

## **Income and funding structures, banking regulation and bank risk-taking: The role of ownership in Central and Eastern European banks**

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## **Abstract**

This paper explores the effects of CEE banks' balance sheet strategies and the impact of banking reforms on their risk-taking behaviour and assesses them with respect to banks' ownership profile. With our asymmetric *Z*-score and Distance to Default, we find that state-owned banks are the riskiest and foreign banks the safest institutions. Moreover, the market perceives the former as being riskier regardless of their balance sheet policies. More interbank deposits and long-term funds increase the *Z*-scores of these banks to a larger extent, but more income diversification has the opposite effect. As for domestic private and foreign banks, these balance sheet policies do not affect the accounting-based risk measure of these institutions. Finally, in countries and periods with banking regulations that conform to the Basel requirements to a greater degree, foreign and private banks are less risky with respect to their *Z*-score and this effect is stronger for foreign institutions.

## **1. Introduction**

Since the late 1980s and early 1990s, Central and Eastern European (CEE) countries have implemented many reforms that have profoundly changed the organisation and structure of their banking systems. Many state-owned banks have been privatised, and many new banks, namely, foreign institutions, have entered these markets. These changes in ownership structure and the increasing presence of foreign investors have been a driving force behind the risk-taking incentives of CEE banks. Their income and funding structures as well as a multitude of banking reforms have strengthened this effect, but these have rarely been taken into account in the analysis of bank risk-taking based on ownership profile. Thus, we address three research questions with respect to CEE banking industries. What is the risk profile of foreign, private and state-owned banks? How do their financing and income diversification activities influence their risk-taking behaviour? Finally, does banking regulation affect the risk-taking of these banks? Although the first question has been explored with regard to CEE economies to a certain extent, we perform an in-depth examination using an asymmetric Z-score measure of bank risk and a measure of market perception of bank risk. The objective of our analysis is therefore to estimate the effects of the balance sheet strategies of CEE banks and the impact of banking reforms on risk-taking behaviour while considering the role of ownership structure.

This issue is of particular interest and importance for both the banking industry and banking regulators in these countries. At the beginning of the transition period, lax entry requirements led to the appearance of many new domestic private banks, some of which were of dubious quality or even fraudulent (Bonin et al, 1998). Even those that had real intentions to carry out profit- and development-oriented banking activities had no experience in monitoring and producing information about their investments (Bonin et al., 2015). Adding to the severe undercapitalisation of these new private banks and given the risky nature of their

activities and the troubles characterising these transition economies, the seeds for a banking crisis were planted, and, in the mid-1990s, crises occurred in most CEE countries. After these episodes and restructuring processes that followed and as a result of new regulatory constraints, new experiences and bank practices, the risk-taking behaviour of these banks changed.

For our analysis, we compute an asymmetric Z-score measure and estimate the market perception of bank risk. The first measure overcomes certain shortcomings of the traditional Z-score, which is often viewed as an approximation of a bank's probability of default (Laeven and Levine, 2009; Jiménez et al., 2013, among others). This approximation is inappropriate because it supposes that *ROA*, as a random variable, must follow a normal law; otherwise, according to the Bienaymé–Tchebycheff inequality, the inverse Z-score must be considered as a bank's maximum probability of default. Laeven and Levine (2009) and Fang et al. (2014) take the natural logarithm of the Z-score and assume that this transformed measure is closer to a normal distribution. Nevertheless, our Monte-Carlo simulation test refutes this assumption – at least in the case of CEE banks.

This work is related to recent papers documenting the risk-taking of banks in transition economies (Demirgüç-Kunt et al., 1998; Detregiache and Gupta, 2004; Dong, 2014; Distinguin et al., 2013). Unlike these works, which make a distinction between foreign and local banks or state-owned and private banks, our paper takes into account all three types of ownership, *i.e.*, foreign, domestic private and state-owned banking institutions, and includes both early transition crises and the 2008 banking crisis.

Our work also complements papers examining the effects of banking regulation and of income diversification and funding policies on bank risk-taking. To the best of our knowledge, few studies focus on CEE banking markets and, with the exception of Fang et al. (2014) regarding banking regulation, no study examines these effects with respect to bank

ownership structure. This perspective is important because foreign, private and state-owned banks have different implicit guarantees regarding their sources of funding and different compositions of products and services (De Haas et al., 2010). In addition, banking regulation may have different effects based on a banks' risk profile (Klomp and De Haan, 2012).

Finally, this paper makes a methodological contribution to the literature on bank risk and brings to light the market perception of bank risk in CEE countries. In terms of the methodological aspect, no work has taken into account the skewness of *ROA*, to the best of our knowledge. Some studies have used the natural logarithm of the Z-score instead of the Z-score itself (Laeven and Levine, 2009), but they have been invalidated by our test. As for market perceptions of bank risk, Distance to Default incorporates bank equity prices, and thus makes it possible to estimate the perceptions of financial markets about the riskiness of CEE banks, which was not attempted in the previous literature.

The next section reviews the related literature and explains the positioning of our paper. Section 3 reviews the shortcomings of most applied methodologies in measuring bank risk and proposes a new measure of the Z-score that takes into account the skewness of banks' *ROA* distribution and Distance to Default, which assesses the market perception of banks' risk. Section 4 describes and explains our data and the construction of bank regulatory variables. Section 5 presents our results and their robustness. Section 6 summarises our main findings and concludes.

## **2. Related literature: What it does and does not say**

The few papers that have addressed the subject essentially focus on the risk-taking behaviour of state-owned and foreign banks. At the beginning of the transition, CEE state-owned institutions did not behave like modern commercial banks. First, they maintained banking relationships with their large, inefficient state-owned enterprises (Bonin et al., 2015),

whose judgement choosing viable projects was dubious. As a consequence, state-owned banks were not only risky but also a possible source of a banking crisis. Second, as sectoral or regional banks, they were a financial instrument of the political and social policies of successive governments (OECD, 1996, Bonin et al., 1998), which weakened these institutions and probably made them riskier. Indeed, politicians were incentivised to use these banking institutions for social purposes or for their own political goals. These incentives are set forth in detail by Shleifer and Vishny (1986) and Shleifer (1998) and documented by Iannotta et al. (2013) in the case of Western European banks. In such countries and periods, financial development and economic growth are lower (Barth et al., 2001; La Porta et al., 2002), and banking markets are less stable (Caprio and Martinez Peria, 2000). However, some of the evidence on emerging countries presents different results. Dong et al. (2014) show that Chinese banks owned by the government have incentives to take on more risk than those owned by private investors, whereas the opposite effect is found by Distinguin et al. (2013) for CEE banks, providing the explanation that state-owned banks may benefit from an implicit government guarantee. We propose a more thorough analysis because it is not as obvious in the case of CEE economies that this guarantee was certain, as these banks were too large to be bailed out by governments with substantial budget deficits.

At the beginning of the transition, foreign banks were eager to enter CEE markets, but not all countries welcomed them, as some were worried about the destabilising effect they might have. Demirgüç-Kunt et al. (1998) test this evidence on a large sample of emerging economies and find that foreign bank presence reduces the likelihood of a banking crisis. This result is strengthened by Detregiache and Gupta (2004), who argue that foreign banks have a stabilising effect before or during financial crises, which was only true of CEE economies with early open-market policies that encouraged foreign investment in the banking market (Bonin et al., 2015).

Foreign banks in CEE countries were viewed as least risky during the first stages of the transition because they alone had the expertise, technology and know-how for credit screening and risk management, among other risk-reducing skills, as well as the financing and reputation of their parents, which were essentially large European banking groups. As international banks, they are capable of investing in more diversified assets and have access to more diversified and stable sources of liquidity in the international markets (Freixas and Holthausen, 2005). Dinger (2009) finds that, although in “normal” times foreign banks in CEE countries hold less liquid assets, the liquidity of their holdings is significantly higher in crisis times, reducing the liquidity risk in CEE economies. However, there is no study on CEE banks that examines the effects of other important balance sheet policies on bank risk-taking.

How banking regulation, bank activity diversification and sources of funding for bank activities affect banks’ risk-taking is an important question in the banking literature. On the one hand, short-term financiers provide market discipline (Calomiris and Kahn, 1991, Calomiris, 1999) and refinance unexpected retail withdrawals (Goodfriend and King, 1998). On the other hand, short-term financiers amplify the effects of crises by withdrawing their funds, leading to inefficient bank liquidations (Huang and Ratnovski, 2011). Conversely, due to depositor insurance protection and high switching costs associated with transaction services that retail depositors receive from banks (Kim et al., 2003; Sharpe, 1997), the “sluggishness” of long-term funds has a stabilising role.

During the transition period, CEE banks diversified their income sources by performing new activities introduced by foreign banks, such as underwriting and trading securities, brokerage and investment and other activities that generate non-interest income. The effect of such changes on the risk-taking is not obvious because previous studies focusing largely on developed countries obtained contradictory results. Berger et al. (1999), Campa and Kedia (2002) and Landskroner et al. (2005) find that diversification increases bank stability, whereas



DeYoung and Roland (2001), Stiroh (2004), Acharya et al. (2006), Stiroh and Rumble (2006), and Demirgüç-Kunt and Huizinga (2010) obtain a contrary result. The first finding is intuitive: Income diversification ensures income stability. Some authors explain the second by the fact that diversification gains are more than offset by the costs related to exposure to volatile non-interest-generating activities.

In spite of significant developments, banking regulation and the effects it has on the risk-taking of CEE banks remain somewhat unaccounted for in the research on CEE countries. Many banking reforms prompt questions about their (de)stabilising role. Permissive entry requirements at the early stages of transition that were meant to enhance competition did wreak havoc on the banking market. Meanwhile, because there were so few knowledgeable personnel, effective supervision did not follow the transition in banking (Bonin et al., 2015). Thus, according to Keeley (1990), financial liberalisation led to increased market competition and hence bank risk-taking, instead of more diversified and stable income sources and less risk-taking, which as argued by Barth et al. (2001), González (2005) and Laeven and Levine, (2009). Then, the strategic policy to join the European Union hastened banking regulation, *i.e.*, the tightening of entry requirements, allowing only those banks that were well-capitalised to enter these markets, the alignment with Basel capital and liquidity requirements, the creation of a depositor protection scheme, etc. These changes affected the risk-taking of CEE banks with ambiguous results. Deposit insurance, for instance, may enhance moral hazard and tends to increase the likelihood of banking crises (Demirgüç-Kunt and Detragiache, 2002); in other words, it may increase the riskiness of CEE banks (Distinguin et al., 2013).

All these subjects (or their omission) guide our empirical investigation. In the following, we provide a methodological overview of the traditional and asymmetric Z-scores as an accounting-based measure of bank risk and of the Distance to Default as a market-based measure of bank risk.

### 3. Methodology: alternative measure of the Z-score and the Distance to Default

Because of the many shortcomings of the traditional Z-score, our approach involves an alternative Z-score measure of bank risk as well as a calculation of the Distance to Default in order to uncover the market perception of the risk of CEE banks.

#### 3.1 Inconsistency of the traditional Z-score and the proposed asymmetric Z-score

Many bank risk measures are applied in the banking literature, but each is subject to shortcomings. The ratios of Loan Loss Provisions to Total Loans and of Impaired Loans to Total Loans as well as the standard deviations of Returns on Assets and of Returns on Equities frequently generate endogeneity because the dependent variable can affect the risk variable in the first place (Berger, 1995). Moreover, with standard deviations, a bank is considered risky if it engages in activities that generate returns that are either higher or lower than the average return, which seems contradictory. In addition, banks that have returns that are higher or lower with the same magnitude with respect to average value are equally risky, which is also inconsistent.

The Z-score is an attempt to address some of these shortcomings. Nevertheless, three important problems should be mentioned. First, the Z-score formula, *i.e.*,  $Z = \frac{CAR+E(ROA)}{\sigma(ROA)}$ , supposes that the return on assets (*ROA*) random variable is normally distributed (Boyd and Runkle, 1993; Hannan and Hanweck, 1988; and Boyd et al., 1993) and that the default event occurs when current losses exhaust capital (see Appendix A, eq. A.1), which excludes any possibility for banks to cover their losses and liabilities with their assets. Moreover, the distribution of *ROA* is asymmetric (skewed), in reality.

Second, Boyd and Runkle (1993), Hannan and Hanweck (1988) and Boyd et al. (1993) argue that even if *ROA* is not normally distributed, under Bienaymé–Tchebycheff inequality,

the  $Z$ -score remains a good measure of bank risk and becomes the inverse measure of the upper bound of the probability of default (see Appendix A, eq. A.2). However, this assertion is valid only for a symmetric distribution of  $ROA$ . Otherwise, Cantelli's inequality must be applied, and it leads to the following expression for the probability of default:

$$\Pr[ROA \leq -CAR] \begin{cases} \leq \frac{1}{1+Z^2}, & \text{if } CAR + E(ROA) > 0 \\ \geq \frac{Z^2}{1+Z^2}, & \text{if } CAR + E(ROA) < 0, \end{cases}$$

which changes the relationship between the  $Z$ -score and the probability of default. Thus, the increase in the  $Z$ -score reduces the upper limit and raises the lower limit, and the opposite effect is observed for the decrease in the  $Z$ -score. In any case, having an interval for the probability of default provides no information about its true value. For this reason, the  $Z$ -score, without a normal distribution assumption, cannot ensure the comparability of bank risk data.

Third, the  $Z$ -score is based on the determination of the expected value and standard deviation of the bank's returns on assets. Thus, their empirical estimations may be very different from their true values if the  $ROA$  distribution is not symmetric.

Taking into account these shortcomings, namely the possible asymmetry of the  $ROA$  distribution, we will consider an asymmetric (skew) normal distribution for  $ROA$  with the following cumulative distribution function  $F(x, \alpha)$ :

$$F(x, \alpha) = N(x) - 2T(x, \alpha), \quad (1)$$

where  $T(x, \alpha)$  is the Owen (1956) function

$$T(x, \alpha) = \frac{1}{2\pi} \int_0^\alpha \frac{e^{-\frac{1}{2}x^2(1+t^2)}}{1+t^2} dt.$$

If  $\alpha = 0$ , then  $T(x, 0) = 0$  and  $F(x, 0) = N(x)$ ; in other words, the distribution function is symmetric. Otherwise, if  $\alpha < 0$ , then  $T(x, \alpha) < 0$  and  $F(x, \alpha) > N(x)$ , and the distribution is left skewed. For  $\alpha > 0$ , we obtain  $T(x, \alpha) > 0$ ,  $F(x, \alpha) < N(x)$  and a right skewed

distribution. Thus, the parameter  $\alpha$  takes into account the asymmetry (skewness) of the distribution.

To construct an asymmetric Z-score, the probability of default is computed as  $\Pr[ROA \leq -CAR] = F(\mu_1, \sigma_1, \alpha, -CAR)$ , where  $\mu_1$ ,  $\sigma_1$  and  $\alpha$  are location, scale and skew parameters, respectively. Because the minus Z-score is the point at which the normal cumulative distribution function is equal to the probability of default under the traditional approach (eq. A.2), our minus asymmetric Z-score will be the point at which the  $N(\cdot)$  function is equal to the probability of default that is computed with the skew normal cumulative distribution function as follows:

$$Zscore1 = -N^{-1}(F(\mu_1, \sigma_1, \alpha, -CAR)). \quad (2)$$

According to equation (A.2), we also compute and apply a Z-score with a normal distribution assumption of  $ROA$ , that is

$$Zscore2 = \frac{CAR + \mu_2}{\sigma_2}, \quad (3)$$

where  $\mu_2 = E(ROA)$  and  $\sigma_2 = \sigma(ROA)$  are location and scale parameters, respectively, for the normal distribution of  $ROA$ . Finally, for purposes of comparability, the traditional Z-score measure is also computed:

$$Zscore3 = \frac{CAR + \text{mean}(ROA)}{\text{sigma}(ROA)}, \quad (4)$$

where  $\text{mean}(ROA)$  and  $\text{sigma}(ROA)$  are empirical estimates of the mean and of the standard deviation of  $ROA$  over the entire 1995-2013 period, respectively. Although some authors computed them within an estimation window (Distinguin et al., 2013; Fang et al., 2015), our computational choice is motivated by the Z-score concept and the comparability among all Z-score results, and has also been applied in the banking literature (Laeven and Levine, 2009).

### *3.2 Market-based measure of bank risk: the Distance to Default*

Estimating the market perception of risk is important because the market evaluates whether banks hold enough assets to cover their liabilities and commitments, but it also evaluates the quality of the bank's management, governance, and organisation. A second approach is based on the estimation of the Distance to Default from the option model of Merton (1974). This risk measure shows how far a bank is from a default event: the lower its values, the closer the bank is to insolvency. One of the main advantages is the consideration of the default state, *i.e.*, when the market value of a bank's assets cannot cover the market value of its liabilities (debt). This approach is widely applied to price deposit insurance (Duan and Yu, 1994; Ronn and Verma, 1986) or to estimate individual (Laeven, 2002; Vassalou and Xing, 2004; Chan-Lau et al., 2004) and systemic bank risk (Lehar, 2005). Its concept and methodological approach are explained in Appendix B. Among the three procedures applied in the banking literature – *i.e.*, Ronn and Verma's (1986) procedure, the KMV estimation approach and Duan's (1994) method – we focus on the KMV and Duan estimates because they respect the hypotheses of the option model and are equivalent (Duan et al., 2005).

#### **4. Data analysis**

In this section, we first present our sample and then explain the selection and construction of the explanatory and control variables.

##### *4.1 Sample presentation*

Our sample of countries consists of 322 banks from ten CEE economies, including Bulgaria, the Czech Republic, Hungary, Estonia, Latvia, Lithuania, Poland, Romania, Slovakia and Slovenia, for accounting-based risk measures and a sample of all 30 listed banks for the Distance to Default. Accounting data for individual banks are extracted on an annual basis from Bankscope Fitch IBCA in millions of USD. The interest rate on bank debt is

determined as the ratio of interest expenses to total debt. To obtain monthly series for debt and the interest rate, we converted the yearly series of debt and interest expenses using the cubic method. Daily stock prices are obtained from DataStream. The sample period is from 1995 to 2013.

#### *4.2. Explanation of variables*

Our dependent variable is one of the aforementioned measures of bank risk: the accounting-based measure of risk (Zscore1, Zscore2 and Zscore3) and the market-based measure of risk (DD\_KMV and DD\_Duan). For the book value of debt  $D$ , we use “Total liabilities”, *i.e.*, both short- and long-term debt. As explained by Vassalou and Xing (2004), it is important to include long-term debt because the interest payments in the service of such debt are part of short-term liabilities and affect bank solvency. Following Laeven (2002), Chan-Lau et al. (2004), Harada and Ito (2008), among others, we include the entire amount of long-term liabilities. In spite of this, the maturity reference taken in the banking literature is one year (Laeven, 2002; Chan-Lau et al., 2004; Harada and Ito, 2008).

##### *4.2.1 Ownership structure*

To study differences in bank risk according to ownership structure, we construct two dummy variables: FOR and PRIV. The first variable takes the value of one if the share of foreign ownership is higher than 50 per cent and zero otherwise. The dummy variable PRIV takes the value of one if domestic private ownership comprises at least 50 per cent of total shares and zero otherwise. When multiplied by bank and country variables, these variables reveal the differences among ownership forms in terms of their effects on bank risk, the benchmark ownership being state-owned institutions.

#### 4.2.2 Bank characteristics

In addition to the determination of the risk profile of CEE banks based on their ownership structure, we also aim to study the effects of funding structure and income diversification on risk-taking. Distinguin et al. (2013) argue that, as interbank deposits are not covered by a depositor protection scheme and are withdrawn immediately after mild negative news or rumours, they might persuade banks to temper their risk-taking behaviour. Fundamentally, interbank depositors are relatively informed and less likely to withdraw from sound banks (Rochet and Tirole, 1996). However, banks with a higher ratio of interbank deposits, which have not been previously “disciplined” in the interbank market, might be ex-post more vulnerable for the same reason (Huang and Ratnovski, 2011). Thus, we use the share of deposits received from other banks in total deposits (BDTD) to examine its effect on banks: risk reduction, as an ex-ante market disciplinary tool, or risk increasing, as an ex-post bank vulnerable factor.

We complete this analysis by incorporating the share of long-term funds in total funds (LTFTF). For CEE banks, these funds essentially consist of term retail deposits, which – as opposed to interbank deposits – are sluggish because of deposit insurance schemes, switching costs and loss of promised interests (Kim et al., 2003; Sharpe, 1997) and may therefore have a stabilising role.

Another point of interest is the role of income diversification in bank risk-taking behaviour. Income diversification may ensure income stability (Berger et al., 1999; Campa and Kedia, 2002; Landskroner et al., 2005) or, on the contrary, may make bank revenue less stable and thus may make banks riskier (DeYoung and Roland, 2001; Stiroh, 2004; Acharya et al., 2006; Stiroh and Rumble, 2006; Demirgüç-Kunt and Huizinga 2010). We therefore apply the income diversification index of Laeven and Levine (2007),

$$DIV = 1 - \left| \frac{\text{Net interest income} - \text{Other operating income}}{\text{Total operating income}} \right|.$$

We use the Liquidity Coverage Ratio (LCR) and the size of banks to control for certain bank-specific characteristics. For LCR, we apply the Basel definition (BIS, 2010a), as adjusted with respect to data availability, and compute LCR as high-quality assets on high-liquid liabilities. For high-quality assets, we use loans and advances to banks, government securities, and cash and due from banks. For high-quality liabilities, we consider current customer deposits, deposits from banks, and repos and cash collateral. We expect that a higher ratio makes banks more resilient, as shown by the Basel working group (BIS, 2010b). Finally, as in Saunders et al. (1990), we take total assets of banks, measured in billions of USD in order to have readable coefficients. Large banks have more and better diversification opportunities, more risk management skills, and more information about their projects (Banz, 1981). Moreover, investors may believe that regulators are unwilling to let larger banks fail, the value of implicit failure guarantees of which rise with bank size. Therefore, size and risk should be negatively related (Saunders et al., 1990); alternatively, the “too-big-to-fail” feature may encourage banks to assume more risk (Brown and Dinç, 2011; Demirgüç-Kunt and Huizinga, 2013).

#### *4.2.3 Country characteristics*

The last effect of interest is the role of banking regulation on CEE banks’ risk-taking. We construct a Banking Regulation Index (BRI) based on the procedure explained in Appendix C. This index takes values between zero and one, and environments in which laws are to a greater extent enforced and are closer to Basel requirements correspond to values that are closer to one. The expected effect is not obvious: Financial liberalisation may be associated with higher bank risk because of greater competition in the banking market (Keeley, 1990) or, conversely, with lower bank risk, thanks to more diversified and stable income sources (Barth et al., 2001; González, 2005; Laeven and Levine, 2009). This effect is exogenous because all



reforms in CEE countries were implemented to support the transition and not because of bank risk (Fang et al., 2014).

Other country-level variables allow for economic conditions and macroeconomic cycles to be taken into account as well as crisis events. We apply the logarithm of the real Gross Domestic Product per capita (LnRGDP) (Laeven, 2002; Laeven and Levine, 2009) to consider the stage of the business cycle and the annual growth rate of the real Gross Domestic Product (RGDPG) (Iannotta et al., 2013) to consider general economic development. As they are not correlated, as in Dinger (2009), both variables are taken simultaneously. We expect that more developed countries (higher LnRGDP) have better capitalised banks and, therefore, a higher Z-score. The market perception of banks' risk should also be improved, and the effects of economic growth are not as obvious. If banks take advantage of economic growth and enhance their capitalisation, their risk is reduced. Otherwise, there is no (or even a negative) effect. It is also useful to consider crisis events (Aebi et al., 2012; DeYoung et al., 2013), and we thus use two crisis dummy variables. CRISIS1 takes a value of 1 for the crisis events of the 1990s, which have been documented in Laeven and Valencia (2010). The CRISIS2 variable takes into account the recent financial crisis (years 2008-2011). Obviously, during financial crises, bank risk is expected to be higher.

All regressions are run to avoid the collinearity problem. Therefore, only regressions with mean VIF lower than 2.5 are considered.

## **5. Econometric method, empirical analysis and robustness checks**

In this section, we first check the consistency of the traditional Z-score and then study the effects of ownership structure on the CEE banks' risk.

### *5.1 Inconsistency of the traditional Z-score as a measure of bank risk*

To estimate the Zscore1 and Zscore2 measures, we determine the skew normal and normal distribution functions, respectively, for each bank that has at least ten observations for *ROA*. If this variable has a symmetric distribution, which is the main principle of the traditional Z-score concept, then, as mentioned in section 3,  $\alpha = 0$  and Zscore1 = Zscore2. However, our estimations for all 322 banks of all countries provide the following range of results for skew parameter  $\alpha$ : for Bulgaria  $\alpha \in [-4.00; 3.73]$ , for the Czech Republic  $\alpha \in [-4.20; 3.83]$ , for Hungary  $\alpha \in [-3.83; 3.96]$ , for Estonia  $\alpha \in [-4.34; 3.50]$ , for Latvia  $\alpha \in [-4.37; 4.53]$ , for Lithuania  $\alpha \in [-4.86; 4.81]$ , for Poland  $\alpha \in [-4.48; 4.26]$ , for Romania  $\alpha \in [-4.38; 3.91]$ , for Slovakia  $\alpha \in [-5.06; 4.61]$ , and for Slovenia  $\alpha \in [-4.02; 3.91]$ . These results clearly show that the traditional computations of the Z-score (eq. 4) and the normal distribution computations (eq. 3) are not consistent, at least for CEE banks.

Some authors (Laeven and Levine, 2009; Fang et al., 2014) argue that taking the logarithm of Z-score alleviates its skewness. We tested this assumption and the inconsistency between skew normal distribution, normal distribution and traditional estimates using Monte Carlo simulations (see Appendix D) and can draw two useful conclusions. First, if *ROA* distribution is skewed, the application of normal distribution and traditional approaches provides spurious results (Figures D1 and D2). Second, the logarithmic transformation does not reduce the skewness and fails to provide appropriate results. In addition, the traditional approach and the normal distribution assumption are not equal (Figure D3). For these reasons, we will focus on Zscore1 as an accounting-based risk measure, and we will keep the results of Zscore 2 and Zscore3 only for comparability reason.

## *5.2 Factors influencing bank risk*

To examine the effects of ownership structure and other factors on bank risk, we regress the following panel data model with bank- and time-fixed effects:

$$Risk_{i,j,t} = \alpha_0 + \sum_{k=1}^n \alpha_k X_{k,i,j,t} + \sum_{l=n+1}^m \alpha_l Y_{l,j,t} + \mu_i + \pi_t + \varepsilon_{i,j,t}, \quad (5)$$

where  $Risk_{i,j,t}$  is one of the following risk measures:  $DD\_KMV$ ,  $DD\_Duan$ ,  $Zscore1$ ,  $Zscore2$  and  $Zscore3$ , for bank  $i$  in country  $j$  at year  $t$ ,  $n$  is the number of bank-specific variables ( $n=6$ ),  $m-n$  is the number of country-specific variables ( $m=11$ ),  $X_{k,i,j,t}$  is the bank-specific factor that controls for the  $k$ -th characteristic of bank  $i$  at year  $t$  in country  $j$ , and  $Y_{l,j,t}$  is the country-specific factor that controls for the  $l$ -th characteristic of country  $j$ .  $\alpha_0$ ,  $\alpha_k$  and  $\alpha_l$  are parameters to be estimated;  $\mu_i$  and  $\pi_t$  are individual and time effects, respectively; and  $\varepsilon_{i,j,t}$  is the error term. Standard errors are robust to heteroscedasticity.

The results of the role of ownership in bank risk are presented in table 1. Two models are estimated; each differs according to the source of bank activity funding. For each model, we find that foreign banks are the least risky, which corresponds to the research on emerging countries (Demirgüç-Kunt et al. 1998; Detregiache and Gupta, 2004). For a long period, foreign banks in CEE countries exclusively held the expertise, technology and know-how for credit screening and developed new and diversified activities, maintaining a low risk profile with diversified and stable sources of liquidity. They are therefore better capitalised with respect to the distribution of their  $ROA$  and thus have higher  $Z$ -scores. These results are in the same vein as Dinger (2009), who finds that foreign banks reduce liquidity risk in CEE economies. However, we provide more precise results showing that CEE financial markets regard these banks as the least risky, also. The market perception is not obvious concerning domestic private banks. We find no difference with state-owned banks applying the  $DD\_Duan$  risk measure and lower risk for domestic private banks with  $DD\_KMV$  (model (b)), but the risk is higher than that of foreign counterparts. Nevertheless, all regressions show that they are better capitalised and thus have higher  $Z$ -scores than state-owned banks but lower scores than foreign institutions. The increasing competition in these banking markets led

TABLE 1. *Factors influencing the bank risk.*

Variables	(a)					(b)				
	<i>DD_KMV</i>	<i>DD_Duan</i>	<i>Zscore1</i>	<i>Zscore2</i>	<i>Zscore3</i>	<i>DD_KMV</i>	<i>DD_Duan</i>	<i>Zscore1</i>	<i>Zscore2</i>	<i>Zscore3</i>
FOR, $\alpha_1$	1.218*** (0.416)	0.917** (0.389)	1.275*** (0.439)	2.299*** (0.666)	1.382*** (0.342)	1.334*** (0.419)	1.002*** (0.394)	1.965*** (0.462)	3.391*** (0.701)	2.065*** (0.374)
PRIV, $\alpha_2$	0.523 (0.390)	0.208 (0.378)	0.947** (0.454)	1.472** (0.646)	1.527*** (0.351)	0.658* (0.400)	0.337 (0.388)	1.126*** (0.480)	1.671*** (0.678)	1.720*** (0.384)
BDTD, $\alpha_3$	-0.360 (0.762)	-0.400 (0.729)	2.373*** (0.785)	3.620*** (0.973)	2.301*** (0.562)					
LTFTF, $\alpha_3$						-0.262 (1.234)	0.258 (1.234)	0.559 (1.751)	1.281 (2.989)	0.172 (2.076)
DIV, $\alpha_4$	-0.443 (0.599)	-0.698 (0.565)	-0.767* (0.480)	-1.104* (0.675)	-0.601 (0.400)	-0.165 (0.627)	-0.311 (0.589)	0.040 (0.607)	0.258 (0.925)	0.539 (0.569)
LCR, $\alpha_5$	0.313 (0.323)	0.238 (0.307)	0.210*** (0.065)	0.295*** (0.087)	0.226*** (0.071)	0.401 (0.317)	0.269 (0.301)	0.097*** (0.025)	0.177*** (0.047)	0.115*** (0.030)
SIZE, $\alpha_6$	0.086*** (0.017)	0.083*** (0.016)	0.098*** (0.024)	0.173*** (0.032)	0.152*** (0.021)	0.090*** (0.019)	0.085*** (0.018)	0.135*** (0.026)	0.244*** (0.034)	0.185*** (0.022)
BRI, $\alpha_7$	1.170 (1.570)	0.887 (1.501)	3.669*** (1.435)	3.805* (2.145)	1.893 (1.350)	1.409 (1.629)	1.039 (1.562)	4.464*** (1.767)	5.170** (2.731)	1.986 (1.781)
RGDPG, $\alpha_8$	2.127 (3.771)	0.114 (3.763)	-4.596 (3.358)	-4.794 (4.696)	-3.740 (2.928)	0.145 (3.996)	-1.326 (3.951)	-4.584 (3.855)	-4.058 (5.406)	-1.771 (3.625)
LnRGDP, $\alpha_9$	7.496*** (1.845)	6.486*** (1.800)	-3.624*** (1.392)	-5.794*** (1.861)	-3.630*** (1.116)	8.360*** (1.930)	7.083*** (1.864)	-2.550 (1.680)	-3.488 (2.371)	-3.169** (1.519)
CRISIS1, $\alpha_{10}$	-1.818** (0.941)	-2.235*** (0.928)	0.449 (0.481)	-0.200 (0.656)	-0.798*** (0.326)	-1.879** (0.926)	-2.202*** (0.909)	0.800 (0.512)	0.161 (0.703)	-0.535* (0.365)
CRISIS2, $\alpha_{11}$	-7.669*** (1.386)	-6.604*** (1.349)	-0.668 (1.230)	-2.877** (1.364)	-2.102*** (0.813)	-8.227*** (1.434)	-7.021*** (1.383)	-2.124 (1.469)	-5.760*** (1.750)	-3.224*** (1.090)
CONSTANT, $\alpha_0$	-6.509*** (2.645)	-4.828** (2.600)	17.868*** (2.032)	29.654*** (2.897)	30.364*** (2.039)	-7.894*** (2.716)	-5.922** (2.628)	15.570*** (2.488)	25.155*** (3.904)	28.778*** (2.708)
Observations	381	381	2782	2782	2781	359	359	2459	2459	2458
R-squared	0.630	0.647	0.763	0.694	0.771	0.636	0.653	0.774	0.733	0.774

*Notes:* This table presents the regression results of risk measures on bank- and country-specific factors. *DD\_KMV* = Distance to Default estimated with KMV approach; *DD\_Duan* = Distance to Default estimated with Duan's approach; *Zscore1* = Zscore estimated with equation (2); *Zscore2* = Zscore estimated with equation (3); *Zscore3* = Zscore estimated with equation (4); FOR = foreign owned bank dummy variable, which takes the value of one for banks in which foreign ownership represents at least 50 percents of total share, and zero otherwise; PRIV = domestic privately owned bank dummy variable, which takes the value of one for banks in which domestic private ownership represents at least 50 percents of total share, and zero otherwise; BDTD = interbank deposits to total deposits ratio; LTFTF = long-term funds to total funds ratio; DIV = income diversification index; LCR = liquidity coverage ratio; SIZE = size of banks, expressed in terms of banks' total assets; BRI = banking regulation index, which takes values between zero and one; RGDPG = real GDP growth rate; LnRGDP = logarithm of the real GDP per capita; CRISIS1 = crisis dummy variable, which takes value of one for crises events of 1990s, and zero otherwise; CRISIS2 = crisis dummy variable, which takes value of one for years 2008-20011, and zero otherwise. Bank and time fixed effects are considered but not reported. Heteroscedastic robust t-statistics are in parentheses. \*\*\*, \*\* and \* are statistical significances at 0.01, 0.05 and 0.10 level, respectively.

domestic banks to provide the same product and services as their foreign counterparts imitating their practices, which allows them to improve their performance. On the contrary, public banks are unresponsive to transformations and evolutions and have no market incentive (Schleifer, 1998). This explanation of our results is consistent with the findings of Caprio and Martinez Peria (2000) and Dong et al. (2014). Despite the implicit provision of insurance from the government, the non-commercial and policy-oriented practices of state-owned banks seem to make them the worst capitalised with the lowest Z-scores. Moreover, financial markets consider them the riskiest.

Calomiris and Kahn (1991) and Calomiris (1999) argue that short-term funds discipline banks in their risk-taking behaviour. Our results show that banks with a higher interbank deposits ratio (BDTD) are less risky because they are better capitalised (model (a)); these results corroborate those of Distinguin et al. (2013). However, although they have higher Z-scores, financial markets are not sensitive and make no distinction between them and banks with a small interbank deposits ratio. Thus, banks offer their excess liquidity only to their counterparts that are well capitalised with respect to the return distribution. This is no longer the case for long-term funds. The banks with a higher ratio of long-term funds to total funds (LTFTF) do not have different risk profiles (model (b)), on average, and the market is also insensitive to the evolution of this source of funding. This surprising result does not correspond to the findings of Kim et al. (2003) and Sharpe (1997) on the risk-improving role of long-term funds, which is likely because banks with different ownership structures behave differently, and the average effect is thus cancelled.

As for sources of bank activity funding, there is no difference in the way that financial markets view banks with different income diversification policies (DIV) and different liquidity coverage ratios (LCR). If some effects cancel one another, further analysis will disclose them. However, considering our asymmetric Zscore1 and normal distributed

Zscore2, we find that riskier banks have more diversified income (model (a)). Although this result is not confirmed by model (b), it should be mentioned that income diversification implies the presence of high instable sources of revenue. According to DeYoung and Roland (2001), Stiroh (2004), Acharya et al. (2006), Stiroh and Rumble (2006), this could explain our results. As for the liquidity coverage ratio, banks with higher levels are also less risky, which corresponds to the findings of the Basel working group on the assessment of the liquidity requirements effects (BIS, 2010b).

Following many studies on developed countries (Stiroh, 2004), on emerging countries (Sanya and Wolfe, 2011; Meslier et al., 2014) and on CEE economies (Distinguin et al., 2013), we find that large banks are less risky, which is likely because of the reasons evoked above: *i*) more and better diversification opportunities and more information on their projects and also *ii*) ‘too-big-to-fail’ guarantees. The first reason may explain the better capitalisation of large banks and the second the market perception about their risk.

Macroeconomic factors play a stabilising role. Our results support the view of Keeley (1990) and show that the alignment of banking regulations (BRI) with Basel requirements inhibits banks from taking on more risk. In the case of CEE countries, it forced banks to increase their capitalisation and other prudential ratios but also liberalised the entry of foreign banks into these markets and permitted the practice of many other modern bank activities. This result is valid for both models only with our asymmetric Zscore1 measure. However, the CEE financial markets are insensitive to the development of banking regulation. They are, on the other hand, very sensitive to real GDP per capita levels (LnRGDP) and to the crisis events of the 1990s (CRISIS1) and 2008 (CRISIS2), and this is true for both models and risk measures. In countries and periods with higher levels of real GDP per capita, markets perceive banks as less risky, and in countries and years affected by both financial crises, the banks are considered riskier. The results of the Zscore1 measure show that CEE banks are

neither worse nor better capitalised during the crisis events if the distribution of their *ROA* is taken into account; there were more opportunities with very high *ROA* operations during the 1990s as well as better capitalisation during the last crisis, which does not necessarily imply, on average, higher probabilities of default  $\Pr[ROA \leq -CAR] = F(\mu_1, \sigma_1, \alpha, -CAR)$  for the majority of CEE banks. Finally, countries with a higher or lower annual growth rate of real GDP (RGDPG) do not have less risky or riskier banks. This result is obtained with all market and accounting risk measures and for all models. For the same region, Dinger (2009) finds that banks hold less liquid assets in times and in countries with higher economic growth, and she explains this result in terms of a lower probability of liquidity shocks and therefore higher opportunity costs from holding liquid assets with economic growth. We think that the same explanation may be used with respect to bank capitalisation intentions.

### *5.3 Income and funding structure, banking regulation and bank risk: Does ownership matter?*

For this point, we extend our analysis and examine whether the revealed relationships are different for foreign, domestic private and state-owned banks.

#### *5.3.1 Sources of bank activity funding*

We now test how the risk of foreign, private and public institutions changes with interbank deposits and long-term fund ratios, and the results for both models and measures of risk are presented in table 2. FOR and PRIV variables are excluded from regressions with Distance to Default risk measures because of collinearity issues. With them, the mean VIF is close to 5 and even close to 15 for some explanatory variables. Without them, it is close to 2. Nonetheless, there is no collinearity problem with Z-score measures because the mean VIF with FOR and PRIV variables is close to 2.

TABLE 2. *Ownership and bank activity funding nexus.*

Variables	(a)					(b)				
	<i>DD_KMV</i>	<i>DD_Duan</i>	<i>Zscore1</i>	<i>Zscore2</i>	<i>Zscore3</i>	<i>DD_KMV</i>	<i>DD_Duan</i>	<i>Zscore1</i>	<i>Zscore2</i>	<i>Zscore3</i>
FOR, $\alpha_1$	-	-	2.946*** (0.477)	5.342*** (0.722)	3.425*** (0.377)	-	-	2.354*** (0.504)	4.129*** (0.798)	2.570*** (0.442)
PRIV, $\alpha_2$	-	-	2.308*** (0.506)	3.308*** (0.784)	2.469*** (0.451)	-	-	1.556*** (0.489)	2.298*** (0.731)	2.088*** (0.431)
BDTD, $\alpha_3$	-4.102*** (1.476)	-2.647** (1.388)	10.717*** (1.860)	18.073*** (3.192)	11.667*** (1.961)					
BDTD□FOR, $\alpha_4$	3.911*** (1.540)	1.910 (1.444)	-10.255*** (2.075)	-18.634*** (3.354)	-12.489*** (2.177)					
BDTD□PRIV, $\alpha_5$	3.558*** (1.489)	2.410* (1.410)	-8.953*** (2.355)	-12.670*** (3.938)	-6.862*** (2.403)					
LTFTF, $\alpha_3$						-12.903*** (4.075)	-14.274*** (3.673)	8.263* (4.665)	14.380* (8.298)	8.640* (5.559)
LTFTF□FOR, $\alpha_4$						14.035*** (4.185)	16.080*** (3.790)	-9.658** (4.574)	-17.254** (8.007)	-11.452** (5.400)
LTFTF□PRIV, $\alpha_5$						10.635** (5.133)	12.602*** (4.592)	-13.707*** (4.875)	-20.319*** (8.178)	-12.064** (5.595)
DIV, $\alpha_6$	-0.393 (0.606)	-0.682 (0.572)	-0.782* (0.478)	-1.161* (0.664)	-0.653* (0.394)	-0.077 (0.637)	-0.177 (0.592)	-0.142 (0.611)	-0.082 (0.931)	0.308 (0.573)
LCR, $\alpha_7$	0.275 (0.324)	0.205 (0.307)	0.258*** (0.074)	0.379*** (0.105)	0.281*** (0.079)	0.457* (0.317)	0.271 (0.298)	0.092*** (0.025)	0.169*** (0.046)	0.110*** (0.029)
SIZE, $\alpha_8$	0.099*** (0.016)	0.092*** (0.0160)	0.094*** (0.023)	0.169*** (0.031)	0.150*** (0.020)	0.097*** (0.018)	0.087*** (0.017)	0.132*** (0.026)	0.240*** (0.034)	0.183*** (0.022)
BRI, $\alpha_9$	1.001 (1.584)	0.726 (1.505)	3.655*** (1.418)	3.850* (2.105)	1.955 (1.313)	1.071 (1.636)	1.061 (1.532)	4.542*** (1.762)	5.207** (2.716)	1.975 (1.772)
RGDPG, $\alpha_{10}$	2.059 (3.794)	0.053 (3.781)	-4.869 (3.305)	-5.474 (4.590)	-4.278 (2.864)	0.224 (4.058)	-1.729 (3.977)	-4.376 (3.848)	-3.501 (5.401)	-1.337 (3.617)
LnRGDP, $\alpha_{11}$	7.146*** (1.797)	5.916*** (1.745)	-4.513*** (1.407)	-6.990*** (1.879)	-4.242*** (1.121)	8.687*** (1.898)	7.502*** (1.821)	-2.540 (1.671)	-3.474 (2.355)	-3.161** (1.510)
CRISIS1, $\alpha_{12}$	-1.591* (0.931)	-1.922** (0.917)	0.299 (0.475)	-0.485 (0.645)	-0.994*** (0.327)	-1.568* (0.929)	-1.982** (0.902)	0.697 (0.514)	-0.020 (0.712)	-0.654* (0.375)
CRISIS2, $\alpha_{13}$	-7.298*** (1.338)	-5.934*** (1.292)	-0.161 (1.253)	-2.194* (1.380)	-1.752** (0.805)	-7.893*** (1.358)	-6.839*** (1.299)	-2.238* (1.477)	-6.001*** (1.763)	-3.398*** (1.102)
CONSTANT, $\alpha_0$	-5.039** (2.583)	-3.475 (2.556)	17.369*** (1.991)	28.243*** (2.917)	29.191*** (2.055)	-8.064*** (2.710)	-6.615*** (2.621)	15.434*** (2.469)	24.992*** (3.863)	28.697*** (2.675)
<b>Ownership implication: Wald test</b>										
State-owned banks: $\alpha_3$	-4.102***	-2.647**	10.717***	18.073***	11.667***	-12.903***	-14.274***	8.263*	14.380*	8.640*
Foreign banks: $\alpha_3 + \alpha_4$	-0.191	-0.737	0.461	-0.561	-0.822	1.132	1.806	-1.395	-2.874	-2.812*
Private banks: $\alpha_3 + \alpha_5$	-0.544	-0.237	1.764	5.403***	4.805***	-2.268	-1.672	-5.444**	-5.939**	-3.424*
Observations	381	381	2782	2782	2781	359	359	2459	2459	2458
R-squared	0.628	0.644	0.767	0.702	0.780	0.637	0.660	0.775	0.736	0.776



*Notes:* This table presents the regression results of risk measures on bank- and country-specific factors, revealing the relationship between the ownership and bank activity funding. DD\_KMV = Distance to Default estimated with KMV approach; DD\_Duan = Distance to Default estimated with Duan's approach; Zscore1 = Zscore estimated with equation (2); Zscore2 = Zscore estimated with equation (3); Zscore3 = Zscore estimated with equation (4); FOR = foreign owned bank dummy variable, which takes the value of one for banks in which foreign ownership represents at least 50 percents of total share, and zero otherwise; PRIV = domestic privately owned bank dummy variable, which takes the value of one for banks in which domestic private ownership represents at least 50 percents of total share, and zero otherwise; BDTD = interbank deposits to total deposits ratio; LTFTF = long-term funds to total funds ratio; DIV = income diversification index; LCR = liquidity coverage ratio; SIZE = size of banks, expressed in terms of banks' total assets; BRI = banking regulation index, which takes values between zero and one; RGDPG = real GDP growth rate; LnRGDP = logarithm of the real GDP per capita; CRISIS1 = crisis dummy variable, which takes value of one for crises events of 1990s, and zero otherwise; CRISIS2 = crisis dummy variable, which takes value of one for years 2008-20011, and zero otherwise. Bank and time fixed effects are considered but not reported. Heteroscedastic robust t-statistics are in parentheses. \*\*\*, \*\* and \* are statistical significances at 0.01, 0.05 and 0.10 level, respectively.

Financial markets only view state-owned banks with a higher proportion of interbank deposits as riskier (model (a)) and do not change their risk perception of foreign and domestic private institutions. Deduced from the evolution of the price of bank stocks, the Distance to Default is a pure risk perception measure of listed banks, the evolution of which cannot, by construction, be directly explained by the balance sheet behaviour of banks. Thus, financial markets regard state-owned banks as the riskiest regardless of the interbank deposits ratio (models (a)), long-term funds ratio (models (b)), or other variables describing the behaviour of these institutions. As expected, foreign and private banks with higher interbank deposits and long-term ratios are viewed by the market as less risky than state-owned institutions (coefficients  $\alpha_4$  and  $\alpha_5$ , respectively), but under the Wald test, the absolute effect is cancelled.

However, the evolution of Z-scores can be related to the balance sheet behaviour of banks. State-owned banks with higher interbank deposits and long-term funds ratios also have the best capitalisation profile with respect to the distribution of their *ROA*. This result may explain both the disciplinary stabilising role of interbank deposits and the confidence of long-term financiers in highly capitalised public banks. As foreign banks in CEE countries are less risky and sufficiently well capitalised, they do not need to guarantee the reimbursement of interbank deposits and long-term funds with increases in capital. Their guarantees are more diversified assets and more stable sources of liquidity (Freixas and Holthausen, 2005) as well as the financial support of their parent companies (Bonin et al., 2015).

### *5.3.2 Income structure*

We found previously that banks that are more income diversifying are riskier. In order to assess if there is any difference among foreign, private and state-owned banking institutions, as previously, we introduce cross-product terms with ownership variables, although without

TABLE 3. *Ownership and bank activity diversification nexus.*

Variables	(a)					(b)				
	<i>DD_KMV</i>	<i>DD_Duan</i>	<i>Zscore1</i>	<i>Zscore2</i>	<i>Zscore3</i>	<i>DD_KMV</i>	<i>DD_Duan</i>	<i>Zscore1</i>	<i>Zscore2</i>	<i>Zscore3</i>
BDTD, $\alpha_3$	-0.487 (0.760)	-0.533 (0.726)	2.411*** (0.786)	3.699*** (0.973)	2.307*** (0.560)					
LTFTF, $\alpha_3$						0.049 (1.269)	0.542 (1.268)	0.793 (1.764)	1.722 (3.016)	0.405 (2.094)
DIV, $\alpha_4$	-1.680** (0.727)	-1.523** (0.687)	-2.198*** (0.628)	-3.727*** (0.965)	-2.569*** (0.521)	-1.562** (0.771)	-1.254* (0.729)	-1.469* (0.885)	-2.304* (1.471)	-1.360* (0.888)
DIV□FOR, $\alpha_5$	1.442*** (0.556)	1.030** (0.530)	1.776*** (0.574)	3.398*** (0.881)	2.323*** (0.446)	1.541*** (0.575)	1.072** (0.549)	2.068*** (0.709)	3.736*** (1.127)	2.484*** (0.636)
DIV□PRIV, $\alpha_6$	1.320*** (0.541)	0.795 (0.519)	1.701*** (0.602)	2.869*** (0.932)	2.584*** (0.489)	1.567*** (0.567)	1.004* (0.547)	1.568** (0.742)	2.343** (1.207)	2.207*** (0.710)
LCR, $\alpha_7$	0.274 (0.321)	0.200 (0.306)	0.219*** (0.066)	0.312*** (0.088)	0.238*** (0.072)	0.396 (0.321)	0.263 (0.306)	0.098*** (0.025)	0.178*** (0.047)	0.116*** (0.030)
SIZE, $\alpha_8$	0.084*** (0.017)	0.082*** (0.017)	0.098*** (0.023)	0.171*** (0.032)	0.149*** (0.021)	0.090*** (0.019)	0.087*** (0.019)	0.141*** (0.026)	0.252*** (0.035)	0.189*** (0.023)
BRI, $\alpha_9$	1.130 (1.567)	0.840 (1.500)	3.488*** (1.426)	3.544* (2.139)	1.814 (1.317)	1.287 (1.631)	0.891 (1.567)	4.064*** (1.718)	4.554* (2.642)	1.678 (1.702)
RGDPG, $\alpha_{10}$	2.265 (3.774)	0.193 (3.764)	-4.644 (3.324)	-4.920 (4.664)	-3.690 (2.926)	0.348 (4.007)	-1.166 (3.961)	-4.254 (3.822)	-3.506 (5.376)	-1.270 (3.628)
LnRGDP, $\alpha_{11}$	6.779*** (1.828)	5.912*** (1.794)	-3.507*** (1.362)	-5.567*** (1.830)	-3.665*** (1.098)	7.563*** (1.914)	6.431*** (1.860)	-2.214 (1.669)	-2.895 (2.372)	-2.969** (1.522)
CRISIS1, $\alpha_{12}$	-1.609* (0.938)	-2.068** (0.927)	0.432 (0.479)	-0.232 (0.656)	-0.813*** (0.326)	-1.596* (0.927)	-1.961** (0.910)	0.758 (0.510)	0.090 (0.705)	-0.565* (0.366)
CRISIS2, $\alpha_{13}$	-6.925*** (1.364)	-5.992*** (1.333)	-0.605 (1.224)	-2.791** (1.361)	-2.022*** (0.814)	-7.406*** (1.416)	-6.336*** (1.729)	-2.051 (1.466)	-5.672*** (1.739)	-3.156*** (1.083)
CONSTANT, $\alpha_0$	-4.740* (2.600)	-3.491 (2.585)	18.722*** (2.056)	31.059*** (2.911)	31.516*** (2.032)	-6.155** (2.682)	-4.614* (2.613)	16.673*** (2.482)	26.897*** (3.847)	30.155*** (2.659)
<b>Ownership implication: Wald test</b>										
State-owned banks: $\alpha_4$	-1.680**	-1.523**	-2.198***	-3.727***	-2.569***	-1.562**	-1.254*	-1.469*	-2.304*	-1.360*
Foreign banks: $\alpha_4 + \alpha_5$	-0.238	-0.493	-0.422	-0.329	-0.247	-0.021	-0.181	0.599	1.432*	1.124**
Private banks: $\alpha_4 + \alpha_6$	-0.360	-0.728	-0.498	-0.858	0.015	0.005	-0.250	0.098	0.039	0.846*
Observations	381	381	2782	2782	2781	359	359	2459	2459	2458
R-squared	0.629	0.646	0.764	0.694	0.772	0.635	0.651	0.773	0.733	0.774

*es:* This table presents the regression results of risk measures on bank- and country-specific factors, revealing the relationship between the ownership and bank activity diversification. *DD\_KMV* = Distance to Default estimated with KMV approach; *DD\_Duan* = Distance to Default estimated with Duan's approach; *Zscore1* = Zscore estimated with equation (2); *Zscore2* = Zscore estimated with equation (3); *Zscore3* = Zscore estimated with equation (4); FOR = foreign owned bank dummy variable, which takes the value of one for banks in which foreign ownership represents at least 50 percents of total share, and zero otherwise; PRIV = domestic privately owned bank dummy variable, which takes the value of one for banks in which domestic private ownership represents at least 50 percents of total share, and zero otherwise; BDTD = interbank deposits to total deposits ratio; LTFTF = long-term funds to total funds ratio; DIV = income diversification index; LCR = liquidity coverage ratio; SIZE = size of banks, expressed in terms of banks' total assets; BRI = banking regulation index, which takes values between zero and one; RGDPG = real GDP growth rate; LnRGDP = logarithm of the real GDP per capita; CRISIS1 = crisis dummy variable, which takes value of one for crises events of 1990s, and zero otherwise; CRISIS2 = crisis dummy variable, which takes value of one for years 2008-20011, and zero otherwise. Bank and time fixed effects are considered but not reported. Heteroscedastic robust t-statistics are in parentheses. \*\*\*, \*\* and \* are statistical significances at 0.01, 0.05 and 0.10 level, respectively.

FOR and PRIV variables because of collinearity. The results presented in table 3 confirm our previous finding with respect to state-owned banks. Regardless of their balance sheet behaviour, they are considered by financial markets to be the riskiest. With regard to foreign and domestic private banks, the market perception of risk does not change with balance sheet considerations. As for Z-scores, only the state-owned banks with more diversified income activities have a different risk profile, *i.e.*, are riskier. Two reasons may explain our result: first, more instable income sources (DeYoung and Roland, 2001; Stiroh, 2004; Acharya et al. 2006; Stiroh and Rumble, 2006; Demirgüç-Kunt and Huizinga, 2010) and, second, the lack of experience with and knowledge of new activities (Bonin et al., 2015).

### *5.3.3 Banking regulation*

Previously, we found that, in countries and years with banking regulation in greater conformance with Basel requirements, banks have higher Z-scores (Zscore 1 and Zscore2). This is not surprising for these countries and periods because the entry requirements for these banking markets have been relaxed for foreign banks, capital and liquidity requirements have been aligned with Basel criteria, and accountability has been improved and made more transparent (Bonin et al. 2015). However, this regulation effect can differ based on banks' risk profiles (Klomp and De Haan, 2012).

We thus test whether foreign and private banks are always less risky than state-owned institutions in countries and years with banking regulation that is closer to the Basel requirements. The results, presented in table 4 without ownership variables because of problems of collinearity, are unambiguous: In these countries and times, foreign banks are less risky with respect to all Z-scores, and this is the case for private banks as well but only with our asymmetric Zscore1. Conversely, changes in the banking regulatory regime do not affect the public institutions' risk. We believe that these findings, particularly for foreign

TABLE 4. *Ownership and banking regulation nexus.*

Variables	(a)					(b)				
	<i>DD_KMV</i>	<i>DD_Duan</i>	<i>Zscore1</i>	<i>Zscore2</i>	<i>Zscore3</i>	<i>DD_KMV</i>	<i>DD_Duan</i>	<i>Zscore1</i>	<i>Zscore2</i>	<i>Zscore3</i>
BDTD, $\alpha_3$	-0.256 (0.748)	-0.304 (0.716)	2.329*** (0.785)	3.544*** (0.973)	2.275*** (0.563)					
LTFTF, $\alpha_3$						-0.336 (1.224)	0.168 (1.224)	0.473 (1.752)	1.146 (2.989)	0.101 (2.073)
DIV, $\alpha_4$	-0.402 (0.595)	-0.663 (0.562)	-0.763* (0.480)	-1.099* (0.675)	-0.598 (0.404)	-0.114 (0.624)	-0.271 (0.588)	0.067 (0.608)	0.303 (0.926)	0.569 (0.571)
LCR, $\alpha_5$	0.320 (0.320)	0.244 (0.305)	0.208*** (0.065)	0.292*** (0.086)	0.224*** (0.071)	0.357 (0.313)	0.230 (0.299)	0.097*** (0.025)	0.177*** (0.046)	0.115*** (0.030)
SIZE, $\alpha_6$	0.081*** (0.016)	0.078*** (0.016)	0.099*** (0.024)	0.174*** (0.033)	0.153*** (0.021)	0.083*** (0.018)	0.078*** (0.018)	0.135*** (0.027)	0.242*** (0.035)	0.185*** (0.023)
BRI, $\alpha_7$	-1.229 (1.602)	-0.947 (1.512)	2.042 (1.624)	0.839 (2.445)	-0.250 (1.329)	-1.262 (1.641)	-1.011 (1.550)	2.019 (1.913)	0.991 (2.945)	-1.042 (1.713)
BRI□FOR, $\alpha_8$	3.425*** (0.856)	2.775*** (0.811)	2.244*** (0.860)	4.216*** (1.300)	2.538*** (0.620)	3.691*** (0.861)	3.005*** (0.819)	3.592*** (0.916)	6.323*** (1.373)	3.965*** (0.682)
BRI□PRIV, $\alpha_9$	1.339* (0.801)	0.682 (0.779)	0.770 (0.961)	1.314 (1.333)	2.010*** (0.678)	1.695** (0.825)	1.030 (0.800)	0.783 (1.041)	1.117 (1.423)	2.115 (0.763)
RGDPG, $\alpha_{10}$	1.024 (3.770)	-0.942 (3.765)	-4.386 (3.372)	-4.588 (4.730)	-3.429 (2.946)	-0.992 (3.990)	-2.391 (3.946)	-4.636 (3.882)	-4.290 (5.444)	-1.785 (3.636)
LnRGDP, $\alpha_{11}$	8.086*** (1.848)	7.042*** (1.801)	-3.487*** (1.371)	-5.485*** (1.829)	-3.580*** (1.097)	8.890*** (1.920)	7.583*** (1.852)	-2.177 (1.669)	-2.786 (2.357)	-2.881** (1.514)
CRISIS1, $\alpha_{12}$	-1.929** (0.941)	-2.335*** (0.929)	0.455 (0.478)	-0.195 (0.655)	-0.779*** (0.326)	-1.984** (0.924)	-2.310*** (0.907)	0.814* (0.509)	0.177 (0.702)	-0.507 (0.366)
CRISIS2, $\alpha_{13}$	-8.279*** (1.390)	-7.180*** (1.352)	-0.828 (1.216)	-3.202*** (1.366)	-2.219*** (0.816)	-8.801*** (1.426)	-7.569*** (1.375)	-2.470* (1.462)	-6.388*** (1.766)	-3.545*** (1.103)
CONSTANT, $\alpha_0$	-6.222*** (2.609)	-4.772* (2.579)	18.758*** (2.050)	31.129*** (2.905)	31.571*** (2.053)	-7.291*** (2.664)	-5.591** (2.585)	16.655*** (1.568)	26.886*** (3.863)	30.180*** (2.671)
<b>Ownership implication: Wald test</b>										
State-owned banks: $\alpha_7$	-1.229	-0.947	2.042	0.839	-0.250	-1.262	-1.011	2.019	0.991	-1.042
Foreign banks: $\alpha_7 + \alpha_8$	2.196	1.828	4.286***	5.055**	2.287*	2.429	1.994	5.612***	7.314***	2.923*
Private banks: $\alpha_7 + \alpha_9$	0.110	-0.265	2.812**	2.153	1.760	0.433	0.019	2.802*	2.108	1.073
Observations	381	381	2782	2782	2781	359	359	2459	2459	2458
R-squared	0.636	0.653	0.763	0.694	0.771	0.643	0.658	0.774	0.734	0.774

Notes: This table presents the regression results of risk measures on bank- and country-specific factors, revealing the relationship between the ownership and banking regulation. *DD\_KMV* = Distance to Default estimated with KMV approach; *DD\_Duan* = Distance to Default estimated with Duan's approach; *Zscore1* = Zscore estimated with equation (2); *Zscore2* = Zscore estimated with equation (3); *Zscore3* = Zscore estimated with equation (4); FOR = foreign owned bank dummy variable, which takes the value of one for banks in which foreign ownership represents at least 50 percents of total share, and zero otherwise; PRIV = domestic privately owned bank dummy variable, which takes the value of one for banks in which domestic private ownership represents at least 50 percents of total share, and zero otherwise; BDTD = interbank deposits to total deposits ratio; LTFTF = long-term funds to total funds ratio; DIV = income diversification index; LCR = liquidity coverage ratio; SIZE = size of banks, expressed in terms of banks' total assets; BRI = banking regulation index, which takes values between zero and one; RGDPG = real GDP growth rate; LnRGDP = logarithm of the real GDP per capita; CRISIS1 = crisis dummy variable, which takes value of one for crises events of 1990s, and zero otherwise; CRISIS2 = crisis dummy variable, which takes value of one for years 2008-2011, and zero otherwise. Bank and time fixed effects are considered but not reported. Heteroscedastic robust t-statistics are in parentheses. \*\*\*, \*\* and \* are statistical significances at 0.01, 0.05 and 0.10 level, respectively.

banks, reflect the realisation of two effects. First, strengthened institutional environments reduce the information barriers faced by foreign banks and therefore their risk with respect to their capitalisation and distribution of their *ROA*. This effect is more pronounced for foreign banks because they enter these unknown CEE markets with asymmetric information within a very permissive regulatory environment and without good and transparent accounting and information disclosure requirements (Bonin et al., 1998, 2015). Second, state-owned banks are more inert to regulatory changes, particularly with respect to capital. Unlike foreign and domestic private banks in which capital plays a role in reducing shareholders' risk-taking incentives and provides a cushion in case of financial distress, in the case of public institutions, the owner (government) and managers have limited risk-taking incentives, and implicit government guarantees are considered by these banks as a capital substitute (Ratnovski and Narain, 2007).

As for the market perception of risk, it remains insensitive to changes in the regulatory environment but remains such for all types of ownership (see the Wald test results). Nevertheless, as for Z-scores, we find that in countries and times with a strengthened regulatory environment, the market perceives foreign (coefficient  $\alpha_8$ , with both *DD* measures) and private banks (coefficient  $\alpha_9$ , only with *DD\_KMV*) as less risky than state-owned institutions.

#### 5.4. Robustness checks

To check our results and refine our conclusions, we conduct our estimations again, adjusting and substituting certain variables. First, we refine our analyses with respect to the Banking Regulation Index. We consider its two components, the Barriers to Entry Index (BEI) and the Stability Regulation Index (SRI) (see Appendix A), separately. BEI values that are closer to 1 indicate lower barriers to entry, namely for foreign banks, and more activities

are permitted for banks to practice. SRI values that are closer to 1 indicate a more regulated banking market, with enforced capital and liquidity ratios, enforced deposit insurance rules, better accounting standards, auditing requirements, internal management, supervisory structure, etc. The results are presented in Appendix E. In countries and times with lenient banking entry requirements for foreign banks, banks are less risky (table E1). Moreover, in such environments, foreign banks are less risky than domestic private institutions, and the risk of public banks does not change (table E3). As for the stability regulation index, in countries and times with more restrictive stability requirements, the banks have, on average, neither more nor less risks (table E2) regardless of their ownership profile (table E3) (with the exception of Zscore2 and Zscore3 risk measures). These results make it possible to refine the interpretation of the effects of banking regulation on the risk of CEE banks. The weakening of the barriers to entry for foreign banks and the permission to exercise additional activities reduce the vulnerability of these institutions and therefore their risk to a greater extent. In other words, they were able to enter these markets without specific constraints and, more importantly, to engage in activities in which they have knowledge, expertise and experience. Conversely, the stability regulation index is not homogeneous, like the BEI, which may lead to the opposite effects. Reinforcement of capital and liquidity requirements as well as provisioning and accounting standards, might reduce the risk of banks, and conversely, deposit protection might encourage banks to take more risks due to the intensification of moral hazard (Demirgüç-Kunt and Detragiache, 2002). Overall, the Barriers to Entry Index dominates CEE banks' risk-taking behaviour and duplicates the results of the banking Regulation Index.

Second, as in Lepetit et al. (2008), we consider the ratio of non-interest income to total operating income (NIOI) instead of DIV and find that the more concentrated CEE banks are in terms of non-interest income activities, the higher their Z-scores are, and this is true to a

greater extent for foreign and private banks.<sup>1</sup> Contrary to some findings on USA banks (Stiroh, 2004; Stiroh and Rumble, 2006) and Western European banks (Lepetit et al., 2008), a higher share of non-interest income is generally associated with lower bank risk in emerging countries (Sanya and Wolfe, 2011; Meslier et al., 2014), and our result is in the same vein. The divergence from the results with the DIV variable is merely due to the nature of NIOI, which does not account for the diversification policy of banks. We think that concentration on non-interest income activities leads to more profit and therefore more capital. In addition, as found by Meslier et al. (2014) with respect to Philippine banks, foreign banks derive the greatest benefit from non-income activities; more precisely, the marginal advantage of non-interest income is increasing for foreign banks and is decreasing for domestic institutions with the increase in non-interest income. This may also be the case for CEE foreign banks that have more non-interest income due to more knowledge, expertise and practice in such activities and due to commissions and fees from relationships with corporations and affiliates of their clients. These strong relationships and the benefits to foreign banks are well argued by DeYoung and Nolle (1996), Grosse and Goldberg (1991), Buch and Golder (2001) for developed countries and are found for CEE banks by Bonin et al. (1998) and Haselmann (2006).

Third, we re-estimate our market-based risk measure with a twelve-month rolling window. Although the magnitude of variations differs, the Distance to Default shows the same trend and qualitative results do not change. Consequently, our conclusions from previous findings are consistent.

## **6. Conclusions**

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<sup>1</sup> Results available upon request.



The purpose of this study is to assess the risk-taking behaviour of CEE banks according to their ownership structure and the role of banking regulation, bank activity diversification and sources of funding in bank activity. Our intention is motivated by important and rapid transformations in banking that supported the transition process of CEE countries. Some of them, for example, the permission given to foreign banks to enter these markets with modern bank activities and the implementation of many banking regulation rules, necessarily changed the risk-taking behaviour of these banks.

Using a sample of 322 banks from ten countries from Central and Eastern Europe for Z-score risk measures and a sample of 30 listed banks for Distance to Default as a measure of the market perception of risk, we find that foreign and domestic private banks are less risky than state-owned banks and that foreign banks are the least risky financial institutions. The market perception may be explained by better management by private and foreign investors than by public institutions. Despite implicit insurance from the government, the non-commercial and policy-oriented practices of CEE state-owned banks are a source of concern for markets. As for Z-scores, these risk measures support the idea that public banks are inert to transformation and evolutions and lack any market incentive (Schleifer, 1998). As a consequence, these institutions are deficient in improving their capitalisation profile according to their *ROA*.

Considering the role of income and funding structures and banking regulation, we find that financial markets perceive the risk of CEE banks regardless of their balance sheet policies. Thus, in the eyes of the market, public banks are still the riskiest. However, with higher interbank deposits and long-term funds ratios, they have also the highest Z-scores. This result may explain both the disciplinary stabilising role of their counterparts and the confidence of long-term financiers only in well-capitalised public banks. We also find that state-owned banks with more diversified income activities are riskiest. Two reasons can

explain this effect: first, more instable income sources (Stiroh and Rumble, 2006) and, second, the lack of experience, knowledge and expertise with respect to new bank activities (Bonin et al., 2015). Finally, in countries and periods with banking regulation closer to Basel requirements, foreign and private banks are less risky with respect to  $Z$ -score measures, and state-owned institutions are insensitive. The latter are more inert to regulatory changes, namely with respect to capital (Ratnovski and Narain, 2007). In consequence, regulators and bank supervisors in CEE economies, caring about bank sector stability, should pay more and special attention to state-owned banks in terms of either the effects of instable sources of income on these institutions or the impact of the banking regulation.

### Appendix A. Traditional $Z$ -score

The traditional  $Z$ -score issues from the probability of default definition, where the default event occurs when the current losses exhaust capital or, equivalently, when the bank's profits,  $\Pi$ , are lower than its negative capital,  $-C$ . Given bank assets  $A$ , the probability of default can be written as

$$\Pr[\Pi \leq -C] = \Pr[ROA \leq -CAR] = \Pr\left[\frac{ROA - E(ROA)}{\sigma(ROA)} \leq -\frac{(CAR + E(ROA))}{\sigma(ROA)}\right], \quad (\text{A. 1})$$

where  $ROA = \Pi/A$  is the return on assets random variable,  $CAR = C/A$  is the capital on assets ratio,  $E(ROA)$  is the expected value of  $ROA$  and  $\sigma(ROA)$  its standard deviation. With the assumption of normal distribution for  $ROA$ , the probability of default becomes

$$\Pr[\Pi \leq -C] = \Pr[ROA \leq -CAR] = N\left[-\frac{(CAR + E(ROA))}{\sigma(ROA)}\right] = 1 - N[Z], \quad (\text{A. 2})$$

where  $N(\cdot)$  is the normal cumulative distribution function. According to the Bienaymé–Tchebycheff inequality, the  $Z$ -score becomes the inverse measure of the upper bound of the probability of default:

$$\Pr[ROA \leq -CAR] = \Pr[ROA - E(ROA) \leq -(CAR + E(ROA))] \leq \frac{\sigma^2(ROA)}{2(CAR + E(ROA))^2} = \frac{1}{2Z^2}. \quad (A.3)$$

## Appendix B. Distance to Default: concept and estimation procedures

The concept of Distance to Default is derived from the option model of Merton (1974), where the value of bank assets follows a geometric Brownian motion and bank liabilities consist of zero-coupon debt and common equity. A bank finances its assets through debt and equity. Thus, it is considered solvent as long as the market value of its assets covers its debt.

### B1. Concept of Distance to Default

Given that bank assets are fully financed by equity  $S_t$  and debt  $D_t^m$ , the following balance sheet identity holds for any time  $t$ :  $V_t = S_t + D_t^m$ , where all variables are expressed in market values. To avoid a negative value for equity, banks will not reimburse their creditors when the market value of their assets is lower than the market value of their debt. Thus, a bank's equity is a call option on the bank's assets, whose strike price is the book value of the bank's debt,  $D$ .  $V_t$  follows a geometric Brownian motion:

$$\frac{dV_t}{V_t} = \mu_V dt + \sigma_V dW_t, \quad (B.1)$$

where  $\mu_V$  and  $\sigma_V$  are the expected return and return volatility of the market value of the bank's assets, respectively, and  $W_t$  is a Wiener process. The risky debt  $D$  is a zero-coupon bond with a maturity  $T$ , which grows with its interest rate  $r$ . Its market value at time  $t$ ,  $D_t^m$ , and that of equity,  $S_t$ , are expressed through Black and Scholes's (1973) model:

$$S_t = V_t N(d_t) - D e^{-r(T-t)} N(d_t - \sigma_V \sqrt{T-t}), \quad (B.2)$$

$$D_t^m = V_t - S_t = V_t N(-d_t) + D e^{-r(T-t)} N(d_t - \sigma_V \sqrt{T-t}), \quad (B.3)$$

where  $N(\cdot)$  is the standard normal cumulative distribution function and

$$d_t \equiv \frac{\ln(V_t/D) + \left(r + \frac{1}{2}\sigma_V^2\right)(T-t)}{\sigma_V\sqrt{T-t}}. \quad (\text{B.4})$$

Solving equation (B.1) and given  $Z_t \equiv \frac{W_T}{\sqrt{T-t}}$ , where  $Z_t \rightarrow N(0; 1)$ , the market value of the bank's assets at debt maturity  $T$  is  $V_T = V_t \exp[(\mu_V - 0.5\sigma_V^2)(T-t) + \sigma_V\sqrt{T-t}Z_t]$ . The market value of equity,  $S_t$ , is an observable variable, as well the book value of total debt,  $D_t$ .

Banks are considered solvent as long as, at the maturity date, they cover their debts with their assets. We thus define default as when  $V_T < D$ . As the Distance to Default is represented by the following expression:

$$DD_t \equiv \frac{\ln(V_t/D) + \left(\mu_V - \frac{1}{2}\sigma_V^2\right)(T-t)}{\sigma_V\sqrt{T-t}}, \quad (\text{B.5})$$

the condition for default can be rewritten as  $Z_t < -DD_t$ .<sup>2</sup>

## B2. KMV estimation approach

Unlike the bank's assets  $V_t$ , the equity market values  $S_t$  are observed at regular time intervals: every trading day. Given the book value of bank debt  $D$ , equations (B.2) and (B.4) make up a one-to-one relationship between asset values and equity prices, which allows for the estimation of the state variable  $V_t$ . The assets value is computed daily through equation (B.2), where debt value  $D_p$  is constant during month  $p$ . For the two estimation approaches, the maturity of debt  $T$  is equal to one year ( $T=1$ ), and estimations are made on a six-month rolling window.

Let  $m$  denote the number of months in our entire sample and  $n_j$  the number of days within the estimation window  $j$ , where  $j=p-5$  and  $p=[6, \dots, m]$ . We therefore express the time series of  $n_j$  daily observations within the estimation window  $j$  of the bank's market capitalisation by  $\{S_{1,j}, \dots, S_{n_j,j}\}$ , considering 260 trading days per year. For each trading day of a given month  $p$

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<sup>2</sup> The standardised return and the Distance to Default are estimated from time  $t$  to maturity  $T$ .

and of the last five months, we compute the implicit market value of the bank's assets using month  $p$ 's level of debt. For this month  $p$ , we then estimate the expected return and the volatility of the bank's asset returns. Finally, we roll the estimation window forward by one month and estimate all unknown model parameters,  $\mu_V$  and  $\sigma_V$ , for all months of our sample period, except for the first five months. The Distance to Default is also computed for each month – more precisely for the last trading day of the month.

The KMV estimation approach is a two-step iterative algorithm. Beginning with an arbitrary value of the asset return volatility  $\hat{\sigma}_{V,j}^{(0)}$ , in the first step, we compute the first series of the implied asset value  $\{\hat{V}_{1,j}(\hat{\sigma}_{V,j}^{(0)}), \dots, \hat{V}_{n_j,j}(\hat{\sigma}_{V,j}^{(0)})\}$ , where  $\hat{V}_{i,j}(\hat{\sigma}_{V,j}^{(0)})$  is estimated for each trading day  $i$  of the estimation window  $j$  using equations (B.2) and (B.4). In the second step, we compute the asset returns and their volatility, which are used for the next iteration. For the  $k^{\text{th}}$  iteration, these two steps can be generalised from equations (B.2) and (B.4) as follows:

$$S_{i,j} = V_{i,j}^{(k)} N(d_{i,j}^{(k)}) - D_{p,j} e^{-r_{i,j}(1-t_{i,p})} N\left(d_{i,j}^{(k)} - \hat{\sigma}_{V,j}^{(k-1)} \sqrt{1-t_{i,p}}\right), \quad (\text{B.6})$$

$$d_{i,j}^{(k)} \equiv \frac{\ln(V_{i,j}^{(k)}/D_{p,j}) + \left(r_{i,j} + \frac{1}{2} \hat{\sigma}_{V,j}^{(k-1)}\right) (1-t_{i,p})}{\hat{\sigma}_{V,j}^{(k-1)} \sqrt{1-t_{i,p}}}, \quad (\text{B.7})$$

where  $p=[1,\dots,m]$ . For all days  $i$  belonging to month  $p$ ,  $D_{p,j}$  is constant.  $t_{i,p} = (i' - 1)/260$ , where  $i'=[1,\dots,n_p]$  has a one-to-one relationship with  $i$ , and  $n_p$  is the number of trading days within month  $p$ .

In the second step, we estimate the implied asset returns  $\{\hat{R}_{2,j}^{(k)}, \dots, \hat{R}_{n_j,j}^{(k)}\}$  and update the return volatility of the bank's assets as follows:

$$\hat{R}_{i,j}^{(k)} = \ln \hat{V}_{i,j}^{(k)} - \ln \hat{V}_{i-1,j}^{(k)}, \quad \forall i \in [2, n_j] \text{ and } j = p - 5 \text{ with } p \in [6, m] \quad (\text{B.8})$$

$$\bar{R}_j^{(k)} = \frac{1}{n_j - 1} \sum_{i=2}^{n_j} \hat{R}_{i,j}^{(k)}, \quad \hat{\sigma}_{V,j}^{(k)} = \sqrt{\frac{260}{n_j - 2} \sum_{i=2}^{n_j} \left(\hat{R}_{i,j}^{(k)} - \bar{R}_j^{(k)}\right)^2}. \quad (\text{B.9})$$

This iterative procedure is repeated until the values of  $\hat{\sigma}_{V,j}^{(k)}$  and of  $\hat{\sigma}_{V,j}^{(k-1)}$  converge with tolerance level of 10E-8. The length of time is measured in years and, as a consequence, all parameters are estimated on an annual basis. The same is done for  $t_{i,p}$ , which denotes the time between the first day and day  $i$  of month  $p$ . The initial value of the asset return volatility is considered to be the volatility of the equity return,  $\hat{\sigma}_{V,j}^{(0)} = \hat{\sigma}_{S,j}$ , with  $\hat{\sigma}_{S,j} = \sqrt{\frac{260}{n_j-2} \sum_{i=2}^{n_j} (\hat{R}_{i,j}^S - \bar{R}_j^S)^2}$ ,  $\hat{R}_{i,j}^S = \ln S_{i,j} - \ln S_{i-1,j}$  and  $\bar{R}_j^S = \frac{1}{n_j-1} \sum_{i=2}^{n_j} \hat{R}_{i,j}^S$ .

For the  $\bar{k}^{\text{th}}$  iteration, after achieving convergence, we estimate the expected return on an annual basis for each month:

$$\hat{\mu}_{V,j} = 260\bar{R}_j^{(\bar{k})} + 0.5 \left( \hat{\sigma}_{V,j}^{(\bar{k})} \right)^2. \quad (\text{B.10})$$

Because the amount of debt is known only for the end of month, the Distance to Default is estimated monthly on an annual basis with the end-of-month asset value:

$$DD_{n,j} = \frac{\ln \left( V_{n,j}^{(\bar{k})} / D_{p,j} \right) + \left( \hat{\mu}_{V,j} - \frac{1}{2} \left( \hat{\sigma}_{V,j}^{(\bar{k})} \right)^2 \right) \left( 1 - t_{n,p} \right)}{\hat{\sigma}_{V,j}^{(\bar{k})} \sqrt{1 - t_{n,p}}}. \quad (\text{B.11})$$

Unlike much of the literature that employs a risk-free interest rate, we consider the debt interest rate  $r_i$  to be specific to each bank  $i$ . Even if in the case of economy-wide troubles, banks are subject to the same conditions in the market, and the effects on their own economic and financial situation could be and are, in most cases, different. Employing own interest rate for each bank allows us to account for each bank's debt and its evolution and to be more precise regarding its risk.

### B3. Duan's (1994) estimation approach

Duan (1994, 2000) develops a maximum likelihood estimator of the model parameters  $\mu_V$  and  $\sigma_V$ , which is maximised considering the values of the bank's assets:

$$\begin{aligned}
L_{S,j}(\mu_V, \sigma_V) = & -\frac{n_j - 1}{2} \ln\left(\frac{2\pi\sigma_V^2}{260}\right) - \sum_{i=2}^{n_j} \ln \hat{V}_{i,j}(\sigma_V) - \sum_{i=2}^{n_j} \ln\left(N\left(\hat{d}_{i,j}(\sigma_V)\right)\right) \\
& - \frac{260}{2\sigma_V^2} \sum_{i=2}^{n_j} \left[ \ln\left(\frac{\hat{V}_{i,j}(\sigma_V)}{\hat{V}_{i-1,j}(\sigma_V)}\right) - \frac{\left(\mu_V - \frac{1}{2}\sigma_V^2\right)}{260} \right]^2, \tag{B.12}
\end{aligned}$$

where  $\hat{d}_{i,j}(\sigma_V)$  corresponds to  $d_{ij}$ , with  $\hat{V}_{i,j}(\sigma_V)$  instead of  $V_{ij}$ . This log-likelihood function depends directly on the market values of the bank's equity through the solution  $\hat{V}_t(\sigma_V)$ . To compute the parameters  $\mu_V$  and  $\sigma_V$ , an iterative optimisation procedure is applied. Using the expected asset returns and asset return volatilities of the first approach as the starting values for  $\mu_V$  and  $\sigma_V$ , respectively, and given data on the values of equity  $S_{ij}$  and debt  $D_{pj}$ , equation (B.2) is solved to yield the sample of bank asset values  $\hat{V}_{i,j}$ . Equation (B.12) is then used to find the values of  $\hat{\mu}_V$  and  $\hat{\sigma}_V$  that maximise this likelihood function. As in the first method, these two parameters are computed for each estimation window, and as we roll this window forward by one month, we obtain monthly estimations for annual values of  $\hat{\mu}_V$  and  $\hat{\sigma}_V$  for the entire sample except for the first five months.

### Appendix C. Construction of Banking Regulation Indicators

This appendix provides details about the coverage and construction of the banking regulatory indicators used in the empirical analysis. Data are from four Bank Regulation and Supervision databases from the World Bank, elaborated by Barth, Caprio and Levine for the years 2000, 2003, 2007 and 2012. These databases consist of approximately 300 questions divided into 12 sub-groups, each of which corresponds to specific aspects of banking regulation and supervision, including requirements for entry into banking, ownership structure, capital adequacy, banking activity, external auditing requirements, internal management and organisational requirements, liquidity and diversification requirements,

depositor protection, provisioning requirements, accounting and information disclosure requirements, discipline and problem institutions exit, and supervisory structure.

Many questions in the surveys require yes/no answers. We assigned a value of 1 to those that involve the enforcement of different aspects of the banking regulatory environment and the weakening of entry barriers into the banking market for foreign banks and 0 otherwise. We then aggregated the answers relative to each of our 14 indicators  $IND_i$  ( $i=1,\dots,14$ ). Three correspond to the Barriers to Entry index (BEI): overall entry index (0.4), foreign entry index (0.4) and permission activity index (0.2). The others correspond to the Stability Regulation Index (SRI): capital adequacy (0.2), activity diversification (0.05), liquidity (0.175), provisioning (0.175), deposit insurance (DI, 0.175), accounting standards (0.05), auditing requirements (0.025), internal management (0.025), ownership (0.05), discipline and enforcement (0.05) and supervisory structure (0.25). To make each of these 14 indicators comparable across countries and years, they are normalised with the formula  $\overline{IND}_{i,t} = (IND_{i,t} - \min_{i,t} IND_{i,t}) / (\max_{i,t} IND_{i,t} - \min_{i,t} IND_{i,t})$  and range in value between 0 and 1. The weights of these indicators in the composition of the Barriers to Entry Index and Stability Regulation Index are presented in parentheses, and the BEI and SRI are equally weighted in the composition of the Banking Regulation Index (BRI).

#### **Appendix D. Tests of consistency between Z-score measures: Monte Carlo simulation**

We conduct a Monte Carlo simulation to test the consistency of different Z-score measures. We take an expected value of *ROA* of 2.5% and a standard deviation of *ROA* of 1.5%, which are empirical levels observed over our sample, and generate 200 samples of years from skew normal distributions with such parameters and with different values of skew parameter  $\alpha$ . The latter varies from -3.3 to 3.3 with step 0.1. The probability of default and Z-score are computed for a *CAR* varying from 0 to 5% with a step of 0.25%, *i.e.*, with 21 values.



For each value of  $\alpha$  parameter, we make the consistency test between different estimation procedures: Skew Normal Distribution, Normal Distribution and the traditional approach. The tests are repeated for each value of  $CAR$  for which we repeat the calculus 50 times, each of them with 200 samples of years. Thus, Figures D1-D3 present the fraction of cases that do not reject the null hypothesis of consistency for the total number of cases, which is  $1050=50 \times 21$ . Thus, for each of these 1050 cases, we perform 200 estimates, and the consistency test is therefore realised for each value of  $\alpha$  parameter with  $210000=200 \times 1050$  computations. We performed this Monte Carlo simulation for samples with 19 years, which corresponds to our 1995-2013 period, and with 100 years, to show the convergence between all estimation procedures for a symmetric distribution, *i.e.*,  $\alpha = 0$ .

According to simulation results, all three risk measures, *i.e.*, the probability of default, the Z-score (eqs. 2, 3 or 4) and the logarithm of the Z-score, reject the null hypothesis of consistency for highly skewed *ROA* distributions. More precisely, for the sample of 19 years, only 85% of cases do not reject the null hypothesis of equality between risk measures computed with Normal Distribution and Skew Normal Distribution assumptions, but this is the case only for  $\alpha = -1.1$ , concerning the probability of default, and for  $\alpha = 1$ , concerning Z-score and  $\ln(\text{Zscore})$  (Figure D1). The result is in the same vein as for the null hypothesis of equality between risk measures computed with the traditional approach and Skew Normal Distribution assumptions (Figure D2). Surprisingly, one cannot apply the traditional approach with the assumption of Normal Distribution for a reasonable sample of 19 years, as in the case of our sample (Figure D3). In order to have a better result, we must increase the sample size, which in practice is not evident with yearly data.

FIGURE D1. Test of equality between Normal Distribution and Skew Normal Distribution

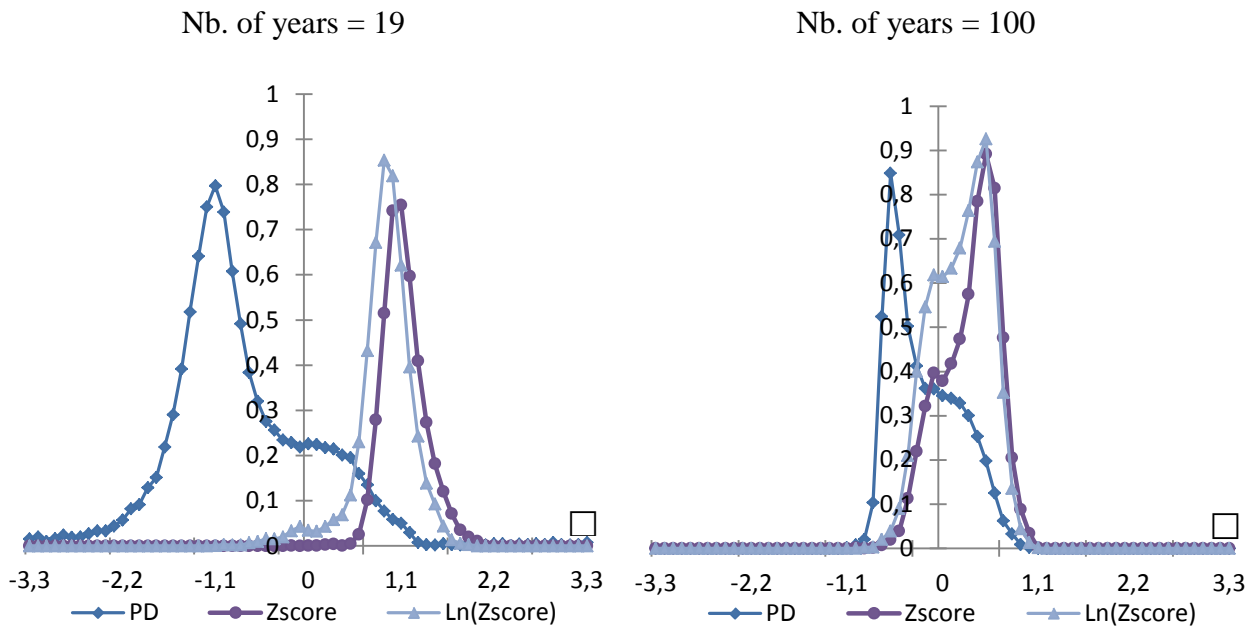


FIGURE D2. Test of equality between Traditional Zscore estimates and Skew Normal Distribution

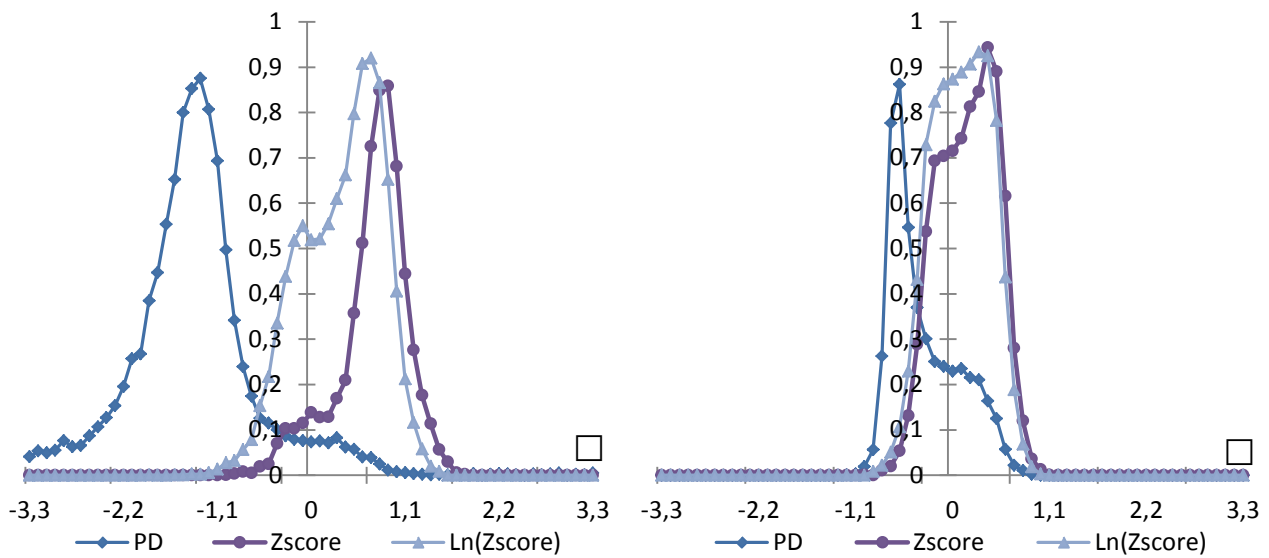
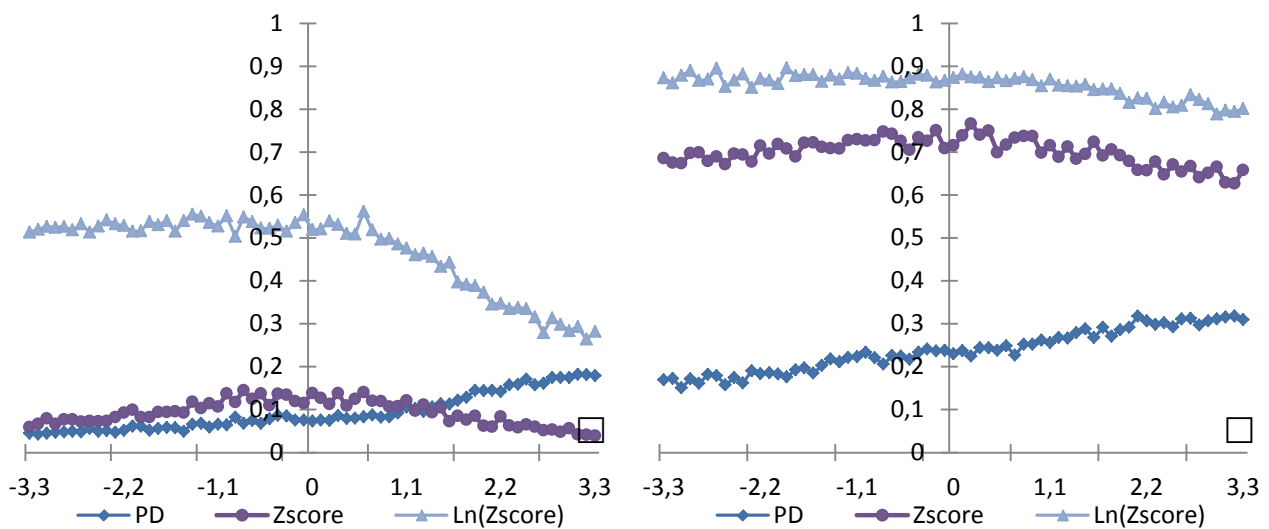


FIGURE D3. Test of equality between Traditional Zscore estimates and Theoretical Normal Distribution



**Appendix E. Robustness checks: regressions with BEI and SRI banking regulation measures**

TABLE E1. *Factors influencing the bank risk, with barriers to entry index.*

Variables	(a)					(b)				
	<i>DD_KMV</i>	<i>DD_Duan</i>	<i>Zscore1</i>	<i>Zscore2</i>	<i>Zscore3</i>	<i>DD_KMV</i>	<i>DD_Duan</i>	<i>Zscore1</i>	<i>Zscore2</i>	<i>Zscore3</i>
FOR, $\alpha_1$	1.210*** (0.415)	0.915*** (0.389)	1.312*** (0.440)	2.363*** (0.667)	1.426*** (0.343)	1.330*** (0.418)	1.005*** (0.393)	2.014*** (0.463)	3.468*** (0.701)	2.113*** (0.375)
PRIV, $\alpha_2$	0.521 (0.392)	0.210 (0.379)	0.942** (0.455)	1.482** (0.647)	1.538*** (0.350)	0.660* (0.403)	0.342 (0.389)	1.119** (0.480)	1.674*** (0.678)	1.731*** (0.382)
BDTD, $\alpha_3$	-0.352 (0.761)	-0.393 (0.728)	2.358*** (0.785)	3.608*** (0.973)	2.297*** (0.561)					
LTFTF, $\alpha_3$						-0.271 (1.237)	0.244 (1.236)	0.674 (1.764)	1.453 (3.012)	0.275 (2.093)
DIV, $\alpha_4$	-0.447 (0.599)	-0.698 (0.565)	-0.756 (0.480)	-1.087* (0.675)	-0.591 (0.404)	-0.165 (0.628)	-0.307 (0.589)	0.063 (0.607)	0.287 (0.925)	0.553 (0.570)
LCR, $\alpha_5$	0.314 (0.323)	0.242 (0.307)	0.210*** (0.066)	0.296*** (0.087)	0.226*** (0.071)	0.404 (0.318)	0.274 (0.302)	0.097*** (0.025)	0.177*** (0.046)	0.115*** (0.030)
SIZE, $\alpha_6$	0.087*** (0.017)	0.083*** (0.016)	0.097*** (0.024)	0.170*** (0.032)	0.150*** (0.021)	0.090*** (0.018)	0.085*** (0.018)	0.132*** (0.026)	0.239*** (0.034)	0.183*** (0.022)
BEI, $\alpha_7$	0.625 (0.904)	0.528 (0.874)	2.341*** (0.829)	2.729** (1.205)	1.488** (0.756)	0.821 (0.946)	0.669 (0.918)	2.909*** (0.969)	3.607*** (1.415)	1.604* (0.920)
RGDPG, $\alpha_8$	2.226 (3.768)	0.126 (3.758)	-4.663 (3.346)	-4.789 (4.677)	-3.706 (2.914)	0.165 (4.003)	-1.392 (3.954)	-4.605 (3.838)	-3.991 (5.384)	-1.661 (3.614)
LnRGDP, $\alpha_9$	7.656*** (1.823)	6.601*** (1.777)	-3.319*** (1.335)	-5.568*** (1.789)	-3.557*** (1.072)	8.549*** (1.918)	7.221*** (1.848)	-2.195 (1.659)	-3.145 (2.396)	-3.100** (1.534)
CRISIS1, $\alpha_{10}$	-1.847** (0.957)	-2.272*** (0.945)	0.399 (0.483)	-0.267 (0.660)	-0.837*** (0.328)	-1.936** (0.946)	-2.263*** (0.929)	0.755 (0.513)	0.100 (0.706)	-0.565 (0.366)
CRISIS2, $\alpha_{11}$	-7.616*** (1.398)	-6.550*** (1.361)	-0.358 (1.254)	-2.428* (1.394)	-1.824** (0.836)	-8.145*** (1.441)	-6.948*** (1.391)	-1.693 (1.505)	-5.159*** (1.792)	-2.901*** (1.111)
CONSTANT, $\alpha_0$	-6.496*** (2.648)	-4.841* (2.611)	17.983*** (2.025)	29.690*** (2.883)	30.346*** (2.026)	-7.905*** (2.720)	-5.964** (2.631)	15.656*** (2.445)	25.181*** (3.810)	28.720*** (2.653)
Observations	381	381	2782	2782	2781	359	359	2459	2459	2458
R-squared	0.630	0.647	0.764	0.694	0.771	0.636	0.653	0.774	0.734	0.775

*Notes:* This table presents the regression results of risk measures on bank- and country-specific factors, with barriers to entry index. DD\_KMV = Distance to Default estimated with KMV approach; DD\_Duan = Distance to Default estimated with Duan's approach; Zscore1 = Zscore estimated with equation (2); Zscore2 = Zscore estimated with equation (3); Zscore3 = Zscore estimated with equation (4); FOR = foreign owned bank dummy variable, which takes the value of one for banks in which foreign ownership represents at least 50 percents of total share, and zero otherwise; PRIV = domestic privately owned bank dummy variable, which takes the value of one for banks in which domestic private ownership represents at least 50 percents of total share, and zero otherwise; BDTD = interbank deposits to total deposits ratio; LTFTF = long-term funds to total funds ratio; DIV = income diversification index; LCR = liquidity coverage ratio; SIZE = size of banks, expressed in terms of banks' total assets; BEI = barriers to entry index, which takes values between zero and one; RGDPG = real GDP growth rate; LnRGDP = logarithm of the real GDP per capita; CRISIS1 = crisis dummy variable, which takes value of one for crises events of 1990s, and zero otherwise; CRISIS2 = crisis dummy variable, which takes value of one for years 2008-20011, and zero otherwise. Bank and time fixed effects are considered but not reported. Heteroscedastic robust t-statistics are in parentheses. \*\*\*, \*\* and \* are statistical significances at 0.01, 0.05 and 0.10 level, respectively.

TABLE E2. *Factors influencing the bank risk, with stability regulation index.*

Variables	(a)					(b)				
	DD_KMV	DD_Duan	Zscore1	Zscore2	Zscore3	DD_KMV	DD_Duan	Zscore1	Zscore2	Zscore3
FOR, $\alpha_1$	1.214*** (0.416)	0.899** (0.389)	1.10*** (0.439)	2.117*** (0.668)	1.287*** (0.328)	1.304*** (0.419)	0.959*** (0.393)	1.770*** (0.458)	3.157*** (0.694)	1.969*** (0.350)
PRIV, $\alpha_2$	0.502 (0.390)	0.186 (0.375)	0.835* (0.457)	1.310** (0.648)	1.426*** (0.351)	0.626 (0.399)	0.307 (0.384)	0.990** (0.483)	1.478** (0.681)	1.614*** (0.382)
BDTD, $\alpha_3$	-0.399 (0.764)	-0.421 (0.731)	2.339*** (0.790)	3.555*** (0.978)	2.556*** (0.562)					
LTFTF, $\alpha_3$						-0.188 (1.223)	0.320 (1.228)	0.191 (1.739)	0.857 (2.961)	0.012 (2.051)
DIV, $\alpha_4$	-0.450 (0.596)	-0.711 (0.563)	-0.792* (0.480)	-1.123* (0.675)	-0.608 (0.404)	-0.189 (0.624)	-0.337 (0.586)	0.030 (0.603)	0.262 (0.916)	0.554 (0.563)
LCR, $\alpha_5$	0.288 (0.321)	0.219 (0.305)	0.208*** (0.065)	0.294*** (0.086)	0.225*** (0.071)	0.373 (0.313)	0.246 (0.298)	0.097*** (0.025)	0.177*** (0.046)	0.115*** (0.030)
SIZE, $\alpha_6$	0.087*** (0.017)	0.084*** (0.016)	0.106*** (0.023)	0.182*** (0.032)	0.157*** (0.021)	0.092*** (0.018)	0.088*** (0.018)	0.145*** (0.026)	0.255*** (0.034)	0.190*** (0.021)
SRI, $\alpha_7$	2.760 (4.104)	1.195 (3.818)	0.605 (2.138)	-2.078 (3.271)	-2.197 (2.077)	2.222 (4.088)	0.679 (3.803)	0.425 (3.112)	-1.536 (5.289)	-2.446 (3.581)
RGDPG, $\alpha_8$	2.268 (3.727)	0.443 (3.727)	-5.181 (3.370)	-5.686 (4.696)	-4.307 (2.909)	0.679 (3.899)	-0.701 (3.869)	-5.667 (3.859)	-5.567 (5.389)	-2.584 (3.579)
LnRGDP, $\alpha_9$	6.953*** (2.149)	6.328*** (2.079)	-2.760** (1.419)	-4.220** (1.947)	-2.556** (1.175)	7.964*** (2.228)	7.050*** (2.136)	-1.464 (1.664)	-1.730 (2.360)	-2.037 (1.586)
CRISIS1, $\alpha_{10}$	-1.587* (0.915)	-2.087** (0.906)	0.521 (0.486)	-0.162 (0.661)	-0.795*** (0.328)	-1.621* (0.899)	-2.042** (0.886)	0.857 (0.521)	0.206 (0.720)	-0.536 (0.376)
CRISIS2, $\alpha_{11}$	-7.984*** (1.414)	-6.779*** (1.369)	-1.375 (1.148)	-3.466*** (1.291)	-2.334*** (0.774)	-8.496*** (1.468)	-7.142*** (1.407)	-2.952** (1.460)	-6.587*** (1.897)	-3.422*** (1.188)
CONSTANT, $\alpha_0$	-6.373*** (2.621)	-4.678* (2.591)	18.550*** (2.072)	30.740*** (2.923)	31.068*** (2.046)	-7.630*** (2.684)	-5.660** (2.599)	16.507*** (2.564)	26.511*** (4.015)	29.547*** (2.745)
Observations	381	381	2782	2782	2781	359	359	2459	2459	2458
R-squared	0.630	0.647	0.763	0.694	0.771	0.636	0.653	0.774	0.734	0.775

Notes: This table presents the regression results of risk measures on bank- and country-specific factors, with stability regulation index. DD\_KMV = Distance to Default estimated with KMV approach; DD\_Duan = Distance to Default estimated with Duan's approach; Zscore1 = Zscore estimated with equation (2); Zscore2 = Zscore estimated with equation (3); Zscore3 = Zscore estimated with equation (4); FOR = foreign owned bank dummy variable, which takes the value of one for banks in which foreign ownership represents at least 50 percents of total share, and zero otherwise; PRIV = domestic privately owned bank dummy variable, which takes the value of one for banks in which domestic private ownership represents at least 50 percents of total share, and zero otherwise; BDTD = interbank deposits to total deposits ratio; LTFTF = long-term funds to total funds ratio; DIV = income diversification index; LCR = liquidity coverage ratio; SIZE = size of banks, expressed in terms of banks' total assets; SRI = stability regulation index, which takes values between zero and one; RGDPG = real GDP growth rate; LnRGDP = logarithm of the real GDP per capita; CRISIS1 = crisis dummy variable, which takes value of one for crises events of 1990s, and zero otherwise; CRISIS2 = crisis dummy variable, which takes value of one for years 2008-20011, and zero otherwise. Bank and time fixed effects are considered but not reported. Heteroscedastic robust t-statistics are in parentheses. \*\*\*, \*\* and \* are statistical significances at 0.01, 0.05 and 0.10 level, respectively.

TABLE E3. Relationship between ownership and BEI and SRI regulatory measures.

Ownership	with BTDI variable					with LTFTE variable				
	DD_KMV	DD_Duan	Zscore1	Zscore2	Zscore3	DD_KMV	DD_Duan	Zscore1	Zscore2	Zscore3
<b>Ownership implication with BEI variable: Wald test</b>										
State-owned banks	-1.697*	-1.177	1.055	0.545	-0.162	-1.831*	-1.332	1.209	0.911	-0.632
Foreign banks	1.449 (3.146***)	1.266 (2.443***)	2.546*** (1.491*)	3.217*** (2.672**)	1.730** (1.892***)	1.555 (3.386***)	1.335 (2.667***)	3.281*** (2.073**)	4.394*** (3.482***)	2.075** (2.707***)
Private banks	-0.118 (1.579**)	-0.245 (0.932)	1.827** (0.772)	1.423 (0.879)	1.321* (1.483**)	0.127 (1.958***)	-0.055 (1.277*)	1.507 (0.299)	0.707 (-0.204)	0.626 (1.258*)
<b>Ownership implication with SRI variable: Wald test</b>										
State-owned banks	1.034	-0.043	-1.327	-5.874*	-4.824**	0.345	-0.637	-2.753	-7.277	-6.369*
Foreign banks	4.297 (3.263***)	2.638 (2.680***)	1.024 (2.351***)	-1.041 (4.833***)	-2.075 (2.749***)	3.830 (3.485***)	2.231 (2.868***)	1.475 (4.228***)	0.591 (7.868***)	-1.785 (4.584***)
Private banks	2.136 (1.102)	0.449 (0.491)	-0.657 (0.669)	-4.135 (1.739)	-2.563 (2.261***)	1.683 (1.338)	0.117 (0.755)	-1.392 (1.361)	-4.431 (2.846**)	-3.474 (2.895***)

Notes: This table presents the regression results of risk measures on bank- and country-specific factors, revealing the relationship between the ownership and regulation of banking entry requirements. Within parentheses are the results of cross product variables, BEI□FOR and BEI□PRIV, for the first part, or SRI□FOR and SRI□PRIV, for the second part. \*\*\*, \*\* and \* are statistical significances at 0.01, 0.05 and 0.10 level, respectively.

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