Credit growth, information sharing and macro-prudential policies in low and middle-income countries

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Abstract

Identifying determinants of financial vulnerabilities is an important question in the economic literature and in policy circles. While many works have studied this issue in the case of developed and emerging economies, the literature focusing on low-income countries is scarce. In this paper, we fulfill this gap by studying the determinants of financial vulnerabilities, measured by annual change of the ratio of non-performing loans to loans, for a sample of 87 developing countries including 25 low-income countries. The results show that credit growth is the main driver of financial vulnerability but its effect is mitigated by the presence of credit information sharing. This mitigation effect also exists in low-income countries, even if the credit growth direct effect is smaller. Sub-Saharan African countries do not significantly differ from other developing economies. These results are robust to alternative measures of financial vulnerabilities.

Introduction

Global financial crisis has shown the vulnerability of financial systems. It has consequently stressed the need for improving the management of financial vulnerability. Policymakers are looking for a more efficient range of tools to identify and to provide an adequate response to financial vulnerability increases. Given the origin of the crisis and the strong financial integration between the high-income economies, the analysis was initially focused on these countries. However, the course of the financial crisis has shown that major systemic risks also exist in emerging markets, given their size and their increasing integration into international financial markets (Bekiros, 2013, Syriopoulos et al., 2015, Baur,

2012). The analysis of the mechanisms and instruments of financial stabilization was therefore extended to middle-income economies, with the aim of adapting the analysis to the characteristics of their financial systems (Agenor & Pereira Da Silva, 2011, Wang and Sun, 2013, Gopinath, 2011). Conversely, very little work has been devoted to the analysis of financial stability in low-income countries (LIC). This work seeks to fill this gap, taking care to analyze the specificity of the mechanisms involved in the low-income countries, to identify effective instruments in the context of their financial systems.

A wide range of financial regulation reforms have been discussed since the onset of the financial crisis, with the view to reduce financial fragility. The first category seeks to reduce the interdependence between the actors of the financial system, on one hand between domestic financial institutions (separation of deposit banks and investment banks) and on the other hand with non-resident financial institutions (restrictions or taxation on international financial flows). The second category aims to change the behavior of financial institutions to reduce their risk taking. It seeks in particular to strengthen the effectiveness of the micro-prudential supervision, both by tightening some rules and improving compliance to these rules. Given the development of international banking groups, it seems essential to establish cross-border supervision. Another track reform is to broaden the supervision of banks to other financial institutions, in particular the shadow banking sector. A third tool is the emergence of macro-prudential policy.

Macro-prudential policies may be defined as the "set of measures and institutional frameworks that is specifically aimed at containing risks in the financial system as a whole" (Vinals, 2011), and thus do not target individual financial institutions (as micro-prudential policies). To achieve this goal, macroprudential policies seek to mitigate two problems: i) the pro-cyclicality of financing (leverage and herd behavior) that generates abrupt reversals of credit and liquidity cycles, ii) the concentration of risk on some financial institutions and financial markets that are highly integrated with the domestic and international financial system (in other words, they are the "nodes" of financial networks).

To address these two problems macro-prudential policy set up rules that depend on the position in the cycle or on the bank's size. The rules are more stringent during the upswing and demanding for systemic banks. Three main categories of macro-prudential tools may be defined (Claessens, 2014)¹. The first category targets borrowers and set-up time-varying caps on loan-to-value (LTV), debt-to-income (DTI). The second category deals with the banks' balance sheet structure, and relies on time-varying

¹ A fourth category is dedicated to taxation and a fifth to « other tools ».

limits on credit growth (CG), limits on foreign lending (FC), or reserve requirements (RR). The third category aims at building buffers to enhance resilience to shocks, through countercyclical capital requirements, leverage restrictions, and dynamic provisioning (surcharge of provisions for loan losses during expansions). These instruments have been widely used since 2008, particularly by emerging countries. This fact is consistent with the idea that these instruments correct market imperfections (Claessens, 2014). Early empirical studies indicate that these measures had a relatively good efficiency in curbing housing price growths, bank leverage and credit growth (Claessens, 2013, Kuttner and Shim, 2013, Zhang and Zoli, 2014).

The financial stability issue is less studied in low-income countries, insofar as the risks they face are lower than in high and middle income economies. First, the size of their financial system is smaller (measured as the ratio credit over GDP), which means that a loss of value of assets will have less impact on economic activity. Second, the various financial institutions are less interconnected and related to financial markets. In other words domestic financial integration is lower, which reduces the risk of financial contagion. Third, international financial integration is also weaker, not only de jure (restrictions on financial flows), but also de facto (smaller flows). Financial systems in LICs thus seem less vulnerable to financial crises.

However, a better understanding of financial fragility mechanisms in LICs is crucial. First, financial vulnerability does exist. The experience of low-income countries shows that they could suffer sharp increases in non-performing loans and banking crises (see Leaven and Valencia, 2008). Second, the cost of banking crises is high and particularly long-lasting in LICs. Indeed, in low-income countries, confidence in the banking system is weak and a banking crisis may permanently hinder the development of banking services demand (see for instance the CEMAC and WAEMU experiences after eighties and early nineties banking crises). Third, financial vulnerability will grow in the next decades. The current dynamics of financial development in many LICs will, in parallel with its beneficial effects on access to financial services, increase the risk of financial instability, unless financial regulation is progressively adapted to this evolution. New risks arise from the increase in the relative size of the financial sector, from the diversification of financial products and from the deepening of domestic and international financial integration. Fourth, reforms are more efficient during quiet periods. The design of control instruments is greatly improved if it is made during periods of moderate vulnerability. Its implementation will also be more readily accepted by financial institutions if the standards seem at that time achievable.

Until now, the main risk of financial vulnerability is a rapid growth of non-performing loans (NPL), without an adequate increase in financial provisions for loan losses. The most frequent sequence is the following: i) a strong increase in credits (credit boom/bubble) accompanied by a decrease in the quality of loan screening, ii) with some delay, a strong increase of non-performing loans, iii) a strong inertia of NPLs growth when the NPL surge is identified. Indeed, even if the screening is tightened on new loans, the existing stock of old loans will induce an upward trend of NPL for several years. The end of the NPL episode may be either a banking crisis (including bankruptcies and/or a restructuration of the banking system, or "only" a phase of write off of bad loans and a recapitalization of banks having suffered significant losses. In both cases, is frequently observed a credit fall after the NPL cycle.

Given these points, the analysis of financial vulnerability in LICs is of particular interest. The main goal of this paper is to improve the understanding of financial vulnerability in LICs to provide efficient tools for financial stability. Compared to the literature, this paper provides four main contributions: First, it will integrate most low-income countries, while literature has focused until now on middle-income and high income countries; ii) second, we focus our analysis on the dynamics of non-performing loans rather than on financial crises, arguing that the analysis of the NPL dynamics allows to better anticipate the financial vulnerability in LICs and then to reduce the cost of NPL cycles; iii) We focus our empirical analysis on NPL variations rather than on NPL stock, to reflect the timing of the relationship between credit growth and NPL; iv) fourth, we analyze if the impact of credit growth on financial vulnerability depends on the existence of information sharing on credit.

We estimate the annual change of the ratio of NPLs to total loans on credit growth, information sharing and control variables. Our main interest is to test – through an interactive variable - if information sharing dampens the positive effect of credit growth on NPL increases. We combine bank-level and country-level databases to build our dataset. The sample used covers 87 developing countries including 25 low-income countries and 37 Sub-Saharan African countries over the period 2008-2014 (cf. table 1). The main results are the following: i) Credit information sharing mechanisms attenuate the detrimental impact of credit expansion on financial fragility; ii) This mitigation effect also exists in low-income countries, even if the credit growth direct effect is smaller, iii) Sub-Saharan African countries do not significantly differ from other developing economies.

The remainder of the paper is organized as follows. Section 2 provides a literature review on financial vulnerability and its links with credit growth and information sharing schemes. Sections 3 and 4 present respectively the empirical methodology and the results of our estimations. Section 5 concludes.

2. Financial vulnerability literature

Four main strands of literature have been used to define our way of analyzing financial vulnerability. These strands deal with i) financial crises leading indicators, ii) the determinants and effects of credit booms, iii) the determinants of non-performing loans and, iv) the effects of information sharing systems. It has driven the choice of our financial fragility variable (NPL variations), our interest variables (credit growth and information sharing), sample design (country panel) and other determinants of financial fragility.

2.1 Why using the change in non-performing loans?

The dynamics of NPL has significant effects on the dynamics of credit even when a banking crisis is avoided, since it will dampen both credit supply (credit channel) and demand. First, the provisioning for bad debts reduces the level of capital and thus the potential for bank credit. Second, the existence of a high level of NPL creates uncertainty on the financial soundness of the bank and reduced its access to finance (Diwan and Rodrik, 1992). Third, the NPL management itself is costly and reduces resources available (human and financial) to supply credits. On the demand side, over-indebted firms anticipate that a significant part of their future profits will be transferred to banks as debt service, which limits their willingness to borrow (Myers, 1977). The combination of these effects will reduce credit after a NPL peak, and induce a decrease in investment and economic growth. Therefore, there is need to identify early and to give a policy response to NPL increases to reduce the economic cost of NPL cycles.

Compared to the occurrence of banking crisis, the NPL variable has thus two major advantages. First, it will track all episodes of financial fragility - and not only episodes that end with a banking crisis. Second, as an intermediate variable between risk-taking operations and financial crises, it will provide earlier information on financial fragility. In addition, episodes of banking crisis in low-income countries are rare since the late 1990s, which limits the reliability of the estimates made on the probability of crisis.²

The choice of using the variations in the NPL ratio rather than its level is based on the experience of banking systems in developing economies and the relationship between credit and NPL. The experience of developing countries shows that financial systems are able to withstand for a long time

² The alternative indicators used in the literature (Z-score, equity ratios) are less relevant to give policy recommendations, since they are either less transparent or or less linked to the lending policy (equity ratios). The Z-score is computed using Return on asset (ROA), volatility of ROA and the ratio equity/assets.

moderate levels of NPL without undergoing crisis if bank capital structure is consistent with this level of NPL (larger interest margins, higher equity ratios) (Brock and Suarez, 2000, Beck and Hesse, 2009). However, financial stability is threatened by a rapid increase in NPL, which does not allow the financial structure to adapt, since the latter can only evolve slowly. For instance, the peak of the ratio of NPLs to loans in 2009 was a signal of the banking crisis in Nigeria, albeit the level of NPLs was moderate in previous years. The recent global financial crisis provides another evidence of this difference between the level and difference of NPLs to signal fragility in banking systems. In addition, there are no positive and significant correlation between credit growth and the ratio of NPL (see Figure A1 in annex). This paradoxical result is notably linked to the usual sequence of credit booms, in which the increase in NPL ratio comes at the end of the boom period and continues after the peak of credit..

The increase in default risk is supposed to be managed through the loan loss provisioning. A charge is made to income statement (provision for loan loss) which builds up loan loss reserves in the balance sheet. An increase in NPLs does not induce problems if NPLs are covered by an adequate level of provisions. Therefore, the best measure of financial vulnerability should be "net NPLs" (gross level of NPLs minus provisions). The quality of "net NPLs" to assess financial vulnerability relies on the way of establishing these provisions. Loans loss reserves depend not only on the probability of default but also the amount that a lender can recover in case of default (collateral). Banks accumulate basic/minimum reserves computed as a fraction of total loans (thus independent from individual credit risks) and additional reserves calculated according to the default risk of each loan (grading of the loan). Ideally, provisions should be forward-looking, to assess the losses expected in the remaining life of the loan. However, banks often create too little provisions in good times and delay provisioning for bad loans when difficulties occur (Laeven and Majnoni, 2003). This bias has been enhanced by the use of inadequate international accounting standard (IAS 39). Following this standard, a reserve can be established after one or more loss event has occurred ("incurred loss model"). In this backward-looking system, provisions tend to be low before the crisis and rise sharply during the loan losses occur. It has been criticized for "only permitting loan losses to be recognized fairly late in the credit cycle and as a consequence, to be pro-cyclical in nature"³. Therefore, net NPLs provide poor information on the evolution of financial vulnerability (see section 3.2 for further details).

³ Angklomkliew et al. 2009, Issues and development of loan loss provisioning: the case of Asia, p.71

2.2 Why using country-level data?

Since the seminal work of Salas and Saurina (2002), a large literature has investigated the determinants of NPLs using case-country or cross-country studies (see Beck et al. 2015, Louzis et al., 2012; Beck, et al., 2015). Klein (2013) uses bank-level data to analyze the determinants of the NPL level in Central, Eastern and South Eastern Europe (CESEE). He found that several bank-level have a significant effect. The level of equity impacts negatively the NPL ratio, which is consistent with a theoretical reduction of bank moral hazard (Hellman et al., 2000). Cost efficiency has an ambiguous effect on NPL. On the one hand, a low cost efficiency may be a signal of a global poor management (including loans screening and monitoring). On the other hand, high cost efficiency may be the result of too little resources allocated to loan management ("skimping" hypothesis). Lastly, excess bank lending - measured as lagged lending growth - increases NPL ratios. However, as mentioned by Klein himself, the overall explanatory power of bank-level variables is very low.⁴. f

Moreover the aim of this paper is to provide policy makers with useful information for conducting macro-prudential policies. It is therefore logical to focus on macroeconomic indicators available systematically and promptly to conduct macro-prudential policy. However, bank-level data is used (after aggregation) to broaden the range of low-income countries included in our sample.

2.3 Determinants of financial vulnerability

Financial vulnerability of the banking system depends on two combined factors. The macroeconomic environment will affect the economic riskiness of all projects. On the other hand bank risk-taking behavior will determine to what extent risky projects will be financed. Several features of the macroeconomic situation may affect borrowers' capacity to service their debt. GDP growth and improved terms of trade increase borrowers' repayment capacity and should reduce the financial fragility. Conversely, rising unemployment, rising real interest rates and the depreciation of the exchange rate in a context of external borrowing should increase financial fragility. The theoretical effect of inflation is ambiguous since inflation reduces the real value of debt service but can also reduce the borrowers' income. Empirical literature identifies a negative impact of GDP growth and improved terms of trade on the likelihood of a banking crisis (Demirguc-Kunt and Detragiache, 1998, Kaminsky and Reinhart, 1999) and on NPL ratio (Glen and Mondragon-Vélez, 2011), Klein, 2013, Beck et al. 2015).

⁴ We obtained the same result using a developing economies sample drawn from the Bankscope database.

Conversely, these studies find a positive impact of inflation and unemployment on financial vulnerability (bank crisis likelihood and NPL ratio).

Financial fragility also depends on the risk-taking by banks in their credit operations. The magnitude of credit risk depends on the rate of credit growth, the quality of credit screening and the diversification of the credit portfolio. Unlike credit growth, the quality of the credit selection and portfolio diversification are not readily observable. Therefore, it is useful to include in the analysis the characteristics of the banking system that affect the incentives for banks to take risks. First, the bank risk-taking is affected by the institutional framework, *i.e.* domestic banking regulation (micro-prudential policy), existence of a deposit insurance scheme or information sharing schemes and financial liberalization. Even if most regulations aim at promoting financial stability, theory predicts that regulations may have an ambiguous influence on it. For instance, existence of deposit insurance might avoid a bank run during a crisis, but it also may intensify the incentives to increase risks due to moral hazard. A second example is given by capital requirements (Rochet, 1992).

Some studies have identified significant impacts of these institutional variables on financial vulnerability. The likelihood of banking crises is increased by financial liberalization (Demirguc-Kunt and Detragiache, 1998) and the generosity of insurance deposit (Demirguc-Kunt and Detragiache, 2002). Barth, Caprio and Levine (2004) analyze the impact of a wide range of banking regulations on bank-level financial soundness indicators. However, most of these studies rely on cross-section or long-run sample to get some variability on these institutional factors. Given the relative shortness of our sample, these variables exhibit a strong inertia that not allows testing their impact on financial vulnerability. Information sharing having experienced a significant development, its impact may more easily tested (see below section 2.5)

Second, the banking market structure may also alter bank incentives. According to the "competition fragility view", the rise in competition will reduce bank margins and give them incentives to increase their risk-taking to preserve banks yields. Conversely, the "competition stability view » argues that market power will increase interest rates and thus the extent of moral hazard and adverse selection from borrowers. It may also increase moral hazard from banks (according to the "too big to fail" effect). These combined effects should induce riskier loan portfolios. When the test is made on the banking crisis likelihood, the majority of works are in line with the competition-stability view, while the evidence is more mixed using bank-level financial indicators (Léon, 2014).

2.4. Why credit growth is a key indicator to manage financial vulnerability in developing economies?

The rationale for choosing credit growth as a variable of interest in the context of developing economies is twofold. First, it allows suggesting policy recommendations with short-term effects. Indeed, economic policy recommendations drawn from academic works on the impact of institutions are well known and - mostly – consensual, as pointed out by Gourinchas et al. (2001) « Eliminating distorsions and improve incentives through increased supervision and training, the establishment of safer, more transparent banking standards ». The main tools of this policy agenda are: i) improving implementation of micro-prudential banking regulations; ii) improve accounting standards and reliability; iii) Developing information sharing schemes. However most these institutional factors exhibit a strong inertia and would hardly be significantly improved in the short-run. This justifies focusing on alternative short-run tools to enhance financial stability. The definition of macro-prudential policies based upon basic variables seem adequate to low-income countries

Second, the literature has shown that excessive credit growth (credit booms or credit bubbles) is one of the main drivers of financial vulnerability. Credit booms can be caused by domestic economic policies (financial liberalization poorly regulated, or a weakly credible exchange rate anchoring) but also by external factors (surge in capital flows, positive terms of trade shock, discovery of natural resources). Credit booms are often associated with a deterioration in the quality of the loan portfolio and ultimately to an increase in non-performing loans. First, a rapid growth of credits can weaken the quality of credit screening (Dell'Ariccia, 2006). It may also push banks to concentrate their loans on a few borrowers or on one sector. Lastly, credit booms can fuel a rapid rise in asset prices (real estate and equity bubbles). Since assets may be used as collateral, the price rise will itself help an acceleration of credit growth ("financial accelerator"). In the context of low-income countries, the main risks come from the "screening" and "concentration" channels, but the asset prices channel may also exist through a real estate bubble.

Many empirical works have shown that credit growth (lagged one or two years) increases the probability of banking crises (Demirgüç-Kunt and Detragiache, 1998, Kaminsky et al., 1998, Kaminsky and Reinhart, 1999). The same result is found using credit boom indicators in Mendoza and Terrones (2008), but not in Gourinchas et al., (2001).

However, a credit boom may reflect an improvement in investment opportunities (Aghion, et al., 1999). This scenario is more plausible when the ratio credit/GDP is initially low, as is the case in low-

income countries. Indeed, some episodes of strong credit growth are not followed by a fall and therefore seem to correspond to a catch-up phenomenon (Gourinchas et al., 2001). However this rapid credit growth will induce an increase in financial fragility if the bank capacity to manage new risks is not significantly improved. To be sustainable, *i.e.* not to cause a rapid rise in NPLs, accelerating credit expansion must be accompanied by a reduction of the information asymmetry on the loan market. As mentioned above, this increase in transparency depends mainly on an improvement of accounting standards and on the development of reliable information sharing systems. The recent development of information sharing systems (credit registries) provides some time variability and gives the opportunity to test its impact on financial vulnerability, particularly if it dampens the impact of credit growth on financial fragility.

2.5 Information sharing and credit growth

Asymmetry of information on the loan market is particularly strong when the institutional framework does not allow reliable evaluation of revenues (lack of accounting rules, external audit) and guarantees (lack of land and real estate registries). The lender has two ways of collecting relevant information: i) direct (first-hand) collecting by its own services (bank screening) or ii) indirect collecting through an institution specialized in credit risk assessment, namely private credit bureaus (PCB) and public credit registries (PCR). The bank screening has typically a large fixed cost, which leads the banks to focus on transparent (large and old) borrowers. The information sharing system may provide either only credit history of credit applicants or a more comprehensive set of information.⁵

The development of PCB and PCR should reduce significantly asymmetries of information and thus combine three main mechanisms: i) Improvement of credit selection by the lenders, since the banks will get the knowledge of past credit behavior and current debt exposure. The history of past credit gives valuable signal (good or bad) on the default risk from the borrower. In addition the knowledge of existing loans from other banks reduces the risk of debt overhang; ii) Enhancement of borrowers' incentives to repay, since the default would be known by all banks, and thus may lead to credit exclusion (blacklist) or higher interest rate (Klein, 1992, Vercammen, 1995, Padilla et Pagano, 2000); iii) Mitigation of the hold-up problem, the exchange of information reduces the lending bank's ability to capture rents from private information, and thus decreases interest rates (Sharpe, 1990; Fisher, 1990; von Thadden, 2004). Therefore, the development of information sharing systems may have an impact on the volume of credit,

⁵ Other information sharing schemes exist: databases on firms balance sheet and payments incidents registers, but they are until now not systematically surveyed as credit registries and credit bureaus.

the cost of credit, the composition of credit (long-run vs short run, new borrowers) and on the default rate. For a given credit growth rate information sharing is expected to reduce the NPL ratio. The impact of credit growth may be thus conditional to the development of information sharing schemes.

A few studies have identified a negative impact of information sharing on financial fragility. Japelli and Pagano. (2002) found a negative impact of public credit registries and private credit bureaus on the "credit risk" drawn from the ICRG database. Powell et al. (2002) found a similar result on loan default rate. Houston et al. (2010) show not only that information sharing reduces bank risk taking (measured by the Z-score) but also that it mitigates the positive effect of creditors' rights on risk taking. In the same vein, in the next section we will test if information sharing is an efficient tool to mitigate the effect of credit growth on NPL ratios.

3. Data and variables

3.1 Data

To explore the determinants of financial fragility in developing countries we combine bank-level and country-level databases. Bank-level data are used to compute our dependent variable and were retrieved from the Bankscope database. Explanatory variables are extracted from the World Development Indicators, the International Financial Statistics and Doing Business. To determine which countries to include, we eliminate countries for which dependent and explanatory variables cannot be obtained. In addition, we drop countries with a GDP per capita exceeding US\$ 5,000 in 2014. Indeed, while we are primarily interested by low-income countries, we also include low-middle that income countries which remain homogeneous enough with LICs. Since we want to investigate the effects on information sharing and because of data availability in the Bankscope database, our study is limited to the period from 2008 to 2014. Our final (unbalanced) sample covers 87 developing countries including 25 low-income countries and 37 Sub-Saharan African countries. The Table 1 presents the list of countries.

Table 1: List of countries

Afghanistan*	<u>Comoros*</u>	Jordan	<u>Nigeria</u>
Albania	<u>Congo, Dem. Rep.*</u>	<u>Kenya</u>	Pakistan
Algeria	<u>Congo, Rep.</u>	Kosovo	Paraguay
<u>Angola</u>	Cote d'Ivoire	Kyrgyz Republic	Peru
Armenia	Djibouti	Lao PDR	Philippines
Azerbaijan	Ecuador	<u>Lesotho</u>	Sao T. and Principe
Bangladesh	Egypt, Arab Rep.	<u>Liberia*</u>	<u>Senegal</u>
Belarus	El Salvador	Lybia	Serbia
<u>Benin*</u>	<u>Ethiopia*</u>	Macedonia, FYR	<u>Sierra Leone*</u>
Bhutan	<u>Gambia, The*</u>	<u>Madagascar*</u>	Sri Lanka
Bolivia	Georgia	<u>Malawi*</u>	Sudan
Bosnia and Herzegovina	<u>Ghana</u>	<u>Mali*</u>	<u>Swaziland</u>
Bulgaria	Guatemala	<u>Mauritania</u>	Tajikistan
<u>Burkina Faso*</u>	<u>Guinea*</u>	Moldova	<u>Tanzania*</u>
<u>Burundi*</u>	<u>Guinea-Bissau*</u>	Mongolia	Thailand
Cape Verde	Guyana	Montenegro	<u>Togo*</u>
Cambodia*	Haiti*	Morocco	Tonga
<u>Cameroon</u>	Honduras	<u>Mozambique*</u>	<u>Uganda*</u>
Central African Republic*	India	<u>Namibia</u>	Ukraine
Chad*	Indonesia	Nepal*	Vietnam
China	Iran	Nicaragua	<u>Zambia</u>
<u>Colombia</u>	Iraq	<u>Niger*</u>	

*: Low-income countries (according to the World Bank's classification in 2014); Underlined countries are Sub-Saharan African countries

3.2 Dependent variables

Our objective is to identify factors affecting banking system (in)stability in developing countries. A critical step consists on selecting a good measure of financial fragility. There are different bank-level indicators of financial stability used in the literature including Z-score, capital ratio, assets quality, or bank defaults. Overall banking system stability is often measured by systemic banking distress, defined as periods where the banking system is not capable of fulfilling its functions. We do not adopt the same perspective in our paper for two major reasons. On the one hand, since the Asian financial distress, banking crises in developing countries are rare events.⁶ On the other hand, a banking crisis is an extreme situation. Our aim is to have an indicator reflecting the fragility of financial system before the occurrence

⁶ According to Laeven and Valencia's (2013) database, only seven countries with a GDP per capita below US\$ 5,000 have experienced a banking crisis since 1999.

of a crisis rather than detecting crisis episodes. We therefore refer to assets quality by using information on non-performing loans (NPLs) as a warning indicator of banking system fragility. Contrary to existing studies on NPLs, we employ the annual change of the ratio of NPLs to total loans as an indicator of financial stability instead of the level of NPLs. Indeed, a banking crisis is often preceded by a degradation of assets quality. The ratio of NPLs to total loans often increases just before the crisis while the level of NPLs does not really signal the fragility of a banking system.

As mentioned in section 2.2, the way banks establish provisions for loan losses reduces the reliability of the "net NPL" variable to assess financial fragility. In the Appendix (Table A2), we report evolution of the ratio of NPLs to loans, NPLs minus provisions to loans and provisions to NPLs for four countries (Albania, Belarus, Burkina and Macedonia) having experienced a rapid increase of NPLs over the period 2008-2014.⁷ We observe that a rapid increase of NPLs is not covered in short-term by sufficient provisions. We show that an increase of NPLs induce a reduction of the ratio of provisions to NPLs, which indicates that provisions are not automatically adjusted to NPLs. This figure also documents that considering variations of gross or net NPLs *(i.e.* NPLs minus provisions) does not really change our conclusions for the same reason (delayed increase of provisions). We therefore focus exclusively on gross NPLs in this paper.⁸

Our calculations are based on individual bank data drawn from the commercially available BankScope database. An advantage of the Bankscope database consists on its coverage of low-income countries.⁹ Insofar as we focus our attention on banking system, we keep commercial, savings and cooperative banks. In addition, we use unconsolidated data when available and consolidated if unconsolidated data are not available, in order not to double count subsidiaries of international banks. The share of NPLs to loans is computed as the sum of NPLs divided by the sum of total loans.

⁷ We present only a handful of countries but these trends are common in many countries experiencing rapid change of the ratio of NPLs to loans.

⁸ In addition data on provisions is less available than NPL data. The use of net NPL would reduce the sample.

⁹ Until recently, the coverage of banks in low-income countries by the Bankscope was limited but many improvements have been made during the past decade. There are two alternative databases, namely the Financial Soundness Indicators database from the IMF and a new international database on financial fragility built by Andrianova et al. (2015). Both include different indicators, especially the ratio of non-performing loans to loans. The IMF's database considers the period from 2005 to 2014 and database from Andrianova et al. (2015) for the period 1998-2012. However, the coverage of low-income countries is limited in both databases due to filters rules applied. As a result, we compute our own measure of NPLs.

3.3 Interest variables

As highlighted in the literature review, we draw special attention to credit growth, information sharing and their interaction. Case studies as well as academic papers point out that a banking crisis is often preceded by a credit boom (see Section 2.4). Our objective is to test how credit growth affects financial stability in low and middle-income countries. We expect that annual change of NPLs is positively affected by a rapid growth of credit in previous year. We employ two alternative measures of credit expansion. The first measure is the annual rate of credit growth and the second one is the annual change in the private credit-to-GDP ratio. Contrary to the annual rate of credit growth, the credit-to-GDP ratio increases only if the growth of credit exceeds the growth of GDP.

Our main objective is to test if credit information sharing alters the relationship between credit growth and NPL variations. The existing literature has studied the effect of credit information on financial stability (see section 2.5). To study the impact of information sharing, a first measure often employed is a dummy indicating whether a private bureau or a credit registry operates in a country. While the dummy variable approach tests whether the existence of credit information sharing matters, it does not distinguish between the different information provided by and the coverage of information sharing mechanisms. To circumvent this limit, an index capturing the depth of information provided is computed by Doing Business. The index ranges from 0 to 6, with higher values indicating the availability of more credit information.¹⁰ Doing Business also provides the coverage of credit information sharing mechanisms. Credit bureau (respectively credit registry) coverage reports the number of individuals and firms listed in a credit bureau's (respectively registry's) database relative to the number of adults. We add credit bureau coverage and credit registry coverage to get the total coverage of information sharing. Due to double counts, this variable may exceed 100% in countries with a credit private bureau and a credit public registry (only 12 countries. We therefore limit this variable to 100% (that concerns only three countries; Honduras, Macedonia and Salvador). In this paper, we use both the depth and the coverage to proxy the development of information sharing mechanisms.

¹⁰ Since 2013, Doing Business provides an index ranging from 0 to 8. However, to allow comparison over time, we use the former index ranging from 0 to 6. Precise description of the index can be found in Djankov et al. (2007) or in Büyükkarabacak and Valev (2012).

3.4 Control variables

The choice of other explanatory variables follows the literature on the determinants of financial crisis (Demirgüç-Kunt and Detragiache, 1998, 2002; Beck et al., 2006; Büyükkarabacak et Valev, 2010, 2012). Variables are grouped in two categories: financial system and macroeconomic factors.

The literature has provided evidence that regulation and structure of financial systems matter for stability. Theory predicts that regulations have ambiguous influence on financial stability. For instance, existence of deposit insurance might avoid a bank run during a crisis, but it also may intensify the incentives to increase risks due to moral hazard. Empirical literature has therefore investigated the effect of capital regulation, restrictions on bank entry, restrictions on nonlending activities (Barth, Caprio and Levine, 2004) or deposit insurance scheme (Demirgüç-Kunt and Detragiache, 2002; Anginer et al., 2014) on bank risk taking or financial stability. These papers use updated data on regulation from Barth, Caprio and Levine (2004) and/or deposit insurance database provided by Demirgüc-Kunt, Kane and Laeven (2015). In our paper, we focus on the structure of banking systems instead of regulation. On the contrary to banking regulation, the structure of banking system varies over time.¹¹ In addition, the level of concentration partially captures changes in terms of regulations (entry rules, capital regulation). A large literature has studied the impact of bank competition on financial stability (see: Beck et al., 2006; 2013). The degree of bank competition has ambiguous impact on financial stability (see section 2.3). The competition-fragility view posits that more competition (less concentration) among banks leads to more fragility, while the proponents of the competition-stability view argue that instability is more likely in less competitive markets (more concentration). We therefore include an indicator of concentration, namely the Hirschman-Herfindahl index, as a control variable.

It could be important to control for the ownership structure of banking systems, especially the share of public banks. Since the seminal paper of La Porta et al. (2002), a large literature has documented the relative inefficiency of public banks. The lending behavior of state-owned banks is affected by political factors (Sapienza, 2004; Dinç, 2005; Khwaja and Mian, 2005; Micco et al., 2007). We may therefore expect that a larger share of government-owned banks affect the quality of loan portfolio and perhaps the credit growth insofar as public banks are less sensitive in their lending to

¹¹ Due to the lack of variation over time, including regulation variables forces us to remove country fixed effects in cross-country studies, especially when we include low-income countries (information on regulations is rarely available at different periods of time). This raises a problem of identification. We cannot be sure that coefficients associated with regulations variables capture the impact of regulations or unobserved country characteristics (governance, political power, etc.).

macroeconomic shocks (Micco and Panizza, 2006). Unfortunately, we cannot consider public banks in our analysis. A panel analysis implies a time-varying variable, while the majority of existing studies focus on cross-country information on banks ownership structure or on a specific country analysis. To our knowledge, only Dinç (2005) and Micco et al. (2007) use information on ownership structure of each bank for each year in different countries. Even if these databases are available, we cannot use them since the y do not cover our sample period..¹² We expect that including country fixed effects control for a large share of difference between countries due to the inertia of ownership structure.

We also control for capital inflows due to their importance in recent financial crises in Asia or Latin America. We therefore control by adding the net total inflows to GDP as a control variable. We build this variable by adding portfolio, FDI and aid flows relative to GDP. In addition, we control for changes of exchange rate. A rapid exchange rate depreciation raises repayment cost for foreign currency loans and could induce less repayment. At the opposite, a rapid appreciation of the real exchange rate might render exporters less competitive and affect their ability to reimburse their loans. Exchange rate variation is computed as the percentage change of value of one dollar in local currency.

Adverse macroeconomic circumstances may induce difficulties for borrowers and thus for banks. To capture adverse macroeconomic shocks that hurt banks by increasing the share of NPLs, we use as regressors the rate of growth of real GDP and the rate of inflation. The rate of inflation is obtained by computing the annual change of GDP deflator. We expect that financial distresses are more likely in period of slow growth and high inflation. We also include the demographic growth. We finally control for political shocks. To do it, we include a dummy equal to one when a country experienced a *coup d'Etat* and 0 otherwise. The list of *coups d'Etat* is extracted from the updated database constructed by Powell and Thyne (2011).¹³

Finally to capture country heterogeneity in terms of economic and financial development, we include the level of GDP per capita and the ratio of private credit to GDP. All explanatory variables are extracted from the IFS and WDI. Summary statistics are reported in Table 2 and presentation of variable is provided in the Appendix (Table A1).

¹² The same work than those done by Micco et al. (2007) and Dinç (2005) could be made to collect information on state-ownership of banks using information provided in the Bankscope database. However, hand-collecting the data on the ultimate ownership of each bank for each year is time- and resource-consuming, especially for a control variable.

¹³ The database is available on the website of Powell (http://www.jonathanmpowell.com/coup-detat-dataset.html)

Table 2: Summary statistics

	∆(NPL)	Credit	$\Delta(\frac{PC}{CDD})$	Info	Info	GDPpc	PC/GDP	Growth	Inflat.	нні	Capital	Δ(Exch.)	Pop gr.	Coup Etat
		Growth	GDP	Depth	Cover.									
Obs	475	475	475	475	475	475	475	475	475	475	475	475	475	475
Mean	0.07	0.20	1.08	2.34	18.65	1615.1	30.97	4.46	7.73	2754.6	0.03	0.03	1.76	0.05
Std. Dev.	2.69	0.18	3.31	2.66	26.15	1291.7	23.24	3.89	9.53	2205.1	0.11	0.10	1.15	0.21
Min	-21.14	-0.15	-17.11	0	0	146.7	2.68	-14.80	-21.37	448.0	0.00	-0.14	-0.79	0
Max	16.56	1.44	18.05	6	100	6136.0	135.44	21.02	103.82	10000.0	1.39	0.68	4.18	1
Correlations														
Δ(NPL)	1													
Credit Growth	0.14	1												
Δ(PC/GDP)	0.09	0.53	1											
Info_coverage	-0.03	-0.24	-0.03	1										
Info_depth	0.01	-0.20	0.00	0.79	1									
GDPpc	0.07	-0.12	-0.02	0.60	0.61	1								
PC/GDP	0.05	-0.15	0.05	0.44	0.35	0.48	1							
Growth	0.01	0.31	-0.03	-0.13	-0.16	0.06	-0.08	1						
Inflation	-0.01	0.21	-0.26	-0.12	-0.08	-0.05	-0.10	0.12	1					
нні	-0.08	0.14	0.02	-0.29	-0.27	-0.20	-0.29	0.05	-0.02	1				
Capital	0.13	0.06	-0.06	-0.03	-0.05	0.04	0.04	0.03	0.00	0.26	1			
Δ(Exch. rate)	-0.08	-0.11	-0.18	-0.01	0.00	-0.02	-0.03	-0.15	0.28	-0.04	-0.0029	1		
Pop growth	-0.10	0.09	-0.11	-0.54	-0.48	-0.65	-0.58	0.08	0.05	0.27	0.07	0.03	1	
Coups d'Etats	-0.03	-0.05	-0.07	-0.08	-0.06	-0.09	-0.12	-0.11	-0.02	0.10	-0.05	0.00	0.14	1

4. Methodology

To investigate determinants of banking system fragility, we regress the annual change of the ratio of NPLs to total loans on credit expansion, information sharing, the interaction between credit expansion and information sharing development and a list of control variables. More formally, we estimate the following equation:

$$\Delta(NPL_{i,t}) = \alpha + \beta_1 Credit_{i,t-2} + \beta_2 IS_{i,t-2} + \beta_3 Credit_{i,t-2} * IS_{i,t-2} + \gamma C_{i,t-2} + \mu_i + \vartheta_t + \varepsilon_{i,t}$$
(1)

where $\Delta(NPL_{i,t})$ is the annual change of the ratio of NPLs to loans between t and t-1, $Credit_{i,t-2}$ is the measure of credit expansion (annual rate of credit growth or change in the ratio of credit to GDP), $IS_{i,t-2}$ the development of credit information sharing mechanisms (depth index or coverage) and $C_{i,t-2}$ a matrix of control variables (see above). To account for country and year unobserved heterogeneity, we include country (μ_i) and time (ϑ_t) fixed effects. The standard errors are clustered at the country level.

According to our hypothesis, we expect that $\beta_1 > 0$ (a rapid credit growth hurts the stability of a banking system) and that $\beta_2 < 0$ (banking system is less prone to crises in countries with a developed information sharing mechanism). We draw special attention to the coefficient associated with interaction term (β_3). A negative (respectively positive) β_3 indicates that the development of information sharing mitigates (amplify) the negative impact of credit growth. A potential concern is the endogeneity issue. Nonetheless we think that the endogeneity issue is largely reduced in our estimation. Endogeneity might be induced by different causes. Reverse causation is certainly the most important source of endogeneity in this paper. The decision to implement, develop or extend the coverage of the credit information sharing institutions may be influenced by the fragility of banking systems. To avoid this issue, we lagged all independent variables, including credit information depth and coverage. Another cause of endogeneity, certainly less likely, is the presence of an unobservable country's characteristic affecting both the functioning of credit information and financial fragility. Due to the inclusion of fixed effects, this unobservable variable has to vary over time to bias our estimation. In addition, this variable should have an impact on the development of credit information (structural mid-term evolution) and simultaneously

a rapid surge of NPLs (short-term evolution). The existence of a potential omitted variable having these characteristics seems unlikely.¹⁴

5. Empirical results

5.1 Baseline model

We report in Table 2, descriptive statistics as well as correlations. Coefficient correlations point out that (lagged) credit growth and (lagged) change in the ratio of private credit to GDP are positively correlated with change in the ratio of NPLs to total loans. Change in the ratio of NPLs to total loans seems uncorrelated with the coverage and depth of credit registry and credit bureau. Credit information is highly correlated with other country characteristics.

To control for unobserved heterogeneity and multiple correlations, we run a fixed effect model (Eq. 1). The baseline results are reported in Table 3. Results should be treated with caution due to the limited explanatory power of our model (R² ranges between 0.12 and 0.14), even if all variables are jointly significantly different from zero. The baseline model provides two main results. First, credit expansion is consistently positive and statistically significant in all specifications, irrespective of the measure of credit expansion used (annual credit growth and variation of the ratio of credit to GDP), lending support that episodes of portfolio degradation are preceded by lending booms. Second, the depth and coverage of credit information sharing mechanisms do not reduce financial fragility *per se* but they attenuate the detrimental impact of credit expansion. The coefficients associated with information sharing coverage are not statistically different from zero in the different specifications, albeit the depth is

¹⁴ Even if we do not believe that endogeneity produce a significant bias in our estimation, we have used an instrumental variables approach. Unfortunately our results are not really conclusive. Due to panel dimension, we cannot use time-invariant instruments employed in the literature such as legal origin, religion, or ethnic fragmentation (see: Djankov et al., 2007; Houston et al., 2010). Büyükkaracak and Valev (2012) propose to use the size of population and urbanization as instruments. They argue that implementation of credit information sharing is more likely in countries with large populations and in countries with large cities. Another potential instrument is the date of implementation of credit information sharing. Indeed the age of credit bureaus and credit registries may influence their coverage and depth. We therefore collect date of implantation using information provided by Djankov et al. (2007) and complete the database by hand-collecting information for countries not covered by the previous database. We use different set of instruments including demographic factors (population and urbanization), age of credit bureaus and credit registries and lagged dependent variables. Unfortunately, instruments cannot correctly explain variation of coverage and depth of information sharing mechanisms. The diagnostic tests (such as partial R²) do not pass usual thresholds. In other words, instruments are weak and results from instrumental approach are highly sensitive to specification.

negatively correlated with financial fragility.¹⁵ However, interactions between credit expansion and information sharing development (coverage and depth) are negative and statistically significant in the three out of four different specifications regressions (and are significant in all regressions if we consider a threshold of 15%). The results points out that the development of credit information does not cancel the destabilizing effect of credit expansions.¹⁶ This finding is in line with results provided by Büyükkarabacak and Valev (2012) documenting that the presence of credit information sharing mechanism reduces the effect of credit growth on banking crisis.

Among the control variables, rapid degradation of portfolio is less likely in the most developed banking systems after controlling for credit expansion. We may expect that countries with a developed financial system have gained a certain expertise in the management of assets quality. Banking concentration tends to play a stabilizing role. Coefficients associated to the degree of bank concentration are negative and statistically significant. This result gives support for the competition-fragility view in line with previous results (Beck et al., 2006; 2013). Our results also document that macroeconomics shocks do not affect NPLs variation at the exception of rapid increase of capital inflows. An increase of capital inflows in previous year is associated with a larger change of the ratio of NPLs to total loans. Albeit we do not discuss the robustness of this result, it survives to the different sensitivity tests presented below.

¹⁵ Estimations using separately public credit registries (PCR) and Private credit bureau (PCB) have been run but do not identify significantly different effects of the two types of information sharing systems. In addition, results are less robust, probably due to the reduction of variability for each variable.

¹⁶ The positive effect of credit growth turns to benegative for very high value of credit information depth and large coverage of credit information. In reality, this concerns a few number of developing countries. For instance, the sign associated to credit growth is reverted only for countries with a coverage exceeding 70% (see: turning points in columns [2] and [4]). This concerns in fact only a handful of countries in recent years (Armenia, Colombia, Ecuador, Salvador, Peru and Serbia).

Table 3: Baseline results

	[1]	[2]	[3]	[4]
Credit growth	3.335***	3.369***		
	(2.84)	(2.79)		
CG*Depth of credit information	-0.639*			
	(-1.94)			
CG*Coverage of credit information		-0.0464~		
		(-1.55)		
Δ(PC/GDP)			0.211**	0.234*
			(2.03)	(1.94)
Δ(PC/GDP)*Depth of credit information			-0.0243~	
			(-1.53)	
Δ(PC/GDP)*Coverage of credit information				-0.00333*
				(-1.82)
Depth of credit information	-0.279~		-0.354*	
	(-1.61)		(-1.96)	
Coverage of credit information		0.00482		0.00603
		(0.31)		(0.40)
GDPpc	0.00359*	0.00253	0.00319*	0.00189
	(1.86)	(1.38)	(1.86)	(1.22)
PC/GDP	-0.0867~	-0.0810~	-0.106~	-0.103~
	(-1.63)	(-1.48)	(-1.61)	(-1.55)
Growth	-0.0215	-0.0155	-0.000647	0.0140
	(-0.45)	(-0.32)	(-0.02)	(0.34)
Inflation	0.00227	0.00638	0.0218	0.0277
	(0.22)	(0.61)	(1.10)	(1.43)
Capital	10.28***	10.41***	10.70***	10.80***
	(5.64)	(5.78)	(6.43)	(6.57)
Δ(exchange rate)	-1.754	-1.744	-1.513	-1.678
	(-1.09)	(-1.07)	(-0.81)	(-0.89)
нні	-0.000571**	-0.000561**	-0.000571**	-0.000567**
	(-2.32)	(-2.24)	(-2.32)	(-2.27)
Population growth	0.329	0.133	0.581	0.340
	(0.47)	(0.19)	(0.82)	(0.50)
Coups d'Etat	0.205	0.159	-0.0794	-0.143
	(0.39)	(0.29)	(-0.15)	(-0.27)
Number of observation	475	475	471	471
Number of countries	87	87	87	87
R² within	0.14	0.12	0.13	0.12

The dependent variable is the annual change of the ratio of NPLs to total loans. Fixed effects model is used and standard errors are clustered at the country-level. Time-dummies are included (not reported. ~, *, ** and *** indicate significance level at 15, 10, 5 and 1%.

5.2 Do low-income countries and Sub-Saharan African countries differ from other developing countries?

Baseline findings point out that the detrimental effect of credit expansion is attenuated by the development of information sharing mechanisms. We investigate whether low-income countries and African economies differ from other developing countries. We therefore adapt the baseline model (Eq. 1) as follows:

$$\Delta(NPL_{i,t}) = \alpha + \beta_1 Credit_{i,t-2} + \tilde{\beta}_1 (Credit_{i,t-2} * D_i) + \beta_2 IS_{i,t-2} + \tilde{\beta}_2 (IS_{i,t-2} * D_i)$$
$$+ \beta_3 (Credit_{i,t-2} * IS_{i,t-2}) + \tilde{\beta}_3 (Credit_{i,t-2} * IS_{i,t-2} * D_i) + \gamma \boldsymbol{C}_{i,t-2} + \mu_i + \vartheta_t + \varepsilon_{i,t} \quad (2)$$

where D_i is a dummy equals to one for low-income countries (respectively Sub-Saharan African economies) and 0 otherwise. The list of LIC and African economies is presented in Table 1. To determine whether LIC and African countries differ from other developing countries we investigate the sign and significance of $\tilde{\beta}_1$, $\tilde{\beta}_2$ and $\tilde{\beta}_3$.

Table 4 provides results for specifications considering a dummy for low-income countries and Table 5 those including dummies for sub-Saharan African countries. Before investigating specificities of LIC, we check the sensitivity of our baseline results. We confirm that credit expansion hurts financial stability but the development of credit information mechanisms mitigates this negative impact of credit booms. Focusing on specificities of LIC, we only document that impact of credit expansion is attenuated for these countries. Indeed, in all specification, coefficient associated to credit growth is positive $(\beta_1 > 0)$ but coefficient associated to interactions between credit expansion and LIC dummy is negative $(\tilde{\beta}_1 < 0)$. The effect of credit growth remain positive for LIC $(\beta_1 + \tilde{\beta}_1 > 0)$ while not always statistically different from zero. Regarding other interaction terms, LIC do not seem to differ from other developing countries.¹⁷

We follow the same methodology to study whether African economies differ from other developing countries. Insofar as many low-income countries are located in Africa, results, reported in Table 5, are similar than those presented above. The effect of credit growth on financial fragility is moderated for African economies. In other aspects, especially the role played by information sharing to mitigate the detrimental impact of credit expansion, African economies do not really differ from other developing countries.

¹⁷ We also consider regressions on the sub-sample of LIC and African economies. Results, reported in the Appendix (Table A5), are broadly in line those provided by the baseline model.

Table 4: Results for LIC and other developing countries

	Credit	growth		Δ(PC/	GDP)
	[1]	[2]		[3]	[4]
Credit growth	5.0778***	5.0039***	Δ(PC/GDP)	0.2711**	0.2881**
	(3.34)	(3.26)		(2.08)	(2.05)
Credit growth*LIC	-3.9364***	-3.8459***	Δ(PC/GDP)*LIC	-0.1914~	-0.2111~
	(-2.76)	(-2.68)		(-1.50)	(-1.55)
CG*Depth of credit information	-0.9651**		Δ(PC/GDP)*Depth of credit information	-0.0373*	
	(-2.56)			(-1.76)	
CG*Depth of credit information*LIC	0.6476		Δ (PC/GDP)*Depth of credit information*LIC	0.0209	
	(0.84)			(0.73)	
CG*Coverage of credit information		-0.0712**	Δ(PC/GDP)*Coverage of credit information		-0.0044*
		(-2.05)			(-1.93)
CG*Coverage of credit information*LIC		-0.1354	Δ(PC/GDP)*Coverage of credit information*LIC		0.0006
		(-0.61)			(0.07)
Depth of credit information	-0.1536		Depth of credit information	-0.3094~	
	(-0.82)			(-1.50)	
Depth of credit information*LIC	0.0886		Depth of credit information*LIC	0.1828	
	(0.32)			(0.81)	
Coverage of credit information		0.0138	Coverage of credit information		0.0106
		(0.83)			(0.67)
Coverage of credit information*LIC		0.0577	Coverage of credit information*LIC		0.0005
		(0.67)			(0.01)
Number of observation	475	475	Number of observation	471	471
Number of countries	87	87	Number of countries	87	87
R ² within	0.16	0.14	R² within	0.13	0.12

The dependent variable is the annual change of the ratio of NPLs to total loans. Fixed effects model is used and standard errors are clustered at the country-level. Timedummies and control variables are included but not reported. Control variables include GDP per capita, ratio of private credit to GDP, real growth, inflation, capital inflows, change of the exchange rate, concentration index of banking system, population growth and a dummy for coups d'Etats. ~, *, ** and *** indicate significance level at 15, 10, 5 and 1%. Table 5: Results for SSA countries and other developing countries

	Credit	growth		Δ(PC/	GDP)
	[1]	[2]		[3]	[4]
Credit growth	4.9980***	4.7842***	Δ(PC/GDP)	0.2563*	0.2674*
	(2.92)	(2.89)		(1.95)	(1.91)
Credit growth*SSA	-2.9556~	-2.5998	Δ(PC/GDP)*SSA	-0.1365	-0.1399
	(-1.50)	(-1.29)		(-1.12)	(-1.09)
CG*Depth of credit information	-0.9617**		Δ(PC/GDP)*Depth of credit information	-0.0342~	
	(-2.27)			(-1.57)	
CG*Depth of credit information*SSA	0.4354		Δ(PC/GDP)*Depth of credit information*SSA	0.0367	
	(0.69)			(1.44)	
CG*Coverage of credit information		-0.0668*	Δ(PC/GDP)*Coverage of credit information		- 0.0040*
		(-1.76)			(-1.74)
CG*Coverage of credit information*SSA		-0.0599	Δ(PC/GDP)*Coverage of credit information*SSA		0.0029
		(-0.38)			(0.67)
Depth of credit information	-0.1343		Depth of credit information	-0.3030	
	(-0.67)			(-1.45)	
Depth of credit information*SSA	-0.0221		Depth of credit information*SSA	0.0770	
	(-0.11)			(0.59)	
Coverage of credit information		0.0117	Coverage of credit information		0.0073
		(0.73)			(0.47)
Coverage of credit information*SSA		0.0298	Coverage of credit information*SSA		-0.0248
		(0.27)			(-0.35)
Number of observation	481	481	Number of observation	477	477
Number of countries	88	88	Number of countries	88	88
R ² within	0.15	0.13	R² within	0.13	0.12

The dependent variable is the annual change of the ratio of NPLs to total loans. Fixed effects model is used and standard errors are clustered at the country-level. Timedummies and control variables are included but not reported. Control variables include GDP per capita, ratio of private credit to GDP, real growth, inflation, capital inflows, change of the exchange rate, concentration index of banking system, population growth and a dummy for coups d'Etats. ~, *, ** and *** indicate significance level at 15, 10, 5 and 1%.

5.3 Robustness checks

We run a battery of sensitivity tests to assess the robustness of our results. First, in the baseline model we focus on change of the ratio of NPLs to loans. However, we are particularly interested by episodes of portfolio degradation. We therefore test whether our main results survive when considering only periods of NPLs increases. We use two strategies. On the one hand, we keep only positive changes of the ratio of NPLs to loans. Results, reported in the Appendix (Table A2 in columns [1] to [4]), confirm our main results. Coefficients associated with credit expansion remain positive and statistically significant in all specifications, while interactions between credit growth and information sharing development are negative and statistically significant in 3 out of 4 regressions. On the other hand, we create a dummy equals to one if annual change of NPLs exceeds 5 points. This variable can be compared to crisis dummies used in many papers insofar as a crisis is often marked by a sharp increase of the ratio of NPLs to loans.¹⁸ In spite of the binary nature of this variable, we use a linear model to facilitate the interpretation of marginal effects in the presence of interactions. Using a non-linear model (such as logit or probit) does not alter our results. We confirm our main findings regarding the impact of credit expansion and the effect of credit information sharing mechanisms. Results, reported in Table A2 (columns [5] to [8]), point out that credit expansions alter loan portfolios quality, but the development of information sharing mechanisms mitigates the negative effect of credit expansion.

Second, we build two additional dependent variables based on situation of individual banks. New variables are computed in two steps. In a first step, we create a dummy identifying whether a bank is in difficulty. We consider a bank as a near-distress bank if the ratio of NPLs to loans exceeds 20%.¹⁹ In the second step, we compute for each country-year observation the percent and the cumulated market share of banks in distress. The percent of near-distress banks is given by the number of near-distress banks divided by the total number of banks. The market share is obtained by the ratio of total assets managed by near-distress banks to total assets of banks in country i in year t. We estimate the same model than previously (Eq 1). Results, reported in Table A3 (in the Appendix), confirm our main findings. First, the annual credit growth is positive and statistically significant. Coefficients associated to change in the ratio of private credit to GDP are positive but not always statistically significant at the usual thresholds

¹⁸ Rapid deterioration of loan portfolio is one of variables used to detect financial crises (Demirgüç-Kunt and Detragiache, 1998, 2002).

¹⁹ Our results are not affected by the choice of threshold (15% or 25%) used to declare a bank as a near-distress bank.

in all specifications. Third, interaction terms enter negatively and are significant in all specifications, with the exception of those considering the change in the ratio of credit to GDP to proxy credit expansion and the depth score to proxy information sharing development.

A final test of sensitivity focuses on the sample considered. In some developing countries, only a handful of banks operate. As a result, variation of NPLs might only capture the difficulties faced by one bank. To test this issue, we select country-year observations where the number of banks exceeds five and ten banks. We re-estimate our model on the two sub-samples. Results provided in Table A4 (in the Appendix) confirm our main findings. Credit expansion is detrimental for financial stability but this detrimental effect is attenuated by the development of information sharing. Coefficients associated with credit expansion are always positive and significant, while interaction terms are negative and statically different from zero in 6 out of 8 regressions.

6. Conclusion

Identifying determinants of financial vulnerabilities is an important question in the economic literature and in policy circles. While many works have studied this issue in the case of developed and emerging economies, the literature focusing on low-income countries is scarce. In this paper, we fulfill this gap by studying the determinants of financial vulnerabilities, measured by annual change of the ratio of non-performing loans to loans, for a sample of 87 developing countries including 25 low-income countries. The results show that credit growth is the main driver of financial vulnerability but its effect is mitigated by the presence of credit information sharing. This mitigation effect also exists in low-income countries, even if the credit growth direct effect is smaller. At last, sub-saharan African countries do not significantly differ from other developing economies. These results are robust to alternative measures of financial vulnerabilities

Our results, although preliminary, have several policy implications. First, a particular attention should be paid to the NPL variations. Second, the credit growth is a key variable to conduct macro-prudential policies in low and middle-income countries. Third, current efforts to develop information sharing schemes should be strengthened, since the latter allow a credit expansion without excessive increase in the overall credit risk. These results also suggest that the use of credit by sector may provide additional information on the relevant indicators to conduct macro-prudential policies. Early information

on the rise of financial vulnerability might be extracted from the sectoral credit growth rate²⁰ or sector concentrations of loans.

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²⁰ India and Korea have implemented such sector-specific rules (Angklomkliew et al; 2009)

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Appendix



Figure A1: Correlation between credit growth and Non-Performing loans (as a % of total loans)



Figure A2: NPLs and provisions in four representative countries



Belarus





Macedonia

Legend :

Blue line : NPL/Loans

Orange line: net NPLs/Loans, with net NPLs=NPLs-provisions

Green line: Provisions/NPLs

Table A1: Variables – Definitions and sources

Variable	Definition	Source
Δ(NPL)	Annual variation of the ratio of NPL to loans	Bankscope
Credit Growth	Annual rate of credit growth	WDI
Δ(PC/GDP)	Annual variation of the ratio of credit to private sector to GDP	WDI
Info_coverage	Coverage of information sharing mechanisms	Doing Business
Info_depth	Depth of information provided by the credit information sharing mechanism (ranging from 0 to 6)	Doing Business
Growth	Rate of growth of real GDP	WDI
Inflation	Percentage change in the GDP deflator	WDI
Capital inflows	(Equity inflows+FDI inflows + Bilateral aid inflows)/GDP	WDI
Δ(Exchange		
rate)	Annual variation of exchange rate (in percent)	IFS
GDPpc	Real GDP per capita	WDI
ННІ	Herfindahl-Hirschmann index of concentration in banking sector	Bankscope
Pop growth	Annual growth of the population	WDI
Coups d'Etat	Dummy equals to 1 for country experienced a coup d'Etat in year t, 0 otherwise	Powell, J. and Thyne, C.

WDI: World Development Indicators; IFS: International Financial Statistics

Table A2: Robustness checks (1/3)

	Asymetric Δ	(NPLs)>=0			Shock			
	Credi	t growth	Δ(F	PC/GDP)	Credi	t growth		Δ(PC/GDP)
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
Credit growth	4.7795***	4.4322***			0.3193***	0.3104***		
	(3.07)	(3.03)			(3.36)	(3.28)		
CG*Depth of credit information	-0.4760				-0.0530***			
	(-1.26)				(-2.78)			
CG*Coverage of credit information		-0.0585~				-0.0055**		
		(-1.55)				(-2.55)		
Δ(PC/GDP)			0.4089**	0.3095**			0.0148***	0.0120***
			(2.27)	(2.62)			(2.92)	(2.64)
Δ (PC/GDP)*Depth of credit information			-0.0882**				-0.0024**	
			(-2.00)				(-2.05)	
Δ (PC/GDP)*Coverage of credit information				-0.0075***				-0.0002**
				(-2.81)				(-2.00)
Depth of credit information	0.2630		0.5030~		-0.0162		-0.0191	
	(1.03)		(1.53)		(-1.09)		(-1.37)	
Coverage of credit information		0.0114		0.0165		-0.0012		-0.0013
		(0.60)		(0.98)		(-0.81)		(-1.00)
Control	Voc	Voc	Voc	Voc	Voc	Voc	Voc	Voc
	105	105	165	185	165	185	125	125
	223	223	221	221	475	4/5	4/1	4/1
Number of countries	//	//	//	//	8/	8/	8/	87
R ² within	0.34	0.34	0.30	0.30	0.21	0.15	0.13	0.07
F-test	16.59***	12.17***	87.59***	152.22***	79.24***	2.30***	24.51***	1.23

The dependent variable is the annual change of the ratio of NPLs to total loans (columns [1] to [4] and a dummy equals to one if annual change of the ratio of NPLs to total loans exceeds 5 points and 0 otherwise in columns [5] to [8]. Fixed effects model is used and standard errors are clustered at the country-level. Time-dummies and control variables are included but not reported. Control variables include GDP per capita, ratio of private credit to GDP, real growth, inflation, capital inflows, change of the exchange rate, concentration index of banking system, population growth and a dummy for coups d'Etats. F-test indicates the joint significance of all variables. ~, *, ** and *** indicate significance level at 15, 10, 5 and 1% resp.

Table A3: Robustness checks (2/3)

	Market shar	e managed by dis	tress banks		Percent of di	stress banks		
	Credi	t growth	Δ(F	PC/GDP)	Credit	growth	Δ(ΡΟ	C/GDP)
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
Credit growth	13.0617*	13.8446**			9.8842**	9.3892**		
	(1.95)	(2.22)			(2.35)	(2.18)		
CG*Depth of credit information	-2.9749*				-3.5970**			
	(-1.66)				(-2.56)			
CG*Coverage of credit information		-0.3866**				-0.2897*		
		(-2.48)				(-1.66)		
Δ(PC/GDP)			0.4980	0.7305**			0.4240	0.5196
			(1.09)	(2.07)			(0.93)	(1.00)
Δ(PC/GDP)*Depth of credit information			-0.0788				-0.0644	
			(-0.71)				(-0.92)	
Δ(PC/GDP)*Coverage of credit information				-0.0180***				-0.0109*
				(-2.65)				(-1.91)
Depth of credit information	-1.3644		-1.8379		-0.1205		-0.8090	
	(-1.00)		(-1.40)		(-0.14)		(-1.05)	
Coverage of credit information		0.0265		0.0079		0.0488		0.0229
		(0.37)		(0.12)		(0.71)		(0.37)
Control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of observation	475	475	471	471	475	475	471	471
Number of countries	87	87	87	87	87	87	87	87
R ² within	0.19	0.18	0.17	0.16	0.14	0.13	0.13	0.13
F-test	29.35***	29.38***	37.15***	31.14***	13.62***	13.65***	12.90***	12.95***

The dependent variable is the market share of assets managed by distress banks (columns [1] to [4] and the percent of distress banks in columns [5] to [8]. Fixed effects model is used and standard errors are clustered at the country-level. Time-dummies and control variables are included but not reported. Control variables include GDP per capita, ratio of private credit to GDP, real growth, inflation, capital inflows, change of the exchange rate, concentration index of banking system, population growth and a dummy for coups d'Etats. F-test indicates the joint significance of all variables. ~, *, ** and *** indicate significance level at 15, 10, 5 and 1%.

Table A4: Robustness checks (3/3)

	Number of c	bservations >5			Number of o	observations >10		
	Credit growth		Δ(Ρ	Δ(PC/GDP)		it growth	Δ(F	PC/GDP)
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
Credit growth	3.4872**	3.5999**			6.2464**	5.5442*		
	(2.41)	(2.44)			(2.19)	(1.98)		
CG*Depth of credit information	-0.4667				-0.9577*			
	(-1.30)				(-1.68)			
CG*Coverage of credit information		-0.0616~				-0.1080**		
		(-1.63)				(-2.01)		
Δ(PC/GDP)			0.2275**	0.2892**			0.3141**	0.3363**
			(2.00)	(2.24)			(2.31)	(2.13)
Δ(PC/GDP)*Depth of credit information			-0.014**				-0.0361*	
			(-2.17)				(-1.68)	
Δ(PC/GDP)*Coverage of credit information				-0.0040**				-0.0056***
				(-2.11)				(-3.04)
Depth of credit information	-0.3713*		-0.4186		-0.3062		-0.4841**	
	(-1.95)		(-0.78)		(-1.22)		(-2.18)	
Coverage of credit information		-0.0016		0.0047		-0.0047		-0.0032
		(-0.10)		(0.26)		(-0.22)		(-0.15)
Control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of observation	323	323	319	319	223	223	219	219
Number of countries	62	62	62	62	44	44	44	44
R ² within	0.14	0.11	0.14	0.13	0.21	0.16	0.23	0.21
F-test	2.90***	1.73*	1.93**	0.96	3.19***	4.37***	7.70***	6.62***

The dependent variable is the annual change of the ratio of NPLs to total loans. Fixed effects model is used and standard errors are clustered at the country-level. Time-dummies and control variables are included but not reported. Control variables include GDP per capita, ratio of private credit to GDP, real growth, inflation, capital inflows, change of the exchange rate, concentration index of banking system, population growth and a dummy for coups d'Etats. F-test indicates the joint significance of all variables. ~, *, ** and *** indicate significance level at 15, 10, 5 and 1%.

Table A5: Sub-samples for LIC and SSA economies

	Sub-sample A: Low income countries				Sub-sample B: SSA economies					
	Credit growth		Δ(PC/0	Δ(PC/GDP)		t growth	Δ(PC/GDP)			
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]		
Credit growth	0.194	0.4472			3.0269~	3.0817~				
	(0.25)	(0.60)			(1.50)	(1.50)				
CG*Depth of credit information	-17.3365**	*			-1.0326					
	(-4.47)				(-0.96)					
CG*Coverage of credit information		- 0.8863~				-0.1254				
		(-1.62)				(-0.71)				
Δ(PC/GDP)			0.0260	0.0384			0.2421	0.2458		
			(0.35)	(0.49)			(1.34)	(1.29)		
Δ(PC/GDP)*Depth of credit information			-1.8587***				-0.0383			
			(-8.69)				(-0.94)			
Δ(PC/GDP)*Coverage of credit information				-0.0413				-0.0049		
				(-1.37)				(-0.65)		
Depth of credit information	8.3122***		19.1807***		0.2659		0.0395			
	(4.38)		(8.66)		(0.76)		(0.21)			
Coverage of credit information		0.3936~		0.3678		0.0909		0.0544		
		(1.68)		(1.28)		(1.14)		(0.61)		
Control										
Number of observation	138	138	138	138	200	200	199	199		
Number of countries	26	26	26	26	37	37	37	37		
R ² within	0.24	0.24	0.26	0.24	0.18	0.18	0.17	0.17		

The dependent variable is the annual change of the ratio of NPLs to total loans. Fixed effects model is used and standard errors are clustered at the countrylevel. Time-dummies and control variables are included but not reported. Control variables include GDP per capita, ratio of private credit to GDP, real growth, inflation, capital inflows, change of the exchange rate, concentration index of banking system, population growth and a dummy for coups d'Etats. ~, *, ** and *** indicate significance level at 15, 10, 5 and 1%.