Research in International Business and Finance 51 (2020) 100921

Contents lists available at ScienceDirect

Research in International Business and Finance

journal homepage: www.elsevier.com/locate/ribaf

The impact of central bank transparency on systemic risk—Evidence from Central and Eastern Europe☆

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ARTICLE INFO

JEL classification:
G21
E58
G28

Keywords:
Systemic risk
Central bank transparency
Supervisory framework

ABSTRACT

The aim of this paper is to analyze the impact of central bank transparency on systemic risk in emerging banking markets using a sample composed of 34 banks from Central and Eastern Europe for a period spanning from 2005 through 2012. Results indicate a positive and significant relationship between central bank transparency and financial institutions' contribution to systemic risk. On the other side, increased central bank transparency significantly reduces the idiosyncratic risk of banks. The relationship is influenced by the restrictiveness of regulatory framework. We argue that a more transparent central bank is beneficial for the banking sector from a microprudential perspective. However, it may create incentives for financial institutions to engage in risky activities and through herd behavior may increase individual contribution to the risk of the banking system.

1. Introduction

During the global financial crisis of 2007–2008, public authorities (both national and supranational) and central banks were forced to step in, making use of different intervention measures and instruments in order to alleviate the consequences and to avoid a major systemic crisis[1] (see Goodhart, 2008; Praet and Nguyen, 2008; Panetta et al., 2009). Regulators emphasized that a bird's-eye view is necessary, shifting from individual bank supervision (microprudential approach) to a common set of regulations and practices approaching banks altogether (macroprudential approach). Hence, alongside the concept of *individual risk,* the concept of *systemic risk* has emerged. Systemic risk (SR, hereinafter) can be defined as a systemic event that affects a great number of institutions or financial markets in the strong sense, distorting the whole financial system (De Bandt and Hartmann, 2000). Researchers and regulatory bodies have since developed a series of systemic risk measures in order to quantify the contribution and exposure of financial institutions to systemic risk. Also, they focused on elaborating policies that improve the regulatory framework and designing specific requirements (especially regarding capital) for banks that pose contagion spillovers to the financial system.

Further on, in order to prevent another financial crisis and to maintain financial stability of the system as a whole, the major interest was to assess determinants of systemic risk and periodically identify systemically important institutions. The most important determinants of banks' contribution to systemic risk identified in the literature include: size, leverage, non-interest income, credit risk, funding structure and liquidity (for a survey see e.g. Bisias et al., 2012). Analyzing a sample of European banks, Weiß et al.

☆ This work was supported by a grant of Ministery of Research and Innovation, CNCS – UEFISCDI, project number PN-III-P1-1.1-TE-2016-1855, within PNCDI III.
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[1] Acharya (2009) highlights that in a systemic crisis *"many banks fail together, or one bank's failure propagates through the system causing the failure of many banks."*

https://doi.org/10.1016/j.ribaf.2018.06.002
Received 30 November 2017; Received in revised form 12 April 2018; Accepted 13 June 2018
Available online 19 June 2018
0275-5319/

(2014) find little empirical evidence in favor of these common factors during crisis. Interestingly, their findings indicate that the characteristics of regulatory regimes across countries are the main factors that drive systemic risk.

The aim of this paper is to assess the impact of central bank transparency (CBT, hereinafter) on systemic risk for a sample of 34 banks representative for the Central and Eastern Europe (CEE) banking market. Using a *Difference-in-Differences (DID)* approach, we also investigate whether this relationship is heterogeneous across different regulatory environments in the emerging European banking market. As pointed-out above, the common factors that explain systemic risk identified by the literature may have little explanatory power during crises. Thus, we undertake this analysis using other relevant explanatory variables in line with the results of Weiß et al. (2014). To the best of our knowledge, this is the first empirical analysis that relates CBT to banks' contribution and exposure to systemic risk.

Central bank transparency can be defined as the degree to which a central bank shares information about its procedures for decision-making, policy decisions and objectives, the implementation of policies and the economic variables relevant for the state of the economy (Yıldırım-Karaman, 2017). Putting it in a nutshell, transparency refers to more information disclosed by central banks. In the last two decades, central banks started to move towards more transparent policies, to make forecasts regarding the economy (Rhee and Turdaliev, 2013) and to give extensive explanations of the reasoning behind their decisions. In contrast with central bank independence (CBI, hereinafter), the literature regarding CBT is scarcer and has gained a special attention after it has been realized that transparency is complement to central bank independence, aiming at providing openness and accountability due to an enhanced degree of independence and more tasks delegated to central banks. De Haan and Eijffinger (2016) conclude that, on an average basis, CBI has not decreased after the global financial crisis, while Dalla Pellegrina et al. (2014) and Masciandaro and Romelli (2017) identified that after the recent turmoil central banks were assigned with more supervisory power.

Indeed, Dincer and Eichengreen (2014) highlight that independence and transparency go together. Geraats (2002), on the other hand, defines CBT as the absence of asymmetric information between monetary policy makers and other economic agents. Market participants take their decision in an environment which is characterized by uncertainty. By making public and explaining in detail their decisions and expected outcomes, policy makers can reduce uncertainty. This leads to an improvement in the effectiveness of monetary policy transmission mechanism, private agents having more accurate defined expectations and therefore making better decisions (Van der Cruijsen and Demertzis, 2007; Crowe and Meade, 2008). Also, this leads to lower risk premiums which are very important in asset valuation, providing lower discount rates. Thus, the economy as a whole can benefit from a greater transparency (or lack of opacity) by increasing the welfare[2]. Furthermore, as Dincer and Eichengreen (2014) argue, transparency is a mean of enhancing the credibility of central bank. Eijffinger et al. (2006) show that greater transparency should increase central bank credibility, flexibility and reputation with an impact on the level of interest rates. Blinder et al. (2001) identify two key reasons for more transparent central banks: accountability and economic benefits.

However, although there is a growing body of literature related to the effects of CBT, the findings are inconclusive. Demertzis and Hughes Hallett (2007) highlight that there is a potential conflict between the ability of central banks to control and the need for transparency. Hence, different authors reached different conclusions. Nevertheless, studies of Chortareas et al. (2002), De Mendonça and Filho (2007), Demertzis and Hughes Hallett (2007), Dincer and Eichengreen (2014) or Papadamou et al. (2014) find that a greater transparency reduces stock market volatility due to an increased ability of central bank to manage expectations. Van der Cruijsen et al. (2010), on the other hand, find that there is an optimum degree of transparency where the inflation is minimized. Beyond this point, confusion and information overload might deteriorate the quality of private sector inflation forecasts. However, the evidence indicates that the opaque regime still dominates the transparent regime (Cukierman, 2001; Geraats, 2006; Rhee and Turdaliev, 2013).

Given these findings, we develop our research framework by undertaking a novel analysis aiming at identifying the potential relationship between CBT and SR. The research question can be stated as follows: *Does the central bank transparency affect banks' contribution and exposure to systemic risk?* Our sample is composed of 34 banks operating in 9 countries from CEE over a period of 8 years (2005–2012). This timeframe includes two major vulnerability periods for CEE banking markets, the 2007–2008 global financial crisis and the 2010–2011 European sovereign debt crisis. The geographic area is of a great interest as it comprises developing and emerging countries that experienced in the last decade significant improvements with respect to regulatory framework and property rights but still have a lower CBT degree comparing to advanced economies (Arnone et al., 2007; Dincer and Eichengreen, 2014; Horváth and Vaško, 2016).

Our contribution to the literature is threefold. First, we contribute to the extant literature by providing additional insights on the determinants of the systemic risk, besides the common fundamental and market factors identified by the literature. Second, we analyze the nexus between SR and CBT to assess whether a greater CBT leads to a decrease in the SR, as we would expect given the previous empirical findings on CBT and financial stability. We anticipate that the more transparent a central bank is, the more information banks have and therefore they can improve their expectations and decisions, leading to a decrease in risk-taking, as well in risk contribution and exposure to the banking sector. Third, we interact CBT with several variables that reflect the quality of regulatory framework and assess their impact on the relationship between the CBT and SR contribution to observe whether the findings are heterogeneous across different prudential policies. The sample of banks we study from CEE presents an interesting setting to investigate these relationships due to differences among central banks' policies in this area. Also, the systemic risk in these countries can be highly influenced by the connections between local banks and their bank holding company from Western Europe as the majority of them have foreign ownership.

[2] See the survey of Geraats (2002) for an analysis of the impact of an increased degree of transparency on several macroeconomic variables.

The remainder of our paper is structured as follows: In Section 2 we present the relevant literature related to our topic, in Section 3 we describe the methodology, sample and data we employ, in Section 4 we discuss the empirical findings, and in Section 5 we conclude.

2. Literature review

The economic desirability of a more transparent central bank has been studied by various researchers leading to inconclusive results (a detailed survey is presented in Van der Cruijsen et al., 2010). Most researchers agree that a transparent framework (in contrast to an opaque one) is beneficial for market participants as it increases the flow of information the investors have access to, thus improving their expectations and decisions (Blinder, 1998; Van der Cruijsen and Demertzis, 2007; Crowe and Meade, 2008). However, the studies of Van der Cruijsen et al. (2010) and Horváth and Vaško (2016) have shown that there is an optimum of central bank transparency and beyond that point more information tends to generate a misleading behavior among investors.

A great strand of literature on central bank transparency is devoted to its impact on stock market volatility. An increased CBT allows banks to manage expectations in a better manner, thus reducing financial market volatility (Chortareas et al., 2002; De Mendonça and Filho, 2007; Demertzis and Hughes Hallett, 2007; Reeves and Sawicki, 2007; Dincer and Eichengreen, 2014). Lunde and Zebedee (2009) find that intraday stock market volatility in the US tends to be lower on days when a monetary policy decision is announced and higher on days following the announcement. Papadamou et al. (2014), who investigated an international sample of 40 countries for the period 1998–2005, found a negative relationship between central bank transparency and stock market volatility. Extending their analysis but this time for 29 countries covering the same period, Papadamou et al. (2017) identify a positive link between the independence of central bank and stock market volatility.

By examining the monetary policy signaling, Andersson et al. (2006) show that central bank transparency can influence the term-structure of interest rates for the short as well as for the long run of the yield curve. Eijffinger et al. (2006) argue that a higher degree of transparency may increase central bank credibility, flexibility, and reputation. Ultimately, these effects will reduce short-term and long-term interest rates. The findings of Neuenkirch (2012) indicate that central bank transparency reduces variation and bias of expectations among the money markets. In addition, the study of Kia (2017) for the US shows that the more transparent the monetary policy is the less risky and volatile the money market will be.

Based on Dincer and Eichengreen (2014)'s work, Horváth and Vaško (2016) develop a new index of central bank transparency for 110 countries covering a period from 2000 to 2011 and highlight a non-linear relationship between CBT and financial stability. Their results indicate that central banks with more transparent monetary policies tend to exhibit greater financial stability but if transparency is too high, it is not beneficial for financial stability. Eichler et al. (2017) examine the impact of transparency on cross-border banking. Using a panel data comprising 68 countries (21 home and 47 destination countries) from 1998 to 2010 the authors find strong evidence that a greater degree of central bank transparency leads to a rise in cross-border claims in destination countries. Furthermore, they identify that the effect of CBT is positive only if central bank is politically independent and operates in a stable economic environment.

Besides central bank transparency, the main argument in favor of a more independent central bank deals with its main objective in maintaining price stability. Indeed, the vast strand of studies has been conducted on this relationship and the main conclusion suggests that the inflation is negatively related to the measures of central bank independence (see Grilli et al., 1991; Cukierman et al., 1992; Eijffinger and de Haan, 1996; Berger et al., 2001; Crowe and Meade, 2008, among others). Thus, the more independent a central bank is, the lower the level of inflation is. Other papers (e.g., García-Herrero and Del Rio Lopez, 2003; Cihak, 2007; Klomp and de Haan, 2009) investigate the link between central bank independence and financial stability and reached the conclusion that there is a positive association between the degree of central bank independence and financial stability. Blinder (2013) argues that in a financial crisis is desirable and inevitable for the central bank to cooperate with other public institutions (such as treasuries) and apply unconventional monetary and macroprudential policy measures. Furthermore, as Klomp and de Haan (2009) and Cihak (2010) point-out, a greater independence from external authorities make central banks less politically constrained in acting to prevent financial crises, also allowing them to intervene earlier and more decisively when a meltdown occurs.

3. Data, sample, and methodology

3.1. Systemic risk measures

There are two major directions in the literature used to determine systemic risk. The first one deals with banks' balance sheet positions and risk exposures and is usually based on confidential information provided by banks to regulatory authorities. Being focused on the concentration of risk within individual banks this approach addresses microprudential concerns. The second one relies on public market data, such as stock returns and CDS spreads (in addition to the accounting data), and has been developed in the aftermath of the 2008 financial crisis especially as an alternative to the first one which uses exclusively accounting data. This approach focuses on the externalities implied by the failure of an individual bank, and targets macroprudential regulations. Within this, Bisias et al. (2012) identified 31 measures of systemic risk, many others emerging since then. To identify the systemically important banks we use the second approach.

In this study we employ two of the most exploited systemic risk measures based on market and accounting data. The first one is Conditional Value at Risk (CoVaR) of Adrian and Brunnermeier (2016). It is based on the well-known Value at Risk (VaR)[3] measure (idiosyncratic risk) which expresses the maximum possible loss that an asset, a portfolio or an institution (a bank, in our case) could register for a given confidence level (usually 99%). CoVaR is the VaR of the banking system conditional on the VaR of a bank being under distress. We define distress as the loss generated by the reduction of the banks' market value of total assets during extreme events. The market value of assets is calculated starting from the book value of total assets that is multiplied with the ratio between the market value of equity (market capitalization) and the book value of equity. System is defined by the total market assets of the banks from our sample. Table A1 in Appendix A provides a detailed description of the variables.

Technically, VaR implies running the *Quantile Regression (QR)* method for an empirical specification where the banks' market value of total assets is regressed on a number of market indices that captures the exposure of financial institutions to common factors. These market indices common for all banks within the sample are adapted to the CEE region we focus on. Most studies in the literature use a set of market indices representative for global financial markets to estimate banks' contribution and exposure to systemic risk. Usually, they account for the change in three-month Treasury bill rate, the change in the slope of the yield curve, the TED spread, the S&P500 market return, or the volatility of CRSP equity return, among others (Adrian and Brunnermeier, 2016; Acharya et al., 2017). As these studies focus on banks from developed markets, we use a different approach by employing market indices that impact the banking sector across the CEE region. We are motivated by Bae et al. (2003) who propose a financial contagion measure across countries within a region and across regions based on the coincidence of extreme return shocks. Their results indicate that regional interest rates, exchange rate changes, and conditional stock return volatility can forecast systemic risk. Analyzing a sample of large European banks, Buch et al. (2017) found that the drivers of systemic risk at the national level are different than those at the euro area level. Pagano and Sedunov (2016) provide evidence that systemic risk can be predicted through a combination among domestic and global factors. Their findings depict a simultaneous relation between systemic risk exposure and government debt yields across European countries.

Following Andrieş and Nistor (2016) we employ the next variables[4] the level of EURO STOXX Financial Index (log-return), the spread among the ten years and one-month euro area government bonds, the change in the Eonia rate, the change in the spread among three months Euribor rate and three months Eoniaswap rate, and the level of foreign exchange market realized volatility index[5]. Through this set of market indices, we account for developments in the interbank market, foreign exchange market, capital market and government bonds market. Estimations are run for each bank separately using time series with weekly frequency.

Next, we compute the systemic risk measure as the VaR of the system conditional on the VaR indicator of each bank from the sample, using the CoVaR methodology developed by Adrian and Brunnermeier (2016). It implies running the *QR* method for an empirical specification where the system's market value of total assets is regressed on the common market indices previously detailed but also on each banks' market value of total assets. These estimations reflect contagion from a particular bank to the system and are run for each bank separately using time series with weekly frequency. The contribution of a bank to systemic risk is the difference between its CoVaR during distress (1% quantile) and the CoVaR for the median state of the bank (50% quantile). A higher value of CoVaR indicates a greater contribution of the bank to systemic risk.

The second metric used is the Systemic Risk indicator (SRISK)[6] developed by Acharya et al. (2017) and Brownlees and Engle (2017). The SRISK corresponds to the expected capital shortfall of a given bank conditional on a crisis affecting the whole financial system. It extends the Marginal Expected Shortfall (MES) to account for both the liabilities and the size of the bank[7]. Financial institutions with the highest capital shortfall are assumed to be riskier and hence have a greater contribution to systemic risk.

All risk measures are computed for a weekly frequency being then aggregated within a year to match the frequency of the Transparency Index. The indicators are based on a combination between market data (the weekly market capitalization of banks) and accounting data (banks' total assets and total equity).

A possible shortcoming of applying these market-based risk models for banks from the CEE region is related to the fact that some financial institutions important to the banking sector are left out as they are not listed on a stock exchange. Also, for some of them the free float can be small, and the liquidity limited as some capital markets in the CEE countries are small compared to developed countries. We try to alleviate these concerns by using weekly frequency instead of daily, which permits us to capture better the reaction of banks' market capitalization. Despite these limits, applying market-based methodologies permits to obtain dynamic risk measures with high frequency, which has many advantages in comparison with accounting-based risk measures in predicting more accurately and timely the build-up phase of systemic risk. Bisias et al. (2012) provides a detailed description of these advantages. Also, banks are treated as part of the system, and systemic risk would indicate the spread of contagion through the system. We are in line with the extensive strand of literature on financial stability that points to the importance of adjusting the risk models' sensitivity to short-term market changes and to the treatment of banks as part of a herd (Brunnermeier et al., 2009).

The transmission of systemic events among the CEE banking market could take place both between and within countries. Among the same country, banks could transfer risk to each other especially via the lending channel, in case banks default on loans. The intensity of the risk transfer depends on the degree of interconnectedness among the interbank market and capital markets. Also, the

[3] For a detailed theoretical description of the VaR see Jorion (1997); Dowd (1998), Saunders (1999), Danielsson (2011), and Hull (2012).

[4] The estimations are run using the financial market indices lagged by one period as in Adrian and Brunnermeier (2016).

[5] All these factors have been checked for stationarity (unit root) using the Augmented Dickey-Fuller test with no lags.

[6] Data on SRISK measures for the largest financial institutions can be found online at vlab.stern.nyu.edu (an initiative of the Stern-NYU's V-Lab). For our sample, we compute the SRISK for every bank in part.

[7] For a discussion and a comparison on these measures performance see Benoit et al. (2016).

geographically and culturally links among countries can have an important role in the propagation of systemic events. Analyzing the systemic risk across the European banking market, Pagano and Sedunov (2016) found that countries affected by the European debt crisis had severe contagion effects on other European countries.

Across countries the risk could be transferred among subsidiaries of the same banking group. Considering that a large part of the banking sector in CEE countries has foreign ownership, systemic risk can be highly influenced by the connections between local banks and their bank holding company from Western Europe. Contagion spillovers from parent banks to their subsidiaries might enhance in stress periods with respect to the transparency practiced by central banks. Deteriorating conditions in home countries could rapidly affect the profitability and enhance credit risk of the parent banks. Due the dependence of foreign-owned subsidiaries on the financing lines from their mother banks these negative events can trigger funding shocks to their subsidiaries (Schoenmaker and Wagner, 2013; Allen et al., 2017). As a significant number of banks from our sample are controlled by large international groups that are systemically important from a global perspective, risk transfers via the funding channel could severely threaten the financial stability in this region.

Nevertheless, the contagion spillovers across banks from emerging countries can differ in comparison with developing countries as they are significantly influenced by characteristics of the banking markets, like competition and governance mechanisms. The banking sectors from our sample have a high degree of concentration which can have a destabilizing role on financial stability (Schaeck and Cihak, 2007 and Uhde and Heimeshoff, 2009). Also, the banking system from the CEE countries we analyze have different levels of tightness regarding the regulatory and supervisory practices. According to Agoraki et al. (2011), higher capital requirements, tighter restrictions on banking activities and greater supervisory power of central banks reduce risk across banks in general, but the effect is significantly weekend for banks with high market power, which is the case of many financial institutions from CEE.

3.2. Central bank transparency index

The main explanatory variable of interest is represented by central bank transparency. We use the Transparency Index (TI, hereinafter) of Dincer and Eichengreen (2014), which is based on the actual information disclosed by the central banks. The TI is constructed for more than 100 central banks for the 1998–2014 period. It is based on 15 questions related to five dimensions of transparency, following the methodology developed by Geraats (2000): (i) political transparency, (ii) economic transparency, (iii) procedural transparency, (iv) policy transparency, and (v) operational transparency. The index takes a minimum value of 0 if the central bank exhibits no degree of transparency and a maximum value of 15 in case of a high degree of transparency.

3.3. Sample and data

The data set includes 34 banks operating in 9 CEE countries[8] from 2005 to 2012. We have retrieved the market data from Thomson Reuters Datastream while the accounting data was collected from Bankscope (Orbis Banks). All 34 banks are listed on stock exchanges and have a size (total assets) greater than EUR 300 million at the end of 2012. We started from a larger sample of more than 400 banks from the CEE zone. The methods we employ to estimate systemic risk, ΔCoVaR (for banks' contribution to systemic risk), and, VaR and SRISK (for banks' exposure to systemic events) require market data (i.e., the weekly market capitalization of banks) which restricts the sample to the financial institutions listed on a stock exchange. From our initial list, 92 banks from CEE meet this criterion. Also, these measures involve balance-sheet data on total assets and total equity. As time series models are used to compute the VaR, ΔCoVaR and SRISK indicators, another restriction is related to the availability of the accounting data employed. Adrian and Brunnermeier (2016) recommend that the missing quarterly values of total assets and equity to be inputted through linear interpolation between two consecutive quarters. This condition implies to eliminate banks with missing total assets or equity data for two consecutive quarters or more. Therefore, we ended up with a list of 34 institutions with stock prices available on Thomson Reuters Datastream that address these concerns.

Among the financial institutions considered, 17 are foreign owned and 17 are domestic financial institutions. The distribution of banks per country varies from one (Czech Republic, Hungary, Lithuania, Ukraine) to 11 (Poland). The size difference among banks is also large, as depicted in Table A1 in Appendix A. Even though the size of some banks is small, these institutions can present systemic importance if they are highly interconnected in the interbank market (Allen and Gale, 2004; Freixas and Holthausen, 2005), if they have common exposures on national, regional or capital markets (Freixas and Rochet, 2008), or if they are dependent on the parent bank funding, in case of foreign-owned banks (Schoenmaker and Wagner, 2013; Allen et al., 2017; Bonin and Louie, 2017). Our approach is in line with the studies that highlight the need of identifying banks that are systemically important at the local level (Black et al., 2016; Benoit, 2014; Buch et al., 2017). Also, the Basel Committee on Banking Supervision extended the framework dedicated to global systemically important banks to include the domestic systemically important banks (BCBS, 2012). Yet, there could be banks that have a significant contribution to systemic risk at the national level but are not included in the BCBS list because they are not systemically important for a global market perspective or in the list of supervised institutions of ECB because they do not generate systemic concerns for the European financial market.

The banks we considered are representative to examine the impact of central bank transparency on systemic risk across CEE region and present an interesting setting to investigate our hypothesis due to the heterogeneity among central banks' policies in this

[8] The countries are Bulgaria, Croatia, Czech Republic, Hungary, Lithuania, Poland, Romania, Slovakia, and Ukraine.

area. These financial institutions are important from a regulatory perspective as four of them are included in the Single Supervisory Mechanism (both significant and less significant institutions) by the European Central Bank (ECB, 2015) and 22 of them (including two from the Single Supervisory Mechanism) have their holding companies considered Other Systemically Important Institutions (O-SIIs) by the European Banking Authority (EBA, 2016 and EBA, 2017). The list of banks from our sample is provided in Table A2 in Appendix A.

3.4. Methodology

The impact of central bank transparency on systemic risk is assessed using the *Ordinary Least Square* method with bank fixed effects *(OLS FE)*. The baseline model has the following form:

$$Risk_{ij,t} = \beta_0 + \beta_1 xCentral\ Bank\ Transparency_{j,t-1} + \beta_2 xBank\ controls_{ij,t-1} + \beta_3 xMacro\ controls_{j,t-1} + \delta_i + \varphi_t + \varepsilon_{ij,t} \quad (1)$$

The dependent variable, $Risk_{ij,t}$, is represented in a first step by the contribution to systemic risk of bank *i* from country *j* in year *t*. In a second step, the dependent variable takes the form of individual risk of bank *i* from country *j* in year *t*. *Central Bank Transparency*$_{j,t-1}$ is the main regressor of interest and is associated with the central bank of country *j* at *t-1*. *Bank controls*$_{ij,t-1}$ represent differences in risk profiles and business strategies among banks (the logarithm of total assets, as proxy for size; the ratio of equity to total assets, as proxy for solvability; net loans to total assets as proxy for specialization; customer deposits to total liabilities, as proxy for the funding structure; and, the return on average assets, as proxy for performance) at *t-1*. We also use country-level controls (*Macro controls*$_{ij,t-1}$) to account for the heterogeneity across different banking systems and macroeconomic environment (central bank assets to GDP, GDP per capita growth, inflation and the Lerner index as proxy for competition within the banking market). To control for unobserved heterogeneity, we add country fixed effects (δ_i) and year fixed effects (φ_t). $\varepsilon_{ij,t}$ is an error term corresponding to bank *i* from country *j* in year *t*.

Further, we include three regulatory indices (Central Bank Independence, Central Bank Involvement in Supervision, and Regulatory Quality Index)[9] in a *Difference-in-Differences* approach, as below:

$$Risk_{ij,t} = \beta_0 + \beta_1 xCentral\ Bank\ Transparency_{j,t-1} + \beta_2 xCentral\ Bank\ Transparency_{j,t-1} xRegulatory\ index_{j,t-1} + \beta_3 x\ Regulatory\ index_{j,t-1} + \beta_4 xBank\ controls_{ij,t-1} + \beta_5 xMacro\ controls_{j,t-1} + \delta_i + \varphi_t + \varepsilon_{ij,t} \quad (2)$$

We construct dummy variables that take the value of 1 if the regulatory indices are greater than the median value of the entire sample and 0 otherwise and interact them with de *Central Bank Transparency* variable. Central Bank Independence Index is an updated version of Cukierman et al. (1992)'s index by Bodea and Hicks (2015). The measure is composed of four dimensions relating to appointment, dismissal, and term of office for the head of the central bank; the resolution of conflicts between the executive branch and the central bank; the objectives of the central bank and the rules limiting lending to the government. Higher values are associated with a greater independence of the central bank. Central Bank Involvement in Supervision Index captures the roles taken by the central banks in supervising financial institutions and is provided by Masciandaro and Romelli (2017). The indicator takes the minimum score in countries where no supervisory responsibilities are assigned to the central bank, and the maximum score otherwise. The dimensions included are as follows: (i) involvement of the central bank in the banking sector supervision; (2) the sharing of supervision among the central bank and other authorities; (3) central bank is responsible only for the banking supervision; (4) central bank is responsible for a unified supervision of the banking and insurance sectors; (5) central bank is responsible for a unified supervision of the banking and securities markets sectors; and, (6) central bank is responsible for a unified supervision across of the entire financial sector. Regulatory Quality Index is provided by World Bank (World Governance Indicators database) and captures perceptions of the government's ability to formulate and implement sound regulatory policies that promote private sector development. The index ranges from approximately -2.5 to 2.5, higher values indicating a stronger regulatory framework.

All explanatory variables are lagged by one period *(t-1)* and winsorized within the 1% and 99% percentiles. To correct for heteroskedasticity and serial correlation we use bank-level clustered standard errors. In order to check the robustness of our results, we employ two additional methods: the *Instrumental Variable Two-stage Least Squares (2SLS)* and the *Hierarchical Linear Modeling (HML)*.

4. Empirical results

4.1. Descriptive statistics

Table 1 summarizes the descriptive statistics of the dependent variables and regressors for our sample of banks from Central and Eastern Europe. During the period 2005–2012, the average individual risk of banks represented about 6.9% loss of the market value of total assets (standard deviation 3.6%). The average contribution of banks to systemic risk reflected by the ΔCoVaR indicator was about 0.7% loss of the system's market assets within a year (standard deviation 1.0%). Considering the capital shortfall under stress conditions (expressed by the SRISK indicator) banks suffered on average a 10 million EUR loss of their market capital when the system as whole registered negative market capitalization returns. The transparency index across central banks from CEE during

[9] A complete description of all variables in provided in Table A2 in Appendix A.

Table 1
Summary statistics (averages over the period 2005–2012).

Variables	Observations	Mean	St. dev.	Min	p25	p50	p75	Max
Dependent variables								
VaR	191	6.908	3.599	0.000	4.827	6.296	8.027	22.279
ΔCoVaR	191	0.698	1.018	−0.866	−0.100	0.505	1.547	3.605
SRISK	191	0.010	0.026	−0.088	−0.001	0.002	0.014	0.109
Explanatory variables								
Transparency Index	187	7.286	3.191	3.000	3.500	7.500	9.000	14.500
Log(Total assets)	190	8.265	1.744	3.611	7.370	8.737	9.542	10.763
Equity/Total assets	190	11.127	4.102	3.700	8.310	10.380	13.140	26.450
Net loans/Total assets	190	61.602	11.879	26.550	55.710	63.025	69.820	86.540
Customer deposits/Total liabilities	190	0.759	0.153	0.281	0.687	0.798	0.867	0.979
Return on Average Assets	190	0.984	2.026	−12.870	0.520	1.210	1.780	8.970
Central bank assets/GDP	187	0.237	0.928	0.000	0.004	0.010	0.047	7.416
GDP/capita growth	191	3.013	4.395	−14.421	1.555	3.903	5.245	12.414
Inflation	191	4.025	2.745	0.556	2.528	3.557	4.349	25.232
Central Bank Independence Index	191	0.846	0.043	0.732	0.812	0.875	0.875	0.894
Regulatory Quality Index	191	0.714	0.332	−0.606	0.545	0.715	0.965	1.320
Central Bank Involvement in Supervision Index	191	2.613	1.375	1.000	1.000	3.000	3.000	6.000

Note: This table reports the summary statistics of the dependent and explanatory variables. Definitions of variables are provided in Table A1 in Appendix A.

2005–2012 was 7.3, with large variations across countries (from 3.0 to 14.5). A detailed description of the variables is provided in Table A1 in Appendix A.

Regarding the bank-level characteristics the average bank from our sample had a capitalization of 11.1%, a high share of net loans in total assets of about 61.6%, a funding structure oriented towards deposits as the ratio of customer deposits to total liabilities was 75.9% and a return on average assets of about 0.9%. At the macro level, the average central bank assets to GDP ratio were about 23.7%, the average economic growth per capita rate was 3.0% and the average inflation was 4.0%.

4.2. Main findings

Table 2 presents the results for the baseline model presented in Eq. (1). Analyzing the effects of central bank transparency on banks' individual risk the results presented in column (1) show a negative influence that is statistically significant at 10%. A one percent increase in the standard deviation of the transparency index generates a 28 percent decrease in banks' Value at Risk indicator, suggesting thus a beneficial effect of information disclosure on individual bank risk taking.

In contrast, for the contribution of the banks to the risk of the system, the coefficient of TI is positive for both systemic risk measures (columns (2) and (3)). This implies that more information disclosure by central banks to public leads to an increase in the systemic contribution of banks. A one percent shock in the standard deviation of the transparency index is associated with about 19 percent increase of the ΔCoVaR indicator (i.e., the loss of the system's market value of total assets conditional on banks' being in distress). The average effect on the banks' market equity loss of a one standard deviation increase in the TI index is about 68 percent increase. In columns (4)-(6) we add as additional control variable the Lerner index that reflects the competition within the banking industry. Our findings remain very similar. Also, we re-run the estimations with standard errors clustered at the country level instead of bank level. Unreported results confirm the robustness of the main output.

Overall, the findings highlight the contrary effects of transparency from the microprudential approach (individual bank supervision) and the macroprudential approach (banking system). The more transparent a central bank is, the more information banks have and therefore they can improve their expectations and decisions in order to reduce the individual risk taking during extreme events. The results could be linked with the studies of Van der Cruijsen and Demertzis (2007) and Crowe and Meade (2008) who found an improvement in the effectiveness of monetary policy transmission mechanism in case of more transparent central banks, that leads to more accurate expectations and better decisions at the individual bank level.

Also, the beneficial effects of central bank transparence for internal management purposes of financial institutions can be attributed to the reduced financial market volatility in case of countries with more information disclosed to public by the central bank (De Mendonça and Filho, 2007; Demertzis and Hughes Hallett, 2007; Dincer and Eichengreen, 2014) or to the reduced money market volatility (Neuenkirch, 2012; Kia, 2017).

From a macroprudential perspective, our results are in contrast with the papers that found a positive association between the degree of central bank transparence and financial stability (e.g., García-Herrero and Del Rio Lopez, 2003; Klomp and de Haan, 2009). A possible explanation for the harmful effect of transparence on contagion spillovers can be explained by the incentives of banks to engage in risky activities. Given more information disclosed by the central bank, financial institutions through a herd behavior might increase individual contribution to the risk of the banking system as a whole. Van der Cruijsen et al. (2010) and Horváth and Vaško (2016), for example, have shown that there is an optimum of central bank transparency and beyond that point more information tends to generate a misleading behavior among investors.

The results might be affected by reverse causality as central banks may become more transparent after an increase in the

Table 2
Estimation results for the baseline model.

Variables	OLS FE					
	(1) VaR	(2) ΔCoVaR	(3) SRISK	(4) VaR	(5) ΔCoVaR	(6) SRISK
Transparency Index	**−0.433***	**0.060*****	**0.005*****	**−0.527****	**0.054****	**0.006*****
	(0.219)	**(0.021)**	**(0.002)**	**(0.230)**	**(0.027)**	**(0.002)**
Bank level controls						
Log(Total Assets)	−2.498*	0.106	0.014**	−2.407*	0.111	0.014**
	(1.435)	(0.125)	(0.005)	(1.348)	(0.126)	(0.005)
Equity/Total Assets	−0.303*	−0.016*	0.000	−0.303**	−0.016*	0.000
	(0.158)	(0.008)	(0.001)	(0.146)	(0.008)	(0.001)
Net Loans/Total Assets	0.001	−0.001	0.000	0.002	−0.001	0.000
	(0.034)	(0.003)	(0.000)	(0.033)	(0.003)	(0.000)
Customer deposits/Total Liabilities	−4.013	−0.403	−0.010	−3.470	−0.372	−0.012
	(2.692)	(0.298)	(0.018)	(2.607)	(0.305)	(0.017)
Return on Average Assets	−0.105	−0.008	−0.000	−0.139	−0.010	0.000
	(0.163)	(0.013)	(0.001)	(0.157)	(0.013)	(0.001)
Country level controls						
Central Bank Assets/GDP	−0.824*	0.026	0.000	−0.690	0.034	−0.000
	(0.416)	(0.024)	(0.002)	(0.446)	(0.024)	(0.002)
GDP per capita growth	−0.130*	−0.016**	−0.000	−0.119*	−0.015*	−0.000
	(0.068)	(0.008)	(0.000)	(0.064)	(0.008)	(0.000)
Inflation	−0.238***	−0.036***	−0.001	−0.312***	−0.040**	−0.001
	(0.075)	(0.013)	(0.001)	(0.100)	(0.015)	(0.001)
Lerner index				15.319**	0.883	−0.055
				(7.316)	(0.782)	(0.068)
Constant	35.436***	0.190	−0.138***	30.984***	−0.067	−0.122***
	(12.232)	(1.006)	(0.042)	(11.057)	(1.030)	(0.044)
Bank fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Cluster level	Bank	Bank	Bank	Bank	Bank	Bank
Observations	191	191	191	191	191	191
Number of banks	34	34	34	34	34	34
Number of countries	9	9	9	9	9	9
R-squared	0.466	0.332	0.405	0.488	0.339	0.409

Note: Standard errors clustered at the bank level are reported in brackets.*, ** and *** denote significance levels of 10%, 5% and 1%, respectively.

contribution of banks to systemic risk. To address potential endogeneity issues between systemic risk and transparency we consider an instrumental variables analysis using the *Two-stage Least Squares* method. The instruments we use are: Rule of Law, Voice and Accountability and Credit to GDP ratio. The Rule of Law index captures property rights and freedom from corruption across countries. Higher values reflect strong laws that protect property rights, an independent judiciary system with a low level of corruption, as well as the ability of individuals and businesses to enforce contracts. The index is retrieved from the Heritage Foundation database and varies across countries and years. The Voice and Accountability index reflects the degree to which citizens of a country are able to participate in selecting their government, their freedom of expression and association, and, the freedom of media. The index is provided by Heritage Foundation and presents variability across countries and years. Credit to GDP ratio reflects the heterogeneity across CEE countries regarding the financial intermediation through the banking sector. Its values are extracted from the database of World Bank.

Table 3 Panel A presents the results corresponding to the *IV 2SLS* method. Model (1) shows the output for the Value at Risk determinants. Although there is no significant impact from the transparency index to individual bank risk taking, the associated sign of CI index remains negative as in the previous estimation specification. The empirical findings related to the systemic risk determinants (models (2) and (3)) are very close to the previous output, indicating that central banks with strong transparency policies have a positive and significant impact on banks' contribution to systemic risk. The economic impact is stronger, as a one percent shock in the standard deviation of the transparency index is associated with about 85 percent increase of the ΔCoVaR indicator. The table also reports the *Kleibergen-Paap Wald rk F test* of weak-identification and the *Hansen J-statistic* of overidentification. They confirm the strengths of the instruments used (in case of VaR and ΔCoVaR) and the validity of the overidentifying restrictions. The *Kleibergen-Paap Wald rk F test* rejects the null hypothesis of weak instrumental variables, providing support for the instruments we considered.[10] The *Hansen J statistic* confirms the validity of the restrictions implied by the existence of more instruments than endogenous variables.[11]

[10] The null hypothesis of *Kleibergen-Paap Wald* rk *Wald F statistic* is that the structural equation is underidentified. A rejection of the null indicates that the model is identified. The values associated with the *Kleibergen-Paap Wald* rk *Wald F statistic* were compared with the critical values of Stock and Yogo (2005).

[11] The null hypothesis of *Hansen J statistic* is that the instruments are not correlated with the residuals. A rejection of the null indicates that the model is overidentified.

Table 3
Estimation results for the baseline model.

Variables	Panel A. IV 2SLS			Panel B. HLM		
	(1) VaR	(2) ΔCoVaR	(3) SRISK	(4) VaR	(5) ΔCoVaR	(6) SRISK
Transparency Index	−0.016	**0.266****	**0.021****	−0.112	**0.088*****	**0.005*****
	(1.068)	**(0.126)**	**(0.010)**	(0.169)	**(0.026)**	**(0.002)**
Bank level controls						
Log(Total Assets)	−3.175***	0.126	0.011*	−0.908***	0.143**	0.002
	(1.052)	(0.084)	(0.006)	(0.314)	(0.056)	(0.002)
Equity/Total Assets	−0.235	−0.018*	−0.001	−0.232***	−0.014*	−0.000
	(0.154)	(0.010)	(0.001)	(0.067)	(0.008)	(0.000)
Net Loans/Total Assets	0.016	0.002	0.001	0.005	−0.002	0.000
	(0.028)	(0.003)	(0.000)	(0.023)	(0.003)	(0.000)
Customer deposits/Total Liabilities	−2.846	−0.341	−0.036	−4.105**	−0.382*	0.001
	(3.112)	(0.315)	(0.026)	(1.754)	(0.218)	(0.012)
Return on Average Assets	−0.323	0.035	0.004**	−0.198*	−0.006	−0.000
	(0.313)	(0.024)	(0.002)	(0.115)	(0.014)	(0.001)
Country level controls						
Central Bank Assets/GDP	−0.888**	0.033	0.000	−0.487*	0.022	0.002
	(0.428)	(0.031)	(0.002)	(0.273)	(0.034)	(0.002)
GDP per capita growth	0.150	−0.016	−0.001	−0.146**	−0.014*	−0.000
	(0.135)	(0.017)	(0.001)	(0.063)	(0.007)	(0.001)
Inflation	0.111	−0.022	−0.003*	−0.179**	−0.038***	−0.000
	(0.138)	(0.017)	(0.002)	(0.084)	(0.010)	(0.001)
IV 2SLS diagnosis						
Kleibergen-Paap Wald rk Ftest	10.046***	10.046***	3.367			
Hansen J-statistic	2.842	1.740	2.338			
Hansen J-statistic p-value	0.241	0.419	0.311			
HLM Random effects parameters						
Country level variance				0.000	0.066	0.008
				(0.000)	(0.439)	(0.006)
Bank level variance				2.664	0.711	0.011
				(0.390)	(0.094)	(0.002)
Residual variance				1.589	0.013	0.180
				(0.092)	(0.001)	(0.010)
LR-test Chi-square				120.72***	374.14***	55.23***
Bank fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Cluster level	Bank	Bank	Bank	Bank	Bank	Bank
Observations	135	105	105	191	191	191
Number of banks	30	26	26	34	34	34
Number of countries	9	9	9	9	9	9
R-squared	0.585	0.113	0.439	0.466	0.332	0.405

Note: Standard errors clustered at the bank level are reported in brackets. *, ** and *** denote significance levels of 10%, 5% and 1%, respectively. Panel A reports the estimation results using *Instrumental Variables Two-stage Least Squares (IV 2SLS)*, Panel B reports the estimation results using *Hierarchical Linear Modeling (HLM)*.

Additionally, we re-estimate the previous empirical specifications using the *Hierarchical Linear Modeling*. This methodology accounts for the shared variance in hierarchically structured datasets. In our case the main explanatory variable (Transparency Index) is aggregated at the country level, while the outcome variables are compounded at the bank level. The results provided in Table 3 Panel B are in line with the *IV 2SLS* estimations and confirm that more central bank transparency significantly enhances the contribution of financial institutions to systemic risk. The *Chi-square statistic* associated with the likelihood ratio test confirms the validity of the results.[12]

4.3. Further extensions

In this section we explore whether the relationship among central bank transparency and banks' contribution to systemic risk is heterogeneous across countries with different regulatory frameworks of the banking sector. A number of studies argue that

[12] The null hypothesis of the *LR-test Chi-square* is that the estimated model is the same with the linear regression. A rejection of the null hypothesis indicates that the model estimated through *HML* is different than the model estimated through linear regression.

Table 4
Estimation results using Difference-in-Differences analysis.

Variables	(1) VaR	(2) ΔCoVaR	(3) VaR	(4) ΔCoVaR	(5) VaR	(6) ΔCoVaR
Transparency Index	0.357	**0.115****	**3.890****	**0.339****	**−0.947****	0.015
	(0.488)	**(0.029)**	**(0.960)**	**(0.138)**	**(0.235)**	(0.022)
Regulatory environment						
Central Bank Independence Index	14.427	0.022				
	(23.465)	(0.771)				
Regulatory Quality Index			−5.260	−0.707		
			(3.164)	(0.445)		
CB Involvement in Supervision Index					−0.297	0.008
					(0.241)	(0.025)
Interactions						
Transparency Index x Central Bank Independence dummy	**−1.177****	**−0.074****				
	(0.479)	(0.029)				
Transparency Index x Regulatory Quality dummy			**−4.305*****	**−0.284***		
			(0.939)	(0.141)		
Transparency Index x CB Involvement in Supervision dummy					**0.467*****	**0.032*****
					(0.078)	(0.009)
Bank level controls	Yes	Yes	Yes	Yes	Yes	Yes
Country level controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	191	191	191	191	191	191
Number of banks	34	34	34	34	34	34
Number of countries	9	9	9	9	9	9
R-squared	0.551	0.389	0.532	0.375	0.604	0.420
Bank fixed effects	No	No	No	No	No	No
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Cluster level	Country	Country	Country	Country	Country	Country

Note: Standard errors clustered at the country level are reported in brackets.*, ** and *** denote significance levels of 10%, 5% and 1%, respectively.

transparency is complementary to central bank independence (Klomp and de Haan, 2009; De Haan and Eijffinger, 2016). Examining an international sample of banks during 1998–2010, Eichler et al. (2017) found evidence that a greater degree of central bank transparency leads to a rise in cross-border claims in destination countries. However, the effects of CBT can be beneficial if the central bank is politically independent. Klomp and de Haan (2009) and Cihak (2010) point-out that a greater independence from external authorities makes central banks less politically constrained in acting to prevent financial crises, also allowing them to intervene earlier and more decisively when a meltdown occurs.

In Table 4 are displayed the results for the *Difference-in-Differences* analysis using three regulatory environment variables: Central Bank Independence Index (CBII) from Bodea and Hicks (2015), Central Bank Involvement in Supervision Index (CBISI) from Masciandaro and Romelli (2017) and Regulatory Quality Index (RQI) from World Governance Indicators database published by the World Bank. We create a dummy for each of the three variables taking value of 1 if it is greater than the median of the entire sample and zero otherwise. The dummy variables are therefore interacted with the Transparency Index.

Regarding the impact of transparency on banks' individual risk taking, results show a lower value of the VaR and ΔCoVaR indicators for banks from countries with a more independent central bank, as indicated by the coefficient on interaction term $TI \times CBII$ (-1.177** in column (1) and -0.074** in column (2)). This suggests that a more transparent central bank with independent policies is beneficial for reducing both the individual risk of banks and the systemic spillovers. Columns (3) and (4) indicate similar findings for transparent central banks from countries with a high level of the regulatory quality. The harmful effect of a more transparent central bank on systemic risk can be reduced in the context of a strong regulatory environment as the coefficient associated with the interaction term $TI \times RQI$ is negative and significant at 10%. Finally, we found strong statistical evidence that transparent central banks from countries with a tight supervisory framework enhance their individual risk and also the contribution to systemic risk. The coefficient associated with the interaction term $TI \times CBISI$ is 0.467** in column (5) and 0.032*** in column (6).

5. Conclusions

In the last two decades, central banks started to move towards more transparent policies and to disclose more information for the public, giving extensive explanations of the reasoning behind their decisions. But does this increase in transparency enhance or control the individual risk taking of banks and their contribution to systemic risk? The present paper aims to answer this research question by analyzing the impact of central bank transparency on systemic risk in emerging banking markets. We use a sample composed of 34 banks from Central and Eastern Europe for a period spanning from 2005 through 2012. These countries experienced in the last decade significant improvements with respect to the quality of the regulatory framework but still present a lower degree of central bank transparency comparing to advanced economies.

Results indicate a positive and significant impact of the central bank transparency on financial institutions' contribution to systemic risk. On the other side, more central bank transparency significantly reduces the idiosyncratic risk of banks. Our findings are

robust to different specifications and methodologies (*OLS*, *IV 2SLS* and *HLM*). We also employed a Difference-in-Differences approach to examine whether the relationship among central bank transparency and banks' risk is heterogeneous across countries with different regulatory frameworks for the banking sector. Robust findings show that a central bank that is more transparent and, also, independent has beneficial effects for the risks accumulated within the banking sector, as might help banks reducing both the individual risk and their systemic spillovers. The harmful effect of a more transparent central bank on systemic risk can be reduced also in the context of a strong regulatory environment. In contrast, transparent central banks that adopt a tight supervisory framework enhance banks' individual risk as well as their systemic contribution.

In terms of policy implications, we argue that a more transparent central bank is benefic for the banking sector from a microprudential perspective, but it may create incentives for financial institutions to engage in risky activities and through a herd behavior, increase individual contribution to the risk of the banking system as a whole.

Appendix A

Table A1
Description of variables.

Variable name	Definition	Source
Dependent variables (bank level)		
Delta Conditional Value at Risk (ΔCoVaR)	Bank *i*'s contribution to systemic risk as defined by Adrian and Brunnermeier (2016). It is measured as the difference of the Value-at-Risk (VaR) of the system's market value of total assets conditional on the distress of a particular bank (1% worst outcomes) and the VaR of the system's market value of total assets conditional on the median state of the bank (median outcomes). System is defined as the market value of total assets of the sample. CoVaR is estimated using the Quantile Regression method for an empirical specification where the system's market value of total assets is regressed on each banks' market value of total assets and on a set of market indices that captures the exposure of financial institutions to common factors. The common factors are: the level of EURO STOXX Financial Index (log-return), the spread among the ten years and one-month euro area government bonds, the change in Eonia rate, the change in the spread among three months Euribor rate and three months Eoniaswap rate, and the level of foreign exchange market realized volatility index. ΔCoVaR is expressed in units of percentage loss of the system's market value of total assets within a year.	Own calculations[a]
Value at Risk (VaR)	The maximum possible loss as a percent of the total market value of the assets that a bank could register for a given confidence level (99%). The loss is found in the left tail corresponding to a given confidence level of the returns distribution function of the market value of total assets. VaR is estimated using the Quantile Regression method for an empirical specification where bank i's market value of total assets is regressed on a set of market indices that captures the exposure of financial institutions to common factors. The common factors are: the level of EURO STOXX Financial Index (log-return), the spread among the ten years and one-month euro area government bonds, the change in Eonia rate, the change in the spread among three months Euribor rate and three months Eoniaswap rate, and the level of foreign exchange market realized volatility index. VaR is expressed in units of percentage loss of the bank i's market value of total assets in year t.	Own calculations[a]
Systemic Risk Measure (SRISK)	The loss of the bank *i* within a year conditioned by the whole system being in distress (1% worst outcomes of the market capitalization). SRISK is determined using DCC-GJR GARCH method as in Acharya et al. (2017) and Brownlees and Engle (2017). SRISK is expressed in billion EUR. System is defined by the market capitalization of the sample.	Own calculations[a]
Bank level variables		
Log of total assets (log(Total assets))	Logarithm of total assets	Bankscope
Equity to total assets (Equity/TA)	Equity/Total assets	Bankscope
Net loans to total assets (NL/TA)	Net loans/Total assets	Bankscope
Customer deposits to total liabilities (CD/TL)	Customer deposits/Total liabilities	Bankscope
Return on average assets (ROAA)	Net income/Average total assets	Bankscope
Macro level variables		
Transparency Index	Transparency of the central banks as defined by Dincer and Eichengreen (2014). It is the sum of 15 questions regarding (i) political transparency, (ii) procedural transparency, (iii) policy transparency, and (iv) operational transparency. The range is between 0 (minimum) and 15 (maximum), greater value indicating a greater transparency.	Dincer and Eichengreen (2014)

(*continued on next page*)

Table A1 (*continued*)

Variable name	Definition	Source
Central Bank Independence Index	Updated version of Cukierman et al. (1992)'s index by Bodea and Hicks (2015). The index has four components relating to (i) appointment, dismissal, and term of office for the head of the central bank, (ii) the resolution of conflicts between the executive branch and the central bank, (iii) the objectives of the central bank, and (iv) the rules limiting lending to the government. Higher values express a greater independence.	Bodea and Hicks (2015)
Central Bank Involvement in Supervision Index	An index that captures the roles of the central bank in supervising all, some or none of the different financial sector actors. CBISI takes the maximum (minimum) score in countries where all (no) supervisory responsibilities are assigned to the central bank. The value assigned are as follows: 1- The central bank is not involved in supervision; 2 - Banking supervision is shared between the central bank and another authority; 3 - Only banking supervision is in the hands of the central bank; 4 - A unified supervision of the banking and insurance sectors inside the central bank; 5 - A unified supervision of the banking and securities markets sectors inside the central bank; 6 - A unified supervision of the entire financial sector inside the central bank.	Masciandaro and Romelli (2017)
Regulatory Quality IndexCentral bank assets to GDP (CBA/GDP) GDP per capita growth (GDP/capita growth) Inflation	Regulatory quality captures perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development. Estimate gives the country's score on the aggregate indicator, in units of a standard normal distribution, i.e., ranging from approximately -2.5 to 2.5. Ratio of central bank assets to Gross Domestic Product. Central bank assets are claims on domestic real nonfinancial sector by the central bank. Annual percentage growth rate of Gross Domestic Product per capita based on constant local currency. Aggregates are based on constant 2010 U.S. dollars. Inflation as measured by the consumer price index reflects the annual percentage change in the cost to the average consumer of acquiring a basket of goods and services that may be fixed or changed at specified intervals, such as yearly.	WGIGFDB GFDBGFDB
Lerner index	A measure of market power in the banking sector that reflects the level of competition.	GFDB

Note: [a]Calculations are based on data from Bankscope (Orbis Banks) and Worldscope. WGI is the World Governance Indicators database of the World Bank. GFDB is Global Financial Development Database of the World Bank.

Table A2
List of banks, their size and contribution to systemic risk ranking at the end of 2012.

Bank	Country	Ownership	Total Assets *Mil. EUR*	VaR *Annual total %*	ΔCoVaR *Annual total %*
Bulgarian-American Credit Bank	Bulgaria	Domestic	424.00	4.59	−0.67
Central Cooperative Bank AD	Bulgaria	Domestic	1,830.00	5.69	0.08
Corporate Commercial Bank AD	Bulgaria	Domestic	2,880.00	3.84	0.09
First Investment Bank AD	Bulgaria	Domestic	3,602.00	5.89	0.29
Hrvatska Postanska Bank DD	Croatia	Domestic	2,285.00	5.17	1.73
Istarska Kreditna Bank Umag d.d.	Croatia	Domestic	354.00	4.70	1.33
Jadranska Banka dd	Croatia	Domestic	405.00	5.76	−0.33
Kreditna Banka Zagreb	Croatia	Domestic	424.00	3.47	0.83
Nava Banka dd	Croatia	Domestic	37.00	4.20	1.83
Podravska Banka	Croatia	Domestic	403.00	6.23	0.83
Privredna Banka Zagreb - Intesa	Croatia	Foreign	9,602.00	4.33	0.68
Zagrebacka Banka - Unicredit	Croatia	Foreign	15,908.00	6.28	−0.16
Komercni Banka	Czech Republic	Foreign	31,296.00	5.27	0.22
OTP Bank Plc	Hungary	Domestic	34,694.00	4.17	0.36
Siauliu Bankas	Lithuania	Domestic	852.00	5.93	−0.31
Bank BGZ BNP Paribas SA	Poland	Foreign	9,107.00	3.24	0.81
Bank BPH SA	Poland	Foreign	8,415.00	13.54	−0.75
Bank Handlowy w Warszawie S.A.	Poland	Foreign	10,639.00	4.47	1.83
Bank Millennium	Poland	Foreign	12,896.00	7.64	0.66
Bank Ochrony Srodowiska SA	Poland	Domestic	4,124.00	8.08	−0.80
Bank Polska Kasa Opieki SA-Bank Pekao SA	Poland	Foreign	36,862.00	9.97	−0.24
Bank Zachodni WBK S.A.	Poland	Foreign	14,676.00	4.21	1.06
BNP Paribas Bank Polska SA	Poland	Foreign	5,093.00	16.59	1.57
ING Bank Slaski S.A. - Capital Group	Poland	Foreign	19,137.00	22.28	0.01
mBank SA	Poland	Foreign	24,976.00	5.76	1.92
Powszechna Kasa Oszczednosci Bank Polski SA	Poland	Domestic	47,228.00	24.36	0.49
Banca Comerciala Carpatica SA	Romania	Domestic	1,067.00	6.18	−1.12
BRD-Groupe Societe Generale SA	Romania	Foreign	11,036.00	4.03	1.50

(*continued on next page*)

Table A2 (*continued*)

Bank	Country	Ownership	Total Assets *Mil. EUR*	VaR *Annual total %*	ΔCoVaR *Annual total %*
Transilvania Bank-Banca Transilvania SA	Romania	Domestic	6,707.00	13.99	0.09
OTP Banka Slovensko, as	Slovakia	Foreign	1,271.00	4.57	0.52
Prima banka Slovensko a.s.	Slovakia	Domestic	1,979.00	4.56	0.77
Tatra Banka a.s.	Slovakia	Foreign	9,073.00	6.53	0.44
Vseobecna Uverova Banka a.s.	Slovakia	Foreign	11,216.00	11.65	−0.54
Joint-Stock Commercial Bank for Social Development - Ukrsotsbank	Ukraine	Foreign	4,271.00	3.53	0.12
Total (34 banks)			**360,426.00**		

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