models on bank risk, since we show that unlisted markedly differ in their lending behavior and business model from listed banks.

Controlling for endogeneity, bank-, year- and country-specific effects we find that it is important to enlarge the number of banks and bank types in the sample to come to general conclusions about the effect of banks' business model on risk-taking in the EU banking sector. While the previous studies suggest that it may be beneficial for banks to reduce their share of non-interest income, our results indicate the opposite. The positive diversification effect of a higher share on non-interest income, however, decreases with bank size possibly because larger banks are more likely to be active in volatile and risky trading and off-balance sheet activities such as securitization that allows them to employ a higher financial leverage than small banks. Overall, thus, our results imply that it is important to broaden the sample of banks to come to general conclusions about the effect of bank's business mix on risk-taking.

Finally, our paper indicates that supervisors should carefully monitor loan growth, since high rates of loan growth are associated with bank risk. Moreover, our results indicate that they should be aware of the development of aggregate credit growth as bank stability significantly decreases if aggregate lending growth is excessive. This even affects those banks that do not exhibit high rates of individual loan growth compared to their competitors. With respect to aggregate credit growth our paper, therefore, provides support for the introduction of countercyclical capital buffers which should reduce credit growth and the build-up of systemic risk during booms.

Literature

Adrian, T. and Shin, H. S. (2009), "Money, Liquidity, and Monetary Policy", *American Economic Review*, Vol. 99(2), pp. 600-605.

Altunbas, Y., Manganelli, S. and Marques-Ibanez, D. (2011), "Bank Risk During the Financial Crisis – Do Business Models Matter?", ECB Working Paper Series, No. 1394, European Central Bank, Frankfurt,

Angbazo, L. (1997), "Commercial Bank Net Interest Margins, Default Risk, Interest Rate Risk, and Off-balance Sheet Banking", *Journal of Banking and Finance*, Vol. 21, pp. 55-87.

Arellano, M. and Bover, O. (1995), "Another Look at the Instrumental Variable Estimation of Error-Components Models", *Journal of Econometrics*, Vol. 68, pp. 29-51.

Bankscope (2011), Bankscope Database, Bureau van Dijk.

Barry, T. A., Lepetit, L. and Tarazi, A. (2011), "Ownership Structure and Risk in Publicly Held and Privately Owned Banks", *Journal of Banking and Finance*, Vol. 35, pp. 1327-1340.

Basel Committee on Banking Supervision (2010), "Countercyclical Capital Buffer Proposal", Basel.

Beck, T., Hesse, H,. Kick, T. and von Westernhagen, N. (2009), "Bank Ownership and Stability", mimeo.

Beltratti, A. and Stulz R. M. (2012), "Why Did Some Banks Perform Better During the Credit Crisis? A Cross-country Study of the Impact of Governance and Regulation", *Journal of Financial Economics*, Vol. 105(1), pp. 1-17.

Borio, C., Furfine, C. and Lowe, P. (2001), "Procyclicality of the Financial System and Financial Stability: Issues and Policy Options", BIS Paper, No. 1, Bank for International Settlement, Basel.

Bikker, J. A. and Metzemaker, P. (2005), "Bank Provisioning Behavior and Procyclicality", *Journal of Financial Markets, Institutions and Money*, Vol. 15, pp. 141-157.

Blundell, R. and Bond, S. (1998), "Initial Conditions and Moment Restrictions in Dynamic Panel Data Models", *Journal of Econometrics*, Vol. 87, pp. 115-143.

Blundell, R. and Bond, S. (2000), "GMM Estimation with Persistent Panel Data: An Application to Production Function", *Economic Reviews*, Vol. 19(3), pp. 321-340.

Bond, S. and Meghir, C. (1994), "Dynamic Investment Models and the Firm's Financial Policy, *Review of Economic Studies*, Vol. 61, pp.197-222.

Bornemann, S., Kick, T., Memmel, C. and Pfingsten, A. (2012), "Are Banks Using Hidden Reserves to Beat Earnings Benchmarks", *Journal of Banking & Finance*, Vol. 36, pp. 2403-2415.

Borio, C. and Lowe, P. (2002), "Asset Prices, Financial and Monetary Stability: Exploring the Nexus", *BIS Working Papers*, No. 114, Basel.

pp. 105–120, Federal Reserve Bank of Chicago.

Borio, C. and Drehmann M., (2009), “Assessing the Risk of Banking Crises – Revisited”, *Bank for International Settlements Quarterly Review*, March.

Boyd, J. H., Hanweck, G. A. and Pithyachariyakul, P. (1980), “Bank Holding Company Diversification”, *in Proceedings from a Conference on Bank Structure and Competition*, May,

Boyd, J. and De Nicoló G. (2005), “The Theory of Bank Risk-Taking and Competition Revisited”, *Journal of Finance*, Vol. 60, No. 3, pp. 1329-1343.

Boyd, J. H., Graham, S. L. and Hewitt, S. R. (1993), “Bank Holding Company Mergers with Nonbank Financial Firms: Effects on the Risk of Failure," *Journal of Banking & Finance*, Vol. 17, pp. 43-63.

Boyd, J. and Runkle, D. (1993), “Size and Performance of Banking Firms: Testing the Predictions of Theory,” *Journal of Monetary Economics*, Vol. 31(1), pp. 47–67.

Busch, R. and Kick., T. (2009), „Income Diversification in the German Banking Industry”, Bundesbank Discussion Paper, No. 09/2009.

Carter, D. A. and McNulty, J. E. (2005), “Deregulation, Technological Change, and the Business-Lending Performance of Large and Small Banks, *Journal of Banking and Finance*, Vol. 29, pp. 1113-1130.

Delis, M. D. and Kouretas, G. P. (2011), “Interest Rates and Bank Risk-Taking”, *Journal of Banking and Finance*, Vol. 28, pp. 840-855.

Dell’Arrica, G. and Marquez, R. (2006), “Lending Booms and Lending Standards”, *Journal of Finance*, Vol. 61(5), pp. 2511-2546.

Dell’Ariccia, G., Igan, D. and Laeven, L. (2008), “Credit Booms and Lending Standards: Evidence from the Subprime Mortgage Market”, IMF Working Paper 08/106, International Monetary Fund, Washington D. C..

Dell'Ariccia, G., Igan, D., Laeven, L. and Tong, H. (2012), “Policies for Macrofinancial Stability: How to Deal with Credit Booms”, IMF Staff Discussion Note, No. 12/06, International Monetary Fund, Washington D. C..

Demirgüc-Kunt, A. and Huizinga, H. (2010), “Bank Activity and Funding Strategies: The Impact on Risk and Returns”, *Journal of Financial Economics*, Vol. 98, pp. 626-650.

Demsetz, R. S. and Strahan, P. E. (1997), “Diversification, Size, and Risk at Bank Holding Companies”, *Journal of Money Credit and Banking*, Vol. 29(3), pp. 300-313.

Drehmann, M., Borio, C. Gambacorta, L. Jimenez, G. and Trucharte, C. (2010), “Countercyclical Capital Buffers: Exploring Options”, *BIS Working Papers*, No. 317, Bank for International Settlement, Basel.

DeYoung, R. and Roland, K. P. (2001), “Product Mix and Earnings Volatility at Commercial Banks: Evidence from a Degree of Total Leverage Model”, *Journal of Financial Intermediation*, Vol. 10, pp. 54-84.

DeYoung, R. and Rice, T. (2004), “Noninterest Income and Financial Performance at U.S. Commercial Banks”, *The Financial Review*, Vol. 39, pp. 101-127.

ECB (2010), EU Banking Structure Report, European Central Bank, Frankfurt.

Foos, D., Norden L. and Weber, M. (2010), “Loan Growth and Riskiness of Banks”, *Journal of Banking and Finance,* Vol. 34(12), pp. 2929-2940.

Gorton, G. B. and He, P. (2008), “Bank Credit Cycles”, *The Review of Economic Studies*, Vol. 75, pp. 1181-1214.

Hesse, H. and Cihak, M. (2007), “Cooperative Banks and Financial Stability”, IMF Working Paper, No. 07/02.

Ho, T. S. Y. and Saunders, A. (1981), "The Determinants of Bank Interest Margins: Theory and Empirical Evidence", *Journal of Financial and Quantitative Analysis*, Vol. 16, pp. 581-600

Hodrick, R. J. and Prescott, E. C. (1997), “Postwar U.S. Business Cycles: An Empirical Investigation”, *Journal of Money, Credit, and Banking*, Vol. 29(1), pp. 1-16.

Huang, R. and Ratnovski, L. (2011), “The Dark Side of Bank Wholesale Funding”, *Journal of Financial Intermediation,* Vol. 20(2), pp. 248-263.

Jimenéz, G. and Saurina, J. (2006), “Credit Cycles, Credit Risk, and Prudential Regulation”, *International Journal of Central Banking*, Vol. 2(2), pp. 65-98.

Jimenéz, G., Ongena, S., Peydró, J.-L. and Saurina, J. (2008), “Hazardous for Monetary Policy: What Do 23 Million Observations Say About the Impact of Monetary Policy on Credit Risk-Taking”, Working Paper, Banco De Espana.

Kashyap, A. K., Stein, J. C. and Wilcox, D. W. (1993), „Monetary Policy and Credit Conditions: Evidence from the Composition of External Finance”, *The American Economic Review*, Vol. 83(1), pp. 78-98.

Laeven, L. and Levine, R. (2009), “Bank Governance, Regulation and Risk-Taking”, *Journal of Financial Economics,* Vol. 93(2), pp. 259-275.

Laeven, L. and Majnoni, G. (2003), “Loan Loss Provisioning and Economic Slowdowns: Too Much, Too Late?,” *Journal of Financial Intermediation,* Vol. 12, pp. 178-197.

Lepetit, L., Nys, E., Rous, P. and Tarazi, A. (2008), “The Expansion of Services in European Banking: Implications for Loan Pricing and Interest Margins”, *Journal of Banking and Finance*, Vol. 32, pp. 2325-2335.

Liikanen (2012), “High-Level Expert Group on Reforming the Structure of the EU Banking Sector”.

Maddaloni, A. and Peydró, J.L. (2011), “Bank Risk Taking, Securitization, Supervision, and Low Interest Rates: Evidence from Lending Standards”, *Review of Financial Studies*, Vol. 24(6), pp. 2121-2165.

Maudos, J. and de Guevara, J. F. (2004), “Factors Explaining the Interest Margin in the Banking Sectors of the European Union”, *Journal of Banking and Finance*, Vol. 28, pp. 2259-2281,

Mendoza, E. G. and Terrones, M. E. (2008), “An Anatomy of Credit Booms: Evidence From Macro Aggregates And Micro Data”, NBER Working Paper, No. 14049.

OECD (2012), OECD Financial Indicators Database.

Ogura, Y. (2006), “Learning from a Rival Bank and Lending Boom”, *Journal of Financial Intermediation*, Vol. 15(4), pp. 535-555.

Rajan, R. (1994), “Why Bank Credit Policies Fluctuate: A Theory and Some Evidence”, *Quarterly Journal of Economics*, Vol. 109(2), pp. 399–441.

Repullo, R. and Saurina, J. (2011), “The Countercyclical Capital Buffer of Basel III: A Critical Assessment”, CEPR Discussion Paper, No. 8304, Centre for European Policy Research.

Roodman, D. (2009), “How to Do Xtabond2? An Introduction to “Difference“ and “System GMM” In STATA”, *STATA Journal*, Vol. 9(1), pp. 86-136.

Ruckes, M. E. (2004), “Bank Competition and Credit Standards”, *Review of Financial Studies*, Vol. 17(4), pp. 1073-1102.

Saunders, A. and Walter, I. (1994), “Universal Banking in The United States”, New York, Oxford University Press.

Shleifer, A. and Vishny, R. W. (2010), “Unstable Banking”, *Journal of Financial Economics*, Vol. 97, pp. 306-318.

Song, F. and Thakor, A. V. (2007), “Relationship Banking, Fragility, and the Asset-Liability Matching Problem”, *Review of Financial Studies*, Vol. 20(5), pp. 2129-2177.

Stiroh, K.J. (2004), “Diversification in Banking: Is Non-Interest Income the Answer?”, *Journal of Money, Credit, and Banking*, Vol. 36, pp. 853-882.

Stiroh, K.J. (2006), “New Evidence on the Determinants of Bank Risk”, *Journal of Financial Service Research*, Vol. 30(3), pp. 237-263.

Stiroh, K.J. and Rumble, A. (2006), “The Dark Side of Diversfication: The Case of US Financial Holding Companies”, *Journal of Banking and Finance*, Vol. 30, pp. 2131-2161.

Windmeijer, F. (2005), “A Finite Sample Correction for the Variance of Linear Efficient Two-step GMM Estimators”, *Journal of Econometrics*, Vol. 126, pp. 25–51.

World Bank (2012), World Development Indicators Database.

Table 1: Sample

Table 1 shows the number of banks and observations by country. The panel includes commercial banks, cooperative banks and savings banks. To assure that we have a sufficient number of observations to analyze risk-taking in the pre-crisis period, we require each bank to report balance sheet data between 2003 and 2006.

Country	Total Number of Observations	Total Number of Banks	of which listed	of which not listed
Austria	1,196	188	3	185
Belgium	270	48	0	48
Denmark	559	84	36	48
Finland	42	6	2	4
France	1,468	239	18	221
Germany	9,059	1,352	12	1,340
Greece	96	15	10	5
Ireland	88	16	0	16
Italy	4,120	633	21	612
Luxembourg	465	76	0	76
Netherlands	74	13	0	13
Portugal	78	13	1	12
Spain	680	115	9	106
Sweden	554	88	3	85
United Kingdom	482	80	0	80
Total	19,231	2,966	115	2,851
of which:				
Commercial Banks	5,006	819	90	729
Savings Banks	4,920	746	6	740
Cooperative Banks	9,305	1,401	19	1,382

Source: Bankscope (2011)

Table 2: Descriptive Statistics for Z-Score

Table 2 shows descriptive statistics for the Z-Score and its components for all banks and different bank types. The Z-Score is defined as the ratio of the return on assets (ROA) plus the capital ratio (CAR) divided by the standard deviation of the return on assets (SDROA). All variables are winsorized at the 1%- and 99%-level. Mean and median values are calculated over the period between 2003 and 2009. Equality of means tests for the Z-Score and its components are reported at the bottom of the table. *** indicates significance at the 1%-level. For a more detailed description of the variables see Table 4.

	Z-Score		CAR		ROA		SDROA	
	Mean	**Median**	**Mean**	**Median**	**Mean**	**Median**	**Mean**	**Median**
All Banks	36.26	30.73	8.49	6.79	0.72	0.58	0.40	0.26
Listed Banks	26.74	17.27	9.77	8.93	1.05	0.97	0.68	0.53
Unlisted Banks	36.66	31.26	8.44	6.74	0.71	0.57	0.39	0.26
Commercial Banks	24.75	17.33	9.88	7.39	0.93	0.76	0.69	0.54
Cooperative Banks	41.99	36.66	8.47	7.34	0.67	0.60	0.29	0.24
Savings Banks	37.15	32.55	7.13	5.72	0.61	0.47	0.32	0.19

Equality of Means Test (t-value)	**Z-Score**	**CAR**	**ROA**	**SDROA**
Listed vs. Unlisted Banks	10.24***	-6.82***	-11.39***	-20.23***
Commercial Banks vs. Savings Banks	-29.48***	21.68***	16.68***	39.77***
Commercial Banks vs. Cooperative Banks	-42.51***	14.39***	17.88***	62.54***
Savings Banks vs. Cooperative Banks	10.22***	19.46***	6.77***	-6.42***

Source: Bankscope (2011) and own calculations.

Table 3: Bank Characteristics

Table 3 shows descriptive statistics for the bank variables used in the regression analysis according to bank type. Mean values are calculated over the period between 2003 and 2009. NIM the net interest margin and NNINC the share of net non-interest income to total income. LOANS denotes the ratio of loans to total assets and LOANGR abnormal loan growth defined as the difference between a bank's annual customer loan growth rate and the median loan growth rate of all banks from the same country and year. LOANDEP is the ratio of customer loans to customer deposits and LIQUID the ratio of liquid assets to total assets. All bank variables are winsorized at the 1% and 99%-level. Equality of means tests are reported at the bottom of the table. *** indicates significance at the 1%-level. For a more detailed description of the variables see Table 4.

	Total Assets (in € Mrd)	**NIM**	**NNINC**	**LOANS**	**LOANGR**	**LIQUID**	**LOANDEP**
All Banks	4.52	2.61	29.84	58.53	2.61	19.99	1.16
Listed Banks	27.51	2.67	36.47	60.93	2.67	19.74	1.55
Unlisted Banks	3.56	2.61	29.57	58.43	2.60	20.00	1.15
Commercial Banks	10.53	2.22	40.77	48.96	6.33	32.31	1.55
Cooperative Banks	1.62	2.82	26.19	62.00	1.57	16.57	1.07
Savings Banks	3.91	2.61	25.62	61.72	0.77	13.92	0.94

Equality of Means Test (t-value)	**Total Assets (in € Mrd)**	**NIM**	**NNINC**	**LOANS**	**LOANGR**	**LIQUID**	**LOANDEP**
Listed vs. Unlisted Banks	-40.94***	-1.60	-12.54***	-3.35***	-0.08	0.40	-11.46***
Commercial Banks vs. Savings Banks	15.65***	-16.95***	45.44***	-27.20***	10.27***	45.96***	26.47***
Commercial Banks vs. Cooperative Banks	29.18***	-33.67***	54.99***	-35.70***	11.62***	50.08***	25.99***
Savings Banks vs. Cooperative Banks	-13.45***	17.65***	3.76***	1.13	3.92***	13.96***	13.13***

Source: Bankscope (2011) and own calculations.

Table 4: List of Variables

Table 4 shows the list of variables used in the regression analysis. All bank variables are winsorized at the 1%- and 99%-level. For descriptive statistics see Table 5.

Variable	Description	Source
CAR	Winsorized Fraction of total equity divided by total assets	Bankscope (2011) and own calculations
CONC	Market share of the three largest banks divided by total banking sector assets	World Bank (2011)
COOPERATIVE	Dummy variable that is one for cooperative banks and zero otherwise.	Bankscope (2011) and own calculations
CREDIT GAP	Annual growth rate of PCRDBGDP minus its long-term trend. The long-term trend is obtained using the Hodrick-Prescott (1981) filter with a smoothing parameter of 6.25. To calculate the long-term trend we annual data on private credit-to-GDP growth for period between 1960 and 2009. There is a small number of gaps in the private credit-to-GDP time series. To close these gaps, we use the predicted values of a regression of private credit-to-GDP on country dummies and a country-specific trend variable. The adjusted R^2 of this regression is 0.66. We test whether our results change if we use smoothing parameter of 100 and 150 and obtain similar results.	World Bank (2011) and own calculations
CREDIT GROWTH	Annual growth rate of PCRDBGDP	World Bank (2011) and own calculations
GDPGR	Real GDP Growth	World Bank (2011) and own calculations
INTEREST RATE	Long-Term Interest Rate calculated as Yield on 10-year government bonds	OECD (2012)
L.LEVERAGE RISK	First lag of LEVERAGE RISK	Bankscope (2011) and own calculations
L.NIM	First lag of NIM	Bankscope (2011) and own calculations
L.PORTFOLIO RISK	First lag of PORTFOLIO RISK	Bankscope (2011) and own calculations
L.Z-SCORE	First lag of Z-SCORE	Bankscope (2011) and own calculations
L2.LEVERAGE RISK	Second lag of LEVERAGE RISK	Bankscope (2011) and own calculations
L2.PORTFOLIO RISK	Second lag of PORTFOLIO RISK	Bankscope (2011) and own calculations
L2.Z-SCORE	Second lag of Z-SCORE	Bankscope (2011) and own calculations
LEVERAGE RISK	Winsorized fraction of the capital ratio (CAR) divided by the standard deviation of the return on assets (SDROA).	Bankscope (2011) and own calculations
LIQUID	Winsorized fraction of liquid assets to total bank assets	Bankscope (2011) and own calculations

LIST	Dummy variable that is one for listed banks and zero otherwise.	Bankscope (2011) and own calculations
LOANDEP	Winsorized fraction of total customer loans divided by total customer deposits	Bankscope (2011) and own calculations
LOANGR	Winsorized fraction of the annual rate of customer loan growth calculated as ((LOANSt-LOANSt-1)/LOANSt-1)*100 minus median customer loan growth rate of all banks in a specific country and year	Bankscope (2011) and own calculations
LOANGR_GROUP	Winsorized fraction of the annual rate of customer loan growth calculated as ((LOANSt-LOANSt-1)/LOANSt-1)*100 minus median customer loan growth rate of all banks of a partiuclar bank type in a specific country and year	
LOANS	Winsorized fraction of total customer loans divided by total bank assets	Bankscope (2011) and own calculations
NIM	Winsorized fraction of net interest revenue divided by average earning assets	Bankscope (2011) and own calculations
NNINC	Winsorized fraction of (1-abs(Net interest income)/abs(Total income))	Bankscope (2011) and own calculations
PCRDBGDP	Private Credit by Deposit Money Banks divided by GDP	World Bank (2011)
PORTFOLIO RISK	Winsorized fraction of the return-on-assets (ROA) divided by the standard deviation of the return on assets (SDROA).	Bankscope (2011) and own calculations
ROA	Winsorized fraction of pre-tax profits divided by total assets	Bankscope (2011) and own calculations
SAVINGS	Dummy variable that is one for savings banks and zero otherwise.	Bankscope (2011) and own calculations
SDROA	Standard deviation of ROA calculated for the period between 2003 and 2009.	
SIZE	Winsorized fraction of the logarithm of total bank assets (in € Mrd.)	Bankscope (2011) and own calculations
SIZE*NNINC	Interaction term between bank size (SIZE) and the ratio of net interest income to total income NINC	Bankscope (2011) and own calculations
Z-SCORE	Bank risk is measured using the Z-score defined as the ratio of the return on assets (ROA) plus the capital ratio (CAR) divided by the standard deviation of the return on assets (SDROA).	Bankscope (2011) and own calculations

Table 5: Descriptive Statistics

Table 5 shows descriptive statistics for the variables used in the regression analysis. The Z-Score is defined as the ratio of the return on assets (ROA) plus the capital ratio (CAR) divided by the standard deviation of the return on assets (SDROA). We decompose the Z-Score into its two components. The first component is the return on average (ROA) divided by the standard deviation of ROA and is a measure of bank's portfolio risk. The second component is the ratio of total equity divided by total assets over the standard deviation of ROA and measures leverage risk. SIZE is the logarithm of total bank assets, NIM the net interest interest margin and NNINC the share of net non-interest income to total income. LOANS denotes the ratio of loans to total assets and LOANGR abnormal loan growth defined as the difference between a bank's annual loan growth rate and the median loan growth rate of all banks from the same country and year. LOANDEP is the ratio of customer loans to customer deposits and LIQUID the ratio of liquid assets to total assets. All bank variables are winsorized at the 1%- and 99%-level. The country variables are the growth rate of real GDP (GDPGR), the ratio of private credit-to-GDP (PCRDBGDP), the Herfindahl Index of banking sector concentration (CONC), the long-term interest rate (INTEREST RATE), private credit-to-GDP growth (CREDIT GROWTH) and the deviation of private credit-to-GDP growth from its long-term trend (CREDIT GAP). For a more detailed description of the variables see Table 4.

	Obs.	Mean	Median	Std.Dev.	Max.	Min.
CAR	19,231	0.08	0.07	0.05	0.37	0.02
CONC	18,749	373.72	220.00	345.96	3160.00	173.00
CREDIT GAP	19,231	-0.79	-0.24	2.75	6.53	-18.68
CREDIT GROWTH	19,231	1.71	0.36	5.18	25.56	-11.78
GDPGR	19,231	0.86	1.21	2.45	6.47	-8.02
INTEREST RATE	19,048	3.95	4.04	0.42	5.23	2.41
LEVERAGERISK	19,231	32.72	28.29	22.66	130.52	3.56
LIQUID	19,231	19.99	14.51	17.88	89.74	0.86
LOANDEP	19,231	1.16	0.92	0.95	5.33	0.17
LOANGR	19,231	2.61	0.00	21.07	150.96	-76.26
LOANGR_GROUP	19,231	2.57	0.00	20.99	150.96	-77.37
LOANS	19,231	58.53	61.93	20.25	95.68	1.01
NIM	19,231	2.61	2.63	0.97	6.11	0.21
NNINC	19,231	29.84	26.67	15.03	82.93	4.94
PCRDBGDP	19,231	1.09	1.05	0.26	2.61	0.60
PROFITRISK	19,231	2.66	2.43	2.13	10.92	-1.69
Z-SCORE	19,231	35.41	30.73	24.13	139.17	3.39
ROA	19,231	0.01	0.01	0.01	0.04	-0.02
SDROA	19,231	0.00	0.00	0.00	0.04	0.00
SIZE	19,231	-0.28	-0.48	1.67	4.91	-3.68

Source: Bankscope (2011), World Bank (2011) and own calculations.

Table 6: Baseline Results

Table 6 shows the results of our baseline regressions including bank variables, year and country dummies. The dependent variable is the Z-Score. SAVINGS, COOPERATIVE and LIST indicated whether a bank is a savings, cooperative and listed bank, respectively. Size is the logarithm of total bank assets, NIM the interest interest margin and NNIC the share of net non-interest income to total income. LOANS is the ratio of loans to total assets and LOANDEP the ratio of customer loans to customer deposits. LOANGR is the difference between bank's loan growth rate and the median loan growth of all other banks in a particular country and year. Alternatively, we use the difference between bank's loan growth and the median loan growth of all other banks of a particular bank type (LOANGR_GROUP). LIQUID is the ratio of liquid assets to total assets. All bank variables are winsorized at the 1%- and 99%-level. OLS/Fixed Effects/System GMM denotes the estimates of an Ordinary Least Squares/Within regression/System GMM regression. Standard errors of the OLS and Fixed Effects estimates are clustered on bank level. The bank type dummies drop out of the Fixed Effects regression due to the within transformation. For System GMM, we use the two-step estimator as proposed by Arellano and Bover (1998) and Blundell and Bond (1998) with Windmeijer's (2005) finite sample correction. We use the first lag of the pre-determined variables and the second lag of the endogenous as instruments. Moreover, we combine the columns of the optimal instrument matrix by addition, and, hence, use only one instrument for each variable rather than one for each period. The validity of the instruments is tested using the Hansen's J test statistic. Furthermore, we test for first-, second- and third-order autocorrelation in the residuals. All test statistics are reported at the bottom of each regression table. Standard errors are reported in parentheses. For a more detailed description of the variables see Table 4. ***/**/* indicates significance at the 1%-/5%-/10%- level.

	OLS	Fixed Effects	System GMM	System GMM
L.Z-Score	0.837***	0.326***	0.768***	0.776***
	(0.015)	(0.020)	(0.045)	(0.044)
L2.Z-Score	0.143***	-0.033**	0.119***	0.121***
	(0.015)	(0.016)	(0.036)	(0.036)
SIZE	-0.002*	-0.289***	0.028	0.037
	(0.001)	(0.019)	(0.051)	(0.050)
NIM	0.074***	0.083***	0.365***	0.360***
	(0.006)	(0.007)	(0.074)	(0.074)
L.NIM	-0.069***	-0.010*	-0.207***	-0.208***
	(0.006)	(0.005)	(0.063)	(0.063)
NNINC	0.000***	0.002***	0.007**	0.006**
	(0.000)	(0.000)	(0.003)	(0.003)
LOANS	0.000	-0.000	0.002	0.002
	(0.000)	(0.001)	(0.003)	(0.003)
LOANGR	-0.001***	-0.001***	-0.005**	
	(0.000)	(0.000)	(0.002)	
LOANGR_GROUP				-0.005**
				(0.002)
LIQUID	-0.000	-0.001	0.005***	0.005***
	(0.000)	(0.000)	(0.001)	(0.001)
LOANDEP	-0.001	0.025***	0.023	0.031
	(0.003)	(0.009)	(0.041)	(0.039)
SAVINGS	0.024***		-0.566*	-0.513
	(0.005)		(0.344)	(0.335)
COOPERATIVE	0.020***		-0.282	-0.269
	(0.005)		(0.206)	(0.206)
LIST	0.006		0.868	0.863
	(0.009)		(0.602)	(0.584)
Constant	0.037**	2.051***	-0.137	-0.110
	(0.016)	(0.076)	(0.251)	(0.246)

No. of Observations	16,071	16,071	16,071	16,071
Adj. R^2	0.95	0.35		
Test for AR(1) (p-value) [1]			0.00	0.00
Test for AR(2) (p-value) [1]			0.22	0.24
Test for AR(3) (p-value) [1]			0.95	0.90
Hansen Test (p-value) [2]			0.55	0.35
Year Dummies	Yes	Yes	Yes	Yes
Country Dummies	Yes	Yes	Yes	Yes

1. AR(1), AR(2) and AR(3) are tests for first-, second and third-order serial correlation in the first-differenced residuals, under the null of no serial correlation

2. Hansen test of over-identification is under the null that all instruments are valid

Table 7: Results with Country Controls

Table 7 shows the results of regressions that additionally include country variables. GDPGR is the growth rate of real GDP and PCRDBGDP the ratio of private credit-to-GDP. CONC denotes the Herfindahl Index which measures the level of banking sector concentration and INTEREST RATE the long-term interest rate level. CREDIT GROWTH is the annual growth rate of the private credit-to-GDP ratio and CREDIT GAP the deviation of credit-to-GDP growth from its long-term trend (CREDIT GAP). All models are estimated using System GMM. All bank variables are treated as endogenous. The country variables are treated as exogenous. We use the first lag of the pre-determined variables and the second lag of the endogenous variable as instruments. Moreover, we combine the columns of the optimal instrument matrix by addition, and, hence, use only one instrument for each variable rather than one for each period. The validity of the instruments is tested using the Hansen's J test statistic. Furthermore, we test for first-, second- and third-order autocorrelation in the residuals. All test statistics are reported together with the total number of instruments used at the bottom of each regression table. Standard errors are reported in parentheses. ***/**/* indicates significance at the 1%-/5%-/10%-level.

	System GMM	System GMM	System GMM	System GMM
L.Z-Score	0.783***	0.776***	0.778***	0.774***
	(0.045)	(0.049)	(0.051)	(0.050)
L2.Z-Score	0.243***	0.218***	0.239***	0.233***
	(0.070)	(0.077)	(0.077)	(0.076)
SIZE	0.129***	0.089*	0.102**	0.099*
	(0.050)	(0.051)	(0.051)	(0.051)
NIM	0.281***	0.259***	0.314***	0.296***
	(0.052)	(0.054)	(0.059)	(0.060)
L.NIM	-0.122***	-0.112***	-0.145***	-0.136***
	(0.036)	(0.040)	(0.044)	(0.045)
NNINC	0.005*	0.004*	0.005**	0.005*
	(0.003)	(0.003)	(0.003)	(0.003)
LOANS	0.002	0.001	0.001	0.001
	(0.002)	(0.002)	(0.002)	(0.002)
LOANGR	-0.008***	-0.007**	-0.008**	-0.008**
	(0.002)	(0.003)	(0.003)	(0.003)
LIQUID	0.004***	0.004***	0.005***	0.005***
	(0.001)	(0.001)	(0.002)	(0.002)
LOANDEP	0.016	0.036	0.050	0.050
	(0.035)	(0.035)	(0.036)	(0.036)
SAVINGS	-0.006	0.047	0.061	0.057
	(0.083)	(0.094)	(0.095)	(0.095)
COOPERATIVE	0.124**	0.130**	0.154**	0.148**
	(0.057)	(0.060)	(0.062)	(0.062)
LIST	-0.205**	-0.131	-0.150	-0.146
	(0.103)	(0.110)	(0.110)	(0.110)
GDPGR	0.006	0.007	0.012	0.011
	(0.008)	(0.008)	(0.008)	(0.008)
PCRDBGDP		-0.063	-0.002	0.002
		(0.039)	(0.050)	(0.046)
CONC		-0.000	0.000	0.000
		(0.000)	(0.000)	(0.000)
INTEREST RATE		0.107**	0.137***	0.118**
		(0.048)	(0.051)	(0.054)
CREDIT GROWTH			0.010***	
			(0.003)	
L.CREDIT GROWTH			-0.013***	
			(0.003)	
CREDIT GAP				0.009***
				(0.003)

L.CREDIT GAP				-0.013***
				(0.003)
Constant	-0.677	-0.893*	-1.285**	-1.155**
	(0.418)	(0.470)	(0.499)	(0.488)
No. of Observations	16,071	15,504	15,504	15,504
Test for AR(1) (p-value) [1]	0.00	0.00	0.00	0.00
Test for AR(2) (p-value) [1]	0.03	0.15	0.13	0.13
Test for AR(3) (p-value) [1]	0.66	0.93	0.99	0.99
Hansen Test (p-value) [2]	0.40	0.37	0.61	0.61
Diff. in Hansen	0.22	0.17	0.50	0.50
Year Dummies	Yes	Yes	Yes	Yes
Country Dummies	Yes	Yes	Yes	Yes

1. AR(1), AR(2) and AR(3) are tests for first-, second and third-order serial correlation in the first-differenced residuals, under the null of no serial correlation

2. Hansen test of over-identification is under the null that all instruments are valid

3. Diff-in-Hansen tests of exogeneity is under the null that the country variables used are exogenous

Table 8: Results with Interaction Terms between SIZE and NNINC

Table 8 shows the results of regressions with interaction terms between the share of net non-interest income to total income and bank size (SIZE*NNINC). In columns (5) and (6) we exclude the smallest and the largest banks. The smallest banks comprise all banks with total assets less than the 5%-quantile of the distribution of bank size and the largest banks are all banks with assets larger than the 95%-quantile. All models are estimated using System GMM. All bank variables are treated as endogenous. The country variables are treated as exogenous. The validity of the instruments is tested using the Hansen's J test statistic. Moreover, we test for first-, second- and third-order autocorrelation in the residuals. All test statistics are reported together with the total number of instruments used at the bottom of each regression table. Standard errors are reported in parentheses. ***/**/* indicates significance at the 1%-/5%-/10%- level.

	System GMM	System GMM	System GMM	System GMM - excl. smallest and largest banks	System GMM - excl. smallest and largest banks
L.Z-Score	0.781***	0.772***	0.774***	0.733***	0.731***
	(0.048)	(0.047)	(0.048)	(0.040)	(0.039)
L2.Z-Score	0.262***	0.266***	0.269***	0.184***	0.182***
	(0.072)	(0.070)	(0.071)	(0.052)	(0.050)
SIZE	0.165***	0.166***	0.168***	0.150**	0.145**
	(0.055)	(0.055)	(0.055)	(0.073)	(0.072)
NIM	0.309***	0.349***	0.337***	0.366***	0.340***
	(0.065)	(0.067)	(0.070)	(0.096)	(0.099)
L.NIM	-0.134***	-0.161***	-0.152***	-0.188***	-0.171**
	(0.048)	(0.051)	(0.053)	(0.071)	(0.074)
NNINC	0.006***	0.007***	0.006***	0.006**	0.005**
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
SIZE*NNINC	-0.002**	-0.002**	-0.002**	-0.003**	-0.003*
	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)
LOANS	0.001	0.001	0.001	0.001	0.001
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
LOANGR	-0.008***	-0.008***	-0.008***	-0.004	-0.004*
	(0.003)	(0.003)	(0.003)	(0.002)	(0.002)
LIQUID	0.005***	0.006***	0.006***	0.006***	0.006***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
LOANDEP	0.044	0.055	0.057	0.044	0.045
	(0.038)	(0.037)	(0.037)	(0.033)	(0.032)
SAVINGS	0.062	0.087	0.075	0.197**	0.183**
	(0.098)	(0.095)	(0.098)	(0.084)	(0.084)
COOPERATIVE	0.166**	0.187***	0.180**	0.231***	0.221***
	(0.071)	(0.071)	(0.073)	(0.067)	(0.068)
LIST	-0.127	-0.119	-0.131	-0.022	-0.029
	(0.097)	(0.095)	(0.097)	(0.065)	(0.064)

GDPGR	-0.000	0.006	0.005	0.008	0.007
	(0.009)	(0.008)	(0.009)	(0.008)	(0.009)
PCRDBGDP	-0.053	-0.011	0.009	-0.005	0.018
	(0.039)	(0.049)	(0.047)	(0.045)	(0.042)
CONC	-0.000	0.000	-0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
INTEREST RATE	0.125**	0.151***	0.133**	0.180**	0.148*
	(0.055)	(0.055)	(0.061)	(0.077)	(0.084)
CREDIT GROWTH		0.011***		0.010***	
		(0.003)		(0.003)	
L.CREDIT GROWTH		-0.012***		-0.012***	
		(0.003)		(0.003)	
CREDIT GAP			0.009***		0.007**
			(0.003)		(0.003)
L.CREDIT GAP			-0.013***		-0.013***
			(0.003)		(0.003)
Constant	-1.278***	-1.502***	-1.446***	-1.295**	-1.142**
	(0.476)	(0.494)	(0.494)	(0.567)	(0.556)
No. of Observations	15,504	15,504	15,504	14,058	14,058
Test for AR(1) (p-value) [1]	0.00	0.00	0.00	0.00	0.00
Test for AR(2) (p-value) [1]	0.08	0.09	0.08	0.02	0.02
Test for AR(3) (p-value) [1]	0.94	0.94	0.97	0.91	0.88
Hansen Test (p-value) [2]	0.55	0.58	0.62	0.12	0.11
Diff. in Hansen	0.46	0.37	0.41	0.06	0.05
Year Dummies	Yes	Yes	Yes	Yes	Yes
Country Dummies	Yes	Yes	Yes	Yes	Yes

1. AR(1), AR(2) and AR(3) are tests for first-, second and third-order serial correlation in the first-differenced residuals, under the null of no serial correlation

2. Hansen test of over-identification is under the null that all instruments are valid

3. Diff-in-Hansen tests of exogeneity is under the null that the country variables used are exogenous

Table 9: Result for Leverage and Portfolio Risk

Table 9 shows the results of regressions with the Z-Score and its components as alternative indicators of bank risk. The first component is the return on average (ROA) divided by the standard deviation of ROA and is a measure of bank's portfolio risk. The second component is the ratio of total equity divided by total assets over the standard deviation of ROA and is a measure of leverage risk. All models are estimated using System GMM. All bank variables are treated as endogenous. The country variables are treated as exogenous. The validity of the instruments is tested using the Hansen's J test statistic. Furthermore, we test for first-, second- and third-order autocorrelation in the residuals. All test statistics are reported together with the total number of instruments used at the bottom of each regression table. Standard errors are reported in parentheses. ***/**/* indicates significance at the 1%-/5%-/10%- level.

	Z-SCORE	PORTFOLIO RISK	LEVERAGE RISK	Z-SCORE	PORTFOLIO RISK	LEVERAGE RISK
L.Z-Score	0.772***			0.774***		
	(0.047)			(0.048)		
L2.Z-Score	0.266***			0.269***		
	(0.070)			(0.071)		
L.Profitability Risk		0.269***			0.275***	
		(0.041)			(0.041)	
L2.Profitability Risk		0.011			0.011	
		(0.044)			(0.044)	
L.Leverage Risk			0.886***			0.896***
			(0.067)			(0.069)
L2.Leverage Risk			0.175**			0.185**
			(0.083)			(0.085)
SIZE	0.166***	-0.033	0.134***	0.168***	-0.013	0.137***
	(0.055)	(0.146)	(0.052)	(0.055)	(0.146)	(0.052)
NIM	0.349***	0.552***	0.245***	0.337***	0.598***	0.226***
	(0.067)	(0.140)	(0.059)	(0.070)	(0.142)	(0.060)
L.NIM	-0.161***	-0.048	-0.123***	-0.152***	-0.070	-0.109**
	(0.051)	(0.121)	(0.043)	(0.053)	(0.123)	(0.045)
NNINC	0.007***	0.014**	0.004*	0.006***	0.013**	0.004*
	(0.002)	(0.006)	(0.002)	(0.002)	(0.006)	(0.002)
SIZE*NNINC	-0.002**	0.001	-0.002**	-0.002**	0.002	-0.002**
	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)
LOANS	0.001	-0.006	0.001	0.001	-0.006	0.001
	(0.002)	(0.004)	(0.001)	(0.002)	(0.004)	(0.001)
LOANGR	-0.008***	0.007	-0.006**	-0.008***	0.005	-0.007**
	(0.003)	(0.006)	(0.003)	(0.003)	(0.006)	(0.003)
LIQUID	0.006***	-0.004	0.005***	0.006***	-0.004	0.005***
	(0.002)	(0.004)	(0.002)	(0.002)	(0.004)	(0.002)
LOANDEP	0.055	0.023	0.062**	0.057	0.043	0.064**
	(0.037)	(0.110)	(0.031)	(0.037)	(0.107)	(0.031)

SAVINGS	0.087	0.305**	0.064	0.075	0.270**	0.039
	(0.095)	(0.136)	(0.101)	(0.098)	(0.136)	(0.106)
COOPERATIVE	0.187***	0.283**	0.144*	0.180**	0.295**	0.128
	(0.071)	(0.140)	(0.078)	(0.073)	(0.138)	(0.082)
LIST	-0.119	0.261	-0.106	-0.131	0.172	-0.124
	(0.095)	(0.205)	(0.088)	(0.097)	(0.201)	(0.092)
GDPGR	0.006	-0.090***	0.008	0.005	-0.079***	0.006
	(0.008)	(0.023)	(0.008)	(0.009)	(0.023)	(0.008)
PCRDBGDP	-0.011	-0.720***	0.054	0.009	-0.542***	0.072
	(0.049)	(0.136)	(0.053)	(0.047)	(0.125)	(0.053)
CONC	0.000	-0.000***	0.000	-0.000	-0.001***	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
INTEREST RATE	0.151***	-0.346***	0.148***	0.133**	-0.277**	0.121**
	(0.055)	(0.122)	(0.046)	(0.061)	(0.123)	(0.051)
CREDIT GROWTH	0.011***	0.014**	0.008***			
	(0.003)	(0.006)	(0.003)			
L.CREDIT GROWTH	-0.012***	0.011**	-0.011***			
	(0.003)	(0.006)	(0.003)			
CREDIT GAP				0.009***	0.003	0.007***
				(0.003)	(0.006)	(0.003)
L.CREDIT GAP				-0.013***	0.006	-0.012***
				(0.003)	(0.006)	(0.003)
Constant	-1.502***	0.748	-1.423**	-1.446***	0.398	-1.375**
	(0.494)	(0.649)	(0.565)	(0.494)	(0.646)	(0.548)
No. of Observations	15,504	14,013	15,504	15,504	14,013	15,504
Test for AR(1) (p-value) [1]	0.00	0.00	0.00	0.00	0.00	0.00
Test for AR(2) (p-value) [1]	0.09	0.81	0.29	0.08	0.78	0.24
Test for AR(3) (p-value) [1]	0.94	0.38	0.35	0.97	0.44	0.46
Hansen Test (p-value) [2]	0.58	0.30	0.82	0.62	0.20	0.90
Diff. in Hansen	0.37	0.32	0.62	0.41	0.42	0.74
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Country Dummies	Yes	Yes	Yes	Yes	Yes	Yes

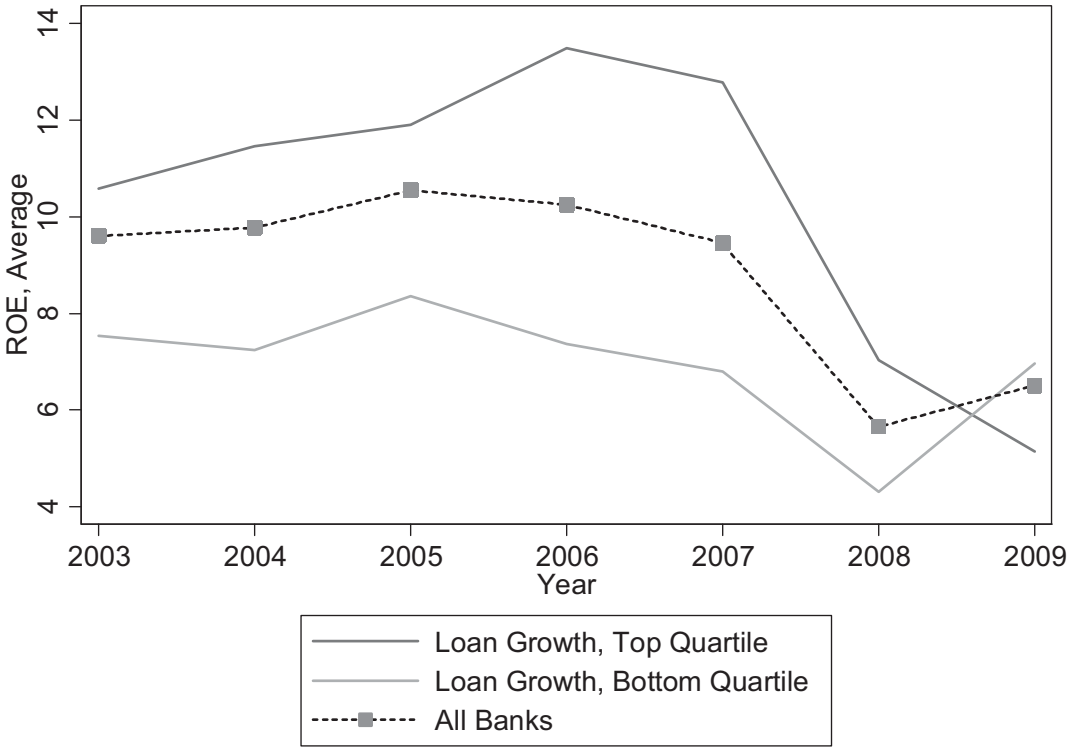
1. AR(1), AR(2) and AR(3) are tests for first-, second and third-order serial correlation in the first-differenced residuals, under the null of no serial correlation

2. Hansen test of over-identification is under the null that all instruments are valid

3. Diff-in-Hansen tests of exogeneity is under the null that the country variables used are exogenous

Figure 1: Bank Profitability

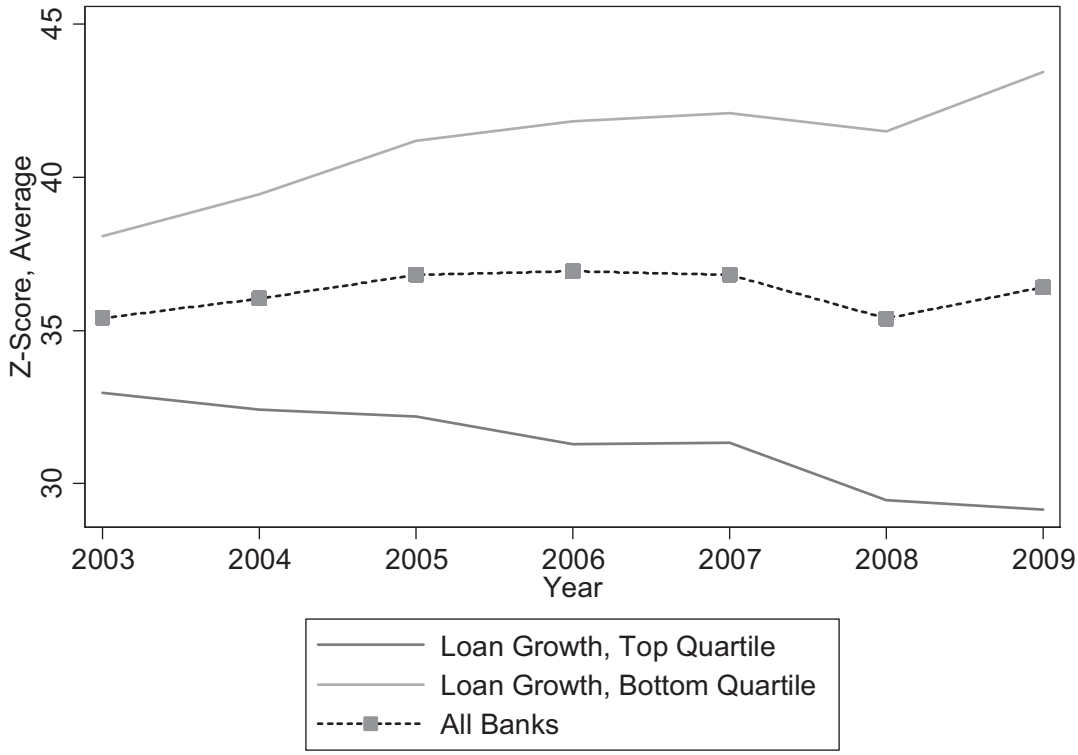
Figure 1 shows the development of the average return-on equity (ROE) for all banks in our sample and for the banks in the bottom (lowest rate of loan growth) and top quartile (highest rate of loan growth) of the distribution of average loan growth between 2003 and 2006. ROE is winsorized at the 1%- and 99%-level. The sample includes 2,966 banks from the 15 EU countries reported in Table 1.



Source: Bankscope (2011) and own calculations.

Figure 2: Development of the Average Z-Score

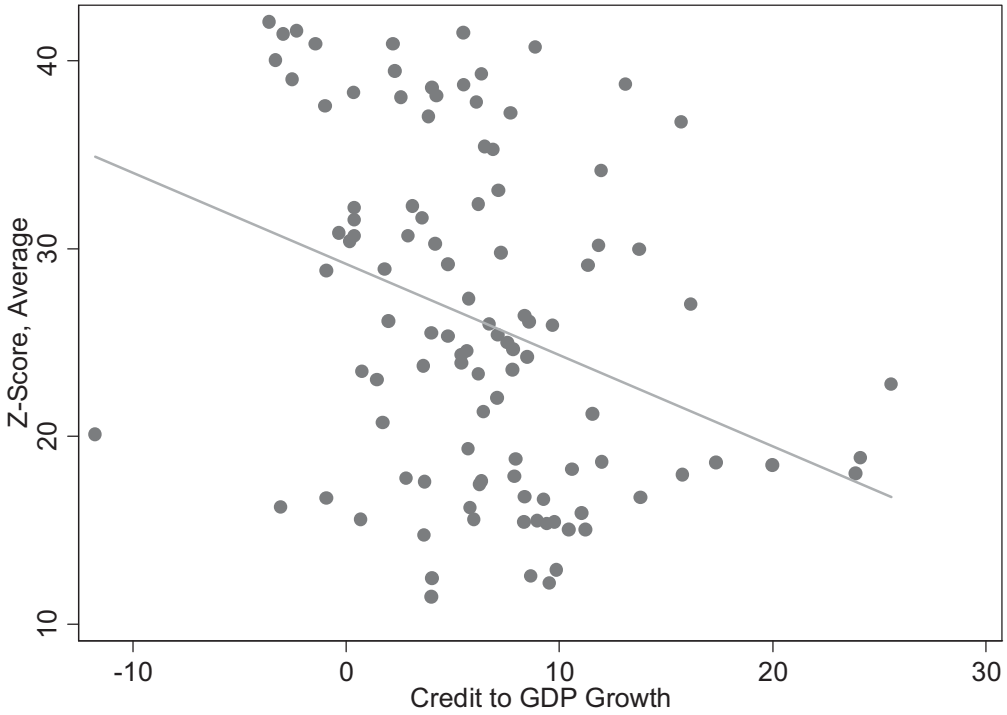
Figure 2 shows the development of the average Z-Score for all banks in our sample and for the banks in the bottom (lowest rate of loan growth) and top quartile (highest rate of loan growth) of the distribution of average loan growth between 2003 and 2006. The Z-Score is the ratio of the return on assets (ROA) plus the capital ratio (CAR) divided by the standard deviation of the return on assets (SDROA). ROA and CAR are winsorized at the 1%- and 99%-level. The sample includes 2,966 banks from the 15 EU countries reported in Table 1.



Source: Bankscope (2011) and own calculations.

Figure 3: Bank Risk-Taking and Private Credit-to-GDP Growth

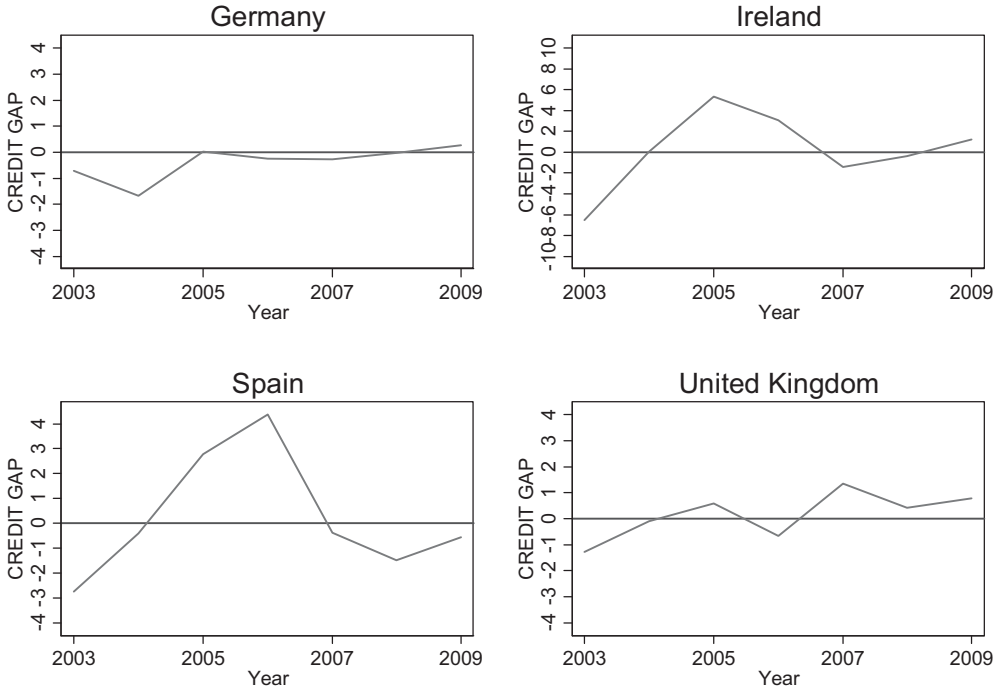
Figure 3 shows the relationship between the Z-Score and Private Credit-to-GDP growth (CREDIT GROWTH). The Z-Score is the ratio of the return on assets (ROA) plus the capital ratio (CAR) divided by the standard deviation of the return on assets (SDROA). Both variables are averaged over countries and years. Bank risk is measured by the Z-Score which is defined as the ratio of the return on assets (ROA) plus the capital ratio (CAR) divided by the standard deviation of the return on assets (SDROA). ROA and CAR are winsorized 1%- and 99%-level. The sample includes 2,966 banks from the 15 EU countries reported in Table 1.



Source: Bankscope (2011), World Bank (2011) and own calculations.

Figure 4: Credit Gap

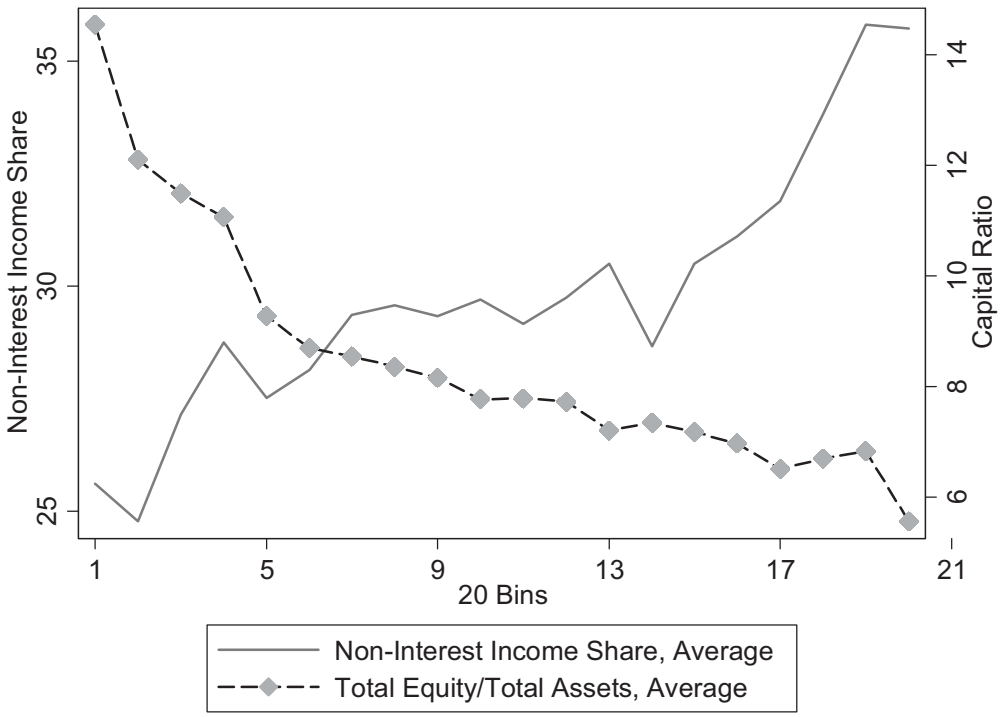
Figure 4 shows the development of the credit gap (CREDIT GAP) in Germany, Ireland, Spain and the United Kingdom between 2003 and 2009. The credit gap is defined as the difference between current private credit to GDP growth and its long-term average. The long-term trend is obtained using the Hodrick-Prescott (1981) filter with a smoothing parameter of 6.25. To calculate the long-term trend we use annual data on private credit-to-GDP growth for period between 1960 and 2009. Please note that the y-axis is labeled differently for Ireland than for the other countries.



Source: World Bank (2011) and own calculations.

Figure 5: Relationship between non-interest income, capital and bank size

Figure 5 shows the relationship between banks' average non-interest income share (NNINC), the ratio of total equity to total assets (CAR) and bank size (SIZE). Banks are divided according to their size into 20 groups each containing 5% of observations. For each of these groups, we calculate the average non-interest income share and average capital ratio and plot them against the 20 bins of the distribution. All variables are winsorized at the 1%- and 99%-level. The sample includes 2,966 banks from the 15 EU countries reported in Table 1.



Source: Bankscope (2011) and own calculations.

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