

Banking regulation and bank performance in the EU – what should be the scope of the regulatory reform?

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Abstract

This study is aimed at investigating the link between banking regulation and bank performance in EU countries during the sample period 2005–2014. It covers 929 banks from 27 EU countries. The three main contributions of the study are: the analysis of banking regulations and their changes in 2003, 2008 and 2012, the investigation of their mutual relation with bank performance in 2005–2014, as well as the analysis of intertemporal effects and endogeneity between the post-crisis changes of regulations and bank performance.

Contrary to the results of previous studies, the analysis conducted in this paper suggests that national banking regulations had a significant impact on individual bank performance. Also, the results show that some unregulated bank characteristics, i.e. individual and systemic bank size may influence bank performance significantly. The obtained results have implications for the ongoing discussion about the banking regulatory reform in EU countries.

Keywords: banking regulation, banking supervision, bank performance, banking system soundness, EU banking

JEL: G21, G28, F36

1. Introduction

The latest financial crisis revealed substantial drawbacks in the banking regulatory frameworks of the EU countries. The regulations put forward in Basel II were not sufficient to prevent unstable credit booms. Even countries with conservative regulations incurred large losses in their banking sectors. The banking regulatory frameworks became subject of criticism among economists and policymakers. Commonly criticized elements were: insufficiently stringent and clear capital adequacy rules, the procyclicality of banking regulations, uniform regulations for banks engaging solely in banking activities and for those engaging in non-bank activities, as well as excessive consolidation leading to market power concentration (Blundell-Wignall, Atkinson 2010). A reaction to the crisis was regulatory reform on national and supranational levels (BCBS 2010; 2011). Nevertheless, the regulatory frameworks in the EU countries seem to be still insufficiently equipped to counteract future financial crises (Quaglia 2013). Also, as shown in this study, despite the harmonization of EU banking rules, the regulatory frameworks of the respective countries differ substantially. To answer the question what the focus of further reform should be, it is essential to analyse which banking features and forms of regulations matter for bank performance.

This study is aimed at investigating the link between banking regulation and bank performance in EU countries during the sample period 2005–2014. Previous papers point to ambiguity in the investigated relation (Pasiouras, Tanna, Zopounidis 2009; Klomp, Haan 2012; Demirgüç-Kunt, Detragiache 2011). The regulations considered in the paper concern bank entry regulations, capital requirements, activity regulations, auditing standards, liquidity requirements, deposit insurance schemes, problematic institutions regulation and supervisory power. The present paper's contribution consists in the computation of detailed banking regulatory indices in 2003, 2008 and 2012 and the analysis of their changes over this period. Moreover, the focus on a broad set of commercial banks allows to investigate the mutual relation between bank regulation and performance. This study is novel in its dynamic approach to regulations, considering that the focus of previous studies in the field was limited to the effects of point-in time regulations. A new approach is also adopted by investigating intertemporal effects and endogeneity between the post-crisis changes of regulations and bank performance.

Contrary to the results of previous studies, the analysis conducted in this paper suggests that national banking regulations had a significant impact on individual bank performance as well as on the systemic banking sector soundness as measured by z-scores, nonperforming loans to assets ratios and loans to assets ratios respectively. In addition, some unregulated bank characteristics, i.e. individual and systemic bank size may influence bank soundness significantly. The obtained results have implications for the ongoing discussion about the banking regulatory reform in EU countries.

The paper is structured as follows: section two reviews the related literature, section three deals with data and sample description, section four describes the empirical model, section five provides the results and the robustness check, section six concludes.

2. Literature review

Banking regulation can influence bank performance through various channels. The impact of regulations on banks' financial results differs depending on the aspect of regulation, banking system structure and institutional factors. Both, theoretical papers and empirical studies point to ambiguity in the investigated relation.

The most commonly studied aspect of banking regulation are capital requirements. Literature is not unanimous about how strict capital regulations impact bank performance. Capital regulation affects competition and intermediation strategies of banks (Mehran, Thakor 2011). It constitutes a guarantee of bank soundness and it is viewed as a buffer against potential losses. Moreover, it is aimed at protecting debtholders against moral hazard arising from deposit insurance (Berger, Herring, Szegő 1995). High levels of capital also constrain the involvement of banks in risky projects and hence mitigate risk-shifting incentives from shareholders to debtholders (Berger, Herring, Szegő 1995; Altunbas, Manganeli, Marques-Ibanez 2011).

Mehran and Thakor (2011) find that the level of capital is positively correlated with the bank value and its respective components. This positive relation is driven by intensified monitoring of borrowers in banks with high capital levels. As a result, the quality of loans and the value of bank portfolios increase. They also show that excessive capital accumulation is undesirable since their model predicts that there are optimal levels of capital for each bank. This argument is also raised by Berger, Herring and Szegő (1995). They stress that if equity exceeds the market requirement for capital, the value of the bank declines and its financing cost increases. Arguments in favour of optimal capital levels are also found by Calem and Rob (1999), who show that both very low and very high levels of capital are conducive to excessive risk-taking by banks.

High levels of capital can influence bank performance negatively due to various factors. Excessively strict regulations may constrain bank activities, i.e. they may reduce deposit funding (Diamond, Rajan 2000; 2001; Gorton, Winton 2014). Given that equity financing is more expensive than deposit financing capital regulations exacerbate the willingness to lend and hence decrease the value of bank's portfolios (Thakor 1996). Moreover, strict regulations impose a financing cost for banks since the levels of capital are chosen for the whole banking sector without accounts for individual bank characteristics (Repullo, Suarez 2008; Allen, Carletti, Marquez 2011).

It is also possible that high equity ratios will align the interest of managers and shareholders to increase risk at the cost of debtholders. A higher leverage ratio motivates borrowers to exert pressure on bank managers and hence mitigates this problem (Diamond, Rajan 2001). Berger, Herring and Szegő (1995), however, point to an opposite effect, hence in the presence of deposit insurance strict capital regulations help to keep the interest of banks and depositors in line and limit risk taking incentives at the cost of depositors.

High capital requirements can also lead to excessive risk taking since they boost banks' risk absorption capability (Berger, Bouwman 2012). This view is also held by Blum (1999) who shows that if accumulating equity becomes more expensive due to high capital requirements, this implies lower profits. The only possibility to increase the future value of equity is to increase the risk of current bank activities. The prospect of future lower profits will render banks less cautious about investments in risky assets. Similarly, Besanko and Kanatas (1996) stressed that the increase of capital requirements, conducive to additional equity issuance may lead to stock price decrease and hence curtail profits and increase banks' financing cost.

Generally, the majority of empirical papers show that well capitalized banks perform better, especially during times of financial crises (Demirgüç-Kunt, Detragiache, Merrouche 2010; Berger, Bouwman 2012; Beltratti, Stulz 2012; Klomp, Haan 2012; Pasiouras, Tanna, Zopounidis 2009; Vallascas, Keasey 2012; de Jonghe 2010).

Another strand of literature focuses on the role of banking activity regulation. Some authors stress that strict regulations e.g. ringfencing of non-banking and banking activity can prevent conflicts of interest between the respective activities. Strict regulations prevent banks from subordinating less profitable activities to more profitable ones, a practice which may increase their propensity to take risk (Boyd, Chang, Smith 1998; Barth, Caprio, Levine 2004). Also the income derived from non-interest activities e.g. investment banking or brokerage is much more volatile than interest income (Altunbas, Manganelli, Marques-Ibanez 2011). In the event of financial distress banks would suffer much higher losses than in the absence of non-interest activities.

Another interaction channel between activity regulation and bank performance is that broadened banking activity increases bank size and banks become harder to supervise. Various studies find that larger banks take on more risk, especially during crises, mainly due to their moral hazard incentives and the possibility to engage in diversified high risk activities (Altunbas, Manganelli, Marques-Ibanez 2011; Vallascas, Keasey 2012; Demirgüç-Kunt, Huizinga 2012). Activity regulation also affects bank performance through competition channels. Allowing banks to get involved in various activities will lead to growing bank size and oligopolistic structures exacerbating competition (Barth, Caprio, Levine 2004). On the other hand, liberalization of activity regulations allowing banks to achieve economies of scale and scope and diversification benefits are conducive to greater bank stability (Barth, Caprio, Levine 2004; Altunbas, Manganelli, Marques-Ibanez 2011).

Empirical evidence leads to contradictory results. Altunbas, Manganelli and Marques-Ibanez (2011) find benefits of banking activity diversification during the latest financial crisis. Lepetit et al. (2008) studied the impact of bank activity diversification in the EU on bank risk. Their results showed that banks involved in non-interest activities faced higher risk than the ones involved only in deposit taking and lending. Still, in the case of small banks their involvement in trading activities instead of commission and fee activities decreased default risks. Also Mercieca, Schaeck and Wolfe (2007) investigated the relation between bank activity diversification and bank performance measured by risk and profitability indicators on a sample of small banks in the EU. They did not find significant improvement in bank performance associated with diversification. De Jonghe (2010) finds that non-interest income increases individual bank risk.

Another important component of banking regulation to consider are entry regulations for new banks. Strict entry regulation leads to monopolistic power of incumbent banks and exacerbates competition (Barth, Caprio, Levine 2004). Nevertheless, Keeley (1990) views monopolistic structures as positive since increased franchise value of banks prevents credit institutions from excessive risk-taking.

Further regulations which are discussed in the literature are deposit insurance schemes and supervisory frameworks. Deposit insurance is viewed as a preventive measure against bank runs, even though Dewatripont and Tirole (1994) show that in the presence of risk-based capital requirements, risk-based deposit insurance may contribute to increased risk-taking. Banks, knowing the level of insurance premia, can take on more risk to achieve a predetermined return. To counteract moral hazard in the presence of deposit insurance, accurate supervision is necessary (Barth, Caprio, Levine 2004). Many studies, though, stress the importance of carefully balanced supervisory power for proper banking

system functioning. If the authorities are granted too much supervisory power, it may lead to politically induced decisions and bring down banks' performance (Djankov et al. 2002; Quintyn, Taylor 2002).

The ambiguity displayed by the economic literature with respect to the impact of banking regulations and bank features on bank performance suggests the necessity of further research. This study contributes to each of the mentioned literature strands by investigating empirically the mutual relation between the respective banking regulatory measures and banks' financial results in the EU. The main difference with respect to related empirical studies lies in the dynamic approach to regulations taken in the present paper. Other studies focus solely on the effects of point-in time regulations. Another facet of a novel approach is the investigation of intertemporal effects and endogeneity between the post-crisis changes of regulations and bank performance.

On the basis of the reviewed literature the following testable hypotheses are developed:

H1: If the risk shifting mitigation channel holds, strict capital requirements should lower bank risk.

H2: If the increased borrower screening channel holds, strict capital requirements should be negatively related to nonperforming loans (NPLs).

H3: If the lending contraction channel holds, strict capital requirements should decrease lending.

H4: If activity diversification allows to achieve economies of scope, strict activity regulation should improve the performance of bigger banks.

H5: If activity diversification increases risk, banks from countries with lax activity regulations should have higher risk.

H6: If the monopolistic power channel holds, strict entry regulations should improve the performance of bigger banks.

The focus of this study on EU framework allows to counter the commonly held view about the unification of banking regulation within this group of countries and to explore the substantial differences in this field among the respective countries. The study of EU-specific regulatory aspects may provide new data on the relation between bank regulation and bank performance and hence may be useful to draw conclusions on the necessary banking regulatory reform.

3. Data and sample description

The study covers 929 banks from 27 EU countries. Banks are investigated during the sample period 2005–2014. The chosen time span allows to capture short term, immediate effects of regulations. Data on individual bank characteristics were taken from the Bankscope. Data are unbalanced due to the different sizes of banking sectors. The number of banks per country included in the sample is presented in Table 1.

The summary statistics (Table 2) point to large variation of banking features within the sample. The mean z-score takes the value of 3.77 over the whole period and 3.33 during the crisis with maximum and minimum values ranging from -10.29 to 220.07 and -3.71 to 112.67 in the respective periods. This points to large variation of default risk resistance among banks in EU countries. The variation of z-scores may be either due to substantial differences in banks' profitabilities (ROA's range between -149.50 and 84.37) or due to differences in capitalization (equity to assets ratios vary from 0.0004 to 0.99 between banks). One can also observe large variation of bank liquidity. The sample is strongly differentiated in terms of bank size. The value of banks' assets ranges from EUR 8.677 million to

EUR 1860 bn. Due to the large differences in bank size as a robustness check the outliers are eliminated from the sample. Banks with assets exceeding EUR 500 bn and those below the EUR 50 million threshold are excluded, which leaves 886 banks in the sample.

The correlation matrix (Table 3) shows low correlations between the majority of bank features with the exception of significant correlation between individual and systemic bank size. In the robustness check the systemic bank size is excluded from the specification in order to rule out its excessive impact (if combined with individual size) on the results. To account for possible collinearity, the specification is tested for variance inflation factors.

The computation of the banking regulatory indices is based on three surveys conducted by the World Bank in 2003, 2008 and 2012. The data allows to measure regulatory features during the sample period with close to 630 indicators and aggregate them into broad groups of regulations by means of principal component analysis. The survey encompasses detailed questions to regulators about the banking regulatory framework in their countries. The questions are grouped into broad categories of regulations: entry into banking (chapter 1 and 2), capital adequacy (chapter 3), banking activity regulation (chapter 4), auditing standards (chapter 5), liquidity requirements (chapter 7), depositor protection schemes (chapter 8), problematic institutions' regulations (chapter 11) and supervision (chapter 12). Chapter 6 on bank governance and chapter 9 on asset quality regulation are not included in the sample due to incomplete data for the majority of the countries. The study excludes also chapter 10 on accounting standards. Since these are substantially harmonized in the EU, there is very little variation in the cross-country data to be found.

To compute the banking regulatory measures, scores are assigned to each answer. The scoring follows the line of Barth, Caprio and Levine (2004), i.e. it assigns higher values to more stringent regulations. The majority of the variables included in the analysis are linked to Yes/No questions, e.g. questions about the existence of certain regulations. The answers are assigned a score of zero in the case of lax regulations and one in the case of strict regulations. Another group of variables is based on quantitative questions, e.g. ratios and currency amounts. For this type of questions pure numbers are used. The third group consists of questions concerning the extent of regulation, where one or more options from a set of alternatives had to be chosen, e.g. to determine whether some procedures are allowed, to what extent, and with what limitations or whether they are prohibited. The scoring assigns values from one to four where higher measures indicate higher stringency of regulations. The regulatory measures are computed by means of principal component analysis. The ultimate measures are based on the first principal component of each group.

The current, post-crisis banking regulatory measures are presented in Table 4. The indicators are computed on the basis of the World Bank Survey (2012). They point to a large differentiation of regulation stringency in the EU. Generally, in all the countries the measures for various groups of regulations vary adopting both positive as negative values, which points to substantial differentiation of regulation stringency within the respective economies.

Worth noting is the high regulatory stringency in some of the large EU economies. Particularly strict regulations can be found in Germany, especially in the domain of asset classification (0.80) and deposit insurance (0.77). Conversely, the statistics point to loose regulations of bank entry and activity (-2.9, -2.21) in this country. France, to take another example, regulates both deposit insurance (0.61), and the scope of banking activity (0.71) quite strictly. High values of activity regulation (0.61), as well as auditing requirements (0.69) can be found in the Italian framework.

Statistics point to loose regulations in two large EU economies – UK and Spain. The UK has one of the most liberal frameworks in the EU – the majority of the measures take on negative values. Especially one has to notice an extremely low indicator of problematic institutions' supervision (-7.02). The other regulatory measures take on negative values as well, with the exception of liquidity requirements, which appear to be relatively strict (0.57). Spain, which is known for conservative banking supervision, has indeed a high positive value for this measure (0.49) and also stringent entry regulations (0.41), but the majority of other measures yield negative signs. Loose regulations might have contributed to the banking crisis experienced by this country, despite stringent supervisory practices.

The stringency of regulations differs among other countries which were hit by banking crises. Ireland has very loose regulations, the majority of the indicators are negative, especially low values correspond to activity regulation (-0.9), problematic institutions' regulations (-0.54) and supervision (-0.57). Statistics point to loose auditing requirements (-0.56) and supervision (-0.30) in Greece. In Portugal, on the other hand, indicators take on positive values with the exception of liquidity requirements (-0.47) and the capital adequacy indicator (-0.42), which is the lowest in the EU.

Central and Eastern European countries are quite conservative in terms of regulations with the exception of Latvia and Estonia. Slovakia and Lithuania have particularly high positive indicators in the majority of regulatory areas.

In the next step of the study the indicators of regulation changes between 2003 and 2008 as well as between 2008 and 2012 are computed. The changes are analysed for each question of the survey. The indicators show that the regulatory frameworks in the EU have undergone substantial changes between the respective World Bank assessments in 2003, 2008 and 2012 (Tables 12 and 13). The modification of the frameworks are described in detail in section 5.2, subsequently to the empirical analysis which allows to test these changes from the perspective of their desirability.

4. Empirical specification

Following Demirgüç-Kunt and Detragiache (2011) the study uses the z-score as the basic measure of bank performance. Z-scores are computed according to the formula:

$$Z_{it} = \frac{ROA_{it} + Equity_{it} / Total\ assets_{it}}{\text{the standard deviation of } ROA_i} \quad (1)$$

where the subscript i denotes a bank and the subscript t denotes the year. The z-score indicates the amount by which profits of a bank must fall to push it into insolvency. The standard deviation of ROA is computed for two periods in the case of each bank, i.e. 2005–2014 and 2007–2010. As a result, respectively ten and four z-scores for each bank are obtained (one z-score per year). For the purpose of the cross-sectional model the averages of the z-scores are computed. Ultimately one average z-score per bank is obtained.

The z-score has many desirable features as a basic risk measure. It is widely used in bank performance studies due to its conceptual simplicity and the fact that it can be computed on the basis of accounting data. Contrary to market-based risk measures it can be constructed also for non-listed banks (Lepetit, Strobel 2013). Its drawback is that it reflects only one aspect of banks' financial situation

– the relation of profitability to capitalization. It abstracts from other forms of banks' resilience to bankruptcy, i.e. funding and profit structures, loan performance or liquidity.

To test the hypotheses pointed out in section 1, the study also uses the level of nonperforming loans to assets and the level of loans to assets as performance measures. For each bank two average values of performance measures are computed – for the whole sample period and for the crisis period respectively. To compensate for the deficiencies of simple performance measures, indicators reflecting funding structures and bank liquidity are used as control variables.

The baseline empirical model is specified for two periods: the whole sample period 2005–2014 and the crisis period 2007–2010. For the whole sample period the impact of banking regulatory measures from 2003 is investigated, for the crisis period the impact of the measures from 2008. The model has the following form:

$$PERFORMANCE_{2005-2014,ij} = \alpha_1 IBF_{ij} + \beta_1 BR_{2003,j} + \gamma_1 MACRO_j + \delta_1 INTERVENED_{ij} + \varepsilon_{1ij} \quad (2)$$

$$PERFORMANCE_{2007-2010,ij} = \alpha_2 IBF_{ij} + \beta_2 BR_{2008,j} + \gamma_2 MACRO_j + \delta_2 INTERVENED_{ij} + \varepsilon_{2ij} \quad (3)$$

The subscript i stands for the respective banks, the subscript j for the respective countries. The performance measures are respectively: z-scores, NPL to asset ratios and loan to asset ratios. IBF_{ij} is a set of individual bank features, BR_j is a set of banking regulatory variables and $MACRO_j$ stands for a set of macroeconomic control variables. ε_{ij} is the error term. Variables describing bank characteristics are: bank individual size measured as the log of total assets, bank systemic size proxied by the ratio of total assets to GDP, liquid assets to deposits and short term funding as a proxy for bank liquidity, and loan loss provisions to assets as an indicator of credit risk resistance. A variable reflecting the funding structure of the bank is long-term funding to short-term funding. The banks activity profile is proxied by the value of net gains from trading and derivatives to assets. These variables are included in the model due to their influence on bank performance. Furthermore, some of these banking features are not yet regulated, which might have implications in terms of the planned reform. The banking regulatory variables encompass the measures specified in section 2. As macroeconomic controls real GDP growth and annual average nominal exchange rates are used. Since the performance of banks may be partially due to the capital provided by state aid, the specification includes a further dummy variable *INTERVENED* which defines whether the bank has received state aid. These data are based on the relevant European Commission decision texts available on the state aid websites of the EC.

The first model specification allows to test the hypotheses no. 1–3. To test the hypotheses 4–6 the model is modified to include interactions between banking regulatory variables and bank size.

$$PERFORMANCE_{2005-2014,ij} = \alpha_3 IBF_{ij} + \beta_3 BR_{2003,j} \cdot Bank\ size_{ij} + \gamma_3 MACRO_j + \mu_{1ij} \quad (4)$$

$$PERFORMANCE_{2007-2010,ij} = \alpha_4 IBF_{ij} + \beta_4 BR_{2008,j} \cdot Bank\ size_{ij} + \gamma_4 MACRO_j + \mu_{2ij} \quad (5)$$

Further on, the inverse relation between bank regulation and bank performance is tested to account for potential endogeneity between those variables. Correlations between changes of z-scores over 2007–2010 and changes of regulations over 2008–2012 are computed to check whether the post-crisis modifications of the frameworks were affected by performance changes of the banks during the crisis.

5. Results

5.1. The impact of regulations on banks' performance

First, a set of analyses conforming to the baseline regressions is performed. The banking regulatory variables are included in separate regressions due to high correlation among some of them. The results are presented in Tables 5–7. The diagnostic tests point to a proper specification. The model fitting is comparable to the results obtained in related studies. The variance inflation factor (VIF) values range between 2.05 and 2.80 indicating a lack of collinearity.

Since some of the variables do not vary among banks only among countries, the standard errors are clustered within countries. The estimates in the first rows of the respective variable lines refer to the whole sample period, i.e. 2005–2014, in the second row to the crisis period, i.e. 2007–2010.

Three out of eight regulatory measures influenced z-scores significantly (Table 5). The impact of entry regulations was positive during the whole sample period while it turned negative and insignificant during the crisis. Depositor protection stringency had a negative influence on z-scores but this effect was only significant during the crisis period. The stringency of problematic institutions' regulations impacted z-scores negatively during both periods.

Significant coefficients are obtained also for some of the individual bank features. Systemic bank size influenced z-scores negatively, whereas individual bank size contributed to an increase in the distance to default. This result might be an indication in terms of regulations of bank size. It is not bank size per se that should be in the scope of regulations but its systemic importance. A rather surprising result is the negative relation between bank z-scores and liquidity and credit risk resistance respectively. A possible explanation is that high levels of loan loss reserves and liquidity buffers impaired the activity and investment possibilities of banks and hence constrained profits and lowered z-scores. Funding structures and activity profiles were insignificant for z-scores. The performance was influenced significantly by exchange rates in the case of banks based in non-euro zone countries. One could also notice a significant impact of state interventions on z-scores. Intervened banks had on average lower z-scores than non-intervened ones. This result could be due to the fact that only underperforming banks were intervened in. Nevertheless, the significance of this effect over the whole period points to failure to improve performance on the part of the intervened banks or their potentially worse performance even before the crisis.

The results in Table 6 show that liquidity requirements helped to constrain NPLs over the whole period, nevertheless this effect turns insignificant during the crisis. Similarly, the regulation of problematic institutions counteracted NPLs over the whole period, but this effect is reversed and becomes insignificant during the crisis.

Individual bank size increased NPLs, while systemic bank size had the opposite effect. A potential explanation for this tendency is that systemically large banks focus their activity more on trading and investment instead of deposit taking and lending. Individually big banks may have acquired a large part of their assets through lending. This view is supported by the significant positive correlation between individual bank size and the value of loans to assets and the negative correlation between bank systemic size and the value of loans to assets (Table 3).

The results also show that banks with a higher share of long-term funding had less NPLs, while banks with a higher share of income from trading and derivatives, on the contrary, had more NPLs.

Both results may be due to various incentives to borrower screening. The impact of a high share of income from trading and derivatives may offer an indication for the adequate scope of activity regulation.

Contrary to the estimates obtained for z-scores there was no significant difference between intervened and not intervened banks in terms of NPLs. This result shows that interventions may have had no influence on borrower screening but had their effects limited to the levels of capital.

The estimates presented in Table 7 show that three banking regulatory measures impacted the level of loans. Activity regulation affected loans positively although this effect turned insignificant during the crisis. Contradictory results are obtained in the case of problematic institutions' regulation. Over the whole period its impact on the level of loans was significantly positive while it turned significantly negative during the crisis period. This result may be due to the fact that the stringency of discipline for problematic institutions materialized only during crisis and might have constrained the willingness of banks to lend. Deposit insurance stringency affected lending positively during the crisis. This relation was negative and insignificant over the whole period.

Intervened banks lent generally less than non-intervened ones, and significantly less during the crisis. Individual bank size impacted loans positively while systemic bank size negatively. This result might reflect the mentioned differences in activity profiles of systemically large banks and regular banks. Banks with higher shares of gains from trading and derivatives overall lent more, although this trend turned negative and insignificant during the crisis. This result may reflect the effects of fluctuations of the gains from trading and derivatives on the one hand, and on the other hand the reduced willingness of banks to lend during times of financial turmoil.

The above-described results allow to verify the hypotheses 1–3 formulated in section 2. Since in none of the regressions capital requirements mattered for risk and other parameters of bank performance, the study finds no support for either of the capital channels. To verify hypotheses 4–6 additional regressions with interactive terms are estimated conforming to the models (4) and (5).

To test hypothesis 4 and 5 individual bank size and activity diversification are linked. The effects are tested over the whole sample period 2005–2014 as well as over the crisis period 2007–2010. The estimates are presented in Table 8. Since the coefficients of the interactive variables are insignificant, the study does not find support for the hypothesis that activity diversification allows to achieve economies of scope, neither that it increases banks' propensity to take risk. To test hypothesis 6 entry regulations and individual bank size are interacted. The obtained coefficient is negative and significant for the whole period. This result provides support for the hypothesis that strict entry regulations exacerbate competition and hence may lead to increased risk taking by bigger banks. At the same time it helps to counter the view that entry barriers allow to achieve economies of scope through oligopolistic bank structures.

5.2. The impact of bank performance on post-crisis regulation changes

To account for potential endogeneity between banks' performance and bank regulations one has to consider whether the changes in regulations were related to bank performance changes. In this section the regulatory changes between the respective World Bank's assessments (2003, 2008 and 2012) are analyzed. We try to verify whether the regulatory framework evolved in a desirable direction as

determined in the analysis in section 5.1. Further on, the study endeavours to investigate whether the post-crisis regulation changes, i.e. the ones which took place between the World Bank's assessments of 2008 and 2012 were influenced by banks' performance changes over the crisis period, i.e. 2007–2010.

Tables 12 and 13 show the changes of regulatory frameworks in the EU in the respective periods. The regulatory modifications were computed on the basis of changes of answers to the respective questions in the survey. Lack of change was assigned a score of 0, increased stringency was assigned a positive number ranging from 1 to 3, depending on the type of the question and on the extent of the change, while decreased stringency was assigned a negative score in a similar way. The ultimate indices for the changes in the respective regulatory groups were based on the first principal components.

Table 12 shows that the regulatory changes in 2003–2008 went in both directions – increased and decreased stringency, even within the same countries. The majority of the countries eased entry regulations, especially in terms of bank ownership. The changes in capital regulations mainly involved the inclusion or exclusion of credit risk in the minimum capital ratios. Activity regulations changed in both directions in the areas of securities, real estate, insurance and bank's ownership of non-financial firms. There was no observable general relaxation of auditing requirements, particularly in terms of reporting standards. Countries differed in terms of changes in the stringency of deposit insurance. There was a common trend consisting in the suspension of the right of the deposit insurance authority to cancel or revoke deposit insurance for participating banks. There was no clear trend in problematic institutions' regulation changes nor in supervisory power changes – the modifications of the respective elements went in both directions in the whole EU. There was no observable common trend within the respective countries either.

Table 13 shows that post-crisis regulation changes also went in both directions. Despite the fact that there was an effort to harmonize banking regulations on the EU level, countries differed in terms of individual reforms. One could observe apparent harmonization only in the case of capital regulations, although even in this regulatory area differences emerged between countries with respect to the scope of risk included in capital ratios and also in terms of capital requirements, depending on the length of the given bank's operating history. All countries coincided in the strengthening of the role of credit, market and operational risk in shaping the capital ratios, and those countries which refrained from the inclusion of credit and market risk into capital ratio, introduced it in 2008. There was no clear trend in entry regulation changes, neither within the regulatory categories nor country-wise.

Surprisingly, the majority of the countries eased the conditions under which banks can engage in securities trading and insurance activities. Changes in real estate activity restrictions and regulations concerning banks' ownership of non-financial firms went in both directions. Increased stringency of auditing standards can be noticed in the majority of the countries but only in the aspect of the right of the supervisory authority to meet with external auditors and discuss their report without the given bank's approval. There were only a few changes in the remaining aspects of auditing and they went in both directions. There were no substantial changes of liquidity requirements. Changes in deposit insurance stringency went in both directions mainly in terms of the rights of deposit insurance agency to intervene in banks. There was an apparent trend of increasing the stringency of problematic institutions' supervision, in particular by strengthening mechanisms of cease and desist-type orders, and supervisory actions, such as superseding shareholder rights, removing and replacing management or directors, or revoking bank licenses. There was no clear trend in changes of supervisory power – changes went in both directions.

In the light of the analysis performed in section 5.1 one can say that some of the regulatory changes went to some extent in the direction of “the best practice”. The increased stringency of problematic institutions’ discipline which was apparent in all EU countries may help constrain NPLs, but might have as well decreased z-scores. Admittedly, this second effect might be attributed to the fact that stringent regulation of problematic institutions limits risky bank activities and hence decreases potential profits.

The general slackening of activity regulations stands in contrast with the result calculated by means of regressions based on loan levels, which suggests that generally activity diversification crowds out the basic banking activity, i.e. lending, with the exception of a few isolated cases of countries where the changes of activity regulations moved in the expected direction.

There were no clear changes in three regulatory areas identified as significant in the analysis carried out in section 5.1, i.e. entry regulations, liquidity requirements and deposit insurance stringency.

The question is: what influenced the respective post-crisis regulatory changes? Were the frameworks modified due to bank performance changes? To test whether there is a relation between performance changes and post-crisis regulatory changes, the correlations of z-score changes over the 2007–2010 period and regulatory changes during 2008–2012 are computed. The correlation coefficients are presented in Table 9.

The results indicate that for the majority of regulatory measures there is no significant correlation between bank performance changes during the crisis and post-crisis regulation modifications with the exception of deposit insurance stringency. The relevant estimated correlation coefficient shows that in countries where banks had on average higher z-scores deposit insurance stringency increased between 2008 and 2012. Other regulatory changes seem to be unrelated to bank performance changes.

5.3. Robustness check

To test the robustness of the results two modifications are introduced in the baseline specification. Since the basic bank sample encompasses banks of various sizes, as a robustness check the outliers are eliminated from the sample. Banks with assets exceeding EUR 500 bn and those below the EUR 50 million threshold are excluded, which leaves 886 banks in the sample. Moreover, to rule out the excessive influence of bank size on the estimates, resulting from high correlation between individual and systemic bank size, the latter variable is excluded from the set of explanatory variables. The results are presented in Tables 10 and 11.

The robustness check confirms the majority of our primary results. A significant impact of banking regulations on z-scores is confirmed for two out of three regulatory measures, i.e. deposit insurance and problematic institutions’ supervision. Statistically significant coefficient values have also been obtained for some of the individual bank features. The positive significant impact of banks’ individual size on z-scores is confirmed as well as a negative relation between bank z-scores, liquidity and credit risk resistance respectively. The results also confirm the insignificance of funding and activity structures for z-scores. The estimates for intervened banks are also in line with the baseline specification.

6. Conclusions

The study allows to draw new conclusions on the relation between banking regulation and bank performance in EU countries using a broad set of commercial banks and time-varying regulatory measures. The contribution of this paper consists in the analysis of banking regulations and their changes in 2003, 2008 and 2012 coupled with the investigation of their mutual relation with bank performance in 2005–2014. In contrast to the established practice of focusing exclusively on the effects of point-in time regulations, the present paper adopts a new dynamic approach to regulations. This study investigates how regulation changes affected banks' financial results. Our paper also endeavours to provide basic evidence on the endogeneity of banking regulations by investigating whether the post-crisis modifications of regulations were related to changes in bank performance. The obtained results have implications for the ongoing discussion about the banking regulatory reform in EU countries.

Contrary to previous papers, this analysis points to a significant nexus between specific banking regulatory features and bank soundness as measured by z-scores, NPL to asset ratios and loan to asset ratios. The results suggest that stringency of entry regulations constitutes a significant factor shaping bank performance positively in terms of z-scores, even though this effect did not hold during the crisis. Moreover, the study finds that entry regulations reduced z-scores in the case of big banks, which contradicts the hypothesis of enhanced economies of scope through entry regulations.

Depositor protection stringency had a negative influence on z-scores and a positive one on lending but this relation was only significant during the crisis period. Such a result may imply that stringent deposit insurance schemes may encourage banks to lend and limit risky banking activities, consequently negatively affecting z-scores.

The stringency of problematic institutions' regulations impacted z-scores negatively during both periods, it also constrained NPLs over the whole period. During the whole sample period the influence of problematic institutions' regulations on loans was significantly positive, while it turned significantly negative during the crisis period. This result may be due to the fact that the stringency of discipline for problematic institutions materialized only during the crisis and might have constrained the willingness of banks to lend.

Activity regulation affected loans positively, although this effect turned insignificant during the crisis. This result may constitute an argument in favour of the proposed ringfencing of banking activity (ICB 2011). Liquidity requirements helped to constrain NPLs over the whole period, nevertheless this effect turns insignificant during the crisis.

The study finds partial support for only one of the six hypotheses developed on the basis of theoretical literature. Stringent entry regulations may lead to exacerbated competition and hence impact bank performance negatively. Since capital requirements were not significant in any of the specifications, no confirmation was possible of the risk shifting channel, or the increased borrower screening channel, or the lending contraction channel being triggered by capital regulations. The study does not support the hypotheses concerning the impact of bank activity diversification on bank performance – neither economies of scope are achieved by big, diversified banks, nor is there evidence for increased risk taking. The results are robust across many specifications.

The study finds that the post-crisis reforms were not strictly related to changes of bank performance during the crisis. The planned reform in the EU should focus on strengthening problematic institutions' supervision, the more so that the measures computed in the study point to lax regulations of this

aspect in many countries. The stringency of entry regulations, on the other hand, seems to affect bank performance negatively and currently the entry into banking is regulated quite strictly in the majority of EU countries. Hence, the reform should focus on lowering the barriers for bank entry and strengthen the supervision over the existing credit institutions instead.

Furthermore, it turns out that individual bank size affects z-scores positively, while systemic bank size has a negative impact on bank soundness. One should note that bank size is not subject to current regulations. Hence, within the reform framework more focus should be given to absolute and systemic bank size.

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Appendix

Table 1
Number of banks per country

Austria	63	Germany	119	Netherlands	30
Belgium	22	Greece	11	Poland	36
Bulgaria	19	Hungary	21	Portugal	17
Cyprus	6	Ireland	9	Romania	19
Czech Republic	17	Italy	88	Slovakia	9
Denmark	39	Latvia	16	Slovenia	14
Estonia	7	Lithuania	9	Spain	46
Finland	13	Luxembourg	57	Sweden	23
France	108	Malta	6	UK	107

Table 2
Summary statistics

Variable	Observations	Mean	Standard deviation	Min	Max
Total assets (thousands of EUR)	929	31 600 000	148 000 000	8 677	1 860 000 000
Bank systemic size	915	69.64	207.95	0.004	1 941.93
Equity to assets	929	0.13	0.14	0.0004	0.9991061
z-score 2007–2010	813	3.34	6.75	-3.71	112.67
z-score 2005–2014	909	3.78	11.04	-10.29	220.07
Nonperforming loans to assets 2007–2010	373	0.06	0.29	0	5.28
Nonperforming loans to assets 2005–2014	638	0.06	0.25	0	5.89
ROE	928	0.32	2.06	-44.30	31.21
ROA	928	4.18	14.06	-149.50	84.37
Loan loss provisions to assets	912	0.007	0.02	-0.04	0.56
Liquid assets to deposits and short term funding	924	29.73	33.97	0.50	498.33

Table 3
Correlation matrix

Variables	Bank systemic size	Liquid assets to deposits and short term funding	Net gains from trading and derivatives to assets	Long term funding to short term funding and deposits	Bank individual size	Loan loss provisions to assets
Bank systemic size	1.00					
Liquid assets to deposits and short term funding	0.10***	1.00				
Net gains from trading and derivatives to assets	-0.02	0.23***	1.00			
Long term funding to short term funding and deposits	-0.01	-0.02	-0.004	1.00		
Bank individual size	0.54***	0.04	-0.10***	0.01	1.00	
Loan loss provisions to assets	-0.03	-0.07**	0.05	0.001	-0.05	1.00
Loans to assets	-0.04	-0.15***	-0.03	0.08**	0.08**	-0.02

*** significance at 0.01 level, ** significance at 0.05 level, * significance at 0.1 level.

Table 4
Banking regulatory measures in 2012

	Entry regulation	Capital adequacy	Activity regulation	Auditing requirements	Liquidity requirements	Asset classification	Deposit insurance	Problematic institutions' regulation	Supervision
Austria	0.13	-0.21	-0.68	-0.38	0.90	-0.06	-0.22	0.02	
Belgium	0.40	-0.06	-0.25	0.28	0.44		-0.20	0.34	-1.12
Bulgaria	-0.03	2.49	-0.58	0.54	-0.12	-0.14	0.09	0.38	0.39
Cyprus	0.39	-0.28	0.77	-0.03	0.64	-0.36	0.03	0.54	-0.43
Denmark	-1.42	-0.13	-0.03	-0.44	0.32		-0.47	0.54	-0.21
Estonia	0.12	1.52	-0.23	-0.94	-2.29	-0.04	-0.40	0.28	
Finland	-0.77	-0.16	-0.22	-0.53	-0.30	-0.04	-0.54	-0.65	0.38
France	0.31	-0.18	0.71	0.44	-0.10	-0.07	0.61	0.68	
Germany	-2.90	-0.14	-2.22	0.12	0.37	0.80	0.77	0.26	
Greece	0.27	-0.30	0.19	-0.56	0.80	0.02	0.13	0.53	-0.31
Hungary	0.38	-0.10	-0.47	0.33	0.22	0.06	-0.42	0.60	0.17
Ireland	0.23	-0.31	-0.90	-0.15	0.16		0.58	-0.54	-0.57
Italy	0.25	-0.27	0.61	0.69	-0.47	-0.13		0.29	0.30
Lithuania	0.53	-0.09	0.39	0.39	0.37	-0.09	-0.25	0.06	-0.06
Latvia	-0.07	-0.22	-0.12	-0.69	-0.68	0.00	0.76	0.72	0.86
Netherlands	0.28	-0.15	-0.05	0.03	-0.23	0.00	-0.40	0.43	-1.23
Poland	0.00	-0.32	2.07	0.06	-0.08	0.03	0.32	0.07	-0.67
Portugal	0.31	-0.42	0.39	0.18	-0.47	-0.10	0.21	0.41	0.53
Romania	0.42	-0.10	-0.23	0.47	0.54	0.26	-0.51	0.60	0.48
Slovakia	0.14	-0.29	1.09	0.35	0.17		-0.35	0.46	0.49
Slovenia	0.51	-0.32	-0.22	-0.27	0.01	-0.01	0.19	0.79	0.36
Spain	0.41	-0.19	-0.43	-0.13	-0.36	-0.05	0.11	-0.38	0.49
United Kingdom	-0.14	-0.25	-0.74	-0.07	0.57			-7.02	

Table 5
Regression results for z-scores

Independent variable	Dependent variable: z-score									
	regression including entry regulation	regression including capital adequacy	regression including activity regulation	regression including auditing standards	regression including liquidity requirements	regression including depositor protection	regression including problematic institutions' regulation	regression including supervision		
Bank individual size	0.61***	0.64***	0.61***	0.64***	0.53***	0.61***	0.54***	0.59***		
	0.58***	0.60***	0.58***	0.57***	0.58***	0.54***	0.57***	0.62***		
Bank systemic size	-0.003***	-0.003***	-0.003***	-0.003***	-0.007***	-0.003***	-0.002***	-0.003***		
	-0.002***	-0.002***	-0.002***	-0.002***	-0.002***	-0.002***	-0.002***	-0.003***		
Long term funding to short term funding	-1.34***	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.018		
	-0.013	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01		
Net gains from trading and derivatives to assets	-4.94	-1.46	-4.20	-5.21	-5.65	-3.73	-0.43	-4.59		
	-2.80	-5.12	-2.97	-2.66	-2.33	-1.96	0.66	-2.16		
Loan loss provisions to total assets	-37.71***	-38.51**	-38.90***	-38.60***	-37.77**	-38.86***	-38.74***	-38.24***		
	-29.65	-27.08**	-29.77*	-29.60**	-29.48 **	-29.65***	-28.54 **	-45.24***		

Liquid assets to deposits and short term funding	-0.03*** -0.02***	-0.03*** -0.02***	-0.03*** -0.02***	-0.03*** -0.02***	-0.03*** -0.02***	-0.03*** -0.02***	-0.03*** -0.02***	-0.03*** -0.02***	-0.03*** -0.02***
Intervened	-1.34*** -1.20***	-1.13** -1.35***	-1.39*** -1.19***	-1.51*** -1.21***	-1.08*** -1.19***	-1.39*** -1.13***	-1.29*** -1.24***	-1.39*** -1.10***	-1.39*** -1.10***
Exchange rate	-0.0042** -0.003***	-0.01* -0.002*	-0.003 -0.003	-0.004** -0.003***	-0.002** -0.003***	-0.003*** -0.004***	-0.002 -0.004***	-0.003* -0.003***	-0.003* -0.003***
GDP growth	0.20 0.06	0.13 -0.03	0.20 0.06	0.15 0.07	0.39 0.08	0.21 0.14	0.37 0.13	0.23 0.01	0.23 0.01
Banking regulatory measure	0.22* -0.02	-0.38 0.19	0.01 0.04	0.15 0.05	-0.31 -0.08	-0.02 -0.14**	-0.25*** -0.58 **	0.16 -0.19	0.16 -0.19
VIF	2.05 2.10	2.09 2.12	2.12 2.11	2.19 2.32	2.53 2.13	2.14 2.56	2.61 2.16	2.16 2.31	2.16 2.31
Prob > F	293.07*** 312.37**	229.23*** 358.36***	382.91*** 505.85***	548.35*** 283.62***	467.71*** 300.37***	354.66*** 496.32***	200.55*** 672.34***	356.81*** 257.50***	356.81*** 257.50***
R ²	0.22 0.46	0.22 0.45	0.22 0.46	0.22 0.46	0.22 0.46	0.22 0.46	0.22 0.46	0.22 0.46	0.22 0.46

Note: the first row indicates estimates for the whole sample period, i.e. 2005–2014, the second one contains the estimates for the crisis period 2007–2010.
*** significance at 0.01 level, ** significance at 0.05 level, * significance at 0.1 level.

Table 6
Regression results for nonperforming loans

Independent variable	Dependent variable: nonperforming loans									
	regression including entry regulation	regression including capital adequacy	regression including activity regulation	regression including auditing standards	regression including liquidity requirements	regression including depositor protection	regression including problematic institutions' regulation	regression including supervision		
Bank individual size	0.001* 0.0006	0.002* 0.0005	0.002 0.0007	0.002* 0.001	0.0002 0.0001	0.001 -0.001	-0.0002 0.0009	0.001 -0.002		
Bank systemic size	-0.00003*** 0.00002	-0.00003*** 0.00002*	-0.00003*** -0.00002**	-0.00003*** -0.00002**	-0.00003*** -0.00002*	-0.00003*** -0.00001	-0.00003*** -0.00002**	-0.00003*** -80.43* 10 ⁻⁶		
Long term funding to short term funding	-0.0002 -0.001***	-0.0002 -0.001	-0.0003 -0.001***	-0.0002 -0.001***	-0.0002 -0.001	-0.0003 -0.001	-0.0003 -0.001***	-0.0002 -0.001***		
Net gains from trading and derivatives to assets	7.88* 6.81	7.91** 7.07	8.09* 6.91	7.92** 6.77	8.04** 6.86	7.95** 6.78	7.96** 6.87	7.95** 5.65*		
Loan loss provisions to total assets	5.15*** 3.95***	5.14*** 3.98***	5.14*** 3.96***	5.13*** 3.95***	5.14*** 3.97***	5.13*** 3.97	5.15*** 3.94***	5.14*** 5.38***		

Liquid assets to deposits and short term funding	-0.0001 -0.00008	-0.0001 -0.00005	-0.0001 -0.00007	-0.0001 -0.0001	-0.0001 -0.00005	-0.0001 -0.0001	-0.0001 -0.0001	-0.0001 -0.0001
Intervened	0.01 0.0005	0.012 0.005	0.01 -0.001	0.009 0.0002	0.02 -0.0004	0.01 0.001	0.01 0.0006	0.011 -0.004
Exchange rate	-0.00008** -0.00011*	-0.00008** -0.00009	-0.00003 -0.00009	-0.00007** -0.0001*	-0.00006* -0.0001*	-0.00007** -0.0001**	-0.00004 -0.0001*	-0.00007** -0.0001
GDP growth	0.009*** 0.006	0.005** 0.003	0.004 0.003	0.004** 0.003	0.008*** 0.005**	0.005 0.008**	0.008** 0.003	0.005** 0.005
Banking regulatory measure	0.001 -0.003	-0.001 0.004	-0.005 -0.004	0.002 -0.006	-0.005*** -0.004	-0.002 -0.006	-0.006* 0.005	0.001 0.004
VIF	2.14 2.48	2.19 2.58	2.20 2.48	2.25 2.71	2.61 2.52	2.17 2.90	2.60 2.52	2.31 2.80
Prob > F	138.00*** 71.69***	210.23*** 68.81***	332.30*** 114.26***	179.42*** 100.58***	151.39*** 80.25***	171.67*** 82.51***	220.38*** 49.54***	488.08*** 78.52***
R ²	0.72 0.73	0.71 0.74	0.72 0.73	0.72 0.73	0.72 0.73	0.72 0.74	0.72 0.73	0.69 0.77

Note: the first row indicates estimates for the whole sample period, i.e. 2005–2014, the second one contains the estimates for the crisis period 2007–2010.

*** significance at 0.01 level, ** significance at 0.05 level, * significance at 0.1 level.

Table 7
Regression results for loans to assets

Independent variable	Dependent variable: loans to assets									
	regression including entry regulation	regression including capital adequacy	regression including activity regulation	regression including auditing standards	regression including liquidity requirements	regression including depositor protection	regression including problematic institutions' regulation	regression including supervision		
Bank individual size	0.10***	0.10***	0.10***	0.10***	0.10***	0.10***	0.11***	0.10***		
Bank systemic size	0.58***	0.60***	0.58***	0.57***	0.58***	0.54***	0.57***	0.62***		
Long term funding to short term funding	-0.0003***	-0.0003***	-0.0003***	-0.0003***	-0.0003***	-0.0003***	-0.0003***	-0.0003***		
Net gains from trading and derivatives to assets	-0.002***	-0.002***	-0.002***	-0.002***	-0.002***	-0.002***	-0.002***	-0.003***		
Loan loss provisions to total assets	0.03	0.03	0.03	0.03*	0.03	0.02	0.03	0.03		
Liquid assets to deposits and short term funding	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01		
Intervened	2.20***	2.22***	1.68**	2.27**	2.18***	1.87**	1.85**	2.10**		
Exchange rate	-2.80***	-5.12	-2.97	-2.66	-2.33	-1.97	0.66	-2.16		
GDP growth	0.36	0.33	0.13	0.31	0.35	0.34	0.29	0.51		
Banking regulatory measure	-29.65**	-27.08**	-29.77**	-29.60**	-29.48**	-29.65**	-28.54401	-45.24***		
VIF	-0.003***	-0.003***	-0.002	-0.003***	-0.002***	-0.002***	-0.002***	-0.002		
Prob > F	-0.02***	-0.03	-0.02***	-0.02***	-0.02***	-0.03***	-0.02***	-0.02		
R ²	-0.02	-0.02	-0.02	-0.02	-0.01	-0.03	-0.03	-0.02		
	-10.20***	-10.35***	-10.19***	-10.21***	-10.20***	-10.13***	-10.24***	-10.10***		
	0.0007***	0.0007***	0.0003**	0.0008***	0.0008***	0.0007***	0.0006***	0.0007***		
	-0.003***	-0.002*	-0.003*	-0.003***	-0.003***	-0.004***	-0.004***	-0.003***		
	0.016	0.02	0.03	0.02	0.02	0.01	-0.002	0.02		
	0.06	-0.03	0.06	0.07	0.08	0.14	0.133	0.01		
	0.006	-0.002	0.05**	-0.006	-0.007	0.02	0.03**	0.04		
	-0.02	0.19	0.06	0.05	-0.08	-0.14**	-0.58**	-0.19		
	2.10	2.14	2.16	2.22	2.55	2.20	2.65	2.21		
	2.10	2.12	2.11	2.32	2.13	2.56	2.16	2.31		
	555.14***	563.85***	1 714.99***	655.17***	570.31***	1 236.59***	1 728.01***	332.49***		
	312.37**	358.36	505.85***	283.62***	300.37***	496.32***	672.34	257.50***		
	0.30	0.30	0.82	0.81	0.81	0.81	0.81	0.81		
	0.46	0.45	0.46	0.46	0.46	0.46	0.46	0.46		

Note: the first row indicates estimates for the whole sample period, i.e. 2005–2014, the second one contains the estimates for the crisis period 2007–2010. ***: significance at 0.01 level, **: significance at 0.05 level, *: significance at 0.1 level.

Table 8
Regressions including interactions between individual bank size and regulations

Independent variable	Dependent variable: z-score			
	entry regulation 2003 · bank individual size 2005–2014	entry regulation 2008 · bank individual size 2007–2010	activity regulation 2003 · bank individual size 2005–2014	activity regulation 2008 · bank individual size 2007–2010
Bank individual size	0.61***	0.58***	0.61***	0.58***
Bank systemic size	-0.003***	-0.002***	-0.003***	-0.002***
Long term funding to short term funding	-0.02	-0.01	-0.02	-0.01
Net gains from trading and derivatives to assets	-4.78	-2.80	-4.34	-2.88
Loan loss provisions to total assets	-37.51***	-29.69**	-38.96***	-29.69**
Liquid assets to deposits and short term funding	-0.03***	-0.02***	-0.03***	-0.02***
Intervened	-1.32***	-1.19***	-1.388001***	-1.198422***
Exchange rate	-0.004**	-0.003**	-0.004	-0.003**
GDP growth	0.21	0.06	0.21	0.06
Interactive banking regulatory measure	0.03**	-0.004	0.004	0.003
VIF	2.06	2.10	2.11	2.10
Prob > F	298.68***	307.74***	334.61***	410.13***
R ²	0.22	0.46	0.22	0.46

*** significance at 0.01 level, ** significance at 0.05 level, * significance at 0.1 level.

Table 9
Correlation of z-score changes in 2007–2010 and regulatory changes in 2008–2012

	Z-score changes 2007–2010	Z-score changes 2007–2010
Entry regulation changes	0.0062	Liquidity requirements changes -0.0439
Capital requirements changes	-0.0369	Deposit insurance regulation changes 0.1010***
Activity regulation changes	-0.0411	Problematic institutions' supervision changes 0.0088
Auditing requirement changes	0.0109	Supervisory power changes -0.0050

*** significance at 0.01 level.

Table 10
Results of the regressions for z-scores over the period 2005–2014

Independent variable	Dependent variable: z-score 2005–2014							
	regression including entry regulation	regression including capital adequacy	regression including activity regulation	regression including auditing standards	regression including liquidity requirements	regression including depositor protection	regression including problematic institutions' regulation	regression including supervision
Bank individual size	0.59***	0.62***	0.59***	0.61***	0.51***	0.58***	0.50***	0.56***
Long term funding to short term funding	-0.01	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.01
Gains from trading and derivatives to assets	-3.71	-0.06	-2.62	-3.57	-4.29	-1.521	1.60	-3.43
Loan loss provisions to total assets	-35.03***	-35.82**	-36.15***	-35.92***	-35.08***	-36.21***	-36.19***	-35.45***
Liquid assets to deposits and short term funding	-0.03***	-0.03***	-0.03***	-0.03***	-0.03***	-0.03***	-0.03***	-0.03***
Intervened	-2.01***	-1.84***	-2.11***	-2.22***	-1.80***	-2.08***	-1.94***	-2.09***
Exchange rate	-0.004**	-0.004	-0.002	-0.003*	-0.002	-0.003**	-0.0007	-0.003**
GDP growth	0.17	0.10	0.17	0.13	0.36	0.19	0.37	0.21
Banking regulatory measure	0.25*	-0.39	-0.007	0.12	-0.31	-0.06	-0.29**	0.21
VIF	2.10	2.14	2.17	2.25	2.64	2.19	2.70	2.21
Prob > F	242.05***	195.25***	361.10***	302.89***	458.86**	281.91***	147.58***	153.49***
R ²	0.22	0.22	0.22	0.21	0.22	0.21	0.22	0.22

*** significance at 0.01 level, ** significance at 0.05 level, * significance at 0.1 level.

Table 11
Results of the regressions for z-scores over the period 2007–2010

Independent variable	Dependent variable: z-score 2007–2010							
	regression including entry regulation	regression including capital adequacy	regression including activity regulation	regression including auditing standards	regression including liquidity requirements	regression including depositor protection	regression including problematic institutions' regulation	regression including supervision
Bank individual size	0.56***	0.58***	0.56***	0.54***	0.56***	0.50***	0.55***	0.58***
Long term funding to short term funding	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
Net gains from trading and derivatives to assets	-1.41	-3.75	-1.59	-0.88	-0.81	-0.16	1.97	0.04
Loan loss provisions to total assets	-27.28**	-24.94*	-27.52**	-27.32**	-27.15**	-27.68**	-26.22**	-42.07***
Liquid assets to deposits and short term funding	-0.03***	-0.03***	-0.03***	-0.03***	-0.03***	-0.03***	-0.03***	-0.03**
Intervened	-1.85***	-1.91***	-1.83***	-1.82***	-1.83***	-1.64***	-1.91***	-1.84
Exchange rate	-0.002***	-0.0009	-0.003	-0.003***	-0.003***	-0.003***	-0.003***	-0.002
GDP growth	0.03	-0.06	0.048	0.08	0.06	0.19	0.10	0.03
Banking regulatory measure	0.05	0.24	0.05	0.20	-0.09	-0.24***	-0.54**	-0.05
VIF	2.14	2.17	2.15	2.35	2.19	2.62	2.22	2.35
Prob > F	296.67***	370.57***	383.48***	211.14***	298.50***	318.45***	808.59***	313.33***
R ²	0.46	0.44	0.46	0.45	0.46	0.45	0.45	0.45

*** significance at 0.01 level, ** significance at 0.05 level, * significance at 0.1 level.

Table 12
Regulation changes in 2003–2008

	Entry regulation	Capital adequacy	Activity regulation	Auditing requirements	Liquidity requirements	Deposit insurance	Problematic institutions' regulation	Supervision
Austria	0.213	-2.747	-0.599	-0.142	-0.142	0.402	0.132	
Belgium	-0.071	-2.747	-1.632	3.033	3.033	-0.020	0.435	-0.730
Bulgaria	-0.071	0.000	1.645	1.071	1.071	0.376	0.748	0.153
Cyprus	-5.882	0.000	-2.004	-0.142	-0.142	-1.012	-3.857	0.153
Czech Republic	-0.071	0.000	0.807	-1.356	-1.356	0.376	-0.006	2.585
Denmark	-0.355	-2.747	1.105	3.033	3.033	-2.506	-1.532	-0.730
Estonia	-0.071	0.000	0.082	-1.356	-1.356	0.376	0.141	-1.168
Finland	0.675	0.000	0.186	-0.142	-0.142	-0.616	-0.448	-0.730
France	-0.444	1.472	1.219	-0.142	-0.142	-0.221	-0.448	-3.600
Germany	-0.816	0.000	-0.599	-0.142	-0.142	-0.892	3.273	0.153
Greece	-0.071	1.472	-0.494	-0.500	-0.500	0.376	-0.943	-0.513
Hungary	-0.071	2.747	1.622	-1.356	-1.356	-1.635	-0.300	-1.168
Ireland	7.036	-1.275	-0.599	-0.142	-0.142	0.376	-0.797	1.473
Italy	-0.071	0.000	-1.518	1.819	1.819	-1.635	1.077	0.153
Latvia	-0.071	0.000	-0.082	-1.356	-1.356	1.395	0.748	0.153
Lithuania	-0.071	0.000	2.624	-0.142	-0.142	1.395	-0.006	1.036
Luxembourg	-0.071	0.000	2.302	-0.142	-0.142	0.376	-0.006	1.473
Malta	-0.071	0.000	-1.169	-1.356	-1.356	-1.288	-1.055	0.153
Netherlands	-0.532	1.275	-2.004	-0.142	-0.142	0.376	0.191	0.153
Poland	0.391	0.000	1.323	-0.142	-0.142	0.376	-1.295	-0.730
Portugal	-0.071	1.275	-0.703	-0.142	-0.142	0.376	-0.006	0.153
Romania	-0.071	0.000	0.022	-0.142	-0.142	2.663	0.287	0.153
Slovakia	-0.071	0.000	-1.383	-0.142	-0.142	-0.642	2.805	0.153
Slovenia	0.763	0.000	1.105	-0.142	-0.142	1.369	-0.006	0.153
Spain	-0.071	0.000	-0.897	-1.356	-1.356	0.376	1.371	-0.730
Sweden	0.085	1.275	1.024	1.819	1.819	-1.885	-0.006	1.702
UK	-0.071	0.000	-1.383	-0.142	-0.142	1.369	-0.497	0.153

Source: computations based on World Bank data.

Table 13
Regulation changes in 2008–2012

	Entry regulation	Capital adequacy	Activity regulation	Auditing requirements	Liquidity requirements	Deposit insurance	Problematic institutions' regulation	Supervision
Austria	-0.132	-2.747	-0.599	-0.076	-0.142	0.402	0.132	
Belgium	-0.244	-2.747	-1.632	-0.076	3.033	-0.020	0.435	-0.730
Bulgaria	0.026	0.000	1.645	-0.076	1.071	0.376	0.748	0.153
Cyprus	-6.184	0.000	-2.004	0.820	-0.142	-1.012	-3.857	0.153
Czech Republic								
Denmark	0.185	-2.747	1.105	-0.076	3.033	-2.506	-1.532	-0.730
Estonia	0.026	0.000	0.082	-0.076	-1.356	0.376	0.141	-1.168
Finland	-0.025	0.000	0.186	-0.428	-0.142	-0.616	-0.448	-0.730
France	0.218	1.472	1.219	-1.324	-0.142	-0.221	-0.448	-3.600
Germany	0.190	0.000	-0.599	-0.076	-0.142	-0.892	3.273	0.153
Greece	0.297	1.472	-0.494	-0.076	-0.500	0.376	-0.943	-0.513
Hungary	0.026	2.747	1.622	-0.076	-1.356	-1.635	-0.300	-1.168
Ireland	7.623	-1.275	-0.599	-0.076	-0.142	0.376	-0.797	1.473
Italy	0.026	0.000	-1.518	-0.076	1.819	-1.635	1.077	0.153
Latvia	0.297	0.000	-0.082	-1.676	-1.356	1.395	0.748	0.153
Lithuania	0.026	0.000	2.624	4.855	-0.142	1.395	-0.006	1.036
Luxembourg	0.297	0.000	2.302	-0.076	-0.142	0.376	-0.006	1.473
Malta	-0.624	0.000	-1.169	-0.076	-1.356	-1.288	-1.055	0.153
Netherlands	-0.351	1.275	-2.004	-1.324	-0.142	0.376	0.191	0.153
Poland	0.674	0.000	1.323	-0.076	-0.142	0.376	-1.295	-0.730
Portugal	0.026	1.275	-0.703	-0.076	-0.142	0.376	-0.006	0.153
Romania	-0.427	0.000	0.022	1.172	-0.142	2.663	0.287	0.153
Slovakia	0.026	0.000	-1.383	-1.324	-0.142	-0.642	2.805	0.153
Slovenia	0.015	0.000	1.105	-0.076	-0.142	1.369	-0.006	0.153
Spain	-0.427	0.000	-0.897	1.172	-1.356	0.376	1.371	-0.730
Sweden								
UK	0.297	0.000	-1.383	-0.076	-0.142	1.369	-0.497	0.153

Source: computations based on World Bank data.

Table 14
Variables and sources

Variable	Measurement	Source
Z-score-individual	$Z = (\text{ROA} + \text{Equity}/\text{Total assets}) / \text{the standard deviation of ROA}$	Bankscope
Z-score changes	$\ln z_{t-1} \ln z_{t-1}$	Bankscope
Nonperforming loans	Nonperforming loans to assets	Bankscope
Loans to assets	Loans to assets	Bankscope
Bank individual size	Log of total assets (thousands of EUR)	Bankscope
Bank systemic size	Total assets to GDP	Bankscope and World Bank (WDI)
Long term funding to short term funding	Long term funding to short term funding	Bankscope
Net gains from trading and derivatives	Net gains from trading and derivatives to assets	Bankscope
Bank liquidity	Liquid assets to deposits and short term funding	Bankscope
Credit risk resistance	Loan loss provisions to total assets	Bankscope
Entry into banking	First principal component of the survey data	World Bank Banking Regulatory Database (2003, 2008, 2012)
Capital adequacy	First principal component of the survey data	World Bank Banking Regulatory Database (2003, 2008, 2012)
Banking activity regulation	First principal component of the survey data	World Bank Banking Regulatory Database (2012)

Auditing standards	First principal component of the survey data	World Bank Banking Regulatory Database (2003, 2008, 2012)
Liquidity and diversification requirements	First principal component of the survey data	World Bank Banking Regulatory Database (2003, 2008, 2012)
Depositor protection schemes	First principal component of the survey data	World Bank Banking Regulatory Database (2003, 2008, 2012)
Asset classification	First principal component of the survey data	World Bank Banking Regulatory Database (2012)
Problematic institutions' regulation	First principal component of the survey data	World Bank Banking Regulatory Database (2003, 2008, 2012)
Supervision	First principal component of the survey data	World Bank Banking Regulatory Database (2003, 2008, 2012)
Interactive variables	Individual bank size · First principal component of the survey data	Bankscope and World Bank Banking Regulatory Database (2003, 2008, 2012)
Real GDP growth	Average annual real GDP	World Bank (WDI)
Exchange rate	Average annual exchange rates	ECB
Intervened	A dummy variable: 1 in the case when a bank received state aid, 0 otherwise	European Commission