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Systemic Banking Crises: The Relationship Between Concentration and Interbank Connections.

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Abstract

In this paper I study the extent to which the nexus between concentration and interbank linkages affects financial stability, using data for a sample of 19,689 banks in 69 countries from 1995 to 2014. I find that high levels of interbank exposures decrease the probability of observing a systemic banking crisis, when the banking system is either highly concentrated or fragmented. The relationship between concentration and stability is found to be non-monotonic, as predicted by Martinez-Miera & Repullo (2010), although not U-shaped.

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Keywords: banking crisis, systemic risk, market structure; interbank linkages, network, contagion.

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In this paper I study the extent to which the nexus between concentration and interbank linkages affects financial stability, using data for a sample of 19,689 banks in 69 countries from 1995 to 2014. I find that high levels of interbank exposures decrease the probability of observing a systemic banking crisis, when the banking system is either highly concentrated or fragmented. The relationship between concentration and stability is found to be non-monotonic, as predicted by Martinez-Miera & Repullo (2010), although not U-shaped.

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1 Introduction

The recent global financial crisis has raised new interest on the importance of the features of the banking system in modern economies. One area, that policymakers have specifically highlighted, is the development of new and trustworthy early warning systems of banking crises (Strauss-Kahn (2008)).

The impact of banking crises on real output is long-lasting. Furcieri & Zdzienicka (2012) estimate that developing countries' real output loss due to an average banking crisis reaches 3% and 4.5%, respectively, in the short and medium term. Moreover, the public debt legacy is significant: Reinhart & Rogoff (2013) find that public debts have almost doubled the value within three years from the onset of a banking crisis.

An important area of research into crises has focused on the role of the banking system's structure, in particular, banking system concentration. The findings are diverse. Some (e.g. Beck *et al.* (2006)) are in favor of the so called "concentration-stability" hypothesis: the more concentrated and the less competitive banking markets, the less likely a systemic crisis occurs. However, Boyd & De Nicoló (2005) highlight that concentration, by leading to higher interest rates, can induce borrowers to invest into riskier projects, ultimately raising the likelihood of observing a systemic banking crisis ("concentration-fragility" hypothesis). At the same time, the empirical evidence is mixed. Martinez-Miera & Repullo (2010) try to reconcile theoretically the two views, but Berger *et al.* (2009) confirm only partially.

This literature focuses mostly on the number of banks in the market, instead of the type of relationships they have and how that potentially impacts the relation between concentration and the risk of systemic crises. In this paper, I test the hypothesis that the impact of concentration on the probability of observing a systemic banking crisis is conditional upon the relationships the banks have. It is well known that banks are linked to each other due to a number of relationships such as interbank debt and credit (e.g. interbank loans), or even cross-ownerships and interlocking boards. There are also indirect links through covariance in assets and liabilities (e.g. they own the same security or their portfolios may be correlated).

In this paper I focus on the impact of a particular type of interbank linkages: interbank debt and credit positions. In principle, debt and credit exposures among banks can both mitigate and propagate shocks occurring to a bank or a group of banks. In this sense, the market structure (a more concentrated banking system versus a less concentrated one) and the intensity of interbank relationships (few and small links among banks versus a network of sizeable interbank exposures) can jointly affect, in different ways, the probability of observing a crisis or, in a less extreme way, the deterioration of the banking system's resilience. To better clarify, Figure 1 presents the four extreme cases of the concentration/interbank linkages mix. Considering the ongoing process of financial integration, the structure mix has become crucially relevant for macro-prudential regulators, as one bank's financial troubles can propagate to the whole banking system with possible spillovers to other countries' banking system.[1]

Using data from different sources, I provide a new empirical assessment of the impact of concentration on the probability of observing a systemic banking crisis conditional upon the relationships the banks have. Moreover, I assess the impact of the latter on: i) the occurrence of a systemic banking crisis; ii) banking system solvency; iii) bank solvency. Finally I infer which concentration/bank interconnectedness mix is the least prone to a crisis. The results are remarkably stable throughout the stages of the analysis and suggest that a high intensity of bank inter-linkages is stabilising, when banking system concentration takes tail distribution values, i.e. the banking system is either highly or weakly concentrated.

The paper is organized as follows: section 2 reviews the existing literature; section 3 presents the data; section 4 discusses the methodology; the analysis is presented in section 5; in section 6 I provide with a set of robustness checks; section 7 concludes.

[1] An example is the dramatic failure of Lehman, which led US banking system to a crisis, that, in turn, triggered 2007–08 global financial crisis.

2 Literature review

This paper draws on three large strands of the literature: early warning systems, systemic risk and banking networks.

Researchers have developed two main methods in order to predict the occurrence of a systemic banking crisis: signal extraction and multivariate logit. Kaminsky & Reinhart (1999) define the signal extraction method[2], which consists in: i) selecting some variables that "lead" the crisis; ii) defining a threshold for each of them such that noise-to-signal ratio[3] is minimized through a non-parametric estimation.

Multivariate logit models have been used to assess the impact of structural variables on the probability of observing a banking crisis and draw the implied policy suggestions: e.g. deposit insurance, foreign ownership, cultural heritage, legal system and other (see, e.g. Demirgüç-Kunt & Detragiache (2002), Beck *et al.* (2006)). Demirgüç-Kunt & Detragiache (2000) motivated the use of this different econometric approach by arguing that signal extraction models suffer from both higher Type I and II errors.

Davis & Karim (2008) compare the two approaches and provide specific advices to improve each of them. In particular, they propose to use a multinomial logit approach in line with Bussiere & Fratzscher (2006). Within this debate, while Barrell *et al.* (2016) stress how capital ratio is relevant in predicting a banking crisis, Acharya (2009) shows how systemic risk can be generated by assets correlation and exacerbated by capital requirements. For this reason, he proposes a correlation-based capital requirement, i.e. a bank level adequacy contingent on interbank correlations.

Unfortunately, both the approaches share the same problem: crisis dating is quite subjective and leaves room to be disputed as being too early or too late. A multinomial logit does not solve this issue, instead it exacerbates it by adding a post-crisis period. Consequently, a part of the literature has moved to the stage preceding a cri-

[2]For a detailed literature review on early warning systems, based on signal extraction, see Basu *et al.* (2017).

[3]The two authors define noise-to-signal ratio as the ratio of two other ratios: false signal/all the possible bad signals and good signals/all the possible good signals.

sis, since a systemic banking crisis is anticipated by the worsening of the solvency of one or more banks. However, the contrary might not be true. A proxy for the banking system's solvency is the so called z-score, whose deterioration hints a weakening of the solvency of the banking system. Nonetheless, it worth clarifying that, while it does not necessarily imply a subsequent systemic banking crisis, it can severely affect economic growth through the so called "credit crunch" mechanism. Some authors have applied Roy (1952)'s z-score to assess changes in banking systems' (and banks') solvency: it measures the number of the return on assets' standard deviations necessary to deplete banking systems' (and banks') equity. Examples of this approach are Laeven & Levine (2009), Berger *et al.* (2009), Ariss (2010) and Beck *et al.* (2013).

Another big theme of literature is the focus on the impact of bank competition on financial stability: both theoretical and empirical views are mixed. Allen & Gale (2004) discuss how much the relationship between competition and financial stability can change, given the different types of competition, such as Cournot, Spatial and Schumpeterian models of competition. The conclude that regulation can have surprising effects on competition and financial stability. In fact, depending on the assumptions made, different policy suggestions are provided (see Boyd & De Nicoló (2005), Boyd *et al.* (2006), Boyd *et al.* (2009b), Boyd *et al.* (2009a)). Anginer *et al.* (2014) find empirically that competition is beneficial to bank stability. Instead, the model of Martinez-Miera & Repullo (2010) focuses on the impact of concentration on banking stability. They find a non-linear U-shaped relationship, only partially confirmed for the Spanish banking system by Jiménez *et al.* (2013). All these papers do not take into consideration banks' relationships.

The theoretical literature on liquidity risk and bank networks is quite rich. Rochet & Tirole (1996) show that, in presence of economies of scope with a Salop interbank market structure, a bad monitoring can lead to the failure of the banking system. Allen & Gale (2000b) show that, given a competitive deposit market, different networks of banks lead to a different degree of financial instability. In particular, there is a non-monotonic relationship between the degree of banking network completeness and the spillover impact of a financial crisis. Their study has been generalized by Sáez & Shi (2004). They also present an alternative market structure (liquidity pools), in which it is possible in some cases to prevent the contagion effect: a region/bank that works like a liquidity pool, i.e. similar to a passive Central Bank. Cifuentes *et al.* (2005) show how (both direct and indirect) linkages among banks can be very destabilizing. Gai *et al.* (2011) find that a higher concentration in financial networks can produce a more fragile banking system. However, on the empirical side, Nier *et al.* (2007) assess empirically that relationship between the degree of connectivity among banks and contagion is non-monotonic. In a related paper, in 't Veld & van Lelyveld (2014) try to estimate the network structure of Dutch banking system.

Billio *et al.* (2012), using a principal component analysis on listed institutions' stock returns, estimate a network diagram of Granger-causality relationship, highlighting the fact that, among finance institutions, banks and insurance companies are a big source of systemic risk. Ballester *et al.* (2016) disentangle systematic contagion from the idiosyncratic contagion using a GVAR approach on banks' daily CDS spreads data. Duan & Zhang (2013) distinguish systemic risk in its two components: systematic and idiosyncratic risks. They apply this framework to the UK banking system finding that the former is more likely to "lead" the systemic risk. Acharya *et al.* (2017) introduce the concept of "systemic expected shortfall", which they apply successfully to predict the recent global financial crisis. Perturbing banking system with a macroeconomic shock, Anand *et al.* (2004) show that with heterogeneous bank balance sheets, despite the failure of some banks, the banking system keeps being resilient. In effect, Hale *et al.* (2016) find that, considering long-term interbank exposures, there is some sort of crisis propagation through the banking system, that experienced a systemic crisis, to another one that has not. Acemoglu *et al.* (2015) prove theoretically that banking system connectedness has a non-linear impact on stability: if the shock is small enough, then a highly connected banking system provides a backstop to the shock. However, this feature is reversed to shock propagation, if the shock is bigger.

Minoiu & Reyes (2013) assess empirically how the global banking network has evolved over the last four decades. They estimate the core banks to be more resilient than the peripheral ones.[4] Moreover, they detect a fall in global banking connection's den-

[4]On the contrary, Rivera-Castro *et al.* (2018) find that two of the largest Brazilian banks were the ones propagating global financial crisis' shock to the Brazilian banking system. Cont *et al.* (2010) argue that this could be avoided by applying capital requirements dependent also on interbank exposures,

sity after the recent global financial crisis. This finding is in line with Hale (2012), who assesses that the crisis dampened the formation of new banking relationships, Demirer *et al.* (2017), who find that global system connectedness has shrunk after the Lehman bankruptcy by applying a LASSO estimation to bank equity and sovereign bonds volatilities, and Cerutti & Zhou (2017), who have estimated that global banking network has become smaller in absolute terms, but more connected at a regional level. Aldasoro & Alves (2017) assess multiple-layered interbank networks through the breakdown of maturity and instrument type of interbank linkages. Their approach allows them to compute different measures of interconnectedness, which, in turn, can help in shaping more effective prudential policies.

3 Data

The data used throughout the analysis is collected from multiple sources: BankScope, Thomson Reuters Datastream, World Bank and Prof. C.M. Reinhart's website. It is a panel that considers 19,689 different banks from 69 countries for the period 1995-2014. Table 1 shows the list of countries, while Table 2 provides variables' summary statistics.

Systemic banking crisis (henceforth $C_{c,t}$) is a dummy variable that takes the value of one if a systemic banking crisis occurs in country c at year t. The literature has produced a few of indices for systemic banking crisis. In the main regressions this work uses the indices proposed by Laeven & Valencia (2008, 2012).[5] They define a systemic banking crisis in country c at year t to be occurred if there have been "significant banking policy intervention measures" (examples of these are bank holidays, deposit freezes, public guarantees, nationalization of banks) when it turns out to be "significant signs of financial distress in the banking system" (defined as bank runs, bank liquidations and severe banks' losses).[6] Their dataset ends in 2012. However, following their detailed definition, I managed to extend it until 2014: this is espe-

similarly to (Acharya, 2009).

[5]They use similar definitions to Caprio *et al.* (2005) and extend both the time series and the country size. Laeven & Valencia (2008, 2012)'s crisis variables can be found in the World Bank DataBank.

[6]See Laeven & Valencia (2008, 2012) for more details.

cially important given the loss of observations due to z-score indices' construction. Since a systemic banking crisis is a "rare event", it is not surprising that I observe only 30 crisis episodes. In order to test the robustness of my results, I also consider Reinhart & Rogoff (2009, 2013)'s definition, which is the following: severe bank runs leading shut-down, merging or takeover by the government of at least one bank or widespread government assistance of systemically-important banks, if the first set of conditions did not occur.[7]

The z-score index was first developed by Roy (1952) and has been applied to the banking industry by several authors (see for example Boyd *et al.* (2006) and Berger *et al.* (2009)) as a proxy of bank resilience.[8] The commonly accepted definition is the following:

$$z\text{-}score_{i,t} = \frac{ROA_{i,t} + leverage\ ratio_{i,t}}{\sigma_{ROA_{i,t}}} \quad with\ i = c, b$$

where $ROA_{i,t}$ is the return on assets of country c's banking system (or bank b) at year t, $leverage\ ratio_{i,t}$ is the ratio between equity and assets at country (if i = c) or bank (if i = b) level at year t, $\sigma_{ROA_{i,t}}$ is the standard deviation of the return of assets, considering a five-year window.[9] The index provides the number of standard deviation of profitability necessary to deplete all the equity. Higher profitability and leverage ratios increase the indicator. In other words, an increase (a decrease) in banking system (bank) z-score indicates an improvement (a worsening) of banking system (bank) solvency. Consequently, in the empirical section, when I estimate OLS regressions with z-score indices as dependent variables, I expect to find opposite signs of the coefficients relative to the logit regressions, where I use the systemic banking crisis dummy variable as dependent variable.

CR_5 is defined as the sum of the share of assets held by the five biggest banks for every country c at year t. Also known as a concentration ratio, I use it as a baseline concentration measure. The variable has been computed by ranking the banks ac-

[7]In this case I have 36 events recorded as banking systemic crisis. Also in this case, I extended their dataset (available in Reinhart's website) until 2014.

[8]Laeven & Levine (2009), Ariss (2010) use the logarithm of z-score in order to reduce scale bias.

[9]The length of the window is the cause of the smaller number of observation I have for the two z-scores. I also use a three-year time window. Results are consistent.

cording to the asset values[10], collected from BankScope.

This data provider collects detailed information on banks' balance sheets. Its database is based on self-reported questionnaires sent to banks. For this reason, the dataset is unbalanced and there is a non-trivial amount of missing data. When I found missing values, I have directly looked at banks' balance sheets. Until 1998, when the data collection greatly improved, BankScope coverage was not providing a good representation of countries' banking system. This issue deeply affected previous papers (e.g. Beck *et al.* (2006), which consider the period 1980–1997). The authors tried to alleviate it in different ways, such as taking the average over the time series, the first year concentration observation for each country or different measures of concentration. Given that my dataset's time span is 1995–2014, it is marginally affected by the coverage deficiency. However, as a robustness check, I consider other ways to construct the concentration variables, such as taking one-year lag, the average over the time series, the first year concentration observation for each country or different measures of concentration, such as the concentration of the three largest banks, the Herfindahl-Hirschman (HHI) and Lerner indices. The HHI index is built as the sum of the squares of the market shares in terms of assets; the Lerner index is a measure of market power in a given banking system, computed as average bank level price mark-up over marginal costs. Being the latter is a competition's proxy and well known that in many sectors concentration and competition do not go hand in hand, one should be careful in its use, when analysing banking system' sector (see Berger *et al.* (2004)).[11] Table 2 shows that these variables have a big variability. The fact that Lerner index presents some negative values may suggest that it is more directly affected than concentration or HHI index by a severe macroeconomic condition. Consequently, as there might be an issue of reverse causality, I use its first lag.

The other main explanatory variables of this study are represented by banking and bank openness. In particular, I am interested in credit to/debt from banks in order to build banking systems' (and banks') openness proxies. This variable is simply the sum of interbank credit and debt. The logic is the same behind countries' degree of

[10] Using the rolling ranking or the historical one is empirically irrelevant, as there is a very high persistence among the biggest banks to maintain high assets values.

[11] My analysis tries to provide a contribution to this debate as well.

trade openness used in the International Trade field. Then, in order to take into account the different country sizes, authors usually normalize by dividing by nominal GDP. In the context of this paper, the banking system (bank) openness is normalized through the aggregate (bank) assets. I have also tried other ways to normalize, such as dividing by the liabilities or the nominal GDP, without losing the results. These variables involve the two sides of the balance sheet, though they are sources of different types of risk.[12] Considering that both of them proved to be relevant in the recent global financial crisis, I treat them together with the proposed measure.

Although these data do not allow me to estimate the global banking network, this measure captures the intensity of interbank relationships. The higher this variable, the more central a bank is in the network and the more it will face (and potentially propagate) risks. Consequently, for both macro- and micro-prudential motivations it is worth considering a measure of overall risk both at banking system and bank level. It is also worth mentioning that, given that the majority of interbank debt and credit turns out to be of a short term maturity, its value can be correlated with crisis observations or banking system (bank) solvency deterioration. For this reason, I use the lag of banking system (bank) openness.[13]

I deploy several control variables.[14] The early warning system literature suggests the following ones. Real GDP growth, depreciation rate of the currency and the change of terms of trade are included in order to control for macroeconomic shocks, that have a deep effect mainly on the asset side of banks' balance sheets. $M2/reserves$ is a measure that, together with the depreciation of the currency rate, is added to control for sudden capital outflows, caused by changes in the exchange rates and loss of trust in country economic performance. In line with previous papers, I control for domestic credit growth at year $t-2$, given that it is well documented that substantial credit growth can fuel assets price bubbles, which have a direct and an indirect effect (e.g. T-bills depreciation and the rise of non performing exposures) on banks' balance

[12] A credit risk ultimately can cast doubts on lender bank' solvency, whereas the debt risk, given that the bulk of them is short term, may create liquidity issues to the borrower bank.

[13] In subsection 6.3 I also use the original variable and this turns out not to be detrimental for my results. However, I prefer to avoid any reverse-causality concern.

[14] I took them from the World Bank DataBank. When possible, I filled the missing values finding comparable series on Thomson Reuters Datastram.

sheets, when the bubble bursts. The logarithm of GDP per capita is meant to proxy for countries' different degree of development.

Real interest rates and banking system (bank) return on equity affect banks' solvency. In fact, in presence of restricted level of competition, a high real interest rate charged on loans may create a perverse incentive for the entrepreneur to select riskier projects, which are more likely to fail and threaten the loans repayment to the banks. This is the so called "risk-shifting effect", detected by Boyd & De Nicoló (2005). However, at the same time high real interest rates mean higher revenues for banks, which in turn increase banks' profits. Martinez-Miera & Repullo (2010) define this driver as "margin effect", which they highlighted through the banking system model they developed. Extending Boyd & De Nicoló (2005) by assuming imperfect correlation of loan defaults, this counteracting effect has emerged. The authors show that there should be a U-shaped relationship between concentration and banking crisis. For intermediate levels of the former, there is a lower probability of the occurrence of a systemic banking crisis. Just as Jiménez *et al.* (2013), I am not fully able to confirm it empirically. I find that there is a non-linear behavior of concentration, but it is not U-shaped.

Finally, I control for banking system (bank) capital ratio, defined as aggregate (bank) equity over aggregate (bank) assets. Barrell *et al.* (2016) prove that it has a strong explanatory power in predicting the occurrence of systemic banking crisis, whose stabilising impact I am able to detect.

4 Methodology

In order to analyze how concentration, banking system and bank openness affect separately and jointly, respectively, the likelihood of observing a systemic banking crisis, the solvency of the banking system and the solvency at the bank level, I use a number of different methodologies.

To predict the occurrence of a systemic banking crisis, I follow the established literature (Demirgüç-Kunt & Detragiache (2002, 2005); Beck *et al.* (2006)) and estimate a multivariate logit probability model robust to heteroskedasticity.[15] Consequently, the procedure is to maximise the model's log-likelihood function as follows:

$$lnL = \sum_{t=1}^{T} \sum_{c=1}^{N_c} \{C_{c,t} ln[F(\beta' X_{c,t})] + (1 - C_{c,t}) ln[1 - F(\beta' X_{c,t})]\} \qquad (1)$$

where $C_{c,t}$ is the dummy dependent variable, which takes the value of one when a crisis occurs in country c at year t and zero otherwise, $X_{c,t}$ is the set of the explanatory variables, β is the vector of coefficients to be estimated, $F(\beta' X_{c,t})$ is the model's cumulative probability distribution function.

In order to understand the magnitude of the impact of a given independent variable, I compute the marginal effects of the variable on the probability of crisis occurrence. Unlike linear models, such as OLS, the marginal effect is not coincident with the estimated coefficient, but it is equal to $f(\beta' X_{c,t})\beta$, where $f(\cdot)$ is the model's probability density function.

Given that the marginal effect depends not only on coefficients, but also on $X_{c,t}$, the choice of the values taken by the explanatory variables is crucial, because marginal effects are sensitive to the independent variables' values. First, I compute the average marginal effects of the main independent variables taking their mean values. This allows that understand the average impact of each of them.

Second, in order to investigate deeply the research question, I compute the average marginal effects of both concentration and banking system openness at different values of the two variables of interest. It is an average marginal effect, because the other explanatory variables take a value equal to their own mean. For example, in section 5 the average marginal effect of concentration on observing a systemic banking crisis at different percentiles of concentration is computed as follows: i) I take the derivative of the model with respect to concentration; ii) I compute this derivative by plugging in the averages of every explanatory variable, except for concentration, for which I

[15] In section 6 I also consider a linear probability model. Despite I believe that the logit model is the most suitable specification for this kind of analysis, the linear probability model has the advantage of a correct and straightforward estimation in the presence of fixed effects, which I do not include in logit regressions. I also provide some results, in which robust standard errors are clustered at country level.

insert the value of each considered percentile. In this way, I have a series of average marginal effects that I plot in a graph, whose horizontal axis varies with respect to the different percentiles of concentration. I repeat the exercise considering different percentiles of banking system openness and I do the same for the average marginal effects of the latter. So, there are four cases.

Taking into account that my aim is to shed light on which set of concentration/banking system openness structures seems to be less prone to a systemic banking crisis, the subsequent step is to compute the average marginal effects of both concentration and banking system openness at different percentiles of these two explanatory variables. In particular, I will show the cases of a transition from a low concentration/high banking system openness situation to a high concentration/low banking system openness' case and from a low concentration/low banking system configuration to banking system that is highly concentrated and linked. By summing the average marginal effects of the two variables, I find a series of average marginal effects for any concentration/banking system openness mix. Minimum values suggest the policy implication.

To perform the analysis of the impact of concentration and banking system openness on banking system (bank) solvency I run a set of linear regressions (robust to heteroskedasticity), given that the two dependent variables are continuous. The model specification is the following:

$$y_{c,t} = \beta' X_{c,t} + \gamma_t + \delta_c + \epsilon_{c,t} \tag{2}$$

where $y_{c,t}$ is the logarithm of country c's banking system z-score at year t, $X_{c,t}$ is the set of the explanatory variables, β is the vector of coefficients to be estimated, γ_t and δ_c are, respectively, the time and country fixed effects, $\epsilon_{c,t}$ is the error term.

Beyond estimating the coefficients, I compute the average marginal effects of each of the main control variables at their own mean values. Second, I focus on the ones of concentration and banking system openness to particular percentiles. This is not redundant as in the most saturated specifications there are quadratic terms and interactions. Consequently, repeating the analysis done for the logit model can provide valuable insights.

When I present the analysis at bank level and consider the bank z-score as dependent variable, the analysis is identical to the previous one. The model to be estimated is specified as follows:

$$y_{b,t} = \beta' X_{b,t} + \gamma_t + \delta_b + \epsilon_{b,t} \quad (3)$$

where $y_{b,t}$ is the logarithm of bank b's z-score at year t, $X_{b,t}$ is the set of the explanatory variables, β is the vector of coefficients to be estimated, γ_t and δ_b are the time and bank fixed effects, respectively, $\epsilon_{b,t}$ is the error term. Considering that bank data sum to country level, I do not include a country fixed effect.[16]

5 Results

As discussed in section 4, this section consists of three parts, correspondent to the analysis of the likelihood of observing a systemic banking crisis, the solvency of the banking system and the solvency at the bank level, respectively.

First, I show results of regressions, involving the banking system (bank) openness variable, its square term and the interaction of the former with the concentration variable. Second, I present the average marginal effects of each of the main independent variables for their mean values. Third, I analyze the average marginal effects of both concentration and banking system (bank) openness for different percentiles of the two mentioned variables. Each time I move only one of them and take the means of the other variables. In this way, I am able to detect the behavior of each of the two variables, considering, respectively, their own or the other variable's distribution: I generate four graphs, one for each case.[17] The fourth and last step is to analyze the average marginal effect of each of the two variables by moving both the variables. Then, I sum the two average marginal effects in order to detect which concentra-

[16] Note that bank fixed effects are thinner than country fixed effects. In one country there are more banks, which are unique for every country. In section 6, I also consider country x time fixed effects, fully isolating the effect of bank openness on the bank solvency from country level explanatory variables.

[17] When I consider the bank solvency's specification, there will be seven graphs.

tion/banking system openness mix turns out to be less prone to a systemic banking crisis (or a worsening of banking system or bank solvency).[18]

The three different analyzes consistently provide a policy implication in favor of a highly concentrated and interconnected banking system. The second best is a completely fragmented, but still highly interconnected banking system.

5.1 Crisis probability

In Table 3 the estimations for the five specifications of logit regressions are shown. The first regression is in line with the "concentration-stability" view of Beck *et al.* (2006). However, introducing the square term of banking system concentration (from column (2) onwards) enriches our understanding. This has also been done by Berger *et al.* (2009) in order to assess empirically the validity of Martinez-Miera & Repullo (2010)'s theoretical insights. Consistent with them, I find that banking system concentration has a non-linear impact on the probability of observing a banking systemic crisis. Although the coefficients are not significant, linearity is rejected by the joint significance test (p-value is 0.003). However, controlling for the concentration's interactions with banking system return on equity and real interest rate (which control for the risk-shifting and margin effects) does not help to explain concentration's non-linearity. This is also the case when I add the banking system openness and its square term (displayed in columns (4) and (5)). Interestingly, this proxy seems to exhibit a non-linear behavior as well.

Figure 2 shows the average marginal effect of each of the main independent variables computed at their own mean values on the probability of observing a banking systemic crisis. We find that, on average, the banking system openness increases the likelihood of a crisis occurrence, whilst the banking system concentration decreases. This does not mean that banking openness is necessarily detrimental, but only that it is when average values of each variable is taken into consideration. At the same time, the real interest rate does not show any impact on the dependent variable, which

[18] This requires another couple of graphs.

might suggest that the risk-shifting and margin effects counteract each other, while the banking system return on equity favors stability. Consistent with Barrell *et al.* (2016), banking system leverage ratio significantly decreases the probability of observing a systemic banking crisis.

Considering Figure 3, Panel 1 indicates that there is a non-linear impact of banking system concentration on the occurrence of a banking systemic crisis, nonetheless it is not too pronounced. Panel 2 suggests that the stabilising feature of concentration is reached for medium-high values of banking system openness. Higher levels of banks' linkages might increase the liquidity provided to each bank and enhance a sort of risk-sharing mechanism. Nevertheless, this effect disappears for extremely high values of banking openness. This might be explained by the bigger size of possible sudden liquidity shocks due to a bank's funds withdrawal from other banks. In Panel 3 I notice that the average marginal effect of banking system openness on the probability of observing a banking systemic crisis is positive. This means that, unless banks do not have any interbank linkages, it is more likely that a crisis occurs. However, the most striking result is given by the impact of banking system openness for different percentiles of its own distribution. In effect, for low and medium levels of banking system openness, the average marginal effect on the occurrence of a banking systemic crisis is positive, but for high levels the impact is reversed. If, on one side, concentration is not beneficial any longer (Panel 2), this is positively counteracted by the negative average marginal effect for high values of banking openness in Panel 4. This suggests that there are two counteracting forces in place: the banking system faces some concentration of risks, but at the same time banks can benefit from a higher liquidity provision.

I now focus on the four market structures of the banking system I have constructed. Figure 4 presents the average marginal effects of both banking system concentration and banking system openness, when moving from a low concentration/highly connected banking system to a high concentration/highly disconnected one (Panel 1) and from a low concentration/highly disconnected banking system to the opposite case (Panel 2). From the banking system stability perspective, the ideal is to be in a situation in which the sum of the two average effects are as negative as possible. This occurs in two cases: a low concentration degree and a high level of banking system inter-linkages (Panel 1) or high levels of concentration and banking system interconnectedness (Panel 2). The constant feature is the high level of banking openness, but how can I explain the two extremes for the concentration levels? A non-concentrated banking system might benefit from the fact that there are no "too-big-too-fail" institutions. So, the presence of significant sizes of interbank linkages enhances each bank's liquidity. Instead, in highly concentrated banking systems, these sizeable interbank connections mean that there are a few of big banks capable to magnify risks, if they fail. This would imply the opposite of what the sum of average marginal effects suggests in Panel 2. I suggest two possible explanations: i) it might be a signal of "collaboration" among banks, perhaps collusion; ii) a highly concentrated and interconnected banking system exacerbates the "too-big-too-fail" implicit guarantee provided by governments. Considering the average marginal effects computed when banking system concentration and return on equity increase (unreported graph), I can rule out hypothesis i).

5.2 Banking system solvency

In Table 4 I change the dependent variable and, consequently, the model specification, since banking system z-score is a continuous variable used as a proxy of banking system solvency. The estimated coefficients show consistently a reversed sign. In regression (1) I find a positive, but not significant coefficient for concentration[19], however this is not an issue. In fact, once that I add its square term, the sign of both concentration and concentration^2 are reversed, as shown in columns (2) to (5) of Table 3. This indicates that the behavior of banking system concentration is non-linear, which is confirmed by the joint significance test (p-value is always equal to 0.000). At the same time, I am still able to detect an impact of banking system openness, albeit somewhat weaker than the one found with logit regressions in subsection 5.1. Interestingly, the coefficient of interaction among the two variables of interest is significant and strongly negative. This is a clear sign that these two variables interact and it motivates again the exploration of their behavior.

[19]In unreported regressions, I find that banking system concentration's coefficient is significant, when country fixed effects are excluded.

Analyzing the average marginal effects of the main independent variables computed at their own mean values on the banking system z-score (Figure 5), signs are reversed, despite less significant than what seen in the previous subsection. Nonetheless, the ”concentration-stability” view and the stabilizing role of the banking system leverage ratio are preserved.

In Figure 6 (Panel 1) I notice that for medium and high percentiles of banking system concentration the impact of this variable is positive in strengthening banking system's solvency. This result is totally coherent with the negative average marginal effect on observing a systemic banking crisis I found in Panel 1 of Figure 3. However, differently from it, low levels of banking system concentration seem to negatively affect banking system solvency, even though it does not seem to magnify the probability of the occurrence of a systemic banking crisis. Panel 2 suggests that the average positive impact of banking system concentration tends to decrease, when the banking system becomes more and more connected. At the same time, banking system openness average marginal impact becomes detrimental to banking system solvency for high concentration levels (Panel 3). The two results suggest that there might be a concentration of risks, which may be superior than the advantages given by the higher provided liquidity and risk-sharing. Nevertheless, banking system openness does not seem to dampen per se banking system solvency, and it becomes slightly beneficial, when its own high values are taken into consideration (Panel 4).

I can now focus on the four market structures. Figure 7 shows the average marginal effects of both banking system concentration and banking system openness, when I move from a low concentration/highly connected banking system to a high concentration/highly disconnected one (Panel 1) and from a low concentration/highly disconnected banking system to the opposite case (Panel 2). From the banking system stability perspective, the ideal is to be in a situation in which the sum of the two average effects are as positive as possible. This occurs in two cases: a highly concentrated, but disconnected banking system or, secondarily, for medium-high values of both the mentioned market features. The latter is in line with previous subsection's findings.

5.3 Bank solvency

In Table 5 I replicate the analysis done in the previous subsection at a bank level. Since the banking system can propagate or mitigate a shock towards a specific bank (and vice versa), I keep previous subsection's country level independent variables as additional controls in order to achieve two goals: detecting more precisely i) the relationship between banking system concentration and bank openness; ii) the impact of banking system openness (separately from and jointly to the other two variables of interest) on bank solvency. Several results are worth mentioning.

Signs (and significance) of coefficients of banking system variables mimic the ones of their own bank level correspondent variable and are in accordance with findings of the previous two subsections. Banking system variables, such as banking system leverage ratio, return on equity, openness and its square have a significant impact on bank solvency. This confirms that the latter is affected by the features of the banking system. As one would think, it is not surprising that bank return on equity and leverage ratio have a higher impact on bank solvency than the correspondent aggregate variables, as the former are crucial determinants of bank profitability and solvency. While banking system openness seems to be more relevant for bank solvency than individual bank openness, the coefficients on squared banking banking system openness are in line with (i.e. opposite sign of) the coefficients estimated through logit regressions. Joint significance tests corroborate the existence of some non-linearities.

Turning to Figure 8, one can notice that the banking system variables show the opposite sign of the ones seen in Figure 2 and similar to the ones analyzed in the previous subsection. Coherently with what written in the previous paragraph, the bank z-score is more affected by the bank leverage ratio and return on equity than their aggregate counterparts, while the opposite can be said for the bank and banking system openness variables. This might suggest that openness play a bigger role at the banking system level.

With Figure 9 I turn to analyze the average marginal effects of my variables of interest on bank solvency, considering different percentiles of their own distributions. The average marginal effect of banking system concentration on bank solvency is not relevant for low concentration levels, however it becomes increasingly beneficial for medium and high levels. This kind of pattern would be in line with a restricted level of competition or with a "too-big-too-fail" issue: this is something I try to explore in section 6. Panels 2 and 3 show concentration's average marginal effect, when I move along banking system and bank openness distributions. It is always positive and quite similar, except for extremely high levels of banking system and bank interconnectedness. This is not too surprising, given that, when a banking system is highly connected, then the single bank is likely to be as well. Banking system and bank openness have, on average, a negative marginal effect on bank solvency, which is not improved by higher levels of concentration. It seems that interbank linkages entail and, perhaps, propagate risks among banks. Nevertheless, Panels 4 and 7 suggest that, as these proxies increase, their impact is less and less detrimental to bank solvency. Also, bank openness becomes beneficial to bank solvency, mirroring what seen in Figure 3's Panel 4.

Similarly to subsection 5.1, Panels 1 and 2 of Figure 10 suggest that, regardless of the concentration levels, it is beneficial to have a high aggregate level of interbank linkages in order to achieve a higher bank solvency. This is especially the case, when banking system concentration is quite high. In Figure 11 I analyze the four cases by moving the distributions for both banking system concentration and bank openness. I find identical implications from the sum of the two average marginal effects. It is worth considering that high levels of banking system openness may imply, in general (but not always) high levels of bank openness. In this case, I find that, once bank openness is high, it is beneficial to have a highly concentrated banking system. Comparing the sums of the two marginal effects, I find that bank solvency is the highest, when bank openness is high. It is noteworthy that, despite average marginal effects are quite different in magnitude[20], when I approach the case of a highly concentrated and interconnected banking system, the sum of the average marginal effects is quite similar (0.874 for Figure 10 and 0.855 for Figure 11).

[20]The average marginal effects of banking system openness is much bigger that those of bank openness.

6 Alternative specifications and robustness checks

In this section, I perform some robustness checks in order to test the strength of previous claims. In particular, in subsection 6.1 I modify the dependent variable definition and model specification. In subsection 6.2 I change the definition of concentration, while in subsection 6.3 I use different definitions of interbank linkages both at banking system and bank level. Each subsection follows the order of previous section's analysis.

6.1 Change of the dependent variable definition

In this subsection I run a set of regressions in order to understand the sensitivity of section 5's estimations to changes in the definition of the dependent variables and model specification.

In column (1) of Table 6 the estimated coefficients are the ones displayed in column (5) of Table 3, as this is the benchmark regression against which I compare the estimations of the other specifications. In regression (2) I replace Laeven & Valencia (2012)'s systemic banking crisis dummy with Reinhart & Rogoff (2009)'s definition. The estimates show that the role of concentration is maintained, however banking system openness seems to constantly decrease the likelihood of observing a systemic banking crisis, while its concentration's interaction coefficient becomes significantly detrimental for banking system stability. In regression (3) I take again Laeven & Valencia (2012)'s crisis definition, but I restrict the time series: it starts from 1999. I do this for two main reasons: i) BankScope's banks coverage increases hugely after 1998; ii) to compare coefficients' behaviors considering the same time series used for banking system and bank solvency analysis. In fact, it is worth reminding the reader that banking system and bank z-scores depend on return on assets' standard deviations, which are computed with a five-year rolling window.[21] The estimates are quite

[21] In the following two paragraphs I modify the rolling window, shortening at three years.

similar, if compared to the first model specification's ones. The only noteworthy difference is represented by the huge change in banking system return on equity and its interaction with concentration: these are also much bigger, however in unreported graphs I do not notice any change in the average marginal effects.[22] In regression (4) I take my benchmark specification and cluster standard errors at country level. Despite standard errors increasing as one would expect (given that in a few cases a country's banking system crisis propagated to others), the significance remains. From column (5) onwards I abandon the logit specification to estimate a linear probability model. The size of the coefficients noticeably change, but not the pattern. In unreported graphs of the average marginal effects, I am able to show that highly concentrated and interconnected banking systems are less likely to observe a systemic banking crisis. Although the specification controls for several macroeconomic variables, it is still likely that the model suffers from an omitted variable bias.[23] For this reason in specification (6) I add country and time fixed effects. Since it is difficult to implement a logit regression with fixed effects, these are often neglected in the literature. Nonetheless, this is straightforward to implement with a linear model. The estimates are even stronger in comparison to those of specifications without these fixed effects, which suggests that the logit estimation could be conservative. Restricting the time series, as before, does not have any detrimental impact on regression (7)'s estimates. In the last two specifications I investigate whether the 2007 Global Financial Crisis had have any impact on the main estimates. For this reason, I split the same in pre-crisis (before 2007) and after-crisis (since 2007 onwards). The two samples are not evenly split, being the first one representing almost two thirds of the whole sample. In effect, the estimated coefficients obtained using the pre-crisis sample drive the results seen with the first model specification, with some exceptions. Notably, the effect of banking system openness is significantly negative, although balanced by a much bigger (and significant) effect of the interaction between concentration and banking system openness. At the same time, in the post-crisis period both the linear and quadratic terms of banking system openness as well as their interaction with concentration, become three times bigger than the original estimations. Column (9)

[22]For the sake of brevity, the graphs of the average marginal effects for the analysis done in this section are not reported, however they are available upon request to the author.

[23]One may argue that, for example, data on non-performing exposures, housing and stock markets enhance the predictability of the model. I share this view, however I did not include them, due to the low quality of the available data.

also shows that banking system concentration seems to negatively affect financial stability in the post-crisis period. Finally, the comparison between columns (8) and (9) could indicate that banking system concentration swapped its impact in favor of the "concentration-fragility" hypothesis after the 2007 Global Financial Crisis, given that the last specification presented in Table 6 explains a sizeable part of the data variability ($R^2 = 0.708$). Nonetheless, ones has to be careful with this conclusion since the sample size decreased significantly.

I can now move to Table 7 in order to consider the banking system solvency analysis. As in the previous paragraph the estimated coefficients of specification (1) are the ones of Table 4's regression (5), which is the benchmark regression. Column (2) does not present any model specification change, except for the fact that robust standard errors are clustered at country level: the impact is trivial. Then, I change the dependent variable for the last three regressions. In specification (3) I do not take the logarithm of countries' z-scores. As mentioned in footnote 9, z-score's distribution is highly asymmetric and my approach was to take the logarithm of z-score, as I find the same distribution feature in my dataset. Despite in this model specification I do not take the logarithm of my dependent variable, this change has a little impact on the results. In specifications (4) and (5) I consider a slightly different definition of z-score, i.e. I use a three-year rolling window to calculate return on assets' standard deviations. This increases the number of observations for regression (4), while these are neglected in regression (5) to keep the same time series dimension. The estimation of both models (and the unreported average marginal effects) confirm the results reported in column (1), despite banking system openness' impact being somewhat weaker. In the last two model specification I consider the possibility that the 2007 Global Financial Crisis can have been a structural break impacting on the separate and joint relationships of the main variables. The two samples are not evenly split, being the first one representing almost 60% of the whole sample. Interestingly, the estimated coefficients obtained using the post-crisis sample seem to drive the results seen with the first model specification, with some exceptions. The most notable one is the banking system openness does not show its non-linear behavior. This is also detectable in the pre-crisis sample, for which the banking system concentration does not exhibit any non-linearities as well. In this case, understanding whether banking system openness and concentration changed their impact due to the crisis is somewhat more unclear and would require a bank level investigation.

I turn to bank solvency with Table 8. Similarly to before, the estimated coefficients of specification (1) are the ones found in column (5) of Table 5, which is the benchmark regression. In column (2), standard errors are clustered at bank level: the impact turns out to be trivial. Regressions (3) and (4) mimic the first two. The difference is that I add country-time fixed effects. Their inclusion absorbs any variation from time invariant and time variant country level variables. In column (5) I use the bank z-score in levels. Although the distribution of bank z-score is highly asymmetric, this change does not have a big impact that one might have expected to notice for the last three estimated coefficients. In particular, bank openness and its interaction with concentration' coefficients have a much bigger size. Finally, for specifications (6) and (7) I change bank z-score's definition by considering a three-year rolling window, when bank return on assets' standard deviations are computed. Regardless of the fact that I consider the whole time series in column (6) or I start from 1999 in column (7), results remain stable. The only exception concerns concentration and its square term's coefficients, which are no longer significant. Nonetheless, from the analysis of the (unreported) average marginal effects, there are no important differences and the policy prescription remains unchanged. In the last two model specification I consider the possibility that the 2007 Global Financial Crisis to clarify whether a structural break impacting on the separate and joint relationships of the main variables occurred, as this is unclear at the aggregate level. The same is split evenly, reflecting the higher number of banks present in my post-crisis sample. Pre-crisis and post-crisis estimations are highly consistent and comparable to the main model specification. This suggests that there has been no structural change on variables' behavior, except for mildly losing the non-linearity of the banking system openness. However, bank openness has remained consistently non-linear.

In conclusion, section 5's results seem robust to the change in the definitions of the dependent variables, standard errors' calculation, time series length, the inclusion of fixed effects and the separation of pre-crisis and post-crisis period.

6.2 Change of the concentration variable definition

In this subsection I run a set of regressions in order to understand the sensitivity of section 5's estimations to the change of concentration's definition.

In column (1) of Table 9 the estimated coefficients are the ones displayed in column (5) of Table 3: this is the benchmark regression against which I compare the other specifications. In column (2) I consider the first lag of my concentration variable and the estimated coefficients are quite stable. Although I am quite skeptical about the use of the first year concentration observation for each country, due to the previously mentioned BankScope data quality at the beginning of the time series, one can notice that estimates of the third specifications are quite similar. However, when using the average value of (country) concentration (specification (4)), its coefficient and its square term's estimates change, while the others are virtually unchanged. This may cast some doubts over the policy implication. In unreported average marginal effects, I can prove that this is not the case: instead, the "call" for a highly interconnected banking system is even reinforced.[24] In regression (5) I use the sum of the market share of the three biggest banks (in assets terms) at a country level as a proxy for concentration and results are quite stable. In specification (6) I use the Herfindahl-Hirschman index (HHI): the signs of concentration and its square term are reversed and this might cast some doubts on what has previously been done. HHI is defined as the sum of squares of whole sample of banks' market shares. It considers the whole distribution, while concentration ratios only the five (or three) biggest banks. One would expect that the two definitions of concentration would deliver the same message. In effect, in unreported analysis I detected a high correlation among the two mentioned variables, however I noticed an inverse-U relationship between concentration ratios and HHI[25], in line with Allen & Gale (2000a). I am also aware that, for any given concentration ratio, there might be associated different values of HHI, due to the market

[24] Comparing with previous section's results, it seems that banking system openness drives the policy implication in the context of logit regressions.

[25] The correlation between HHI and CR_5 is 0.699, while the one between HHI and CR_3 is 0.819. I estimated the following regression (clustering standards errors at country level): $CR5_{c,t} = \beta_0 + \beta_1 HHI_{c,t} + \beta_2 HHI^2_{c,t} + \delta_c + \gamma_t + \eta_c t + \epsilon_{c,t}$, where δ_c, γ_t, $\eta_c t$ are, respectively, country, time and country trend fixed effects. $\hat{\beta_1}$ is positive, while $\hat{\beta_2}$ is negative. Both of them have p-values equal to 0.000, when a significance test is performed. Relaxing model saturation by excluding some of the fixed effects does not alter the estimation at all.

share distribution. My finding is possibly due to the fact the my concentration ratios' distributions are left-skewed. In order words, in my sample countries usually show high levels of concentration ratios (the median of CR_3 is 0.748, while its mean is 0.719), despite this cannot be said for HHI (the median is 0.188, while its mean is 0.245), which is right-skewed. This may suggest a different policy implication. The unreported average marginal effects confirm that the policy suggestion is always to keep a high level of interbank connection, despite the fact that a low concentration level is preferred to a high one in order to decrease the likelihood of observing a systemic banking crisis. Finally, in regression (7) I consider the first lag of Lerner index. It is worth stressing that the latter is not a concentration measure, but a competition one: it is the price-cost mark-up. Coefficients' estimation (and the average marginal effects) are in line with the previous regression. This is not surprising, as it can theoretically be shown that there is a positive linear relationship between HHI and Lerner Index,[26] which means that while the latter is a concentration index, it is fully correlated to a competition index. These results are in line with Anginer *et al.* (2014)'s findings.

I now use all the previous concentration definitions to check for the robustness of the banking system solvency analysis (Table 10). As above, in column (1) I report coefficients' estimation of specification (5) of Table 4. Using the lag of CR_5 does not alter the results. Then, I consider the first-year and average concentration ratio, respectively, in columns (3) and (4), finding similar results. Obviously, concentration and its square term's coefficients can no longer be estimated, given that these two definitions imply that within the same country they are time invariant in a context in which I control for country fixed effects. In regression (5) I use CR_3 and, despite the fact that concentration is no longer significant, the other results are confirmed. Finally, regressions (6) and (7) use, respectively, HHI and Lerner index. HHI and its square term's coefficients do not seem to be coherent, however, when Lerner index is used, one can notice the same opposite pattern with respect to regression (1) as seen in the previous paragraph.

Turning to the bank solvency analysis, regression (1) of Table 11 is the same as regres-

[26] In Cournot competition models Lerner Index is equal to HHI divided by demand elasticity.

sion (5) of Table 5. The first lag of CR_5 is used in the regression (2). Estimates are quite stable and the policy implication does not change.[27] Using the first-year or the average CR_5 does not impact on the main findings (regressions (3) and (4)). I consider CR_3 in specification (5) and again results are quite stable. In the last two regressions, I use HHI and Lerner index. The same comment I made in the previous paragraph applies here: the estimates of HHI and HHI^2 are not coherent with concentration ratio's coefficients, but with the ones estimated with Lerner index, whose estimated coefficients are in line with predictions.

In conclusion, section 5's results and policy implications seem robust to the change in how concentration is defined. However, when I use variables related to competition, I find that a more competitive banking system enhances banking system and bank stability, decreasing the likelihood of observing a systemic banking crisis, in the presence of a high intensity of interbank linkages. Looking at average marginal effects of banking system return on equity at the different percentiles of Lerner index (not reported here), I cannot rule out the more competition, via higher efficiency, is leading to higher banking and bank solvency. Another hypothesis is that the positive effect of higher competition might be due the so called too-many-too-fail issue, suggested by Acharya & Yorulmazer (2007) and Ratnovski (2009) among others.

6.3 Change of the interbank linkages variable definition

In this subsection I run a set of regressions in order to understand the sensitivity of section 5's results to the change in the definition of banking and bank openness.

In column (1) of Table 12 the estimated coefficients are the ones displayed in column (5) of Table 3: the benchmark regression. In column (2) I do not use the lag of banking system openness and the results are remarkably stable. The fact that the strict majority of interbank credit and debt positions are of a short term nature might hugely affect banking system openness, its square and interaction terms, when I replace each

[27] Some coefficients change, such as banking system openness and its interaction with concentration and the same happens at bank level. However, in unreported average marginal effects I noticed that the changes are such that they counteract each other.

country's banking system openness observations with its own first-year observation (specification (3)) in addition to the caveat about any BankScope data before 1998. This might also suggest that, while banking system concentration is a structural market feature, banking system openness is somewhat less structural and more volatile. In effect, unfortunately the joint significance test strongly rejects the non-linearity of banking system openness. I overcome the issue when considering the each country's average banking system openness over its whole time series (column (4)). The only noticeable difference with respect to the benchmark model is for the coefficients of banking system openness and its interaction with concentration. In unreported average marginal effects, I am able to confirm the previous policy implications: regardless of the concentration level, a high level of bank interconnectedness decreases the likelihood of a systemic banking crisis occurrence (with a slight preference for a highly concentrated banking system). Specifications (5) and (6) mirror the first two with a small difference in the definition of banking system openness: this time the sum of interbank credit and debt is divided by banking system liabilities. As one could have expected, I do not find appreciable differences.

The focus now moves onto banking system solvency in Table 13. I follow the previous paragraph's steps. It is quite striking to notice that there is virtually no change in coefficients. Obviously, when I use the first-year observation and the average banking system openness level, I am not able to estimate the coefficients of the banking system openness and its square term, as they are absorbed by country fixed effects.

I can now consider bank solvency by analysing Table 14. Again, there is little change in either the size or significance of the estimated coefficients. A couple of interesting features are worth mentioning. First, when I use the first-year observation and the average banking system openness level (columns (3) and (4)), banking system and bank openness and their square terms cannot be estimated, because they are absorbed by bank fixed effects. However, their impact is expressed in larger (in absolute value) coefficients of their interactions with concentration. Anyway, the unreported average marginal effects show that this does not have much impact on the conclusions. Second, when I use banking and bank openness (normalized, respectively, by each country's banking and bank liabilities), all the coefficients related to these variables (the last six ones in the table) are smaller. This is expected, given that, unless for the few cases of a negative bank equity due to a bank crisis, banking system and bank liabilities are smaller than their own assets counterparts. This means that, on average, the new banking system and bank openness proxies are bigger. This impact is especially relevant at bank level, because at country level this can be (and, in general, is) partially driven by the biggest banks, who have a larger influence on the aggregate variable. This explains the reason why bank openness and its square term's coefficients are much smaller than the ones estimated when the original proxy is used, and this size difference is much more pronounced than for the banking system openness and its square term' case. The fact that bank openness, its square and interaction terms keep the same signs and significance reassures that the normalization is not driving the results. Even in this case, policy implications are not affected.

In conclusion, section 5's results seem robust to the change in the definition of banking system and bank openness.

7 Conclusions

This paper analyzes the relationship between banking system concentration and the intensity of banking system interconnections through the interbank market. I find that, not only the former, but also the latter need to be considered in order to prevent a worsening of banking system and bank solvency and, ultimately, to decrease the likelihood of a systemic banking crisis.

The policy implication is that banking system relationships should not be viewed as damaging per se as long as the network is complete, in line with the conclusions of Allen & Gale (2000b). Policy makers need to analyze each feature of the supervised banking system, as each of them exert its own and joint impact on financial stability. These impacts can significantly variate at the different values of the many banking system's features. In other words, when implementing a new policy to enhance banking system stability, the policy makers need to consider carefully the whole set of banking system's features.

I find that banking system concentration, banking system and bank openness have a non-linear relationship with financial stability. Nevertheless, in contrast with Martinez-Miera & Repullo (2010), this relationship seems to have a L-shape and not U-shaped. Coherently, the risk-shifting and margin effects are not detected at mean values, as the two seem to neutralize each other.

This paper implicitly suggests a possible direction for future research. The empirical evidence advices the need for further theoretical work. In fact, the analysis does not fully corroborate Martinez-Miera & Repullo (2010)' model. However, this does not mean that it has to be discarded. On the contrary, the features of their model are a necessary starting point, where to insert the contribution of the theoretical research done in the field of banking networks. In this sense, some elements of Cifuentes *et al.* (2005) and Acemoglu *et al.* (2015) might be considered in order to extend and generalize the framework. In this way, every feature of the banking system can be integrated in the new model, thus producing a valuable tool for simulating policy impacts in a consistent way and well calibrating the stabilizing policies.

In the empirical side, once that a sophisticated theoretical model has been developed, the direction should be to move towards a bank level analysis, as it can account for the structural breaks that are likely to occur over time. The cost of this is not to rely any longer on crisis dating as dependent variable, so other ways to detect bank fragility, beyond the z-score, need to be explored. In this sense, developing and testing some proxies of liquidity fragility might be a promising complement to the z-score.

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Tables and Figures

Figure 1: A stylized banking system's concentration/interconnectedness mix.

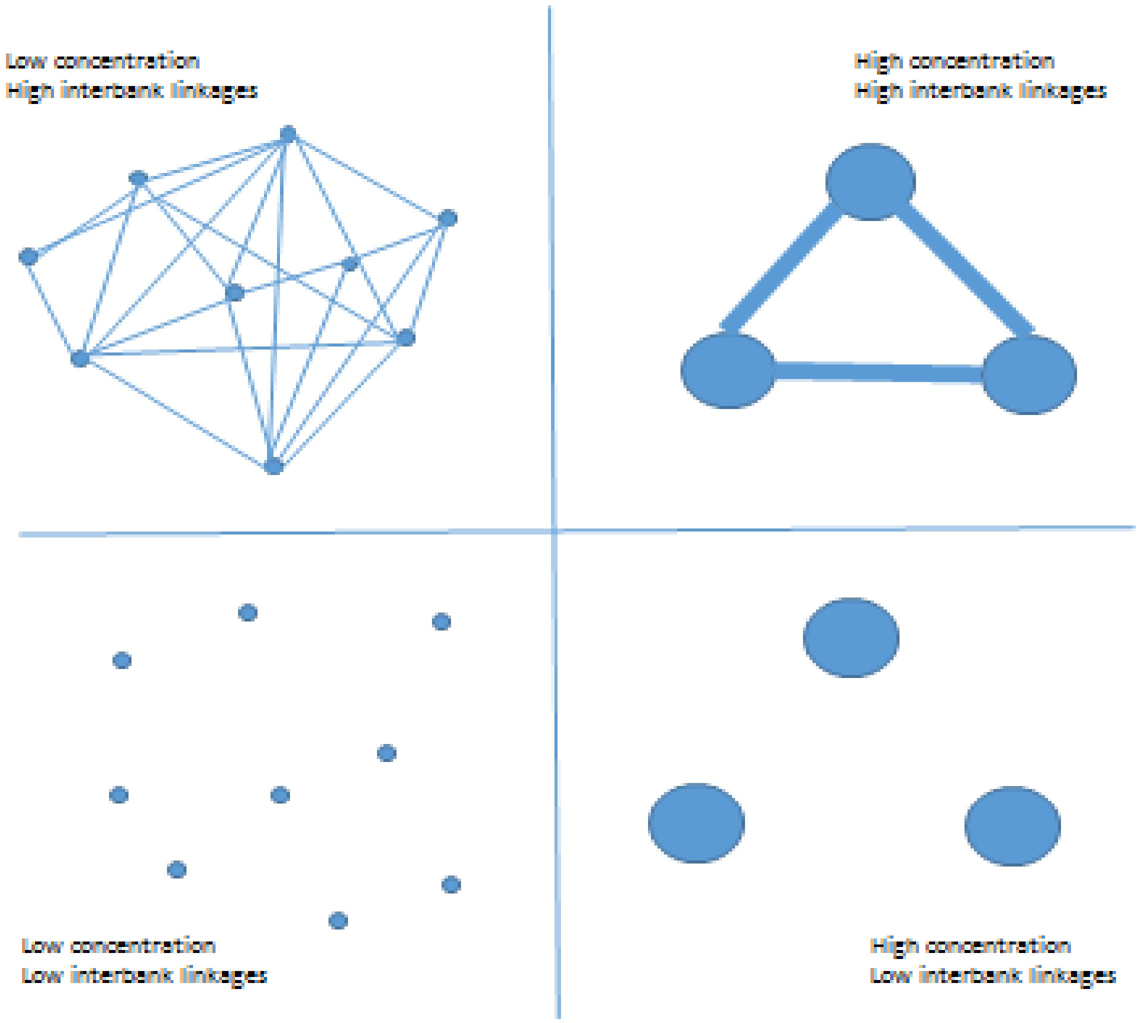

Figure 1 shows the four extreme cases, that can feature a banking system. Panel 1 represents a weakly concentrated and highly connected banking system, while Panel 2 shows a highly concentrated and connected banking system. Panel 3 represents a weakly concentrated, bust disconnected banking system, while Panel 4 show a highly concentrated, but disconnected banking system.

Table 1: Countries.

Asia & Pacific	Europe & North America	LatAm & Caribbean	MENA	SSAF
Australia	Austria	Chile	Bahrain	Benin
India	Belgium	Colombia	Egypt	Botswana
Indonesia	Canada	Dominican Rep.	Israel	Burundi
Japan	Cyprus	Ecuador	Jordan	Cameroon
Malaysia	Denmark	El Salvador	Tunisia	Congo
Nepal	Finland	Guatemala	Turkey	Ghana
New Zealand	France	Guyana		Ivory Coast
Papua New Guinea	Germany	Honduras		Kenya
Philippines	Greece	Jamaica		Lesotho
Singapore	Ireland	Panama		Mali
South Korea	Italy	Peru		Mauritius
Sri Lanka	Mexico	Uruguay		Nigeria
Thailand	Netherlands	Venezuela		Senegal
	Norway			Sierra Leone
	Portugal			South Africa
	Sweden			Swaziland
	Switzerland			Togo
	United Kingdom			Zambia
	United States of America			

Table 1 presents the list of countries used in my analysis. Their definition follows IMF's country classification for region determination.

Table 2: Summary statistics.

Variables	Observations	Mean	Std. Dev.	Minimum	Maximum
Systemic banking crisis	1,338	0.113	0.317	0	1
Banking system z-score	1,104	37.990	40.868	-11.902	479.794
Real GDP growth	1,365	0.035	0.032	-0.079	0.144
ln GDP p.c.	1,360	8.502	1.654	4.922	11.357
Depreciation	1,365	0.033	0.124	-0.193	0.960
Real interest rate	1,315	0.043	0.081	-0.353	0.417
M2/reserves	1,296	0.103	0.176	0.004	1.337
Δ terms of trade	1,324	0.346	14.173	-40.834	102.103
Inflation	1,360	0.066	0.101	-0.071	0.860
Credit growth$_{-2}$	1,324	0.013	0.053	-0.213	0.245
B. s. leverage ratio	1,365	0.086	0.044	-0.057	0.258
B. s. return on equity	1,365	0.116	0.152	-1.384	0.613
CR_5	1,365	0.822	0.195	0.295	1.000
CR_3	1,365	0.719	0.230	0.216	1.000
HHI	1,365	0.245	0.197	0.013	1.000
Lerner index	1,254	0.256	0.144	-0.153	0.797
Banking system openness	1,365	0.253	0.169	0.000	1.244
Bank z-score	134,714	70.513	119.242	-105.740	1,080.406
Bank leverage ratio	229,697	0.109	0.142	-10.000	1.000
Bank return on equity	228,733	0.058	0.253	-1.998	1.497
Bank openness	226,796	0.145	0.193	0.000	1.399

Table 2 shows summary statistics of the variables considered throughout the analysis. Systemic banking crisis is a binary variable that takes value of one when there is a systemic banking crisis in country c at year t, and value of zero otherwise. B. s. z-score is the z-score index computed for every country c's banking system at year t. Real GDP growth represents the rate of growth of real GDP for every country c at year t. ln GDP p.c. is the logarithm of GDP per capita. Depreciation represents country c's depreciation rate, computed with respect to US Dollar. Real interest rate is equal to the nominal interest rate decreased by the inflation rate corresponding at the same period of time. $M2/reserves$ is defined as the ratio between money supply M2 and international reserves owned by country c at year t. Δ terms of trade is the change of the ratio between export and import prices. Inflation is country c's inflation rate at year t. Credit growth$_{-2}$ represents the real growth of credit at year $t-2$. B. s. leverage ratio is equal to the ratio between the overall banking system equity and the overall banking system assets. B. s. return on equity is computed by taking the ratio between the overall banking system net income before taxes and the aggregated equity for every country c at year t. CR_5 is equal to the sum of the share of assets detained by the five biggest banks for every country c at year t. CR_3 is equal to the sum of the share of assets detained by the three biggest banks for every country c at year t. HHI index measures concentration as the sum of square of (assets) market shares of all the banks. Lerner index is a measure of market power in a given banking system, computed as average bank level mark-up of price over margin costs. Banking system openness is a measure of interbank linkages, which is measured as the sum of aggregated credit to banks and debit from banks for every country c at year t, normalized by the aggregate assets of the banking system. Bank z-score is z-score index for every bank b's banking system at year t. Bank leverage ratio is equal to the ratio between the each bank equity and its correspondent assets. Bank return on equity is computed by taking the ratio between bank b's net income before taxes and its correspondent equity at year t. Bank openness is a measure of interbank linkages, which is measured as the sum of credit to banks and debit from banks for each bank b at year t, normalized by the bank assets.

Table 3: Systemic banking crisis: concentration and banking system openness.

Variables	(1)	(2)	(3)	(4)	(5)
B. system leverage ratio	-11.066***	-10.473***	-10.508***	-8.576**	-7.952**
	(3.352)	(3.456)	(3.428)	(3.462)	(3.512)
Real interest rate	0.243	-0.037	-15.993***	-16.102**	-17.711***
	(1.728)	(1.776)	(5.617)	(6.268)	(6.314)
B. system return on equity	-1.230**	-1.190**	-0.582	-0.200	0.008
	(0.485)	(0.481)	(1.468)	(1.395)	(1.434)
Concentration	-1.763***	3.538	3.164	5.359	3.465
	(0.492)	(4.018)	(4.048)	(4.295)	(4.413)
Concentration^2		-3.734	-3.874	-5.700*	-5.383*
		(2.894)	(2.896)	(3.076)	(3.196)
Concentration x *Real interest rate*			21.983***	22.763***	24.587***
			(7.018)	(7.789)	(7.845)
Concentration x *B. s. return on equity*			-1.295	-2.113	-2.457
			(1.901)	(1.925)	(2.105)
B. system openness$_{-1}$				1.013*	5.568*
				(0.575)	(3.352)
B. system openness$^2_{-1}$					-11.184***
					(3.430)
Concentration x *B. s. openness*$_{-1}$					4.451
					(3.145)
Country controls	Yes	Yes	Yes	Yes	Yes
Observations	1,273	1,273	1,273	1,273	1,204
R^2	0.255	0.258	0.270	0.288	0.301
Test for Concentration non-linearity	–	0.003	0.001	0.001	0.002
Test for B. s. openness$_{-1}$ non-linearity	–	–	–	–	0.004

Table 3 presents logit regressions of the probability of observing a systemic banking crisis on banking system concentration (1), its square (2), its interaction with real interest rate and banking system return on equity (3), banking system openness (4), banking system openness' square and the interaction between banking system concentration and openness (5). Banking system leverage ratio is considered in every specification. For the sake of brevity, I omitted from the table the following control variables: Real GDP growth, logarithm of GDP p.c., Depreciation rate, M2/Reserves ratio, Terms of trade change, Inflation rate, Credit growth$_{-2}$. Standard errors robust to heteroskedasticity are in parentheses. Significance *** at 1% level, ** at 5% level, * at 10% level.

Figure 2: Average marginal effects on observing a systemic banking crisis.

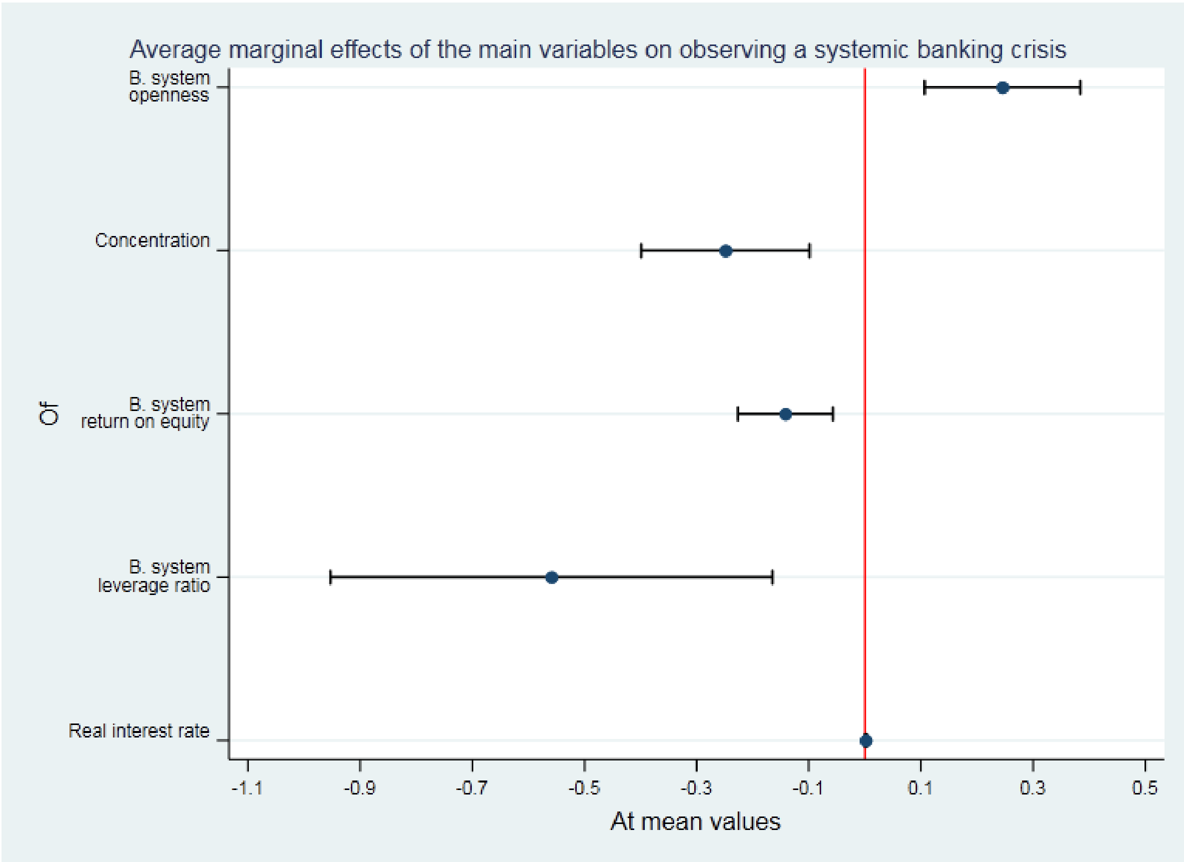

Figure 2 presents the average marginal effects (dots) of each variable (shown in column (5) of Table 3) computed at their own means on observing a systemic banking crisis. The lines represent 90% confidence intervals.

Figure 3: Average marginal effects on observing a systemic banking crisis.

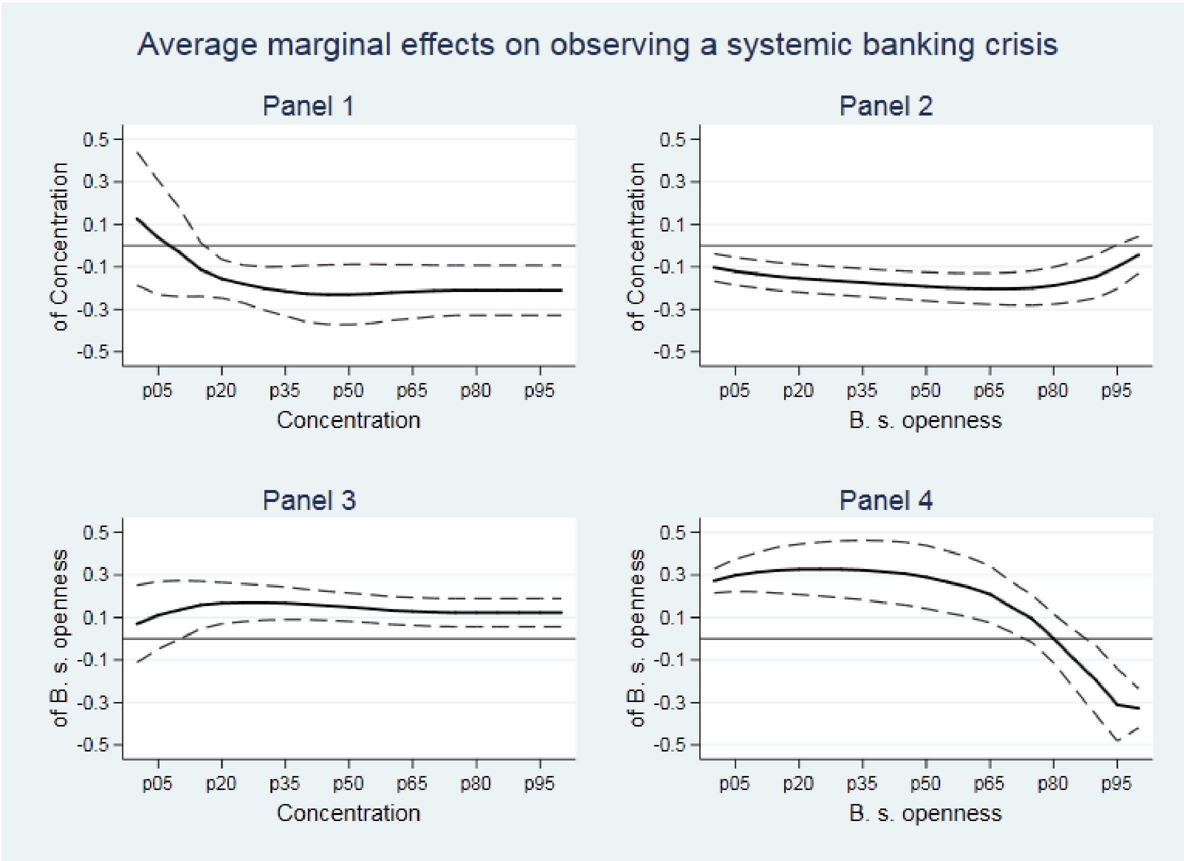

Figure 3 shows the average marginal effects of concentration and banking system openness on observing a systemic banking crisis. The two panels on the top describe the average marginal effect of concentration with respect to variations of percentiles of concentration (Panel 1) and banking system openness (Panel 2). The other two panels show how changes in concentration (Panel 3) and banking system openness (Panel 4) affect the average marginal effect of banking system openness on observing a systemic banking crisis. Dashed lines represent 90% confidence intervals.

Figure 4: Four cases: marginal effects on observing a systemic banking crisis.

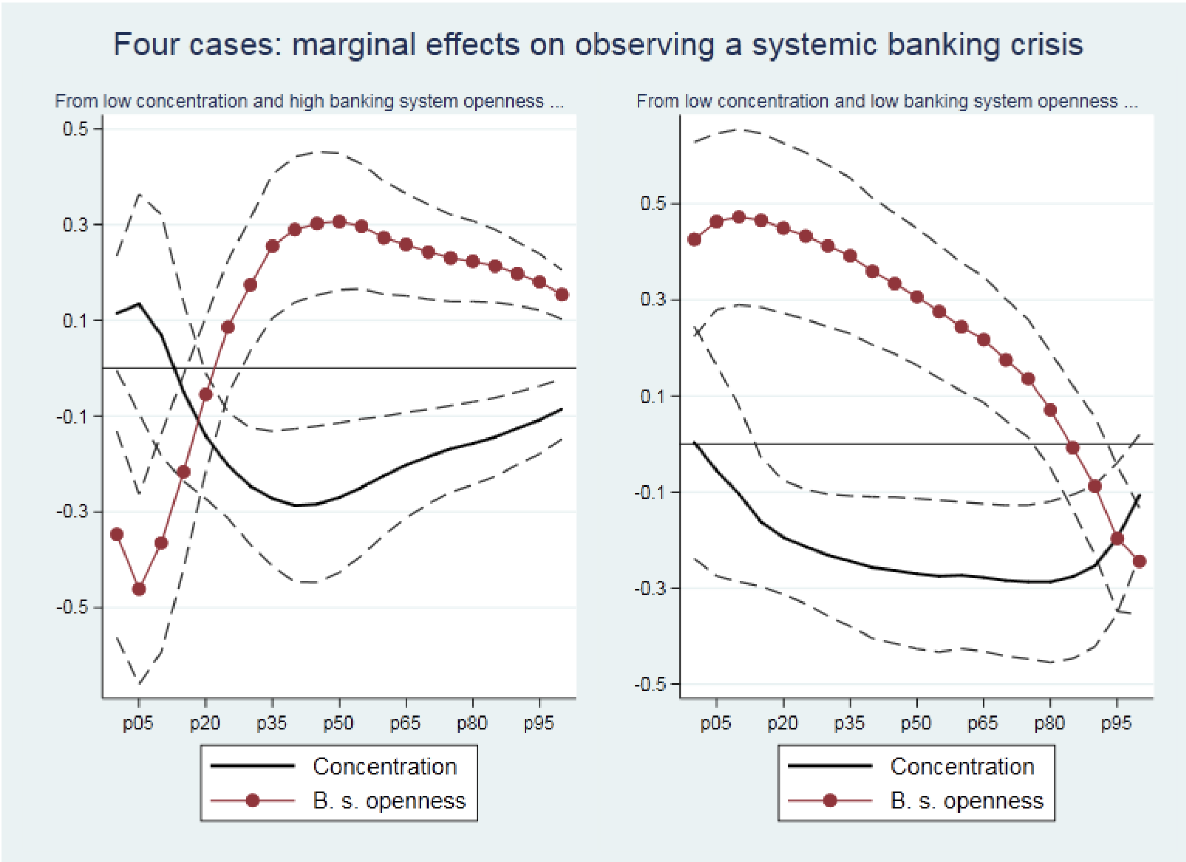

Figure 4 shows the marginal effects of concentration and banking system openness on observing a systemic banking crisis. Panel 1 considers these effects at 1^{st} percentile for concentration and 99^{th} percentile for banking system openness, with the first one increasing until its 99^{th} percentile, while the second one decreasing, contemporaneously, until its 1^{st} percentile. Panel 2 considers the marginal effects of concentration and banking system openness on observing a systemic crisis, with both concentration and banking systemic openness increasing at the same pace. Dashed lines represent 90% confidence intervals.

Table 4: Banking system solvency: concentration and banking system openness.

Variables	(1)	(2)	(3)	(4)	(5)
B. system leverage ratio	7.142***	7.016***	6.697***	6.651***	6.767***
	(1.490)	(1.480)	(1.440)	(1.439)	(1.407)
Real interest rate	-0.539	-0.636	0.259	0.148	0.295
	(0.912)	(0.881)	(2.486)	(2.461)	(2.451)
B. system return on equity	0.364	0.315	6.286*	6.231*	6.429*
	(0.551)	(0.518)	(3.697)	(3.691)	(3.691)
Concentration	0.613	-9.460***	-7.627***	-7.802***	-5.213*
	(0.376)	(2.417)	(2.514)	(2.507)	(2.662)
Concentration^2		6.879***	6.286***	6.404***	5.883***
		(1.656)	(1.631)	(1.626)	(1.644)
Concentration x *Real interest rate*			-0.941	-0.863	-1.025
			(2.829)	(2.812)	(2.776)
Concentration x *B. s. return on equity*			-6.976*	-6.905*	-7.089*
			(3.766)	(3.761)	(3.758)
B. system openness$_{-1}$				-0.353	4.958**
				(0.314)	(1.722)
B. system openness$^2_{-1}$					0.910*
					(0.512)
Concentration x *B. s. openness*$_{-1}$					-6.704***
					(1.807)
Country FE	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes
Country controls	Yes	Yes	Yes	Yes	Yes
Observations	1,067	1,067	1,067	1,067	998
R^2	0.487	0.503	0.520	0.521	0.531
Test for Concentration non-linearity	–	0.000	0.000	0.000	0.000
Test for B. s. openness$_{-1}$ non-linearity	–	–	–	–	0.002

Table 4 presents OLS regressions of the country c's z-score on banking system concentration (1), its square (2), its interaction with real interest rate and banking system return on equity (3), banking system openness (4), banking system openness' square and the interaction between banking system concentration and openness (5). Banking system leverage ratio is considered in every specification as well as country and time fixed effects. For the sake of brevity, I omitted from the table the following control variables: Real GDP growth, logarithm of GDP p.c., Depreciation rate, M2/Reserves ratio, Terms of trade change, Inflation rate, Credit growth$_{-2}$. Standard errors robust to heteroskedasticity are in parentheses. Significance *** at 1% level, ** at 5% level, * at 10% level.

Figure 5: Average marginal effects on banking system solvency.

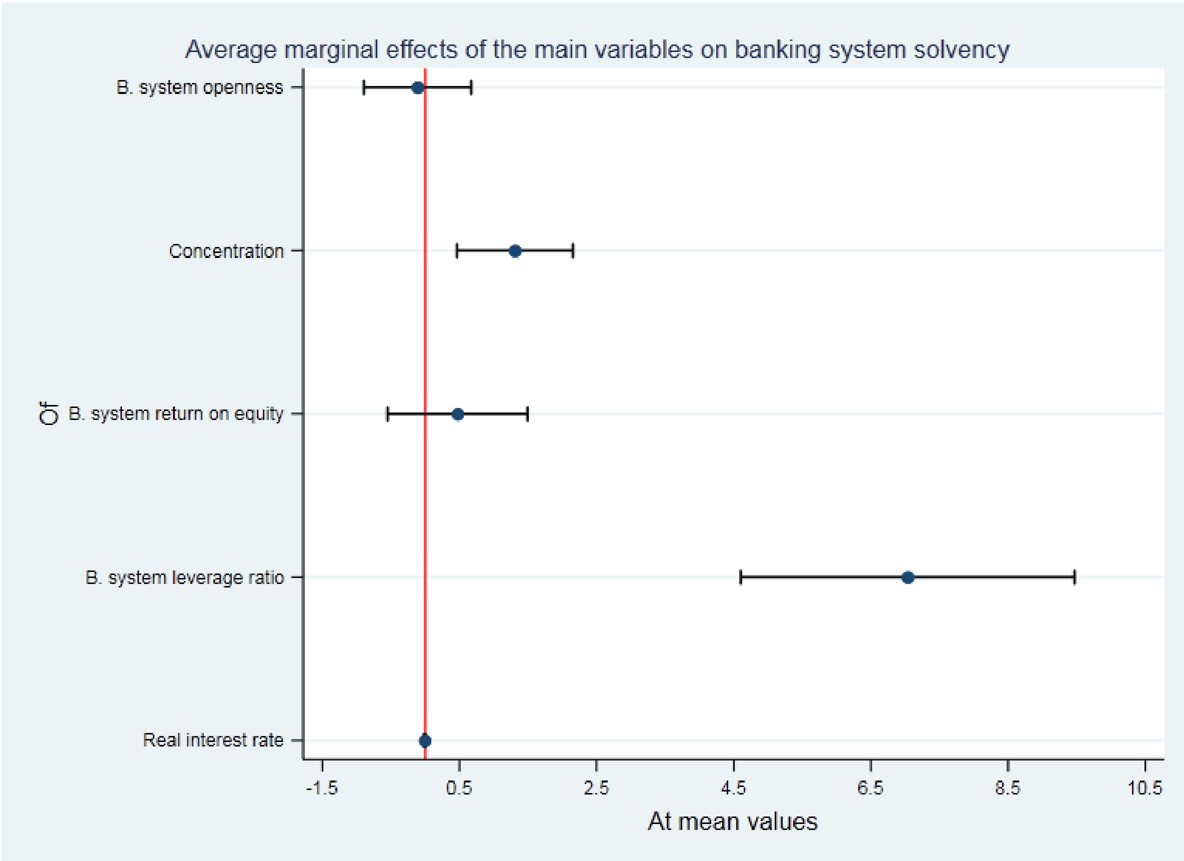

Figure 5 presents the average marginal effects (dots) of each variable (shown in column (5) of Table 4) computed at their own means on banking system solvency. The lines represent 90% confidence intervals.

Figure 6: Average marginal effects on banking system solvency.

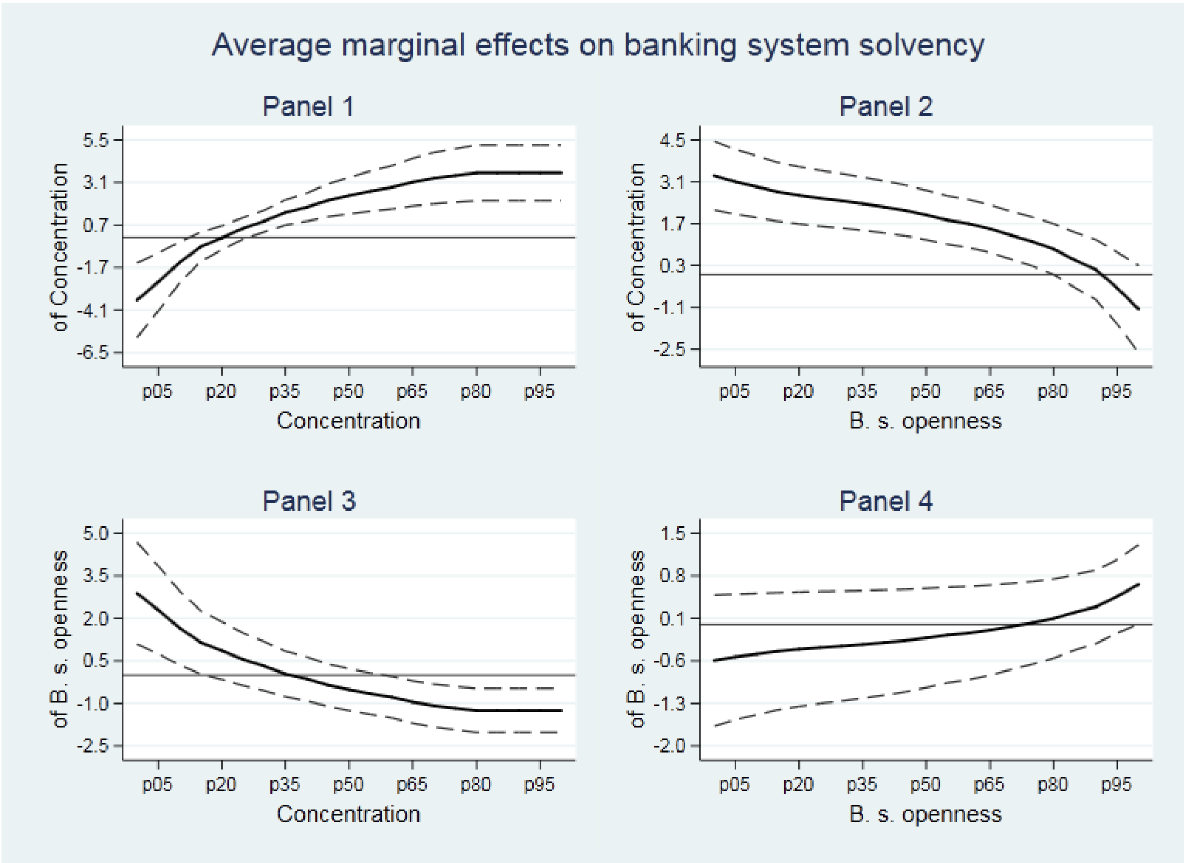

Figure 6 shows the average marginal effects of concentration and banking system openness on banking system solvency. The two panels on the top describe the average marginal effect of concentration with respect to variations of percentiles of concentration (Panel 1) and banking system openness (Panel 2). The other two panels show how changes in concentration (Panel 3) and banking system openness (Panel 4) affect the average marginal effect of banking system openness on banking system solvency. Dashed lines represent 90% confidence intervals.

Figure 7: Four cases: marginal effects on banking system solvency.

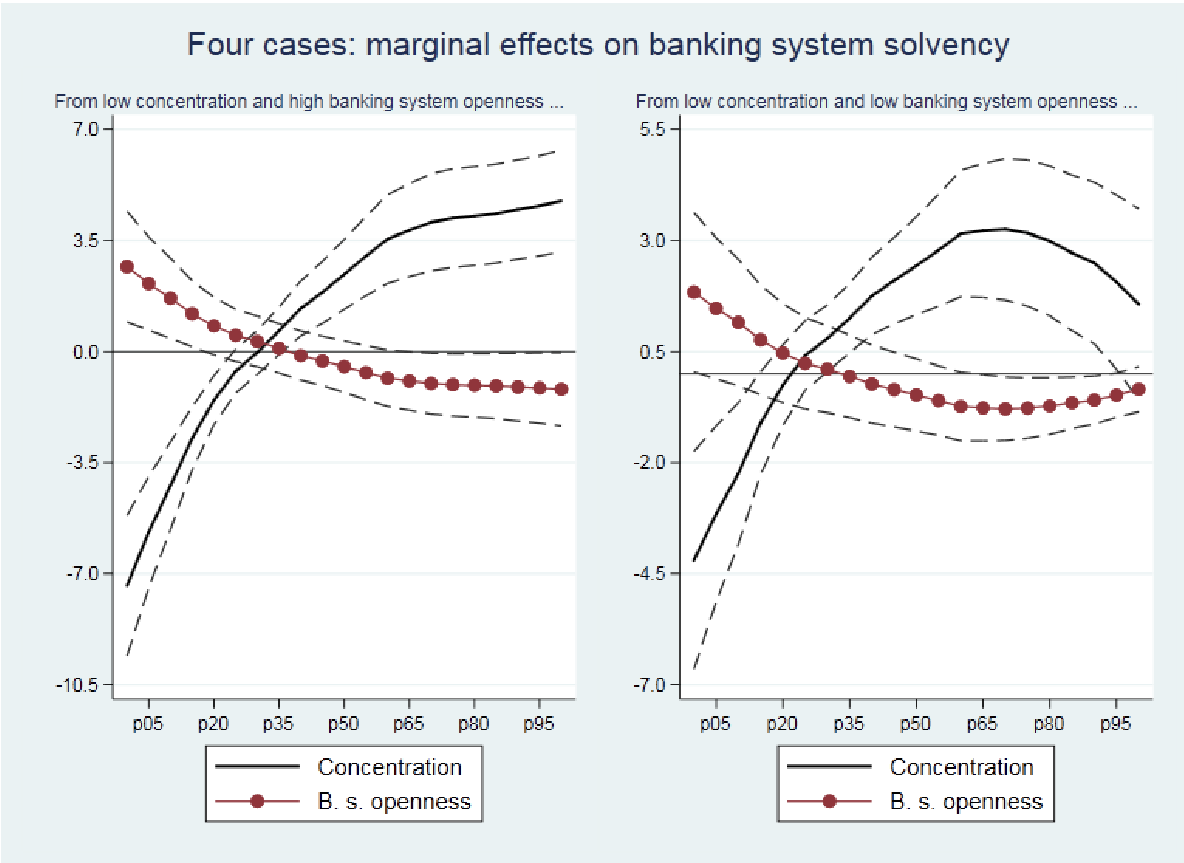

Figure 7 shows the marginal effects of concentration and banking system openness on banking system solvency. Panel 1 considers these effects at 1^{st} percentile for concentration and 99^{th} percentile for banking system openness, with the first one increasing until its 99^{th} percentile, while the second one decreasing, contemporaneously, until its 1^{st} percentile. Panel 2 considers the marginal effects of concentration and banking system openness on banking system solvency, with both concentration and banking systemic openness increasing at the same pace. Dashed lines represent 90% confidence intervals.

Table 5: Bank solvency: concentration, banking system and bank openness.

Variables	(1)	(2)	(3)	(4)	(5)
B. system leverage ratio	2.102***	2.107***	2.026***	2.078***	1.753***
	(0.340)	(0.339)	(0.337)	(0.338)	(0.348)
Bank leverage ratio	3.290***	3.295***	3.296***	3.269***	4.042***
	(0.360)	(0.360)	(0.361)	(0.359)	(0.167)
Real interest rate	0.210	0.161	-1.036**	-1.039**	-1.055**
	(0.200)	(0.199)	(0.451)	(0.452)	(0.454)
B. system return on equity	0.199***	0.185***	0.840***	0.684***	0.740***
	(0.067)	(0.066)	(0.215)	(0.209)	(0.221)
Bank return on equity	1.482***	1.480***	1.485**	1.448**	1.566**
	(0.276)	(0.276)	(0.650)	(0.649)	(0.718)
Concentration	0.220***	-0.455	-0.457	-0.340	-0.268
	(0.083)	(0.292)	(0.326)	(0.374)	(0.393)
Concentration^2		0.550**	0.552**	0.398*	0.528**
		(0.225)	(0.232)	(0.230)	(0.240)
Concentration x *Real interest rate*			1.976***	1.692***	1.840***
			(0.599)	(0.593)	(0.602)
Concentration x *B. s. return on equity*			-1.152***	-0.998***	-1.101***
			(0.336)	(0.330)	(0.352)
Concentration x *Bank return on equity*			-0.005	0.048	0.075
			(0.767)	(0.770)	(0.850)
B. system openness$_{-1}$				-3.070***	-2.756***
				(0.439)	(0.532)
B. system openness$^2_{-1}$				2.350***	2.263***
				(0.386)	(0.418)
Concentration x *B. s. openness*$_{-1}$				0.362	0.032
				(0.328)	(0.379)
Bank openness$_{-1}$					-0.232**
					(0.115)
Bank openness$^2_{-1}$					0.356***
					(0.075)
Concentration x *Bank openness*$_{-1}$					-0.177
					(0.187)
Bank FE	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes
Country controls	Yes	Yes	Yes	Yes	Yes
Observations	102,522	102,522	102,522	102,522	101,627
R^2	0.682	0.682	0.682	0.683	0.686
Test for Concentration non-linearity	–	0.001	0.001	0.083	0.002
Test for B. s. openness$_{-1}$ non-linearity	–	–	–	0.000	0.000
Test for Bank openness$_{-1}$ non-linearity	–	–	–	–	0.000

Table 5 presents OLS regressions of the bank b's z-score on banking system concentration (1), its square (2), its interaction with real interest rate and banking system return on equity (3), banking system and bank openness (4), banking system and bank openness' squares and the interaction between banking system concentration and, respectively, banking system and bank openness (5). Banking system and bank leverage ratios are considered in every specification as well as bank and time fixed effects. For the sake of brevity, I omitted from the table the following control variables: Real GDP growth, logarithm of GDP p.c., Depreciation rate, M2/Reserves ratio, Terms of trade change, Inflation rate, Credit growth$_{-2}$. Standard errors robust to heteroskedasticity are in parentheses. Significance *** at 1% level, ** at 5% level, * at 10% level.

Figure 8: Average marginal effects on bank solvency.

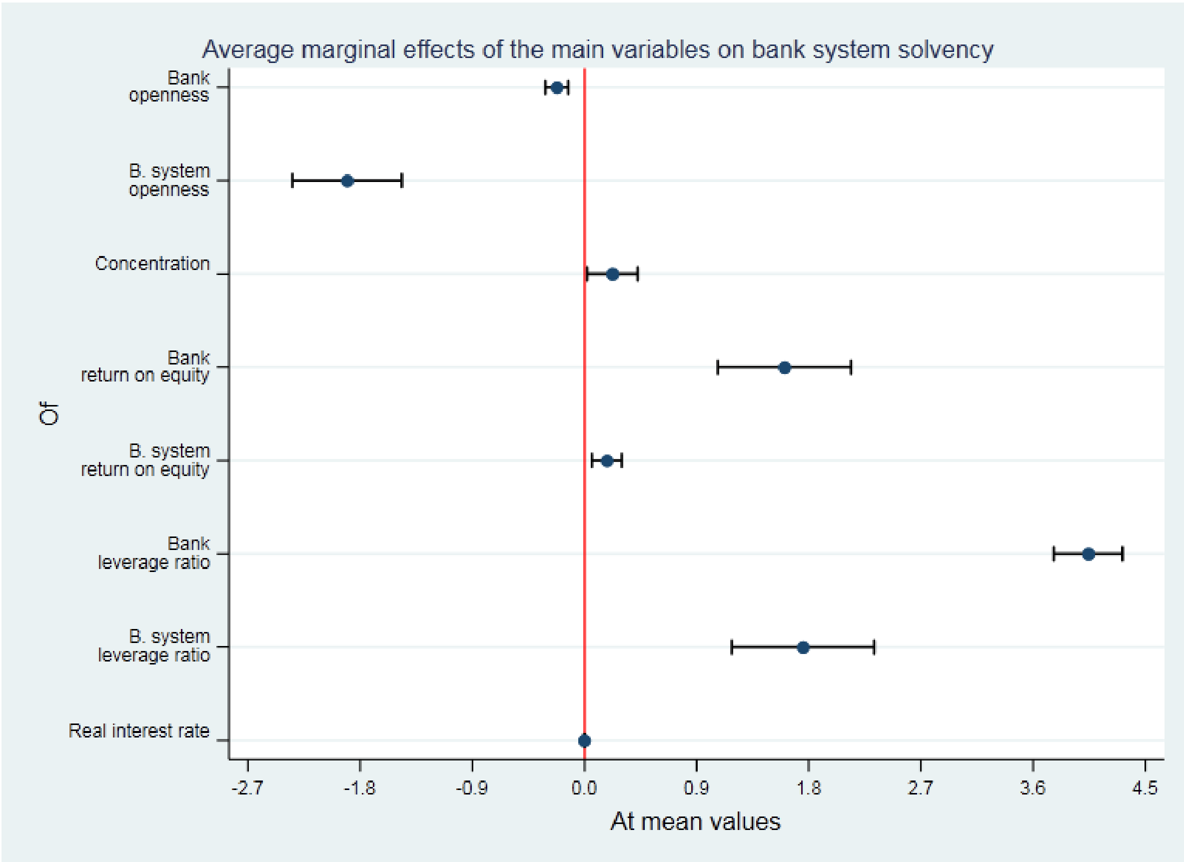

Figure 8 presents the average marginal effects (dots) of each variable (shown in column (5) of Table 5) computed at their own means on bank solvency. The lines represent 90% confidence intervals.

Figure 9: Average marginal effects on bank solvency.

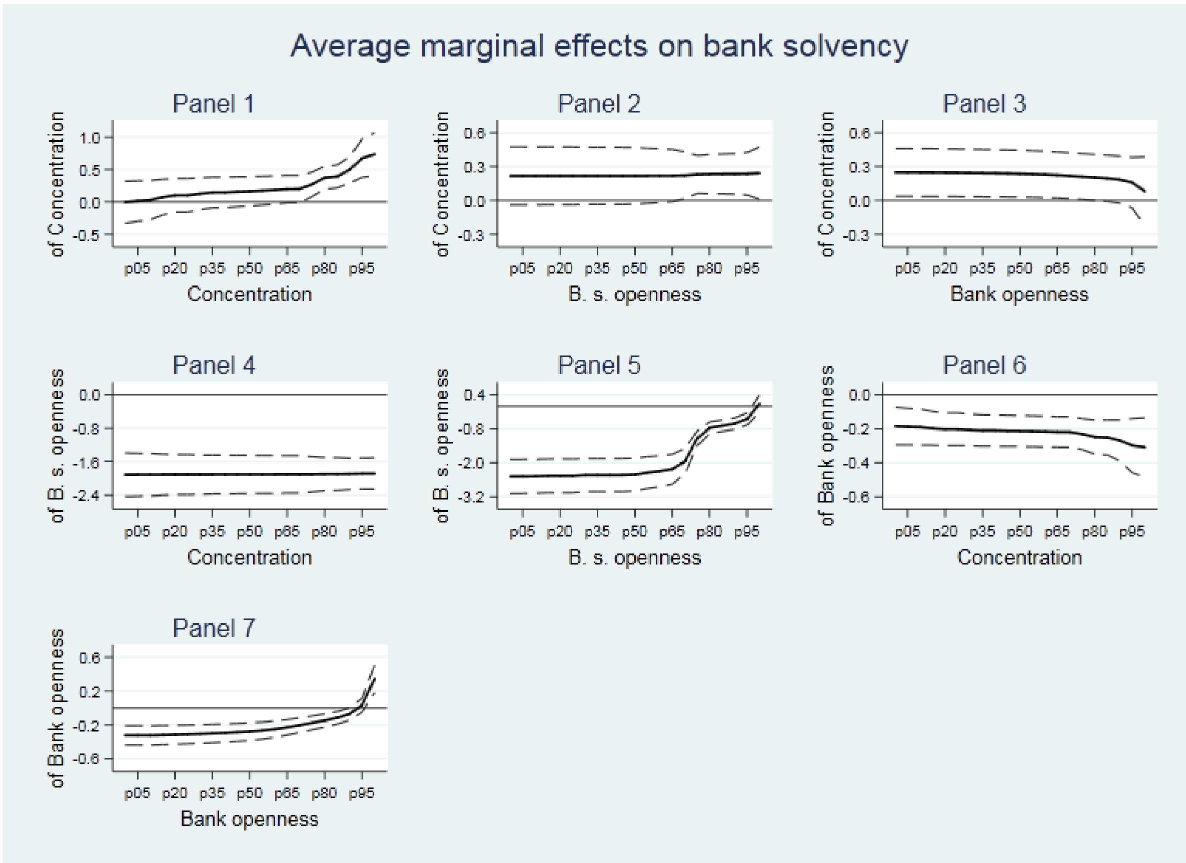

Figure 9 shows the average marginal effects of concentration, banking system openness and bank openness on bank solvency. The first three panels describe the average marginal effect of concentration with respect to variations of percentiles of concentration (Panel 1), banking system openness (Panel 2) and bank openness (Panel 3). Panels 4 and 5 show how changes in concentration and banking system openness affect the average marginal effect of banking system openness on bank solvency. Panels 6 and 7 follows the same analysis, focusing on how changes in concentration and bank openness affect the average marginal effect of bank openness, on bank solvency. Dashed lines represent 90% confidence intervals.

Figure 10: Four cases: marginal effects on bank solvency.

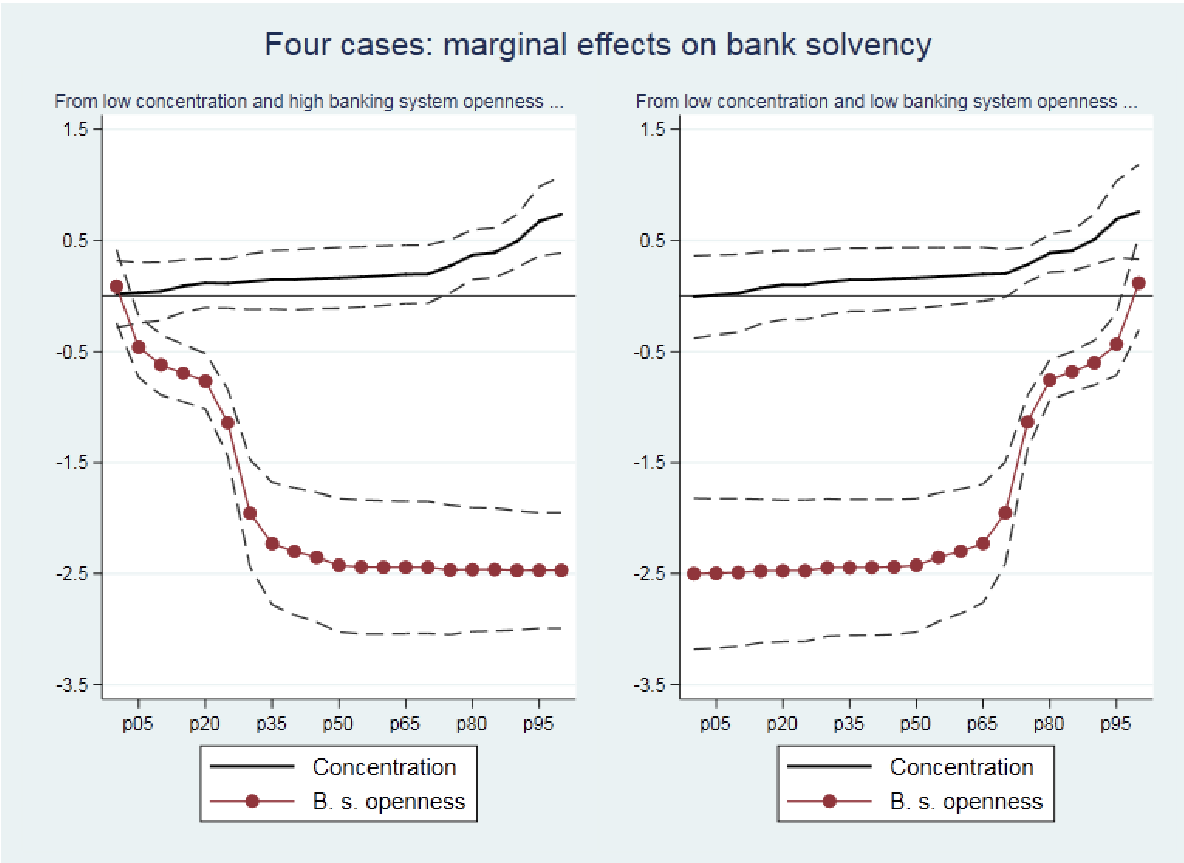

Figure 10 shows the marginal effects of concentration and banking system openness on bank solvency. Panel 1 considers these effects at 1^{st} percentile for concentration and 99^{th} percentile for banking system openness, with the first one increasing until its 99^{th} percentile, while the second one decreasing, contemporaneously, until its 1^{st} percentile. Panel 2 considers the marginal effects of concentration and banking system openness on bank solvency, with both concentration and banking systemic openness increasing at the same pace. Dashed lines represent 90% confidence intervals.

Figure 11: Four cases: marginal effects on bank solvency.

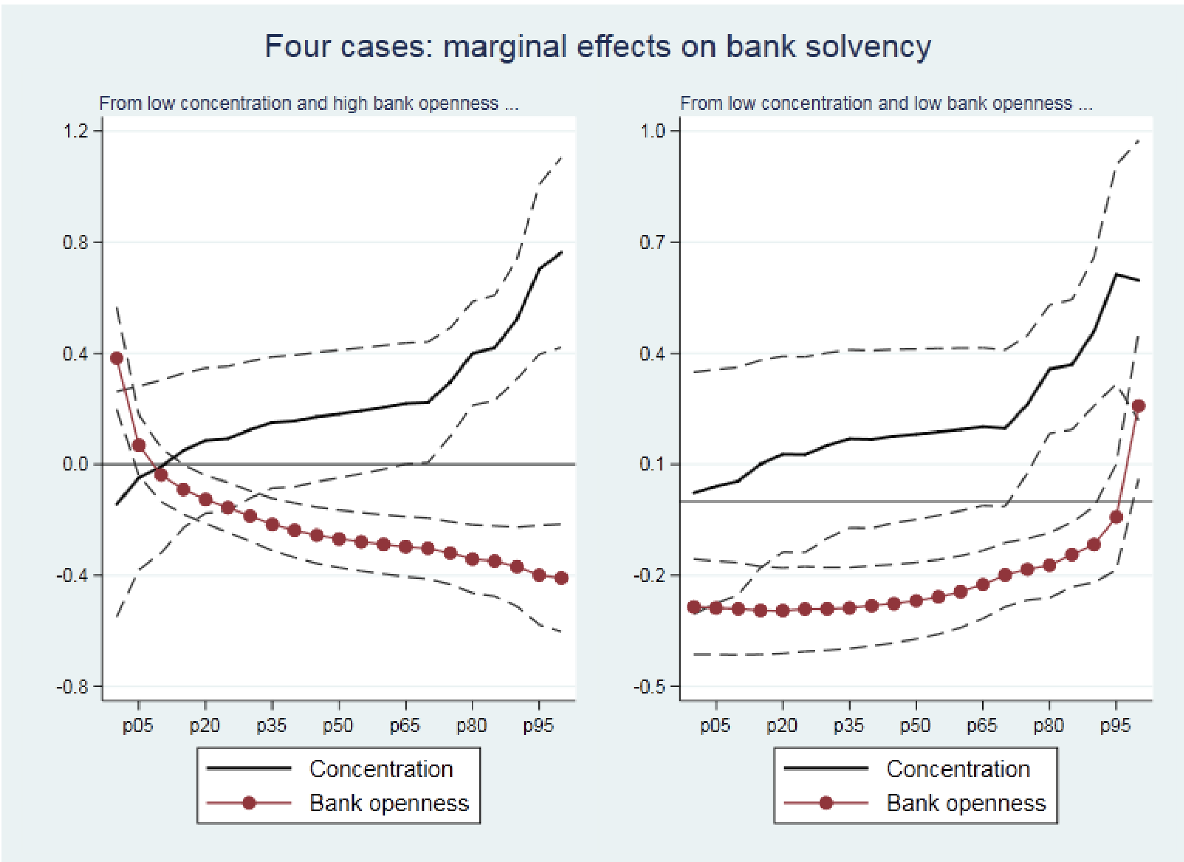

Figure 11 shows the marginal effects of concentration and bank openness on bank solvency. Panel 1 considers these effects at 1^{st} percentile for concentration and 99^{th} percentile for bank openness, with the first one increasing until its 99^{th} percentile, while the second one decreasing, contemporaneously, until its 1^{st} percentile. Panel 2 considers the marginal effects of concentration and bank openness on bank solvency, with both concentration and bank openness increasing at the same pace. Dashed lines represent 90% confidence intervals.

Table 6: Systemic banking crisis: change of model specification and dependent variable definition.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
B. system leverage ratio	-7.952**	-6.069**	-6.945	-7.952	-0.523**	-1.374***	-1.018***	-7.876**	-27.335***
	(3.512)	(2.495)	(4.751)	(6.119)	(0.216)	(0.276)	(0.294)	(3.908)	(7.785)
Real interest rate	-17.711***	-12.001**	-38.065***	-17.711**	-1.398***	-1.201*	-0.804	-7.636	3.339
	(6.314)	(5.958)	(13.093)	(7.723)	(0.511)	(0.656)	(0.560)	(6.960)	(37.088)
B. system return on equity	0.008	1.041	-29.188**	0.008	-0.131	-0.227**	-0.509*	0.784	-22.652
	(1.434)	(1.306)	(12.554)	(1.861)	(0.183)	(0.114)	(0.289)	(1.184)	(32.005)
Concentration	3.465	5.016	3.634	3.465	0.237	1.159*	2.499***	6.096	-6.967
	(4.413)	(3.786)	(5.722)	(6.212)	(0.372)	(0.698)	(0.885)	(5.927)	(17.291)
Concentration^2	-5.383*	-6.242**	-8.719**	-5.383	-0.349	-1.029**	-1.814***	-7.524*	-6.487
	(3.196)	(2.842)	(3.827)	(4.499)	(0.246)	(0.439)	(0.566)	(4.397)	(13.377)
Concentration x *Real interest rate*	24.587***	17.036**	47.855***	24.587**	1.881***	2.111***	1.521***	14.591*	10.346
	(7.845)	(8.116)	(15.798)	(10.524)	(0.580)	(0.696)	(0.588)	(8.488)	(45.358)
Concentration x *B. s. return on equity*	-2.457	-3.523*	24.592*	-2.457	-0.013	0.150	0.355	3.569*	17.865
	(2.105)	(2.142)	(12.973)	(2.716)	(0.211)	(0.154)	(0.329)	(1.911)	(34.844)
B. system openness$_{-1}$	5.568*	-5.000**	4.099	5.568	0.284	-0.094	-0.557	-14.541**	14.926*
	(3.352)	(2.263)	(4.387)	(3.656)	(0.263)	(0.454)	(0.598)	(6.387)	(9.046)
B. system openness$^2_{-1}$	-11.184***	-0.010	-12.652***	-11.184***	-0.355***	-0.513***	-0.386**	-7.799*	-33.206**
	(3.430)	(1.321)	(4.228)	(3.648)	(0.127)	(0.187)	(0.167)	(4.346)	(13.844)
Concentration x *B. s. openness*$_{-1}$	4.451	6.320**	8.048*	4.451	0.082	0.680	1.036	21.684***	16.073
	(3.145)	(3.100)	(4.291)	(4.044)	(0.287)	(0.478)	(0.636)	(7.474)	(11.648)
Country FE	No	No	No	No	No	Yes	Yes	No	No
Time FE	No	No	No	No	No	Yes	Yes	No	No
Country controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Observations	1,204	1,204	1,023	1,204	1,204	1,204	1,023	791	413
R^2	0.301	0.210	0.433	0.301	0.215	0.387	0.453	0.264	0.708
Test for Concentration non-linearity	0.002	0.001	0.000	0.028	0.007	0.002	0.002	0.016	0.001
Test for B. s. openness$_{-1}$ non-linearity	0.004	0.087	0.005	0.009	0.017	0.019	0.044	0.011	0.053

Table 6 presents a set of logit regressions of the probability of observing a systemic banking crisis on banking system concentration, its square, its interaction with real interest rate and banking system return on equity, banking system openness, banking system openness' square and the interaction between banking system concentration and openness. (1) reports the estimation of Table 3's regression (5). Regression (2)'s dummy crisis is replaced by the one that follows Reinhart & Rogoff (2009)'s systemic banking crisis definition. (3) has the same specification of (1), but the time series starts in 1999. Regression (4) is the same of (1), but robust standard errors are clustered at country level. Regressions' coefficients are estimated following a linear probability model specification (5), with the addition of country and time fixed effects (6), whose times series starts from 1999 (7). Regression (8) shows the coefficients of column (1) regressions before 2007 Global Financial Crisis, while regression (9) considers the successive period. Banking system leverage ratio is considered in every specification. For the sake of brevity, I omitted from the table the following control variables: Real GDP growth, logarithm of GDP p.c., Depreciation rate, M2/Reserves ratio, Terms of trade change, Inflation rate, Credit growth$_{-2}$. Standard errors robust to heteroskedasticity (when not differently stated above) are in parentheses. Significance *** at 1% level, ** at 5% level, * at 10% level.

Table 7: Banking system solvency: change of model specification and dependent variable definition.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
B. system leverage ratio	6.767***	6.767***	48.309***	6.731***	5.872***	7.001***	5.753**
	(1.407)	(1.601)	(7.493)	(1.356)	(1.545)	(1.436)	(2.542)
Real interest rate	0.295	0.295	11.318	-1.025	0.028	2.281	-2.214
	(2.451)	(2.731)	(8.757)	(2.220)	(2.495)	(2.811)	(4.302)
B. system return on equity	6.429*	6.429*	0.383	2.547	5.487	5.893*	6.125
	(3.691)	(3.697)	(3.157)	(2.215)	(4.349)	(3.555)	(4.088)
Concentration	-5.213*	-5.213*	-42.490***	-4.317*	-6.119*	1.005	2.708
	(2.662)	(3.105)	(13.909)	(2.506)	(3.147)	(3.553)	(6.141)
Concentration^2	5.883***	5.883***	35.875***	3.888**	5.821***	-0.361	0.720
	(1.644)	(1.950)	(9.291)	(1.644)	(1.930)	(2.104)	(3.839)
Concentration x *Real interest rate*	-1.025	-1.025	7.884	-0.197	-1.590	-1.714	1.613
	(2.776)	(2.982)	(10.828)	(2.548)	(2.942)	(3.079)	(5.065)
Concentration x *B. s. return on equity*	-7.089*	-7.089*	-0.294	-2.797	-5.986	-6.696*	-6.594
	(3.758)	(3.773)	(4.625)	(2.354)	(4.443)	(3.657)	(4.660)
B. system openness$_{-1}$	4.958***	4.958***	29.302***	2.181	3.001	-1.309	3.333
	(1.722)	(1.915)	(10.798)	(1.608)	(2.039)	(2.265)	(3.924)
B. system openness$^2_{-1}$	0.910*	0.910*	0.641	1.247**	0.930	0.158	2.817
	(0.512)	(0.550)	(3.729)	(0.534)	(0.582)	(0.584)	(2.520)
Concentration x *B. s. openness*$_{-1}$	-6.704***	-6.704***	-33.153***	-4.419***	-4.792**	0.571	-4.290
	(1.807)	(1.995)	(12.269)	(1.696)	(2.204)	(2.338)	(3.950)
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	998	998	1,023	1,042	998	574	424
R^2	0.531	0.531	0.748	0.390	0.379	0.635	0.592
Test for Concentration non-linearity	0.000	0.000	0.000	0.011	0.001	0.916	0.004
Test for B. s. openness$_{-1}$ non-linearity	0.002	0.005	0.025	0.015	0.085	0.832	0.152

Table 7 presents a set of OLS regressions of the country *c*'s z-score on banking system concentration, its square, its interaction with real interest rate and banking system return on equity, banking system openness, banking system openness' square and the interaction between banking system concentration and openness. (1) reports the estimation of Table 4's regression (5). Regression (2) is the same of (1), but robust standard errors are clustered at country level. Regression (3)'s dependent variable is not taken in logarithms. Regression (4) uses the logarithm of z-score, when return on assets' standard deviation is computed with a three-year rolling window, as well as regression (5), whose time series starts from 1999. Regression (6) shows the coefficients of column (1) regressions before 2007 Global Financial Crisis, while regression (7) considers the successive period. Banking system leverage ratio is considered in every specification as well as country and time fixed effects. For the sake of brevity, I omitted from the table the following control variables: Real GDP growth, logarithm of GDP p.c., Depreciation rate, M2/Reserves ratio, Terms of trade change, Inflation rate, Credit growth$_{-2}$. Standard errors robust to heteroskedasticity (when not differently stated above) are in parentheses. Significance *** at 1% level, ** at 5% level, * at 10% level.

Table 8: Bank solvency: change of model specification and dependent variable definition.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
B. system leverage ratio	1.753***	1.753***				3.136***	2.827***	1.667***	2.637***
	(0.348)	(0.366)				(0.373)	(0.407)	(0.470)	(0.581)
Bank leverage ratio	4.042***	4.042***	4.023***	4.023***	4.195***	2.996***	3.119***	2.775***	5.008***
	(0.167)	(0.183)	(0.161)	(0.174)	(1.071)	(0.150)	(0.164)	(0.219)	(0.302)
Real interest rate	-1.055**	-1.055**				0.057	-0.940	0.179	1.637
	(0.454)	(0.454)				(0.515)	(0.537)	(0.541)	(1.191)
B. system return on equity	0.740***	0.740***				1.033***	1.160***	0.371*	0.853**
	(0.221)	(0.225)				(0.277)	(0.266)	(0.202)	(0.3859)
Bank return on equity	1.566**	1.566**	1.470**	1.470**	3.414**	1.425**	1.348**	0.305	1.834*
	(0.718)	(0.740)	(0.728)	(0.752)	(1.633)	(0.585)	(0.744)	(0.397)	(0.940)
Concentration	-0.268	-0.268				0.099	0.029	1.377***	0.510
	(0.393)	(0.421)				(0.360)	(0.429)	(0.389)	(0.561)
Concentration^2	0.528**	0.528**				-0.284	0.261	-1.004***	-0.849**
	(0.240)	(0.358)				(0.266)	(0.270)	(0.278)	(0.397)
Concentration x *Real interest rate*	1.840***	1.840***				-1.443**	1.157	-0.164	0.405
	(0.602)	(0.602)				(0.683)	(0.706)	(0.735)	(1.205)
Concentration x *B. s. return on equity*	-1.101***	-1.101***				-1.335***	-1.874***	-0.461	-0.853
	(0.352)	(0.357)				(0.476)	(0.428)	(0.338)	(0.548)
Concentration x *Bank return on equity*	0.075	0.075	0.213	0.213	-3.170	-0.127	0.889	0.946*	0.234
	(0.850)	(0.890)	(0.889)	(0.932)	(1.929)	(1.043)	(0.860)	(0.533)	(1.109)
B. system openness$_{-1}$	-2.756***	-2.756***				-2.603***	-3.083***	-1.209**	-2.355***
	(0.532)	(0.576)				(0.489)	(0.582)	(0.600)	(0.678)
B. system openness$^2_{-1}$	2.263***	2.263***				2.242***	2.150***	0.756	1.765***
	(0.419)	(0.455)				(0.420)	(0.459)	(0.470)	(0.556)
Concentration x *B. s. openness*$_{-1}$	0.043	0.043				0.238	0.605	0.708	0.370
	(0.379)	(0.418)				(0.354)	(0.443)	(0.474)	(0.577)
Bank openness$_{-1}$	-0.232**	-0.232*	-0.313***	-0.313**	49.292**	-1.016***	-0.724***	-0.206	-0.443**
	(0.115)	(0.126)	(0.115)	(0.126)	(23.526)	(0.114)	(0.139)	(0.148)	(0.186)
Bank openness$^2_{-1}$	0.356***	0.356***	0.419***	0.419***	1.996	0.525***	0.658***	0.279***	0.488***
	(0.075)	(0.081)	(0.075)	(0.081)	(1.310)	(0.093)	(0.091)	(0.107)	(0.119)
Concentration x *Bank openness*$_{-1}$	-0.177	-0.177	-0.147	-0.147	-101.933**	0.831***	0.219	-0.434*	-0.121
	(0.187)	(0.208)	(0.187)	(0.207)	(46.726)	(0.173)	(0.226)	(0.244)	(0.327)
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country x Time FE	No	No	Yes	Yes	Yes	No	No	No	No
Country controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	101,627	101,627	101,627	101,627	102,493	125,798	118,536	50,513	51,114
R^2	0.686	0.686	0.694	0.694	0.377	0.555	0.565	0.724	0.765
Test for Concentration non-linearity	0.002	0.008	–	–	–	0.066	0.099	0.001	0.012
Test for B. s. openness$_{-1}$ non-linearity	0.000	0.000	–	–	–	0.000	0.000	0.131	0.002
Test for Bank openness$_{-1}$ non-linearity	0.000	0.000	0.000	0.000	0.078	0.000	0.000	0.029	0.000

Table 8 presents a set of OLS regressions of the bank b's z-score on banking system concentration, its square, its interaction with real interest rate and banking system return on equity, banking system and bank openness, banking system and bank openness' squares and the interaction between banking system concentration and, respectively, banking system and bank openness. (1) reports the estimation of Table 5's regression (5). Regression (2)'s coefficients standard errors are clustered at bank level. Regression (3) adds country x time fixed effects as well as regression (4), whose coefficients' standard errors are clustered at bank level. Regression (5) has the same specification of (4), but its dependent variable is not taken in logarithm. Regression (6)'s dependent variable is the logarithm of the bank z-score, when return on assets' standard deviation is computed with a three-year rolling window, as well as for regression (7), whose time series starts from 1999. Regression (8) shows the coefficients of column (1) regressions before 2007 Global Financial Crisis, while regression (9) considers the successive period. Banking system and bank leverage ratios are considered in every specification as well as bank and time fixed effects. For the sake of brevity, I omitted from the table the following control variables: Real GDP growth, logarithm of GDP p.c., Depreciation rate, M2/Reserves ratio, Terms of trade change, Inflation rate, Credit growth$_{-2}$. Standard errors robust to heteroskedasticity (when not differently stated above) are in parentheses. Significance *** at 1% level, ** at 5% level, * at 10% level.

Table 9: Systemic banking crisis: change of concentration definition.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
B. system leverage ratio	-7.952**	-7.696**	-10.938**	-7.839*	-8.326**	-8.969***	-7.892**
	(3.512)	(3.467)	(4.384)	(4.045)	(3.460)	(3.410)	(3.604)
Real interest rate	-17.711***	-15.149**	-23.254***	-35.140***	-12.168***	-3.267	0.562
	(6.314)	(6.628)	(9.033)	(11.533)	(4.605)	(2.775)	(1.975)
B. system return on equity	0.008	0.596	-1.129	1.183	0.443	-0.760	-0.834
	(1.434)	(2.059)	(2.401)	(3.505)	(1.151)	(0.768)	(0.866)
Concentration	3.465	4.046	0.022	-5.508	-0.476	-6.210***	-6.733***
	(4.413)	(4.147)	(3.349)	(5.776)	(3.093)	(1.948)	(2.630)
Concentration^2	-5.383*	-6.694**	-5.144	-0.995	-2.162	3.667*	4.863*
	(3.196)	(2.979)	(2.424)	(4.018)	(2.356)	(2.141)	(2.805)
Concentration x *Real interest rate*	24.587***	20.853**	27.827***	46.247***	21.048***	17.808**	-2.643
	(7.845)	(8.468)	(9.997)	(14.145)	(6.347)	(7.153)	(7.597)
Concentration x *B. s. return on equity*	-2.457	-3.076	-0.630	-5.110	-3.772*	-4.358**	-1.883
	(2.105)	(2.982)	(3.308)	(4.281)	(1.931)	(2.094)	(5.533)
B. system openness$_{-1}$	5.568*	4.865	4.428	5.599	7.045**	7.631***	6.031**
	(3.352)	(3.196)	(2.993)	(3.594)	(3.093)	(2.248)	(2.559)
B. system openness$^2_{-1}$	-11.184***	-12.144***	-15.302***	-14.194***	-11.087***	-11.268***	-8.620***
	(3.430)	(3.641)	(3.772)	(3.762)	(3.389)	(2.873)	(3.181)
Concentration x *B. s. openness*$_{-1}$	4.451	6.602*	11.384***	7.677**	2.883	7.034**	4.779
	(3.145)	(3.567)	(3.620)	(3.751)	(2.841)	(3.114)	(5.444)
Country controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,204	1,204	1,204	1,204	1,204	1,204	1,163
R^2	0.301	0.315	0.310	0.326	0.302	0.283	0.283
Test for Concentration non-linearity	0.002	0.000	0.000	0.000	0.013	0.006	0.038
Test for B. s. openness$_{-1}$ non-linearity	0.004	0.003	0.000	0.000	0.004	0.000	0.026

Table 9 presents a set of logit regressions of the probability of observing a systemic banking crisis on banking system concentration, its square, its interaction with real interest rate and banking system return on equity, banking system openness, banking system openness' square and the interaction between banking system concentration and openness. (1) reports the estimation of Table 3's regression (5). In regression (2) *Concentration*$_{-1}$ is considered, while the first year concentration and the average concentration level are used, respectively, in (3) and (4) for every period. Concentration of the three largest banks is considered in (5), while HHI is used in (6). The first lag of Lerner index is considered in (7). Banking system leverage ratio is considered in every specification. For the sake of brevity, I omitted from the table the following control variables: Real GDP growth, logarithm of GDP p.c., Depreciation rate, M2/Reserves ratio, Terms of trade change, Inflation rate, Credit growth$_{-2}$. Standard errors robust to heteroskedasticity are in parentheses. Significance *** at 1% level, ** at 5% level, * at 10% level.

Table 10: Banking system solvency: change of concentration definition.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
B. system leverage ratio	6.767***	6.723***	7.256***	6.894***	6.974***	7.398***	5.514***
	(1.407)	(1.423)	(1.440)	(1.370)	(1.470)	(1.428)	(1.365)
Real interest rate	0.295	-1.676	-4.023	-2.561	1.736	-0.893	-0.512
	(2.451)	(2.542)	(3.042)	(3.499)	(1.976)	(1.088)	(1.048)
B. system return on equity	6.429*	6.919*	4.282	10.824**	4.072***	1.604	1.176
	(3.691)	(3.963)	(2.618)	(4.453)	(1.234)	(1.055)	(0.898)
Concentration	-5.213*	-2.974			-0.963	0.340	5.139***
	(2.662)	(2.522)			(1.518)	(0.778)	(1.017)
Concentration^2	5.883***	3.891**			1.928*	1.469*	-3.840***
	(1.644)	(1.601)			(1.014)	(0.812)	(1.103)
Concentration x *Real interest rate*	-1.025	1.641	3.687	2.926	-3.364	1.143	4.354*
	(2.776)	(2.758)	(3.213)	(3.920)	(2.287)	(2.916)	(2.459)
Concentration x *B. s. return on equity*	-7.089*	-7.634*	-4.917*	-12.090***	-4.175***	-3.913**	-5.191*
	(3.758)	(4.016)	(2.716)	(4.612)	(1.539)	(1.758)	(2.762)
B. system openness$_{-1}$	4.958***	4.782***	4.027**	6.368**	3.378***	0.631	0.045
	(1.722)	(1.680)	(1.978)	(2.910)	(1.028)	(0.761)	(0.792)
B. system openness$^2_{-1}$	0.910*	0.926*	0.339	0.788	1.031*	0.933	1.877***
	(0.512)	(0.518)	(0.524)	(0.513)	(0.530)	(0.574)	(0.642)
Concentration x *B. s. openness*$_{-1}$	-6.704***	-6.488***	-5.371**	-8.162**	-5.352***	-4.536***	-5.990***
	(1.807)	(1.736)	(2.102)	(3.244)	(1.122)	(0.877)	(1.211)
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	998	998	998	998	998	998	957
R^2	0.531	0.523	0.501	0.518	0.511	0.513	0.539
Test for Concentration non-linearity	0.000	0.000	–	–	0.000	0.001	0.000
Test for B. s. openness$_{-1}$ non-linearity	0.028	0.000	0.034	0.002	0.000	0.004	0.020

Table 10 presents a set of OLS regressions of the country c's z-score on banking system concentration, its square, its interaction with real interest rate and banking system return on equity, banking system openness, banking system openness' square and the interaction between banking system concentration and openness. Banking system leverage ratio is considered in every specification as well as country and time fixed effects. (1) reports the estimation of Table 4's regression (5). In regression (2) $Concentration_{-1}$ is considered, while the first year concentration and the average concentration level are used, respectively, in (3) and (4) for every period. Concentration of the three largest banks is considered in (5), while HHI is used in (6). The first lag of Lerner index is considered in (7). For the sake of brevity, I omitted from the table the following control variables: Real GDP growth, logarithm of GDP p.c., Depreciation rate, M2/Reserves ratio, Terms of trade change, Inflation rate, Credit growth$_{-2}$. Standard errors robust to heteroskedasticity are in parentheses. Significance *** at 1% level, ** at 5% level, * at 10% level.

Table 11: Bank solvency: change of concentration definition.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
B. system leverage ratio	1.753***	2.191***	2.204***	1.848***	2.293***	2.163***	2.001***
	(0.348)	(0.330)	(0.345)	(0.328)	(0.352)	(0.338)	(0.356)
Bank leverage ratio	4.042***	4.059***	4.020***	4.061***	4.016***	4.046***	4.024***
	(0.167)	(0.168)	(0.166)	(0.168)	(0.169)	(0.166)	(0.165)
Real interest rate	-1.055**	2.933	-1.791***	1.049*	2.916***	-0.330	-0.913***
	(0.454)	(0.532)	(0.349)	(0.576)	(0.456)	(0.250)	(0.281)
B. system return on equity	0.740***	-0.202	0.006	0.688***	-0.514	0.132	-0.040
	(0.221)	(0.260)	(0.277)	(0.244)	(0.337)	(0.162)	(0.119)
Bank return on equity	1.566**	1.867**	1.874***	1.982**	2.208***	1.691***	1.281*
	(0.718)	(0.776)	(0.595)	(0.824)	(0.668)	(0.405)	(0.682)
Concentration	-0.268	-0.811*			0.369	-0.862*	0.892***
	(0.393)	(0.436)			(0.376)	(0.459)	(0.265)
Concentration^2	0.528**	1.112***			0.630*	-0.737	-2.642***
	(0.240)	(0.332)			(0.325)	(0.537)	(0.397)
Concentration x *Real interest rate*	1.840***	-4.346***	2.791***	-1.856**	-5.429***	1.288	4.676***
	(0.602)	(0.621)	(0.469)	(0.754)	(0.649)	(1.343)	(1.176)
Concentration x *B. s. return on equity*	-1.101***	0.525	0.199	-0.959**	1.041**	-0.132	0.897
	(0.352)	(0.377)	(0.465)	(0.384)	(0.515)	(0.645)	(0.604)
Concentration x *Bank return on equity*	0.075	-0.493	-0.895	-0.791	-1.441	-1.798	1.340
	(0.850)	(0.922)	(0.959)	(1.051)	(0.980)	(1.783)	(1.930)
B. system openness$_{-1}$	-2.756***	-0.664	-2.457***	-2.041***	-2.556***	-3.038***	-2.851***
	(0.532)	(0.430)	(0.509)	(0.608)	(0.467)	(0.363)	(0.414)
B. system openness$^2_{-1}$	2.263***	2.331***	2.133***	2.240***	2.900***	2.126***	2.323***
	(0.419)	(0.377)	(0.398)	(0.398)	(0.401)	(0.390)	(0.424)
Concentration x *B. s. openness*$_{-1}$	0.043	-2.603***	0.967***	-0.947	-0.999**	2.682***	0.567
	(0.379)	(0.377)	(0.482)	(0.606)	(0.406)	(0.576)	(0.486)
Bank openness$_{-1}$	-0.232**	-0.632***	-0.386***	-0.520***	-0.430***	-0.365***	-0.294***
	(0.115)	(0.112)	(0.087)	(0.149)	(0.103)	(0.072)	(0.103)
Bank openness$^2_{-1}$	0.356***	0.296***	0.368***	0.338***	0.364***	0.341***	0.349***
	(0.075)	(0.077)	(0.080)	(0.078)	(0.082)	(0.076)	(0.075)
Concentration x *Bank openness*$_{-1}$	-0.177	0.550***	0.061	0.392	0.189	0.470	-0.160
	(0.187)	(0.181)	(0.176)	(0.281)	(0.204)	(0.346)	(0.297)
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	101,627	101,668	101,627	101,681	101,671	101,681	101,576
R^2	0.686	0.685	0.686	0.686	0.689	0.686	0.687
Test for Concentration non-linearity	0.002	0.000	–	–	0.000	0.005	0.000
Test for B. s. openness$_{-1}$ non-linearity	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Test for Bank openness$_{-1}$ non-linearity	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 11 presents a set of OLS regressions of the bank b's z-score on banking system concentration, its square, its interaction with real interest rate and banking system return on equity, banking system and bank openness, banking system and bank openness' squares and the interaction between banking system concentration and, respectively, banking system and bank openness. (1) reports the estimation of Table 5's regression (5). In regression (2) *Concentration*$_{-1}$ is considered, while the first year concentration and the average concentration level are used, respectively, in (3) and (4) for every period. Concentration of the three largest banks is considered in (5), while HHI is used in (6). The first lag of Lerner index is considered in (7). Banking system and bank leverage ratios are considered in every specification as well as bank and time fixed effects. For the sake of brevity, I omitted from the table the following control variables: Real GDP growth, logarithm of GDP p.c., Depreciation rate, M2/Reserves ratio, Terms of trade change, Inflation rate, Credit growth$_{-2}$. Standard errors robust to heteroskedasticity are in parentheses. Significance *** at 1% level, ** at 5% level, * at 10% level.

Table 12: Systemic banking crisis: change of banking system openness definition.

	(1)	(2)	(3)	(4)	(5)	(6)
B. system leverage ratio	-7.952**	-9.943***	-10.645***	-11.531***	-8.455**	-10.465***
	(3.512)	(3.320)	(3.359)	(3.504)	(3.578)	(3.361)
Real interest rate	-17.711***	-17.359***	-17.234***	-18.098***	-17.841***	-17.708***
	(6.314)	(5.591)	(6.132)	(6.189)	(6.291)	(5.582)
B. s. return on equity	0.008	-0.465	-0.392	-0.376	-0.070	-0.455
	(1.434)	(1.508)	(1.416)	(1.456)	(1.416)	(1.492)
Concentration	3.465	1.050	6.080	5.748	3.395	0.913
	(4.413)	(4.159)	(4.801)	(5.370)	(4.425)	(4.164)
$Concentration^2$	-5.383*	-3.585	-5.653*	-5.536*	-5.341*	-3.542
	(3.196)	(3.028)	(3.047)	(3.287)	(3.225)	(3.037)
Concentration x *Real interest rate*	24.587***	23.235***	23.291***	24.556***	24.600***	23.617***
	(7.845)	(6.938)	(7.538)	(7.622)	(7.813)	(6.919)
Concentration x *B. s. return on equity*	-2.457	-1.585	-1.733	-1.830	-2.340	-1.553
	(2.105)	(2.064)	(1.882)	(1.976)	(2.097)	(2.070)
$B.\ system\ openness_{-1}$	5.568*	6.407**	4.309	10.990**	5.693*	6.426**
	(3.352)	(3.262)	(3.838)	(5.369)	(3.211)	(3.155)
$B.\ system\ openness^2_{-1}$	-11.184***	-14.462***	-2.579	-12.016**	-10.807***	-13.630***
	(3.430)	(3.574)	(2.734)	(5.845)	(3.161)	(3.373)
Concentration x $B.\ s.\ openness_{-1}$	4.451	5.424*	-0.770	-0.738	4.132	5.204*
	(3.145)	(3.224)	(3.137)	(4.182)	(2.956)	(3.039)
Country controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,204	1,273	1,204	1,204	1,204	1,273
R^2	0.301	0.291	0.278	0.275	0.301	0.292
Test for Concentration non-linearity	0.002	0.003	0.036	0.027	0.002	0.002
Test for B. s. $openness_{-1}$ non-linearity	0.004	0.000	0.531	0.093	0.002	0.000

Table 12 presents a set of logit regressions of the probability of observing a systemic banking crisis on banking system concentration, its square, its interaction with real interest rate and banking system return on equity, banking system openness, banking system openness' square and the interaction between banking system concentration and openness. (1) reports the estimation of Table 3's regression (5). Regression (2)'s banking system openness is not lagged by one period, while (3) and (4) use, respectively, the first year banking system openness and the average banking system openness for every period. Banking system openness is not normalized by banking system assets, but through banking system liabilities (5). Regression (6) uses the non-lag banking system openness of (5). Banking system leverage ratio is considered in every specification. For the sake of brevity, I omitted from the table the following control variables: Real GDP growth, logarithm of GDP p.c., Depreciation rate, M2/Reserves ratio, Terms of trade change, Inflation rate, Credit $growth_{-2}$. Standard errors robust to heteroskedasticity are in parentheses. Significance *** at 1% level, ** at 5% level, * at 10% level.

Table 13: Banking system solvency: change of banking system openness definition.

	(1)	(2)	(3)	(4)	(5)	(6)
B. system leverage ratio	6.767***	6.539***	6.754***	6.735***	6.798***	6.542***
	(1.407)	(1.398)	(1.434)	(1.437)	(1.390)	(1.393)
Real interest rate	0.295	-0.147	0.289	0.279	0.266	-0.184
	(2.451)	(2.471)	(2.464)	(2.444)	(2.441)	(2.464)
B. system return on equity	6.429*	6.434*	6.311*	6.182*	6.433*	6.451*
	(3.691)	(3.693)	(3.623)	(3.633)	(3.682)	(3.694)
Concentration	-5.213*	-5.029*	-5.483**	-5.300*	-4.739*	-4.882*
	(2.662)	(2.610)	(2.770)	(2.745)	(2.642)	(2.609)
Concentration^2	5.883***	5.732***	5.671***	5.667***	5.764***	5.688***
	(1.644)	(1.644)	(1.656)	(1.647)	(1.641)	(1.643)
Concentration x *Real interest rate*	-1.025	-0.568	-1.078	-1.104	-0.982	-0.525
	(2.776)	(2.802)	(2.802)	(2.777)	(2.767)	(2.791)
Concentration x *B. s. return on equity*	-7.089*	-7.110*	-6.973*	-6.831*	-7.079*	-7.125*
	(3.758)	(3.765)	(3.693)	(3.705)	(3.749)	(3.766)
B. system openness$_{-1}$	4.958***	6.262***			5.411***	6.055***
	(1.722)	(1.616)			(1.516)	(1.491)
B. system openness$^2_{-1}$	0.910*	-0.130			0.772	-0.164
	(0.512)	(0.520)			(0.476)	(0.494)
Concentration x *B. s. openness*$_{-1}$	-6.704***	-6.713***	-4.112**	-5.519**	-7.079***	-6.377***
	(1.807)	(1.729)	(1.925)	(2.729)	(1.605)	(1.594)
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Country controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	998	1,067	998	998	998	1,067
R^2	0.531	0.531	0.523	0.523	0.534	0.531
Test for Concentration non-linearity	0.000	0.000	0.000	0.000	0.000	0.000
Test for B. s. openness$_{-1}$ non-linearity	0.028	0.013	–	–	0.006	0.007

Table 13 presents a set of OLS regressions of the country c's z-score on banking system concentration, its square, its interaction with real interest rate and banking system return on equity, banking system openness, banking system openness' square and the interaction between banking system concentration and openness. (1) reports the estimation of Table 4's regression. Regression (2)'s banking system openness is not lagged by one period, while (3) and (4) use, respectively, the first year banking system openness and the average banking system openness for every period. Banking system openness is not normalized by banking system assets, but through banking system liabilities (5). Regression (6) uses the non-lag banking system openness of (5). Banking system leverage ratio is considered in every specification as well as country and time fixed effects. For the sake of brevity, I omitted from the Table the following control variables: Real GDP growth, logarithm of GDP p.c., Depreciation rate, M2/Reserves ratio, Terms of trade change, Inflation rate, Credit growth$_{-2}$. Standard errors robust to heteroskedasticity are in parentheses. Significance *** at 1% level, ** at 5% level, * at 10% level.

Table 14: Bank solvency: change of banking system and bank openness definitions.

	(1)	(2)	(3)	(4)	(5)	(6)
B. system leverage ratio	1.753***	1.652***	1.816***	2.027***	1.809***	1.746***
	(0.348)	(0.345)	(0.360)	(0.346)	(0.352)	(0.349)
Bank leverage ratio	4.042***	3.997***	4.166***	3.392***	4.148***	4.539***
	(0.167)	(0.170)	(0.174)	(0.370)	(0.169)	(0.154)
Real interest rate	-1.055**	-1.019**	-1.082**	-0.912**	-0.951**	-1.046**
	(0.454)	(0.459)	(0.460)	(0.454)	(0.458)	(0.469)
B. system return on equity	0.740***	0.769***	0.803***	0.808***	0.762***	0.658***
	(0.221)	(0.224)	(0.219)	(0.215)	(0.224)	(0.221)
Bank return on equity	1.566**	1.587**	1.605**	1.401**	1.593**	2.498***
	(0.718)	(0.718)	(0.723)	(0.656)	(0.719)	(0.541)
Concentration	-0.268	-0.248	-0.353	-0.808*	-0.133	0.108
	(0.393)	(0.384)	(0.429)	(0.431)	(0.381)	(0.344)
Concentration^2	0.528**	0.521**	0.856***	0.686***	0.541**	0.400*
	(0.240)	(0.239)	(0.246)	(0.241)	(0.237)	(0.228)
Concentration x *Real interest rate*	1.840***	2.063***	2.173***	2.030***	1.792***	1.919***
	(0.602)	(0.610)	(0.626)	(0.600)	(0.610)	(0.625)
Concentration x *B. s. return on equity*	-1.101***	-1.061***	-1.064***	-1.097***	-1.076***	-0.932***
	(0.352)	(0.355)	(0.341)	(0.341)	(0.355)	(0.352)
Concentration x *Bank return on equity*	0.075	0.045	0.019	0.181	0.031	-0.881
	(0.850)	(0.850)	(0.856)	(0.785)	(0.849)	(0.728)
B. system openness$_{-1}$	-2.756***	-1.134***			-1.038***	-0.893**
	(0.532)	(0.402)			(0.394)	(0.348)
B. system openness$^2_{-1}$	2.263***	0.585*			0.667**	0.566**
	(0.419)	(0.310)			(0.281)	(0.272)
Concentration x *B. s. openness*$_{-1}$	0.043	-0.188	-0.896*	1.403**	-0.404	-0.441
	(0.379)	(0.360)	(0.497)	(0.581)	(0.335)	(0.315)
Bank openness$_{-1}$	-0.232**	-0.651***			0.010	-0.021
	(0.115)	(0.125)			(0.045)	(0.028)
Bank openness$^2_{-1}$	0.356***	0.344***			0.000***	0.000***
	(0.075)	(0.092)			(0.000)	(0.000)
Concentration x *Bank openness*$_{-1}$	-0.177	0.122	-0.067	-0.985***	-0.086	-0.130**
	(0.187)	(0.213)	(0.262)	(0.317)	(0.095)	(0.066)
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Country controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	101,627	101,623	101,037	102,330	101,491	101,478
R^2	0.686	0.686	0.685	0.682	0.686	0.692
Test for Concentration non-linearity	0.000	0.002	0.000	0.008	0.000	0.000
Test for B. s. openness$_{-1}$ non-linearity	0.014	0.018	–	–	0.026	0.036
Test for Bank openness$_{-1}$ non-linearity	0.000	0.000	–	–	0.017	0.000

Table 14 presents a set of OLS regressions of the bank b's z-score on banking system concentration, its square, its interaction with real interest rate and banking system return on equity, banking system and bank openness, banking system and bank openness' squares and the interaction between banking system concentration and, respectively, banking system and bank openness. (1) reports the estimation of Table 5's regression. Regression (2)'s banking system and bank openness are not lagged by one period, while (3) and (4) use, respectively, the first year banking system (and bank) openness and the average banking system (and bank) openness for every period. Banking system and bank openness are not normalized by banking system and bank assets, but through banking system and bank liabilities (5). Regression (6) uses the non-lag banking system and bank openness of (5). Banking system and bank leverage ratios are considered in every specification as well as bank and time fixed effects. For the sake of brevity, I omitted from the Table the following control variables: Real GDP growth, logarithm of GDP p.c., Depreciation rate, M2/Reserves ratio, Terms of trade change, Inflation rate, Credit growth$_{-2}$. Standard errors robust to heteroskedasticity are in parentheses. Significance *** at 1% level, ** at 5% level, * at 10% level.