The main determinants of banking crises in OECD countries

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Abstract

Banks' stability can be affected by economic fluctuations, banks' risk-taking behavior, connections among banks and countries' financial system structure. At the same time, banking regulation and supervision were designed to protect banks from failure, but a large number of banking crises were not prevented recently. Using binary response models for panel data and focusing on OECD countries, this paper studies the main determinants of banking crises over a period of 21 years. Results suggest a bank's high debt and a country's low GDP growth rate as the major determinants of banking crises. There is also evidence of contagion across countries from the same geographical region and from G7 to other countries, and that bank-based financial systems are less prone to borderline banking crises. Regulatory and supervision practices are found not to have been relevant in bankruptcy prevention.

Keywords: Banking crises, regulation, supervision, OECD countries, contagion effect.

JEL classification: G01; G21; G28.

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1. Introduction

The central aim of this paper is to identify the main determinants leading countries to experience banking crises. In particular, because banks' stability is expected to be influenced by their characteristics, macroeconomic conditions, contagion effects, banking regulation and supervision and countries' financial systems, this paper offers some insights into the impact of each of those five groups of characteristics on the probability of a country experiencing a banking crisis. This study differs from previous research due to the comprehensive set of potential determinants of banking crises analyzed, the focus on OECD countries and the relatively long time period (1991-2011) considered, which covers 108 country-year banking crisis episodes.

Many banking attributes and characteristics such as leverage, dimension and solvency tend to be emphasized in the literature as major determinants of banking crises (Benston e*t al.*, 2003; Cebenoyan and Strahan, 2004; Brewer *et al.*, 2008; Inderst and Muller, 2008). Moreover, the influence of the economic context on the occurrence of banking crisis episodes has also been frequently analyzed; see *inter alia* Demirgürç-Kunt and Detragiache (1998, 2000), Duttagupta and Cashin (2011) and Klomp (2010). These authors concluded that low real GDP growth rates, high real interest rates, sharp increases in credit expansion and banks' exposure to the private sector increase the likelihood of banking crises. In this paper, these findings are revisited in order to answer the following general questions: (1) "Do the bank-specific characteristics in each country influence the probability of banking crises?"; and (2) "Do the country-specific macroeconomic conditions affect the probability of banking crises?".

Due to its relevance for banks' activities, banking regulation and supervision may also be important determinants of the probability of a banking crisis. Some authors concluded that countries with fewer episodes of banking crises are those presenting lower regulation (Joyce, 2011). However, other authors, such as Barth *et al.* (2001), observed greater implementation of regulation requirements after a banking crisis. Typically, regulation focuses on capital requirements and assumes that (commercial) banks with lower required capital ratio are more prone to fail and that a well-capitalized bank will remain solvent even if it suffers a shock with many potential losses. However, some banking crises are characterized by other issues and may be originated by non-commercial banks. For example, the capital-based regulation following Basel II principles did not prevent the recent subprime crisis, which was characterized mainly by banks' liquidity and leverage issues and emerged from the weak risk management policy of investment banks; see, *e.g.*, Moosa (2010). In order to take into account other aspects besides capital-based requirements, in this paper two indices, a regulation index and a

supervision index, are used as a scheme to compile diverse information about these activities and answer the question: (3) “Can regulation and supervision prevent banking crises?”.

The contagion effect considered in this paper refers to the transmission of systemic and non-systemic banking crises across countries where one or more bank failures in one country may lead to a banking crisis in another country. This effect is commonly observed in bordering countries, connected by their institutions’ businesses, but sometimes the initial shock is strong enough to reach institutions in distant countries, affecting a wide geographical area (Allen and Gale, 2007). In order to answer the question (4) “Can banking crises result from a contagion effect across countries?”, this article considers three distinct types of contagion effects, evaluating the likelihood of a banking crisis to spread to a given country when the initial shock takes place: in a country in the same geographical region; in a country in any other region; or in a G7 country.

The final question that this paper tries to answer is the following: (5) “Do countries with bank-based financial systems have a lower probability of a banking crisis?”. Using Demirgüç-Kunt and Levine’s (2001) classification, this paper separates countries in market-based and bank-based countries and investigates which financial system is more prone to banking crises. According to those authors, in bank-based financial systems, banks play a crucial role in mobilizing savings, allocating capital, controlling corporate managers’ decisions about investment and developing risk management vehicles. On the other hand, in market-based financial systems, corporate control, allocation of firms’ savings and risk management are shared by banks and securities markets. Hence, answering this research question will bring some insights about how those differences in countries’ organization and banks’ role can influence the probability of a country experiencing a banking crisis.

To investigate empirically the five questions formulated, a dataset composed of longitudinal data for OECD countries and the period 1991-2011 is analyzed. Because the variable of interest (occurrence of a banking crisis) is a binary outcome, several alternative binary panel data models are applied to study the determinants of a banking crisis. Similar models have been used *inter alia* by Demirgüc-Kunt and Detragiache (1998, 2005), Davis and Karim (2008a), Boyd *et. al.* (2009), Moshirian and Wu (2009), Barrell *et al.*(2010), Joyce (2011), Klomp (2010) and Lainà *et. al.*(2015), in the context of banking crises, and Eichgreen *et al.*(1996) and Bussiere and Fratzscher (2006) in the context of other types of financial crises. While most of those papers focused on the use of pooled models, in this paper the panel structure of the data is fully taken into account throughout the whole econometric analysis.

The paper is organized in six sections. Following this introduction, Section 2 reviews the literature on banking crises and formulates the empirical hypotheses that this paper examines. Section 3 presents the data and describes banking crises in OECD countries. Section 4 describes the econometric methodology. Section 5 discusses the results. Finally, Section 6 provides some conclusions.

2. The determinants of banking crises

A bank's stability depends on its ability to remain solvent and meet its obligations. However, banks, just like all market players, are exposed to the systemic risk that they cannot diversify and sometimes become insolvent, ask for governmental intervention or even collapse. When bankruptcy occurs, the banking system of the affected country experiences a banking crisis. Hence, through the years, several studies of banking crises have emerged in the financial and economic fields, but these events are recorded by regulators, central banks and academics from many different perspectives. This section briefly reviews some of the most relevant studies on this subject and describes the hypotheses tested in the empirical component of this paper.

2.1. Previous research on banking crises

The literature on banking crises is extensive and includes many studies developed using different methodologies and perspectives. Some studies focus on the influence of macroeconomic factors, business cycles and economic growth on banks' failure (Miskhin, 1978; Calomiris and Mason, 1997; Demirgüç-Kunt and Detragiache, 2000; Čihák and Schaeck, 2010). Others consider the role in banking crises of a variety of factors such as: depositors' low expectations about banks' financial health; bank-specific characteristics; regulatory and supervisory boards; and the socioeconomic context (Diamond and Dybvin, 1983; Gorton, 1988; Demirgüç-Kunt and Detragiache, 1998; Hutchinson and McDill, 1999; and Hutchinson, 2002). At the empirical level, the focus has been on the general determinants of banking crises, but specific issues such as banking capital, regulation and contagion effects have also been largely analyzed in the literature.

There is no common agreement on the extent of the influence of capital on the stability of banks. According to Diamond and Rajan (2000), more capital makes banks safer and improves their performance during periods of crisis (Berger and Bouwman, 2013), because it ensures their profitability and the continuation of business even after a crisis. Moreover, Benston *et al.* (2003) point out that government concern for banks' capital requirements works as a protection not just for banks

but for the government itself. On the other hand, Gropp and Heider (2010) conclude that regulation does not affect banks' capital structure, because banks tend to present more capital than is required by supervisors, especially in countries such as the USA (Jacques and Nigro, 1997; Aggarwal and Jacques, 2001) and Switzerland (Rime, 2001).

After a banking crisis, countries often adopt stricter regulatory and supervisory practices (Dincer and Neyapti, 2008), but over the years these levels do not change substantially, as observed by Barth, Caprio and Levine (2008). In particular, these authors found there have been no visible changes in regulation adopted by countries during the first decade of the 21th century. Moreover, they found that while some countries may have enforced required capital levels and increased the number of supervisory agencies, their banks' stability and efficiency does not seem to have improved.

Banking crises may also spread from the region in which they begin to neighboring regions and other economically linked countries due to cross-border banking linkages (Allen and Gale, 2007): countries' borrowing and lending positions in other countries clearly promotes the spillover of crisis events through inter-connected countries (Tonzer, 2015). This contagion effect is also the result of asymmetric information (Kodres and Pritsker, 2002; Calvo and Mendoza, 2000), because, without precise knowledge of the causes of the initial banking crisis, market players expect it to be repeated in other regions and their nervous behavior helps to propagate it.

In this paper, most of the discussed features of banking crises are taken into account. In addition, because some countries, due to their particular characteristics, may be more prone to banking crises, a mechanism to act as a control for country-specific differences is also considered. One possibility would be to use the La Porta *et al.* (1998) classification of countries' legal and cultural systems as based on common law (those presenting British influence) or civil or code law (those inspired in the continental European tradition, such as French, Scandinavian and German traditions). Instead, this paper uses Demirgüç-Kunt and Levine's (2001) classification of countries according to their financial system. According to these authors, in countries classified as having bank-based financial systems, banks mobilize the necessary capital for firms pursuing the right projects and the activities of managers can be monitored by banks that are influential enough to enforce firms to disclose information and meet their obligations. Alternatively, countries are classified as having market-based financial systems when those activities are shared by banks and securities markets and information disclosure is permanent, investment diversification is frequent and standard risk management mechanisms are applied.

2.2. Empirical hypotheses

The literature review undertaken in the previous section allows the identification of several factors as possible determinants of banking crises. In this section, a number of hypotheses on the impact of each factor on the probability of a country experiencing a banking crisis are formulated. Five groups of hypotheses are considered, each group corresponding to one of the research questions defined in Section 1 and comprising several related hypotheses. For the factor mentioned in each hypothesis, a brief discussion on its expected effect (positive / negative) on the occurrence of a banking crisis is provided.

Research Question 1: "Do the bank-specific characteristics in each country influence the probability of banking crises?"

To answer this first research question, four hypotheses, each related to a different bank characteristic, are formulated.

H_{1a}: *Bank size decreases the probability of banking crises*

Large banks can influence government and supervisory entities due to their importance in the financial system. For such institutions, political intervention is more likely and hence they present a lower chance of becoming distressed (Bongini *et al.*, 2001). In addition, depositors and firms tend to place greater trust in large banks for deposits and investment financing. Large banks are also expected to present better internal organization and be more likely to recover from distress (Berger and Bouwman, 2013). Therefore, in countries where banks are larger, the probability of experiencing a banking crisis is expected to be lower.

H_{1b}: *Bank debt increases the probability of banking crises*
H_{1c}: *Customers' deposits decrease the probability of banking crises*

Banks finance their activity with deposits, (non-deposit) debt and equity capital. Each source of funds implies different risk-taking levels and, as such, is expected to influence the probability of banking crises in distinct ways. Therefore, in this paper deposits and debt are treated separately, in contrast to other banking studies, where deposits are not distinguished from other forms of debt (*e.g.*, Prescott, 2001; Inderst and Muller, 2008). Because what matters is the relative importance of each financing source, no explicit hypothesis on the effect of equity capital needs to be formulated.

High debt means banks are more dependent on creditors and consequently less liquid, mainly if at the same time the amount of equity finance – referred to by Aiyar *et al*. (2015) as a buffer to bank loan loss prevention - is low. If a massive deposit withdrawal occurs, banks with a large proportion of debt will not have enough liquidity and may collapse. Thus, a positive relationship is expected between debt and the probability of banking crises: the greater the debt, the greater the probability of failure.

Customers' deposits are an alternative and complementary buffer to avert bankruptcy. They are a source of both capital and liquidity, protecting banks from default. Hence, the greater the amount of deposits, the larger the liquidity of banks and the lower the probability of a banking crisis.

H_{1d}: *Bank solvency decreases the probability of banking crises*

More solvent banks are in better conditions to meet their medium and long-term liabilities. This capacity should be a fundamental characteristic of any bank, according to Cebenoyan and Strahan (2004). If banks respond to all creditors and remain solvent, the probability of failure through bankruptcy will be lower, implying a negative relationship between banks' solvency and the probability of banking crises.

Research Question 2: "Do country-specific macroeconomic conditions affect the probability of banking crises?"

In this framework, three empirical hypotheses involving different macroeconomic aggregates will be investigated.

H_{2a}: *The real gross domestic product growth rate is negatively related to the probability of banking crises*

The real gross domestic product (GDP) growth rate is the main economic indicator. Its fall is a sign of recession and a collapse of the economy. Thus, a negative relationship is expected between high GDP and the probability of a country experiencing a banking crisis (Bordo *et al.*, 2001; Demirgüç-Kunt and Detragiache, 1998, 2000; Joyce, 2011).

H_{2b}: *Inflation is positively related to the probability of banking crises*

When the inflation rate is higher, the demand for domestic products decreases in the international context (Hoggarth *et al.*, 2005). The labor market is compromised and some jobs may be lost. Economic indicators slow down, failures will increase and favorable conditions for banking crises emerge. As observed by Demirgüç-Kunt and Detragiache (1998), banking crises tend to occur mostly when growth is low and inflation is high. They argue that high inflation is associated with high and volatile nominal interest rates that hinder the maturity transformation function performed by banks. Thus, a positive relationship is expected between inflation and the probability of a country experiencing a banking crisis.

H_{2c}: *Domestic product per capita is negatively related to the probability of banking crises*

GDP *per capita* is a measure of a country's average income and is commonly used as an indicator of its development. More developed countries are expected to have sounder institutions and more developed financial systems, being thus less prone to bank failures and banking crises; see *inter alia* Klomp (2010). Hence, in accordance with the observation of Boyd *et al.* (2009), a negative relationship is expected between GDP *per capita* and the probability of a country experiencing a banking crisis.

Research Question 3: "Can regulation and supervision prevent banking crises?"

This research question involves the following two hypotheses:

H_{3a}: *Strong regulation reduces the probability of banking crises*
H_{3b}: *Strong supervision reduces the probability of banking crises*

These two hypotheses are described together because the same effect is expected from both regulation and supervision activities. Regulation and supervision were designed to promote bank stability, and are therefore expected to prevent the occurrence of banking crises. However, the empirical evidence provided so far is inconclusive. On the one hand, some of the recent literature on this topic concluded on no relationship between regulation/supervision and banks' performance (Barth, Caprio and Levine, 2008) or found a lower probability of a banking crisis in countries with more open regulations (Glick *et al.*, 2006; Dincer and Neyapti, 2008; Joyce, 2011). On the other hand, several studies dealing with specific regulation topics (*e.g.*, deposit insurance, bank capital requirements, restrictions on banking activity) corroborate the hypotheses formulated in this paper. For example, Angkinand (2009) found that: output losses of crises are smaller in the presence of deposit insurance; the severity

of crises (especially for systemic ones) could be mitigated by higher bank capital requirements and fewer restrictions on bank activities; and requiring banks to hold sufficient capital could reduce their excessive risk-taking.

Research Question 4: "Can banking crises result from a contagion effect across countries?"

Contagion across countries can happen at many levels. In this paper, three levels of contagion are considered: contagion across countries from the same region; contagion between countries from different regions; and contagion induced by G7 countries. The empirical hypotheses to be tested may be expressed as follows:

H_{4a}: *Banking crises are originated by contagion across countries from the same geographical region*

The most significant contagion is expected to occur inside the same region, because the nearest countries are culturally similar, have common businesses and straight negotiable relations. Thus, a crisis in one country may easily spread to a bordering one.

H_{4b}: *Banking crises are originated by contagion across countries from any geographical region*

The globalization of financial services and the rise of large multinational financial groups led to the growth of business relations between remote countries, including some from different continents. Even when one of a series of geographically-distant banks collapses, the entire network of financial relations can follow suit and fail too. Consequently, the crisis can be extended worldwide irrespective of the distance from the country that suffered the initial shock (Allen and Gale, 2007).

H_{4c}: *Banking crises are originated by contagion induced by G7 countries*

Financial dealings frequently occur with the most developed countries in the world. According to Chenguel (2014), all G7 countries (excluding Japan) were the major contagion sources of the subprime crisis, so contagion induced by G7 countries will also be tested in this paper.

Research Question 5: "Do countries with bank-based financial systems have a lower probability of a banking crisis?"

This last research question concerns the financial system of each country, involving two empirical

hypotheses.

H_{5a}: *Bank-based financial systems are less prone to banking crises*

In bank-based financial systems, banks have a central role and benefit from greater government protection, being more powerful than in market-based financial systems. Bank-based countries usually present less competitive capital markets and investments are well controlled and collateralized in order to prevent default. Hence, the probability of a banking crisis is lower in countries with bank-based financial systems (Čihák and Schaeck, 2010).

H_{5b}: *The negative effect of debt on the likelihood of a banking crisis is higher for countries with market-based financial systems*

In bank-based financial systems, banks are included in a larger safety net than in market-based financial systems (a similar effect is obtained for countries with deposit insurance schemes, see Miao and Wang, 2015). Therefore, it is expected that in the former system there will be higher government guarantees and protection patterns that may allow banks to recover more easily from systemic shocks. Moreover, when confronted with the possibility of a financial collapse, the national government will tend to bail out banks in order to promote stability. This behavior implies that a large amount of debt is likely to be a more frequent determinant of banking crises in countries with market-based financial systems, where banks are less protected by government and other authorities.

3. Data sources and model variables

This section describes the sample and the variables used in this paper for investigating the determinants of banking crises. It also gives a brief characterization of past OECD banking crises.

3.1. Sample

The dataset used in this paper comes from several sources. Banking data were taken from Bureau Van Dijk's Osiris database, which compiles financial information about financial and non-financial firms publicly listed worldwide. Banks with negative values of equity and observations from New Zealand, due to the low representation in the dataset (only one bank observed in a few years), were excluded. Overall, the sample includes 2.964 publicly listed banks from 33 OECD countries[4] during

[4] All OECD countries except New Zealand.

the period from 1991 to 2011. The number of banks per country is reported in Table 1.

Table 1 also reports the financial system orientation of the sample countries. Most countries have bank-based financial systems, but 74% of the observed banks are located in market-based economies due to the predominance of United States banks and the market-orientation of this country. Data on the financial system orientation of each country were taken from Demirgüç-Kunt and Levine (2001), which, to the best of the authors' knowledge, provides the most complete analysis of this issue in the financial literature. Given its structural characteristics, the financial system orientation of each country is assumed to be constant over the whole sample period. Demirgüç-Kunt *et al.* (2011) and Deltuvaité and Sinevičiené (2014) are examples of recent papers that considered a subset of OCDE countries and classified them also as reported in Table 1.

Table 1

Distribution of countries according to their financial system orientation. Source: Authors, based on Demirgüç-Kunt and Levine (2001).

Bank-based		Market-based	
Country	N. of banks	Country	N. of banks
Austria	18	Australia	27
Belgium	16	Canada	26
Czech Republic	4	Chile	16
Estonia	3	Denmark	61
Finland	10	Iceland	8
France	119	Mexico	32
Germany	68	Netherlands	16
Greece	22	South Korea	70
Hungary	4	Sweden	12
Ireland	10	Switzerland	47
Israel	14	Turkey	32
Italy	75	United Kingdom	111
Japan	262	United States	1 742
Luxembourg	10		
Norway	40		
Poland	26		
Portugal	18		
Slovakia	12		
Slovenia	7		
Spain	26		
Total (n.)	764	Total (n.)	2 200
Total (%)	25,78%	Total (%)	74,22%

Macroeconomic information was extracted from EIU country data, also distributed by Bureau Van Dijk. Due to missing data, the final panel is unbalanced, with a total of 647 country-year observations

and an average number of 19, 6 yearly observations per country.

Data for regulation and supervision indices were drawn from the Bank Regulation and Supervision Survey (BRSS) carried out by the World Bank, which contains comparable world-wide data on how banks are regulated and supervised around the world. Four versions of BRSS have been released so far, namely in 2001, 2003, 2007 and 2012, which are available at the following link: http://go.worldbank.org/SNUSW978P0. For the countries analyzed in this paper, the data for each version was collected between 1997 and 1999 (2001 BRSS), in 2001 (2003 BRSS), between 2005 and 2006 (2007 BRSS) and yearly in the period 2008-2010 (2012 BRSS). For reasons explained in section 3.3, the 2012 BRSS was not used in the construction of the regulation and supervision indices.

Data on banking crises were taken from Laeven and Valencia's (2013) database. As in their paper, banking crises are classified as systemic or borderline/non-systemic. A banking crisis is classified as systemic when two conditions are fulfilled: (1) the occurrence of significant bank runs, losses in the banking system and/or bank liquidation; and (2) significant banking policy intervention measures in response to significant losses in the banking system. It is considered as a borderline or non-systemic crisis when the two conditions above are not simultaneously met, but at least 3 out of 6 policy interventions from the following list are experienced: extensive liquidity support, substantial bank restructuring gross costs, significant bank nationalizations, significant guarantees put in place, significant asset purchases and deposit freezes and/or bank holidays. The sample used in this paper comprises 108 out of the 126 (country-year) banking crisis episodes registered in OECD countries from 1991 to 2011, including 76 out of 86 systemic crises.[5]Throughout most of the paper, systemic and non-systemic crises are not analyzed separately.

Finally, to investigate the various dimensions of the contagion effect considered in this paper, the OECD countries were divided into the four geographical regions described in Table 2. The assignment of countries to specific groups was based on the classification used by the United Nations' statistics division for defining geographical regions, apart from the 'Asia and Pacific' group. Instead of using, as in Joyce (2011), geographical criteria, other grouping criteria such as international linkages in interbank markets (see Tonzer, 2015) could have been considered. However, criteria based on financial connectedness imply, in general, that the closest areas to a given country are its neighboring countries in geographical terms and, given their weight in the world economy, some of the G7 countries. Therefore, because in this paper contagion effects induced by G7 countries are

[5] A banking crisis episode occurs when a country experiences a banking crisis in a given year. Therefore, if in the same year two countries experience a banking crisis, two episodes are considered; if the banking crisis in a given country spans over two years, two episodes are also considered.

considered separately, a classification based on geographical criteria is preferred.

Table 2

Border territory definition.
Data source (except the 'Asia and Pacific' group): United Nations' statistics division, available at https://unstats.un.org/unsd/methodology/m49/#geo-regions.

Region	Countries
Eastern Europe	Czech Republic, Hungary, Poland, Slovakia and Slovenia.
Western Europe	Austria, Belgium, France, Germany, Luxembourg, Netherlands, Switzerland, Greece, Italy, Portugal and Spain.
Northern Europe	Denmark, Finland, Iceland, Ireland, Sweden, United Kingdom, Estonia and Norway.
Asia and Pacific	Canada, United States of America, Mexico, Chile, Japan, South Korea, Turkey, Israel and Australia.

3.2. Banking crisis in the period 1991-2011

Table 3 reports the banking crises identified in the period 1991-2011. The only countries not experiencing any banking crisis during this 21-year period were Australia, Canada, Chile and Israel. On the other hand, Hungary and Sweden were the countries most affected by such events, with each country suffering 7 episodes. Not surprisingly, 2008 to 2011 were the years when more banking crisis episodes were recorded, involving 19 OECD countries and a total of 76 banking crisis episodes. In addition to the subprime crisis, other crises occurring over five consecutive years were observed in Finland, Sweden and Hungary from 1991 to 1995; in the Czech Republic from 1996 to 2000; in Slovakia from 1998 to 2002; and in Japan from 1997 to 2001. As Table 3 illustrates, during the period of analysis, banking crises tended to occur in the same or adjacent years in several countries in the same region, suggesting that a contagion effect of the type considered in hypothesis H_{4a} may be one of the reasons for such crises.

3.3. Model variables

Table 4 contains a detailed description of all variables used in the empirical study carried out in Section 5. The dependent variable, *Crisis*, as well the variables measuring contagion effects and bank orientation, are dummy variables. Because this study is performed at the country level, the bank-specific variables are defined as the country/year average values (or their logarithm) of each bank characteristic for all sample banks operating in each country in a given year.

Table 3

Banking crisis by region.
This table shows the concentration of banking crises *per* region (defined in Table 2) across time. Each reference to each country represents one year experiencing a crisis.
Data source: Laeven and Valencia (2013).

<table>
<tr><th>Year</th><th>Eastern Europe</th><th>Western Europe</th><th>Northern Europe</th><th>Asia and Pacific</th><th>N. of banking crisis episodes</th></tr>
<tr><td>1991</td><td>Hungary</td><td rowspan="13"></td><td>Finland, Sweden, Norway</td><td rowspan="3"></td><td>4</td></tr>
<tr><td>1992</td><td>Hungary, Poland, Slovenia</td><td rowspan="3">Finland, Sweden, Norway, Estonia</td><td>7</td></tr>
<tr><td>1993</td><td rowspan="2">Hungary, Poland</td><td>6</td></tr>
<tr><td>1994</td><td rowspan="3">Finland, Sweden, Estonia</td><td rowspan="3">Mexico</td><td>6</td></tr>
<tr><td>1995</td><td>Hungary</td><td>5</td></tr>
<tr><td>1996</td><td rowspan="2">Czech Republic</td><td>2</td></tr>
<tr><td>1997</td><td rowspan="2">Japan, South Korea</td><td>3</td></tr>
<tr><td>1998</td><td rowspan="3">Czech Republic, Slovakia</td><td>4</td></tr>
<tr><td>1999</td><td>Japan</td><td>3</td></tr>
<tr><td>2000</td><td rowspan="2">Japan, Turkey</td><td>4</td></tr>
<tr><td>2001</td><td rowspan="2">Slovakia</td><td>3</td></tr>
<tr><td>2002</td><td>1</td></tr>
<tr><td>2003</td><td colspan="4" rowspan="4">No banking crises</td><td rowspan="4">0</td></tr>
<tr><td>2004</td></tr>
<tr><td>2005</td></tr>
<tr><td>2006</td></tr>
<tr><td>2007</td><td></td><td></td><td>United Kingdom</td><td rowspan="5">United States of America</td><td>2</td></tr>
<tr><td>2008</td><td rowspan="4">Hungary, Slovenia</td><td rowspan="4">Austria, Belgium, France, Germany, Italy, Luxembourg, Switzerland, Netherlands, Greece, Portugal, Spain</td><td rowspan="4">Denmark, Iceland, Ireland, United Kingdom, Sweden</td><td>19</td></tr>
<tr><td>2009</td><td>19</td></tr>
<tr><td>2010</td><td>19</td></tr>
<tr><td>2011</td><td>19</td></tr>
<tr><td colspan="5">Total</td><td>126</td></tr>
</table>

To construct regulation and supervision indices that incorporate the multiple aspects of these activities, all the 12 topics that BRSS comprises were considered: 1. Entry into banking; 2. Ownership; 3. Capital; 4. Activities; 5. External auditing requirements; 6. Internal management/organizational requirements; 7. Liquidity and diversification requirements; 8. Depositors' (savings) protection schemes; 9. Provision requirements; 10. Accounting/information disclosure requirements; 11. Discipline/problem institutions/exit; and 12. Supervision. Each topic comprises several questions and sub-questions that might differ slightly across the four BRSS released. To construct the indices, 1 point was added whenever an expected answer was observed to selected leading questions and 0,5 points for each expected answer observed to selected sub-

questions. Then, they were normalized to the unit interval. An expected answer is the response that induces the best compliance of regulatory and supervisory practices and was defined according to the authors' expectations about what should be a strong regulation and strong supervision. Full details about the construction of these indices may be found at http://home.iscte-iul.pt/~jjsro/RWE-appendix.pdf.

Table 4

Variables description.

Variable	Description
Crisis	1 if there is a crisis in country *i* in year *t*. 0 otherwise.
Size	Logarithm of average banks' total assets, deflated by the consumer price index (2005=100), by country/year.
Debt	Average ratio of banks' non-deposit debt to total liabilities and equity, by country/year.
Debt including customers' deposits	Average ratio of banks' non-deposit debt plus customers' deposits to total liabilities and equity, by country/year.
Customers' deposits	Average ratio of bank customers' deposits to total liabilities and equity, by country/year.
Debt structure	Average ratio of bank customers' deposits to deposits and non-deposit debt, by country/year.
Solvency	Average bank's solvency ratio by country/year (equity / total assets).
Real GDP growth rate	Growth rate of real GDP.
Inflation rate	Growth rate of consumer price index (annual average).
GDP per capita	Logarithm of GDP *per capita* (gross domestic product divided by mid-year population) by country/year, deflated by consumer price index (2005=100).
Contagion same region	1 in year *t* if there was a crisis in one or more countries from the same region in year *t-1*. 0 otherwise.
Contagion other region	1 in year *t* if there was a crisis in one or more countries from another region in year *t-1*. 0 otherwise.
G7 contagion	1 in year *t*, if there was a crisis in one or more G7 countries in year *t-1*. 0 otherwise.
Regulation index	For country *i* and year *t*, 1 point for each regulatory practice and 0,5 points for each sub-practice registered in the BRSS that uses data collected in year *t-2* or earlier (t = 2001,…,2011) or in the 2001 BRSS (t = 1991,…,2000), including: 4 questions about 'entry into banking', 1 question about 'ownership', 11 questions about 'capital', 4 questions about the topic 'activities' (considered together as only one practice), 5 questions about 'external auditing requirements', 4 questions about 'liquidity and diversification requirements', 6 questions about 'depositor (savings) protection schemes', 3 questions about 'provisioning requirements', 5 questions about 'accounting/information disclosure requirements' and 2 questions about the topic 'discipline/problem institution/exit'.
Supervision index	For country *i* and year *t*, 1 point for each regulatory practice and 0,5 points for each sub-practice registered in the BRSS that uses data collected in year *t-2* or earlier (t = 2001,…,2011) or in the 2001 BRSS (t = 1991,…,2000), including 8 questions about 'supervision', 6 questions about 'external auditing requirements', 1 question about 'internal management/organizational requirements', 1 question about 'accounting/information disclosure requirements' and 1 question about 'discipline/problem institutions/exit'.

Bank orientation	1 if country's financial system is bank-based. 0 otherwise.

Because regulation and supervision activities tend to be adjusted in response to a banking crisis, the corresponding indices may not be exogenous, especially in recent years given the magnitude of the global crisis beginning in 2007/2008. In order to deal with this potential endogeneity problem, the indices constructed for year *t* are, whenever possible, based on survey data that was collected at least two years earlier. In particular, the indices for the period 2008-2011 use data collected in 2005-2006 (BRSS 2007); the indices for the period 2003-2007 use data collected in 2001 (BRSS 2003); and the indices for the remaining years use data collected in 1997-1999 (BRSS 2001). This implies that for the first years of the sample (1991-1999) future or contemporary survey data had to be used to compile the indices. However, given the more limited scope of the banking crises registered in that period, eventual endogeneity issues are not expected to significantly bias the econometric estimates.

Table 5 provides some descriptive statistics for all variables. The wide dispersion displayed by some variables reveals that the banking industry and the countries analyzed are very heterogeneous. For example: the average debt of banks in some countries is close to zero, while in others it is over half of the total liabilities and equity value; the solvency ratio ranges from 2,35% to 59,95%; the growth rate of real gross domestic product varies between a negative rate of 13,90% and a maximum of 24,17%; and the inflation rate ranges from a negative value of 4,48% to an extreme maximum of 104,54% registered in 1994 in Turkey.

Table 5

Descriptive statistics.

Variable	Obs.	Mean	Standard deviation	Minimum	Maximum
Crisis	647	0,161	0,368	0	1
Size	647	16,848	1,389	10,250	20,383
Debt	647	0,184	0,111	0,000	0,615
Debt including customers' deposits	647	0,880	0,076	0,384	0,973
Customers' deposits	628	0,695	0,219	0,000	0,967
Debt structure	599	0,787	0,215	0,000	1,000
Solvency (%)	647	12,916	9,448	2,350	59,950
Real GDP growth rate (%)	647	2,817	3,248	-13,899	24,617
Inflation rate (%)	647	5,402	10,733	-4,480	104,540
GDP per capita	647	10,070	0,728	8,431	14,575
Contagion same region	647	0,389	0,488	0	1
Contagion other region	647	0,750	0,434	0	1
G7 contagion	647	0,419	0,494	0	1
Regulation index	647	0,596	0,088	0,377	0,793
Supervision index	647	0,711	0,135	0,391	0,958
Bank orientation	647	0,595	0,491	0	1
Debt x bank orientation	647	0,105	0,124	0,000	0,615

4. Econometric methodology

This section describes the panel data binary outcome models used in this study to find the determinants of the probability of a country experiencing a banking crisis. The following models are used:

- Pooled logit and pooled probit;
- Pooled logit and pooled probit with individual-specific effects;
- Fixed effects logit;
- Random effects logit and probit.

The pooled models without individual-specific effects are the typical models used in the cross-sectional framework:

$$Pr(y_{it} = 1 \mid x_{it}, \beta) = G(x_{it}\beta), \quad (1)$$

where y_{it} is the *Crisis* variable defined in Table 4; x_{it} is the vector of k explanatory variables observed for country i in year t; $G(z) = e^z/(1 + e^z)$ (logit model) or $G(z) = \Phi(z)$, with $\Phi(\cdot)$ being the standard normal cumulative distribution function (probit model); and $\beta$is a vector of parameters. Estimates for β are obtained by maximizing the log-likelihood function based on following density function for the i-th observation $y_i \equiv (y_{i1}, \ldots, y_{iT})$:

$$f(y_i|x_i, \beta) = \prod_{t=1}^{T} G(x_{it}\beta)^{y_{it}}[1 - G(x_{it}\beta)]^{1-y_{it}}. \quad (2)$$

Typical panel data models include individual-specific effects (α_i). In linear models, it is usual to apply the within transformation or first differencing to remove them before estimation. However, for binary models such transformations are not available in general, so one alternative is to estimate the individual-specific effects directly. These so-called pooled models with individual-specific effects (which in the linear framework are equivalent to fixed effects models) are defined using expressions similar to (1) and (2), but with the index function z in $G(z)$ being given by $z = x_{it}\beta + D_i\alpha_i$, where D_i assumes the value 1 if the observation regards the country i and is 0 otherwise, and x_{it} does not include a constant term.[6]

[6] Country dummies were only included for countries with recorded banking crises.

Fixed effects estimation that eliminates $\alpha_i$from the model is possible in the case of the logit. In this case, see Cameron and Trivedi (2005), the model is estimated by maximum likelihood conditional on the sufficient statistic $\sum_t y_{it} = c$. Let $\boldsymbol{B}_c = \{\boldsymbol{d}_i | \sum_t d_{it} = \}$be the set of all possible sequences of 0 and 1 for which the sum of *T* binary outcomes is defined by $\sum_t y_{it} = c$. Subsequently, estimates for β are obtained by maximizing the log-likelihood function based on the following density function:

$$f(y_i | \sum_t y_{it} = c, x_i, \beta) = \frac{\exp[(\sum_t y_{it} x_{it})\,\beta]}{\sum_{\mathbf{d}\epsilon\mathbf{B}_c} \exp\,[(\sum_t d_{it} x_{it})\,\beta]} \tag{3}$$

In this context, it is not possible to estimate the model for countries with $c = 0$, so the panel used in this case comprises only countries that suffered at least one banking crisis in the period 1991 to 2011. As in linear fixed effects models, unchanged country characteristics (namely, *Bank orientation*) are removed from the model.

Finally, random effects models assume that the individual effects are normally distributed, with α_i~*N*(0,σ_α^2). In this case, maximum-likelihood estimation of β and $\sigma_\alpha^2$is based on the following density function:

$$f(y_i | x_i, \beta, \sigma_\alpha^2) = \int f(y_i | x_i, \alpha_i, \beta)\, \frac{1}{\sqrt{2\pi\sigma_\alpha^2}} \exp\left(\frac{-\alpha_i}{2\sigma_\alpha^2}\right)^2 d\alpha_i, \tag{4}$$

where $f(y_i | x_i, \alpha_i, \beta)$is defined similarly to (2) but with *G*($x_{it}\beta$) replaced by *G*($x_{it}\beta + \alpha_i$).

5. Empirical results

This section begins with the results obtained for five variants of the panel data probit model with individual-specific effects described in the previous section. Then, the remaining models discussed in Section 4 are estimated and some specification tests and robustness checks are applied. All models were estimated using Stata 13 and considering cluster-robust standard-errors.

5.1. Main results

The five models considered in Table 6 differ in how debt is included. Models (1) and (5) consider only non-deposit debt, model (2) includes also customers' deposits in the definition of debt and

models (3) and (4) include variables that allow the separation of the effects on banking crisis probability of customers' deposits and non-deposit debt. Model (5) is the only one where the effect of (non-deposit) debt is allowed to be different according to the financial system orientation of the country.

Table 6

Regression results.
Statistical significance is represented as *, ** and ***, denoting significance at 10%, 5% and 1% levels, respectively. Standard errors adjusted for 33 clusters (countries) are presented in parentheses.

Variable	Probit with individual-specific effects				
	(1)	(2)	(3)	(4)	(5)
Size	-0,327*	-0,153	-0,340*	-0,154	-0,349*
	(0,193)	(0,200)	(0,206)	(0,215)	(0,192)
Debt	4,232***		4,129***		7,515***
	(1,260)		(1,267)		(2,280)
Customers' deposits			-0,125		
			(0,418)		
Debt including customers' deposits		-2,621		-2,817	
		(2,116)		(2,061)	
Debt structure				-0,815**	
				(0,385)	
Solvency	-0,015	-0,026	-0,008	-0,024	-0,018
	(0,026)	(0,029)	(0,025)	(0,030)	(0,026)
Real GDP growth rate	-0,141***	-0,166***	-0,166***	-0,189***	-0,136***
	(0,036)	(0,034)	(0,041)	(0,038)	(0,037)
Inflation rate	0,054**	0,042	0,054**	0,040	0,056**
	(0,025)	(0,026)	(0,027)	(0,026)	(0,023)
GDP per capita	0,333	0,366	0,387	0,404	0,324
	(0,347)	(0,341)	(0,369)	(0,366)	(0,338)
Regulation index	-3,090	-3,465	-3,504	-3,128	-3,384
	(4,336)	(4,193)	(4,811)	(4,715)	(4,391)
Supervision index	-1,558	-0,794	-1,914	-1,055	-1,661
	(1,952)	(1,853)	(1,954)	(2,002)	(2,067)
Contagion same region	1,830***	1,597***	1,989***	1,705***	1,821***
	(0,330)	(0,321)	(0,402)	(0,387)	(0,331)
Contagion other region	-0,274	-0,395	-0,201	-0,182	-0,296
	(0,290)	(0,306)	(0,329)	(0,348)	(0,288)
G7 contagion	0,883***	0,794***	0,914***	0,771***	0,927***
	(0,296)	(0,283)	(0,314)	(0,298)	(0,288)
Banks orientation	-4,571***	-4,789***	-4,866***	-4,953***	-3,756***
	(0,965)	(1,020)	(0,983)	(0,986)	(1,169)
Debt x banks orientation					-4,154*
					(2,379)
Number of countries	33	33	33	33	33
Number of observations	647	647	628	599	647

The results in Table 6 show that most of the bank-specific characteristics considered in the first set of potential determinants of banking crises are important in influencing the probability of banking crises. The results reveal a significant, positive effect of non-deposit debt on the probability of countries experiencing a banking crisis. This effect is found in models (1), (3) and (5) by analyzing the coefficient of the *Debt* variable and also in model (4) through the *Debt structure* variable. In contrast, customers' deposits are not a relevant factor in model (3) and have a negative influence on banking crises in model (4); see the *Debt structure* variable. Given the opposite effects of both financing sources, it is no surprise that no relevant effect is found when they are considered together, see models (2) and (4). Overall, the results provide full support for hypothesis H_{1b}, since the probability of banking crises is higher for countries where banks are on average more indebted; and partial support for hypothesis H_{1c}, in the sense that a higher proportion of customers' deposits in total debt mitigates the probability of failure by representing a buffer against bankruptcy.

In three of the models, bank size is also a (marginally) significant variable, having a negative influence on the probability of a country experiencing a banking crisis, as stated in hypothesis H_{1a}. Hence, countries where banks are, on average, larger, have a lower probability of failure. On the other hand, the coefficient on bank solvency is negative as expected, but it is not significant in any of the five models. Therefore, hypothesis H_{1d} is not supported by the data.

At the macroeconomic level, the results highlight the roles of economic growth and inflation in countries' financial stability, as suggested by previous research. The most robust results are presented by the *Real GDP growth rate*, the only significant variable in all estimated models, at a significance level of 1%, of this second group of variables. As formulated in hypothesis H_{2a}, economic growth is thus found to be negatively related to the probability of banking crises, suggesting that crises are more likely in a weak macroeconomic environment. *Inflation rate* also seems to be an important determinant of a banking crisis, affecting positively the probability of its occurrence, as conjectured in hypothesis H_{2b}, in three of the estimated models. As regards *GDP per capita*, this variable appears to have no relevance in explaining a banking crisis, and hence, no support is found for hypothesis H_{2c}.

Concerning Research Question 3, the results show that regulation and supervision activities have not been successful in preventing banking crises, since neither of the corresponding indices, although displaying the expected negative sign, is significant in any of the estimated models. Therefore, hypotheses H_{3a} and H_{3b} are not corroborated by the data.

In contrast, there is strong evidence of contagion between OECD countries, be it between those in the same region or induced by G7 countries. After accounting for these types of contagion, banking crisis in other regions does not seem to be relevant. Thus, the major inducers of the propagation of banking crises across countries are those from the same geographical area and, due to their global financial relevance, G7 countries. Hence, hypotheses H_{4a} and H_{4c} are validated, unlike hypothesis H_{4b}.

The final set of hypotheses tested concern the influence of financial system orientation on the probability of banking crises and its interaction with bank debt. The results suggest clearly that crises are less probable in countries with bank-based financial systems. Moreover, the interaction variable has a negative sign, which indicates that debt is likely to be a more relevant determinant of banking crises in countries with market-based financial systems, where banks are less protected by the government and other authorities. Hence, both hypotheses H_{5a} and H_{5b} are supported by the results.

5.2. Alternative methods and specification tests

Given the conclusions about the effects of debt-related variables on banking crises, from now on only model (5) is considered. Table 7 presents the results obtained for this model when the alternative functional forms discussed in Section 4 are used.

In general, the six alternative regression models estimated corroborate the conclusions achieved in the previous section. For most variables, the sign and significance of the effects are the same, with two exceptions. The first is bank size, which before was only significant at the 10% level and now is not significant in any of the estimated models. The second exception is more relevant: there is a major difference between pooled and random effects models, on the one hand, and fixed effects models, on the other hand. According to the former models, bank-based financial systems are more prone to banking crises, while in the latter the opposite occurs. Therefore, it is important to use econometric tests to assess, from a statistical point of view, which type of model is more suitable to describe the data.

For the same reason that traditional fixed effects models are not available for panel data binary regression models, Hausman tests cannot be applied in this context. As an alternative, a simple LR test that compares pooled models with and without individual-specific effects was applied. Because pooled models produce consistent estimators only when effects are random (in which case individual-specific effects should not be present in the model), this test is an indirect form of assessing whether

the individual effects may be interpreted as fixed or random. The test was applied both for the probit case, testing the simple pooled model (6) against the pooled model with individual-specific effects (5), and the logit case, comparing the corresponding versions given by models (10) and (8). In both cases, the null hypothesis of the correct specification of the pooled model was rejected with a p-value of 0. This shows that the most suitable models are the pooled models with individual-specific intercepts and reinforces that, as concluded in the previous section, in bank-based financial systems there is a lower probability of a banking crisis occurring.

Table 7

Regression results – alternative models.
All results were obtained considering model (5) – see Table 6.
Statistical significance is represented as *, ** and ***, denoting significance at 10%, 5% and 1% levels, respectively. Standard errors adjusted for 33 or 28 clusters (countries) are presented in parentheses.

	Other probit models		Fixed effects logit models		Other logit models	
Variable	Pooled probit	Random effects probit	Pooled logit with individual-specific effects	Panel data fixed effects logit model	Pooled logit	Random effects logit
	(6)	(7)	(8)	(9)	(10)	(11)
Size	-0,081	-0,120	-0,506	-0,236	-0,193	-0,241
	(0,098)	(0,091)	(0,398)	(0,273)	(0,195)	(0,174)
Debt	4,613***	5,990***	14,691***	15,308***	8,784**	11,538***
	(1,768)	(1,729)	(4,295)	(4,756)	(3,624)	(3,389)
Solvency	0,010	0,007	-0,013	-0,009	0,028	0,024
	(0,011)	(0,011)	(0,048)	(0,027)	(0,022)	(0,021)
Real GDP growth rate	-0,140***	-0,138***	-0,260***	-0,217***	-0,263***	-0,262***
	(0,032)	(0,026)	(0,079)	(0,061)	(0,066)	(0,052)
Inflation rate	0,011	0,020**	0,144***	0,107***	0,019	0,040**
	(0,009)	(0,010)	(0,053)	(0,037)	(0,016)	(0,020)
GDP per capita	0,367**	0,559***	0,220	1,074**	0,726**	1,093***
	(0,164)	(0,175)	(0,729)	(0,482)	(0,343)	(0,332)
Regulation index	-0,449	-0,099	-5,347	-0,557	-0,845	0,074
	(1,491)	(1,423)	(9,035)	(4,182)	(2,754)	(2,801)
Supervision index	-0,376	-0,952	-3,247	-3,381	-0,872	-2,314
	(0,762)	(0,911)	(4,034)	(2,516)	(1,466)	(1,786)
Contagion same region	1,273***	1,505***	3,686***	3,185***	2,382***	2,927***
	(0,185)	(0,224)	(0,644)	(0,500)	(0,337)	(0,449)
Contagion other region	0,192	0,165	-0,637	-0,034	0,482	0,428
	(0,296)	(0,297)	(0,511)	(0,638)	(0,559)	(0,598)
G7 contagion	0,402	0,540**	1,818***	1,484***	0,764	1,058***
	(0,268)	(0,209)	(0,599)	(0,437)	(0,525)	(0,395)
Banks orientation	1,114**	1,496***	-11,708***	-	2,247**	3,033**
	(0,518)	(0,503)	(2,044)	-	(1,038)	(0,991)
Debt x banks orientation	-2,587**	-3,413*	-7,940*	-10,068**	-4,734	-6,338*
	(1,764)	(1,875)	(4,352)	(4,969)	(3,552)	(3,621)
Intercept	-5,064**	-6,868***	-	-	-9,323*	-13,335***

	(2,538)	(2,086)	-	-	(4,807)	(4,601)
Number of countries	33	33	33	28	33	33
Number of observations	647	647	647	548	647	647

5.3. Robustness checks and summary of results

In this section, two robustness checks are performed. As reported in Table 1, US banks account for more than half the sample and hence they have a major influence on the results obtained. Therefore, in order to check the robustness of the previous findings, the probit model with individual-specific effects (5) was re-estimated excluding US banks. The results are presented in Table 8 and confirm the conclusions found for the original panel. All variables maintain their statistical significance and type of effect in explaining banking crises.

Table 8

Robustness checks.
All results were obtained considering model (5) – see Table 6.
Statistical significance is represented as *, ** and ***, denoting significance at 10%, 5% and 1% levels, respectively. Standard errors adjusted for 33 (systemic crises) or 32 clusters (results excluding USA crises) are presented in parentheses.

Variable	Excluding US crises	Systemic crises
	(12)	(13)
Size	-0,393*	-0,492**
	(0,206)	(0,241)
Debt	7,976***	8,737***
	(2,366)	(3,116)
Solvency	-0,017	-0,018
	(0,026)	(0,028)
Real GDP growth rate	-0,131***	-0,110**
	(0,038)	(0,035)
Inflation rate	0,063***	0,041*
	(0,023)	(0,021)
GDP per capita	0,208	0,427
	(0,386)	(0,320)
Regulation index	-0,706	-4,319
	(3,909)	(4,728)
Supervision index	-1,486	-2,019
	(2,302)	(2,369)
Contagion same region	1,877***	1,691***
	(0,370)	(0,331)
Contagion other region	-0,159	-0,289
	(0,288)	(0,363)
G7 contagion	0,976***	0,930***
	(0,315)	(0,345)
Banks orientation	-3,921***	-1,349
	(1,089)	(1,925)
Debt x banks orientation	-4,162*	-4,801

	(2,417)	(3,195)
Number of clusters	32	33
Number of observations	626	647

The second robustness test concerns the type of crises included in the analysis. So far, all types of crises, whether classified as systemic or borderline, have been considered (see Section 3.1). However, some countries only suffered borderline crises (Czech Republic, France, Hungary, Portugal, Slovenia, Sweden and Switzerland). Hence, in order to ascertain whether there are differences when only systemic crises are considered, model (5) was re-estimated setting the *Crisis* variable to zero in the presence of borderline banking crisis episodes. Table 8 reveals that in general most of the previous conclusions are still valid when considering only systemic crises. The most relevant difference is that, for systemic crises, there are no relevant differences between bank and market-based financial systems. This suggests that the greater government protection that banks have in the former system does not significantly reduce the probability of banking crisis in case of major financial shocks.

Table 9 provides a brief summary of the main conclusions of the empirical study carried out in this paper, which involved the estimation of 13 regression models. For each tested hypothesis, the table indicates the models where the hypothesis was corroborated by the data, those where the effect is not statistically relevant and those where the opposite sign was found. Apart from Research Question 4 (Regulation and Supervision), in all the other cases full or partial support was found for most of the formulated empirical hypotheses. Note that the opposite, significant effect found for two hypotheses are relative to pooled and random-effects models, which were found unsuitable from a statistical point of view.

6. Conclusions

The aim of this paper was to identify the determinants of banking crises in OECD countries. The results suggest that banking crises tend to occur mostly in countries where banks are smaller and present higher levels of debt and when the economic environment slows down and a higher inflation rate is registered. There is evidence of a contagion effect across countries, namely between those located in the same region or induced by G7 countries. In contrast, regulation and supervision of banking activities seem to have failed to prevent banking crisis episodes. It was also found that countries with bank-based financial systems present less probability of banking crises and that debt is a more important determinant of distress for market-based countries, namely when borderline crises are considered.

Table 9

Summary of conclusions.

Research question	Empirical hypotheses	Conclusion (model #)		
		Postulated effect	Insignificant effect	Opposite effect
1. Do the bank-specific characteristics in each country influence the probability of banking crises?	H_{1a}: Bank size decreases the probability of banking crises	1, 3, 5, 12-13	2,4, 6-11	---
	H_{1b}: Bank debt increases the probability of banking crises	1, 3-13	---	---
	H_{1c}: Customers' deposits decrease the probability of banking crises	4	3	---
	H_{1d}: Bank solvency decreases the probability of banking crises	---	1-13	---
2. Do the country-specific macroeconomic conditions affect the probability of banking crises?	H_{2a}: The real gross domestic product growth rate is negatively related to the probability of banking crises	1-13	---	---
	H_{2b}: Inflation is positively related to the probability of banking crises	1, 3, 5, 7-9, 11-13	2, 4, 6, 10	---
	H_{2c}: Domestic product *per capita* is negatively related to the probability of banking crises	---	1-5, 8, 12-13	6-7, 9-11
3. Can regulation and supervision prevent banking crises?	H_{3a}: Strong regulation reduces the probability of banking crises	---	1-13	---
	H_{3b}: Strong supervision reduces the probability of banking crises	---	1-13	---
4. Can banking crises result from a contagion effect across countries?	H_{4a}: Banking crises are originated by contagion across countries from the same geographical region	1-13	---	---
	H_{4b}: Banking crises are originated by contagion across countries from any geographical region	---	1-13	---
	H_{4c}: Banking crises are originated by contagion induced by G7 countries	1-5, 7-9, 11-13	6, 10	---
5. Do countries with bank-based financial systems have a lower probability of a banking crisis?	H_{5a}: Bank-based financial systems are less prone to banking crisis	1-5, 8, 12	13	6-7, 10-11
	H_{5b}: The negative effect of debt on the likelihood of a banking crisis is higher for countries with market-based financial systems	5-9, 11-12	10, 13	---

References

Aggarwal, R. and Jacques, K. T. (2001), "The impact of FDICIA and prompt corrective action on bank capital and asset risk: Estimates using a simultaneous equation model", *Journal of Banking & Finance*, 25, 1139-1160, doi:10.1016/S0378-4266(00)00125-4.

Aiyar, S., Calomiris, C. W. and Wieladek, T. (2015), "Bank capital regulation: theory, empirics, and policy", *IMF Economic Review* 63(4), 955-983, doi:10.1057/imfer.2015.18.

Allen, F. and Gale, D. (2007), *Understanding Financial Crises*, 1st edition, 2-94, New York, Oxford

University Press.

Angkinand, A. (2009), "Banking regulation and the output cost of banking crises", *Journal of International Financial Markets, Institutions and Money*, 19(2), 240-257, doi:10.1016/j.intfin.2007.12.001.

Barrell, R.,Davis, E. P., Karim, D. ad Liadze, I. (2010), "Bank regulation, property prices and early warning systems for banking crises in OECD countries", *Journal of Banking and Finance*, 34(9), 2255–2264, doi:10.1016/j.jbankfin.2010.02.015.

Bank for International Settlements (2015), *International Consolidated Banking Statistics*, BIS Basel, available at: http://www.bis.org/statistics/consstats.htm.

Barth, J. R., Caprio, G and Levine, R. (2001), "Banking systems around the globe: Do regulation and ownership affect performance and stability?", in Frederic S. Mishkin (editor) *Prudential Supervision – What Works and What Doesn't*, 31-96, University of Chicago Press.

Barth, J. R., Caprio, G. and Levine, R. (2008), "Bank regulations are changing: for better or worse?", *Comparative Economic Studies*, 50, 537–563, doi:10.1057/ces.2008.33.

Benston, G., Irvine, P., Rosenfeld, J. and Sinkey Jr, J. F. (2003), "Bank capital structure, regulatory capital, and securities innovations", *Journal of Money, Credit and Banking*, 35(3), 301-322.

Berger, A. N. and Bouwman, C. H. S. (2013), "How does capital affect bank performance during financial crises?", *Journal of Financial Economics*,109(1), 146-176, doi:10.1016/j.jfineco.2013.02.008.

Bongini, P., Claessens, S. and Ferri, G., (2001),"The political economy of distress in East Asian financial institutions", *Journal of Financial Services Research*, 19(1), 5–25, doi:10.1023/A:1011174316191.

Bordo, M., Eichengreen, B., Klingebiel, D. and Martinez-Peria, M. S. (2001), "Is the crisis problem growing more severe?", *Economic Policy*, 16 (32), 53-82, doi:10.1111/1468-0327.00070 52-82.

Boyd, J., Nicolò, G. and Loukoianova, E. (2009), "Banking crises and crisis dating : theory and evidence", *IMF working paper* WP/09/141, 1-50.

Brewer III, E., Kaufman, G. G. and Wall, L. D. (2008), "Bank capital ratios across countries: Why do they vary?", *Journal of Financial Services Research*, 34(2-3), 177–201, doi:10.1007/s10693-008-0040-9.

Bussiere, M. and Fratzscher, M. (2006), "Towards a new early warning system of financial crises", *Journal of International Money and Finance*, 25, 953-973, doi:10.1016/j.jimonfin.2006.07.007.

Calomiris, C. W. and Mason, J. R. (1997), "Contagion and bank failures during the great depression: The June 1932 Chicago banking panic", *American Economic Review*, 87(5), 863-883.

Calvo, G. A. and Mendoza, E. G. (2000), "A capital-market crises and economic collapse in emerging markets: an informational frictions approach", *American Economic Review*, 90, 59-64.

Cameron, A. C. and Trivedi, P. K. (2005), *Microeconometrics: Methods and Applications*, 1st edition, 795-798, New York, Cambridge University Press.

Cebenoyan, A. S. and Strahan, P. E. (2004), "Risk management, capital structure and lending at banks", *Journal of Banking & Finance*, 28, 19–43, doi:10.1016/S0378-4266(02)00391-6.

Chenguel, M. B. (2014), "The subprime crisis contagion effect on developed countries", *Journal of Business and Management Research*, 3, 61-70.

Čihák, M. and Schaeck, K. (2010), "How well do aggregate bank ratios identify banking problems?", *Journal of Financial Stability*, 6(3), 130-144, doi:10.1016/j.jfs.2010.03.001.

Davis, E. P. and Karim, D. (2008a), "Comparing early warning systems for banking crises", *Journal of Financial Stability*, *4*(2), 89–120, doi:10.1016/j.jfs.2007.12.004.

Davis, E. P. and Karim, D. (2008b), "Could early warning systems have helped to predict the sub-prime crisis?", *National Institute Economic Review*, *206*(1), 35–47, doi:10.1177/0027950108099841.

Deltuvaité, V. and Sinevičiené, L. (2014), "Research on the relationship between the structure of financial system and economic development", *Procedia – Social and Behavioral Sciences*, 156, 533-537.

Demirgüç-Kunt, A. and Detragiache, E. (1998), "The determinants of banking crises in developing and developed countries", *Staff Papers International Monetary Fund*, 45(1), 81-109, doi:10.2307/3867330.

Demirgüç-Kunt, A. and Detragiache, E. (2000), "Monitoring banking sector fragility: A multivariate logit approach", *World Bank Economic Review*, 14(2), 287-307, doi:10.1093/wber/14.2.287.

Demirguc-Kunt, A.and Detragiache, E. (2005),"Cross-country empirical studies of systemic bank distress: a survey", *National Institute Economic Review*, *192*(1), 68–83, doi:10.1177/002795010519200108.

Demirgüç-Kunt, A. and Levine, R. (2001), "Bank-based and Market-based financial systems: Cross-country comparisons", in Asli Demirgüç-Kunt and Ross Levine (Eds.) *Financial Structure and Economic Growth: A Cross-Country Comparison of Banks, Markets, and Development*, 81-140, Cambridge, MA: MIT Press.

Demirgüç-Kunt, A., Feyen, E. and Levine, R. (2011), "Optimal financial structures and development: the evolving importance of banks and markets", *World Bank*. Available at: http://siteresources.worldbank.org/INTFR/Resources/DemirgucFeyenLevine060311.pdf.

Diamond, D. W. and Dybving, P. H. (1983), "Bank runs, deposit insurance, and liquidity", *Journal of Political Economy*, 91(3), 401-419.

Diamond, D. W. and Rajan, R. G. (2000), "A theory of bank capital", *The Journal of Finance*, 55(6), 2431-2465.

Dincer, N. and Neyapti, B. (2008), "What determines the "legal" quality of bank regulation and supervision?", *Contemporary Economic Policy*, 26(4), 607-622.

Duttagupta, R. and Cashin, P. (2011), "The anatomy of banking crises in developing and emerging market countries", *Journal of International Money and Finance*, 30, 354–376, doi:10.1016/j.jimonfin.2010.08.006.

Eichengreen, B., Rose, A. and Wyplosz, C. (1996), "Contagious currency crises: first tests", *The Scandinavian Journal of Economics*, 98(4), 463-484, doi:10.2307/3440879.

Englund, P. (1999), "The Swedish banking crisis: Roots and consequences", *Oxford Review of Economic Policy*, 15(3), 80-97, doi:10.1093/oxrep/15.3.80.

Glick R., Guo X. and Hutchison, M. (2006), "Currency crises, capital account liberalization, and selection bias", *Review of Economics and Statistics*, 88(4), 698-714, doi:10.1162/rest.88.4.698.

Gorton, Gary (1988), "Banking panics and the business cycle", *Oxford Economic Papers*, 40, 751-781.

Gropp, R. and Heider, F. (2010), "The determinants of bank capital structure", *Review of Finance*, 14, 587-622, doi:10.1093/rof/rfp030.

Hoggarth, G., Jackson, P. and Nier, E. (2005), "Banking crises and the design of safety nets", *Journal of Banking & Finance*, 29(1), 143-159, doi:10.1016/j.jbankfin.2004.06.019.

Hutchinson, M. and McDill, K. (1999), "Are all banking crises alike? The Japanese experience in international comparison", *Journal of the Japanese and International Economies*, 13(3), 155-180, doi:10.1006/jjie.1999.0427.

Hutchinson, M. M. (2002), "European banking distress and EMU: Institutional and macroeconomic risks", *Scandinavian Journal of Economics*, 104(3), 365-389, doi:10.1111/1467-9442.00292.

Inderst, R. and Muller, H. M. (2008), "Bank capital structure and c*redit* decisions", *Journal of Financial Intermediation*, 17(3), 295-314, doi:10.1016/j.jfi.2008.02.006.

Jacques, K. and Nigro, P. (1997), "Risk-based capital, portfolio risk, and bank capital: A simultaneous equations approach", *Journal of Economics and Business*, 49, 533-547, doi:10.1016/S0148-6195(97)00038-6.

Joyce, J. P. (2011), "Financial globalization and banking crises in Emerging Markets", *Open Economies Review*, *22*(5), 875-895.

Klomp, J. (2010), "Causes of banking crises revisited", *North American Journal of Economics and Finance*, 21(1), 72-87, doi:10.1016/j.najef.2009.11.005.

Kodres, L. and Pritsker, M. (2002), "A rational expectations model of financial contagion", *The Journal of Finance*, 57, 768-799, doi:10.1111/1540-6261.00441.

Laeven, L. and Valencia, F. (2013), "Systemic banking crises database", *IMF Economic Review*, 61(2), 225-270, doi:10.1057/imfer.2013.12.

Lainà, P., Nyholma, J. and Sarlin, P. (2015), "Leading indicators of systemic banking crises: Finland in a panel of EU countries", *Review of Financial Economics*, *24*, 18–35, doi:10.1016/j.rfe.2014.12.002.

La Porta, R., Lopez-de-Silanes, F., Shleifer, A. and Vishny, R. W. (1998), "Law and finance", *Journal of Political Economy*, 106(6), 1113-1155.

Miao, J. and Wang, P. (2015), "Banking bubbles and financial crises", *Journal of Economic Theory* 157, 763-792, doi:10.1016/j.jet.2015.02.004.

Miskhin, F. (1978), "The household balance sheet and the great depression," *Journal of Economic History*, 38(4), 918–937.

Moshirian, F. and Wu, Q. (2009),"Banking industry volatility and banking crises", *Journal of International Financial Markets, Institutions and Money*, *19*(2), 351–370, doi:10.1016/j.intfin.2008.02.002.

Moosa, I. A. (2010), "Basel II as a casualty of the global financial crisis", *Journal of Banking Regulation*, 11(2), 95-114, doi:10.1057/jbr.2010.2.

Prescott, E. S. (2001), "Regulating bank capital structure to control risk", *Federal Reserve Bank of Richmond Economic Quarterly*, 87(3), 35-52, doi:10.1.1.201.9205.

Rime, B. (2001), "Capital requirements and bank behavior: Empirical evidence for Switzerland", *Journal of Banking & Finance*, 25, 789-805, doi:10.1016/S0378-4266(00)00105-9.

Tonzer, L. (2015), "Cross-border interbank networks, banking risk and contagion", *Journal of Financial Stability*, 18, 19-32, doi:10.1016/j.jfs.2015.02.002.