The Regulation of Risk-Based Capital Ratio alongside the Leverage Ratio: Implications for Credit Union Stability

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January 2021

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We acknowledge the financial support from the Social Sciences and Humanities Research Council of Canada (SSHRC), the Fonds de recherche AMF sur la gestion intégrée des risques des institutions financières, and the Fonds Conrad Leblanc.

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Abstract

US credit union (CU) recent amendments of the Prompt Corrective Action (PCA) include a new bank-like risk-based capital rule (*RBC*) that will be regulated alongside the existing net worth or leverage ratio (*LR*). The new *RBC* targeting large CUs (with assets above $500 million) will be implemented by 2022. The proposed reform draws heavy criticisms claiming that it is inadequate for the credit union business model which is different from the one followed by profit-oriented banks. This study compares the ability of the new *RBC* with the aptness of the *LR* in enhancing US CUs' solvency and in predicting their failure risk. Using semiannual panel data from NCUA call reports from 1994 to 2015, we find that the regulatory asset risk measure used in the computation of the *RBC* is congruent with credit union performance and risk measures, and that both capital measures (*RBC* and *LR)* are powerful in predicting CU solvency proxied by the *Z-score*. However, in explaining CU failure, only the *LR* matters. The relevance of the *RBC* becomes material for the prediction of failure of low-capitalized credit unions (with average *LR* of 7%). Since single bond CUs are more prone to failure than their multiple bond counterparts, regulators should give attention to membership concentration risk. In addition, since asset performance and economic conditions play an important role in the prediction of large credit unions failure, regulators should impose capital add-on based on asset performance dynamics and countercyclical capital measures especially on large credit unions.

Keywords: Credit unions (CUs), stability, failure, risk-based capital ratio (RBC)

1. Introduction

The 2007 global financial crisis gave rise to important reforms for all quarters of the financial system, especially for depository institutions (banks and credit unions (CU)). Being not systemically important, credit unions have received scant attention in the academic literature. This paper addresses issues stemming from the implementation of a minimum risk-based capital ratio (RBC) for US credit unions. The *RBC* is supposed to complement the existing simple capital to asset known as the net worth ratio or leverage ratio (LR, hereafter)[4]. The new *RBC* limit is 10% of the asset risk and will be applied on CUs with assets above $500 million[5], starting January 2022.

Insert Figure 1 about here

This reform initiated by the National Credit Union Administration (NCUA) in 2015 generates a round of criticisms from the Cooperative Credit Union Association (CCUA) on the inadequateness of a risk-adjusted capital limit on the credit union industry. Three important arguments have been put forward to justify why credit unions should be exempted from the new risk-based capital regulation. The first one is that capital play a little role in predicting credit union failure. As an illustration, commenters point out that the existing net-worth ratio (*LR*) has not played any role in predicting the failure of credit union during the last financial crisis. For example, as shown in Figure 1, 82% of the credit unions that failed in the last 10 years had enough net-worth of leverage ratio, 24 months before their bankruptcy. The second argument is related to the better performance of the deposit insurance fund (the NCUSIF)[6] during and after the last financial crisis, and other considerations[7] suggesting that credit unions have a safe business model. The third argument is the

[4] Under the new capital regime, CUs are considered as well-capitalized if they hold a risk-based capital ratio of 10% and a net worth to asset or leverage ratio of 7%. Before this new capital regime, a regulatory capital ratio in terms of capital to risk weighted assets has been applied on Credit Union (CU) with assets higher than $10 million which includes a simple leverage ratio (LR) requirement (Capital/Total assets) that must exceed 6%, and a risk-based net worth ratio (RBNW) requirement that must be lower than the LR. The RBNW is obtained as the weighted LR assigned to different asset risk classes (for more details, see section 2).

[5] The final settlement manuscript written by the NCUA on September 10, 2015 indicates that the new RBC ratio will be applying to federally insured and natural person credit unions with total asset more than $100 million but this changed in November 2018 to complex credit unions with total asset greater than $500 million.

[6] Some commenters argued that "only 112 credit unions failed during the 2007-2009 recession, costing the insurance fund less than $1 billion, which they suggested was remarkable considering the dollars and number of commercial banks that failed" (NCUA, 2015).

[7] The commenters nearly all agreed that because the proposal assigned higher risk weights to some credit union asset classes, it would have placed credit unions at a competitive disadvantage to banks. Other commenters argued that risk-based capital requirements, to which banks have been subject for approximately 25 years, have not worked well. In addition, they argued that bank regulators are now moving away from risk-based capital structures after they failed to help banks during the 2007-2009 recession. In support of this argument, many commenters cited a statement in which one FDIC Board Member, the FDIC's Vice Chairman, stated publicly that he believed the risk-based capital approach to regulation was a bad idea. (NCUA, 2015).

distinctive ownership structure of credit unions compared to banks. In fact, CUs are "member-owned" and "member-controlled" cooperative financial institutions (NCUA, 2003).[8] Accordingly, credit union objective ("non-for-profit") is to provide benefits to their members in the form of lower lending rates and higher deposit rates. On the other side, the benefits provided by banks is for shareholders, by charging customers the maximum possible lending rates and minimum deposit rate to maximize the wealth of shareholders. Given this difference in mission and vocation, there is an indication that shareholders' value increases with bank asset risk, and that credit union total assets and its risky assets should be strongly correlated. In this regard, there may be no need to impose a risk-based capital ratio to limit credit union risk-taking behavior as it is for banks.

These arguments must be contrasted with the realities of the modern credit union industry. Firstly, the "member-owned" and "member-controlled" status is somewhat weakened by the high non-participation rate in annual meetings by members. Non-participation conveys more discretionary power to managers and may embolden empire-building behavior through excessive risk-taking justified by the objective to create more value to the members. In fact, many credit union asset portfolios risks peaked during the last subprime crisis followed by substantial drops in their net worth.[9] In addition, as most of the large credit unions are occupational credit unions where members have a common employer, the loan portfolios of credit unions are expected to be concentrated among borrowers (with a common bond[10]) with similar risk profiles which may induce high levels of concentration risk and higher asset risk.[11] This notion of greater risk concentration is supported by an empirical study done by Kohers (1986) who reported that occupational credit unions serving sponsors operating in unstable business-cycle environments experienced higher loan delinquency rates and held higher levels of liquidity (Trip et al., 2014). Against this background, to reduce the burden on the NCUSIF[12] and safeguard the credit union system, ensuring that credit unions are

[8] www.ncua.gov/Resources/Documents/CUDev/Chartering%20And%20Field%20of%20Membership%20Manual.pdf

[9] According to NCUA, 46 CUs failed in 2008 and 2009, loan charge-offs surged from 0.51 percent to 1.21 percent and net worth declined from 11.41 percent to 9.90 percent. Among other things, two of the largest CUs went bankrupt due to their exposure to the mortgage market. This suggests that the new Basel III RBC would have been more effective in predicting the risk in these credit unions that share similarity with banks in terms of the complexity of their activities.

[10] A common bond is defined as the obligation of CU members to share similar occupation, association or to belong to groups within a well-defined neighborhood, community or rural district (Emmons and Schmid, 1998).

[11] Yet, concerns about the concentration of risk are softened by the fact that member proximity discourages delinquent behaviors from members. Similarly, the NCUA felt that occupational credit unions serving only a single employer had very high levels of concentration risk (Trip et al., 2004). In fact, Credit Union may switch their type of membership and by doing so, they are somehow modifying their risk profiling as the field of membership can be a source of risk concentration or risk diversification (see Frame et al., 2002; Ely, 2014; Goddard et al., 2008).

[12] CUs are relatively important in the US financial system for small business lending. Nevertheless, the reported payouts of the National Credit Union Share Insurance Fund (NCUSIF) in respect of credit union failures were $1260.9 million during years 2008 to 2011 combined (see Goddard et al, 2015).

adequately capitalized in a way that reflect their real risk is of paramount importance. Thus, by introducing the new *RBC*, regulators aim to force complex credit unions to hold more capital. Hence, constrained credit unions should find ways of filling capital shortfall due to the implementation of the new capital limits. The problems is that unlike banks, credit unions because of their members' own status[13] cannot raise capital in the financial markets. Since credit unions provide valuable service to the unbanked population, regulators should trade-off the additional stability brought by the new *RBC* ratio with the cost associated with its potential burden on credit unions lending. While differences in the ownership structure, the business model and capital adjustments need to be considered to deliver a consistent and effective capital regulation framework for credit unions, the extent to which of these differences, theoretically could induce a lower (or no limit) on a risk-based capital measure is an empirical issue.

Accordingly, we investigate the effectiveness of the *RBC* in reinforcing credit union solvency alongside the existing leverage ratio (Capital or Net worth to Total assets). We seek answers to the following research question: *If it has been imposed by regulation, would the RBC ratio outperform the existing simple leverage ratio in explaining credit unions' asset risk and solvency?*

This study is close to those that compare the performance of the *RBC* and the *LR* in the banking sector. Two strands of literature can be clearly distinguished. The first strand documents the effect of banks' leverage and risk-based capital ratio on their default probability and the second investigates the linkage between the different capital rules and banks risk measures, all with contrasting results on the role played by each ratio.

A first attempt to compare the *RBC* and the *LR* is provided by Avery and Berger (1991). They reconstruct (artificially) RBC from bank holding historical data (1982-1989) and find evidence that the RBC provides an improvement over the simple old standard (the leverage ratio). This finding is confirmed recently by Hogan and Meredith (2016) who replicate their data on more recent data (1999-2010). In the same vein, Jacques and Nigro (1997) analyze U.S. bank balance sheets in 1991, the year that *RBC* regulation took effect, and document that the *RBC* was effective at increasing bank capital and reducing portfolio risk.

[13] CUs are "member-owned, member-controlled, not-for-profit cooperative financial institution formed to permit groups of persons to save, borrow and obtain related financial services and to participate in its management" (NCUA, 2003).

In contrast to the previous literature, the hypothesis that the simple leverage ratio outperforms the complex risk-based capital ratio is strongly supported in the banking literature (Berger et al., 1995) both prior and after the 2007- subprime financial crisis. Prior to the crisis, Estrella et al. (2000), using a sample of all FDIC-insured commercial banks[14], find evidence that the leverage ratio is as performing as the complex risk-based capital ratio over one- or two-year horizons. Following the crisis, the poor performance of the risk-based capital ratio and the introduction of the leverage ratio under the Basel III framework, revived interest in analysis of the performance of capital ratios. Mayes and Stremmel (2012), using similar data but more extended[15] than the one by Estrella et al. (2000), find evidence that the simple leverage ratio outperforms the risk-based capital ratio for large and complex banks and that the two ratios performed equally in explaining the failure of banks. In the same context of the 2007 financial crisis, Demirguc-Kunt et al. (2010) compare the performance of banks stock return around the last 2007 financial crisis and find that the relation between stock performance and capital is stronger for the simple leverage ratio than it is for the risk-based capital ratio. Based on international data covering global banks (116 banks across 25 countries, with more than $100 billion in assets at end-2006) around the world from 2007 to 2009, Aikman et al. (2014) document that the leverage ratio is more powerful in predicting banks failure compared to the risk-based capital ratio. Hogan et al. (2017) also document that the simple leverage ratio is still strongly effective in the period following the subprime lending crisis. All these findings are in line with the Haldane's presentation to the 2012 Jackson Hole Conference (Haldane and Madouros, 2012). He argues that simple rules such as the leverage ratio work better as indicators of problems.

Since the literature in banking is inconclusive about the distinctive role of each capital ratio, the analysis of the new *RBC* in the credit union context, characterized by its cooperative and mutual vocation, could uncover useful insights. Our empirical strategy is designed as follows. Firstly, we reconstruct "conservative" risk-based capital ratio (*RBC*) based on credit unions historical semi-annual data spanning the year period 1994-2015. The historical (reconstructed) values of the *RBC* are obtained by weighting historical assets with their risk weights as proposed in the new *RBC* reform. Secondly, we regress credit union risk and solvency measures such as the *Z-score*[16] and

[14] Commercial banks that failed or were in business between 1989 and 1993.

[15] The data pertain to US banks for a period that includes the financial crisis (1992 to 2012).

[16] The Z-score (with his extension: Lepetit and Strobel (2013), Lepetit and Strobel (2015) identify five main approaches to compute the Z-score (see Mare et al., 2017)). It is computed as the number of standard deviations below the average ROA at which the institution would reduce its net worth (see Boyd et al., 1993; Demirgüç-Kunt and Huizinga, 2010; Laeven and Levine, 2009; Demirgüç-Kunt et al., 2008; Anginer et al., 2014; Williams, 2014; Anollia et al., 2014; Chortareas et al., 2012; Niu, 2012; Fiordelisi and Mare, 2014; Ely, 2014; Ion, 2016; Chiaramonte et al., 2016; Noth and Schüwer, 2017).

failure dummy on their risk-based and simple leverage ratio. As robustness checks, we exploit the fact that some credit unions have been optionally subject to an *RBC*-like requirement since the first introduction of the PCA in 2000, as a quasi-natural experiment to test the robustness of our main results.

To preview the outcomes, we find that both the *RBC* and the *LR* are powerful in predicting credit union solvency proxied by the Z-*score*, and that new Risk-Weighted Assets Density *(Risk-Weighted Assets/Total Assets)* is consistent with credit union performance and risk measures. However, when it comes to explaining credit unions failure, only the leverage ratio matters. The relevance of the *RBC* only becomes material in predicting failure of low-capitalized credit unions (with average net worth of 7%). Our analysis also suggests that regulators should care about membership concentration risk since single-bond credit unions are more prone to failure than their multiple-bond counterparts. Furthermore, since asset performance and economic conditions play an important role in the failure prediction of large credit unions, regulators should impose capital add-on based on asset performance dynamics and countercyclical capital measures especially for large credit unions.

To the best of our knowledge, this study is the *first* to compare the performance of the leverage ratio and the newly introduced risk-based capital ratio for credit unions. Prior to this study, only Sollenberger and Schneckenburger (1994) examine the predictive power of potential Basel-like *RBC* ratio in the context of US credit unions and find evidence of the usefulness of the risk-based capital ratio and suggest the implementation of the risk-based capital requirements in a similar fashion to those imposed on commercial banks. Since their paper is written before the Prompt Corrective Action (PCA (Part 702)) was established in 2000, this study provides a better outlook on the role that the two ratios (*RBC* and *LR*) is expected to play in the future regarding the performance of the leverage ratio during the last 2007 financial crisis.

The rest of this paper is structured as follows. In Section 2, we describe the chronology of capital regulation in the credit union industry. In Section 3 and 4, we describe respectively the data and the econometric framework. Sections 5 and 6 are devoted to the main findings and robustness check, and Section 7 concludes.

2. Capital regulation in the U.S. credit union industry

Economic capital is part of financial institutions' risk management because it allows them to absorb any source of unexpected losses. However, since credit unions benefit from a common flat deposit insurance provided by the NCUA (the National Credit Union Share Insurance Fund (NCUSIF)), it

becomes desirable to discipline their risk taking through regulatory capital regulation to reduce potential burden on the deposit insurance fund.[17]

Insert Chart 1 about here

Capital regulation in the U.S. credit union industry can be subdivided into three periods (for more detail, see Goddard et al., 2015 and Hampel, 2003).

- The period before 1998: Credit unions were required to adjust their capital reserves to their risky assets composed of loans (credit risk) and long-term investments (maturity, interest rate and liquidity risk). There were no formal limit on credit union capital reserve-to-asset ratio.

- The period from 1998 to 2019: Under Prompt Corrective Action (PCA) initiated in 1998, the section of the Credit Union Membership Access Act (CUMAA) set formal "capital" and "reserve" requirements. The requirement includes a simple leverage ratio (*LR*) requirement (Capital/Total assets) that must exceed 6% and a risk-based net worth ratio (*RBNW*) requirement that must be lower than the *LR*. The risk-based net worth requirement is only applied to credit unions with assets above $10 million (changed to $50 million by 2013). The *RBNW* is obtained as the weighted *LR* assigned to different asset risk classes. The *LR* associated with the different classes of assets varies between 0 and 20%[18] (that varies with assets' credit and interest rate risk[19]). The *LR* associated with asset classes varies with their credit and interest rate risk.

- The period after 2019: The 1998 PCA *RBNW* requirement is subjected to an amendment initiated in 2015, being effective in 2022. The new risk-based measure looks more like the Basel risk-based capital ratio (*RBC*), and it will be applied on federal credit unions with assets above $500 million. The new rules were supposed to be implemented in 2019 but were initially postponed to 2020 and then delayed to 2022 in order to conduct a well-integrated implementation.[20]

[17] Moral hazard through excessive risk-taking could arise from the fact that credit unions paid a flat deposit insurance premium. In this regard, capital regulation aims at curbing the excessive risk-taking incentive. https://www.ncua.gov/files/publications/regulation-supervision/final-risk-based-capital-rule-report.pdf

[18] For example, a credit union with a portfolio of equal-weighted assets A and B, with respective LR of 0% and 6% will report a RBNW of 3% (0.5*6%+0.5*14%) which is below the simple LR limit of 6% and then will be considered as adequately capitalized.

[19] For example, assets such as members business loans are subject to a minimum of 6% if they are held up to 15% of total assets but the requirement increases to 14% when member business loan assets exceed 25% of total assets.

[20] The NCUA said it would tackle three issues prior to the rule going into effect: a separate plan to expand the use of subordinated debt by credit unions, new regulations on asset securitization and the possibility of creating a credit union equivalent of the community bank leverage ratio. https://www.ncua.gov/newsroom/press-release/2019/board-proposes-delaying-risk-based-capital-rule-until-2022

There are some differences between the existing risk-based net worth ratio (*RBNW*) requirement and the new *RBC* requirement. Firstly, the new *RBC* is obtained as the ratio of credit unions "Capital" or "net worth" to their risk-weighted assets (*RWA*) while the *RBNW* is a weighted sum of the LR associated with each asset category. Secondly, unlike the *RBNW* that has no formal limit (except being lower than the LR), the *RBC* requirement introduced under the PCA amendment should exceed 10% for a credit union to be considered as adequately capitalized. Comparing the *RBNW* to the new *RBC*, we can infer the risk weight associated with asset classes by comparing the *LR* associated with an asset category with the 6% limit on the simple leverage ratio (*LR*). For example, an asset class with 12% of net worth should be interpreted as being two times risky than the average asset.

The banking literature on the performance of the capital ratios (*LR* and *RBC*) is strongly skewed toward the over performance of the leverage ratio over the risk-based capital ratio. Since the *RBC* is being implemented for credit unions, similar arguments regarding the possible over performance of the *LR* has been put forward by the credit union association to justify that the *RBC* is not necessary. Then, to discuss the potential contribution of the *RBC* for the credit union industry it is desirable to understand the differences and similarity between them. Since the two ratios share a similar numerator (the total capital or net worth), the difference lies mostly in their denominator. Firstly, the complex risk-based measure is vulnerable to uncertainty risk and therefore could be misleading if the measure used by regulators to assess the ex-ante risk of assets (namely the risk-weighted assets) is poorly calibrated (see Aikman et al., 2014).[21] Secondly, the denominator of the *RBC*, the risk-weighted assets (*RWA*), is vulnerable to regulatory arbitrage or capture (through asset window-dressing) or risk manipulation [22] and thus, doesn't reflect bank's real risk posture (Cizel et al., 2017).[23] Compared to the *RBC*, the denominator of the leverage is the total bank assets that is hard to manipulate and easy to measure. Therefore, the leverage ratio is likely to provide backstop against asset risk mismeasurement. The extent to which credit unions are exposed to the highlighted weaknesses of the *RBC* might determine which of the ratios will perform the best for the credit union industry.

[21] As evidenced by Mayes and Stremmel (2012), Northern Rock, one of the first banks to collapse, was fully compliant with the risk-weighted measures shortly before its failure (Mayes and Wood, 2009). As witnessed, its leverage ratio was, however, extreme and would not have met the Basel III criterion (Shin, 2009).

[22] As an illustration, Hau et al. (2013) argue that "Basel risk-weights applied to claims on institutions do not reflect underlying relative risk."

[23] Specifically, the unreliability of the RWA (risk-weighted assets) is material for banks that adopt the IRB approach, under which they can use their own risk parameters. Cizel et al. (2017) provide evidence that metrics related to risk-weighted asset calculation method are not significantly related to distress of large banks that primarily use the IRB approach but are significantly related to distress in smaller banks less akin to manipulate their assets risk.

As large credit unions are the ones that hold complex assets, we conjecture that, the new regulatory measure of asset risk, namely the *RWA*, by penalizing the complex assets, will be more effective in explaining the ex-ante asset risk embedded in the ex-post measures of asset risk (failure, loan charge-offs, delinquencies, etc…). We distinguish ex-ante asset risk from ex-post asset risk, since the ex-post performance of assets depends on assets monitoring, asset risk management and macroeconomic condition. For example, large credit unions with large ex-ante *RWA* could have a more performing ex-post asset if they manage efficiently their asset risk.

> **Hypothesis 1:** *The regulatory measure of risk, the risk-weighted assets (RWA) will be more "powerful" in capturing the ex-post asset risk of large credit unions assets.*

Unlike the banking industry where large banks are allowed to use their internal risk model, credit unions will be subject to the standard risk-based asset with predefined risk weights that are common to all credit unions. While this approach reduces model uncertainty, it could induce credit union to be involved in window dressing practices to minimize their capital requirements. This is mostly expected from more complex credit unions. Since the credit unions in our sample were not formally regulated by the new ratio, we expect that the new risk-based capital ratio will be associated with credit union stability even when controlling for the *LR*. Therefore, we posit that:

> **Hypothesis 2:** *The RBC is significantly associated with credit unions stability even after controlling for the leverage ratio.*

There is evidence that credit unions are well-capitalized (in the regulatory sense) since they hold capital above the minimum requirement. Therefore, we conjecture that among credit unions with less capital (in terms of the *LR* requirement), the ones with more risk-based capital (aimed at covering losses from potentially complex assets) are more likely to survive and less prone to failure.

> **Hypothesis 3:** *The RBC will be complementary to the leverage ratio by being useful in predicting distress among poor-LR capitalized credit unions.*

3. Data

We extract and merge half annual[24] financial statements data on U.S. credit unions over 1994.1-2015.2. Data are extracted from the "5300 Call Reports" published quarterly by the NCUA. The number of credit unions exhibits a decreasing trend over the years. It drops from 12,363 in 1994.1 to 6,147 in 2015.2. To deal with potential outliers, we winsorized the variables used in our analysis.[25] Our analysis covers both the targeted "complex or large" credit unions (those with total assets above $500 million) and the rest with assets below $500 million. We do so to investigate whether the size limit really matters. As an illustration, in 2015, the year of the introduction of the first proposal of the RBC, 8% of credit unions (470 out of 5871 credit unions in our sample) had assets higher than $500 million.[26] We divide the sample of credit unions with assets below $500 million into two groups: medium-sized credit unions (with assets between $100 million and $500 million) and small credit unions (with assets below $100 million).[27] We describe in bullet points the different credit union size according to their proportions in terms of number and total assets in 2015.

- Large credit unions represent 8% (478 out of 5871) credit unions in 2015. Despite their small proportion in term of the number of credit unions, large credit unions concentrate in average 72% of the credit union total assets in 2015. This statistic is consistent with the NCUA report in 2016.[28]
- Medium-sized credit unions represent 17.88% (1050 out of 5871) of the total number of credit union in 2015. They concentrate 19% of the credit union system's total assets. Taken together, large and medium-sized credit unions concentrate 91% of total assets.
- Small credit unions are the largest proportion of credit unions (73.91% of the total number) but they concentrate less than 9% of the total assets.

We also consider the distribution of credit union size across subperiods (pre-crisis, crisis and post-crisis) and the data distribution can be found in Table 1.

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[24] Quarterly financial statements are not available for some credit unions for some years of our sample. Since half annual data are available for all of them, we employ a half-annual frequency.

[25] We exclude outliers from the analysis in the robustness check analysis.

[26] Prior to 2015, we identify complex credit unions as the ones in the last percentile of the half-yearly asset distribution. We don't extend our data beyond 2015 to avoid contamination since credit unions would have started their adjustment since the introduction of the reform in 2015.

[27] To define which credit unions are more likely to be subject to the requirements for year preceding 2015, we discount the $500 million and $100 million asset limits with a 2.4% average asset growth computed through the sample. For example, to be classified as large credit unions, we estimate that the credit unions need to hold assets above 180 million in 1994 compared to $500 million in 2015.

[28] https://www.ncua.gov/newsroom/news/2016/credit-union-deposits-surpass-1-trillion

Insert Table 1 here

4. The econometric framework

4.1 Model description

Since the main question of the paper relies on the relevance of the new RBC, we start our analysis by investigation the "real new" of the *RBC*, namely its denominator, the measure of asset risk (*RWA*). Specifically, we test our first hypothesis (H1) regarding the relation between the new regulatory *RWA* measure, and the ex-post measure of credit union asset performance. Our main objective is to test whether the *RWA scaled by total assets (hereafter, the Risk-Weighted Asset Density, RWAD)* would have played (if it had been regulated) a substantial role in predicting future asset performance after controlling for other factors that influence asset performance. To achieve that, we run the following regression.

$$Y_{it} = \alpha_i + \beta RWAD_{it-1} + \gamma X_{it-1} + \gamma Z_{t-1} + \varepsilon_{it} \quad \textbf{(1)}$$

where Y_{it} is the asset performance measure at date *t*. Many variables are used to proxy Y_{it} (the charge off rate (*CHOFF*), the non-performing loans or delinquent loans (NPL), the profitability measured by the return on assets (*ROA*) and the standard deviation of the return on assets (*SdROA*)). $RWAD_{it-1}$ is the lag value of the credit union risk-weighted assets density ratio (the risk-weighted assets divided by total assets). X_{it-1} is a lag-vector of covariates that captures credit union individual characteristics that affect their risk level. Z_{t-1} is a vector of covariates that is time dependent but common for all credit unions. It includes macroeconomic variables, economic condition. The null hypothesis tested: H1_0: $\beta = 0$, against the alternative that the *RWAD* has an explanatory value on top of the credit union characteristics and macroeconomic condition.

To answer our second and more relevant research question of whether the new *RBC* has any additional value on top of the simple leverage ratio (*LR*), we run a regression of credit union solvency measures against credit union capitalization, measured by the existing leverage ratio (*LR*) and the new risk-based capital ratio (*RBC*), separately or jointly. The ultimate measure of credit union solvency is the likelihood of their failure[29] by discriminating failed credit unions from successful

[29] As argued by Avery and Berger (1990, page 13), "…*Only in the event of failure does the insurer take a loss and are significant social costs generated. Moreover, some types of risk cannot be measured directly (e.g., propensity for fraud), but these are at least captured somewhat by the probability of failure*…."

ones. However, conducting this strategy is complicated by the small number of failures (382 credit unions) over the entire sample.[30] In addition, among the 382 credit unions that failed only three are large credit unions (see Table 4, and Figure 3), our object of interest. Age, Atlantic Coast and Harborone are the three large credit union that disappear respectively in 2000, 2000 and 2013. As can be noticed, none of them failed during the last financial meltdown that is of interest for our study. Therefore, we might be limited in using the failure dummy variable as a general solvency measure for large credit unions. Instead, we employ the *Z-score* since it captures the relative distance-to-default of the credit unions (see Boyd et al., 1993; Esho et al., 2005; Demirgüç-Kunt and Huizinga, 2010; Laeven and Levine, 2009; Demirgüç-Kunt et al., 2008; Anginer et al., 2014; Williams, 2014; Anollia et al., 2014; Niu, 2012; Ely, 2014; Noth and Schüwer, 2017). We check for this conjecture by computing the average *Z-score* for credit union that failed and the one that survived at each half-annual time. Figure 3 supports our guess. There is evidence that surviving credit unions hold an average Z-*score* of 3, above the failed ones. On top of the traditional Z-score, we compute a "risk-adjusted" *Z-score* as the number of standard deviations below the average risk-adjusted *ROA* (Total Income/RWA) at which the institution would reduce its risk-based capital ratio. The *Z-score* is commonly considered as a solvency ratio, stability measure and risk measure. In some instances, the traditional *Z-score* could represent a form of Coefficient of Variation of the Leverage Ratio and the "risk-adjusted" *Z-score* as the coefficient of variation of the risk-based capital ratio. The estimated regression is the following:

$$Zscore_{it} = \alpha_i + \beta_1 RBC_{it-1} + \beta_2 LR_{it-1} + \gamma X_{it-1} + \gamma Z_{t-1} + \varepsilon_{it} \quad \textbf{(2)}$$

where RBC_{it-1} and LR_{it-1} are respectively the lag values of the credit union risk-based capital ratio and leverage ratio. X_{it-1} is a lag-vector of covariates that captures credit union individual characteristics that affect their risk level. We include in the control variable X, the CAMELS[31] characteristics other than the capital adequacy ratio or Leverage Ratio. Z_{t-1} is a vector of covariates that is time dependent but common for all credit unions. It includes macroeconomic variables, economic condition and time dummies (quarter and year fixed effects). Three versions of equation Equation 2 is estimated. The first one only includes the risk-based capital ratio (*RBC*) as covariate, the second includes only the net worth or leverage ratio (*LR*) and the last has both capital ratios in

[30] This is comparable to the 341 failure cases reported by Goddard et al. (2014).

[31] Capital adequacy – Asset – Management – Earnings – Liquidity– Sensitivity (see for example, Rostami, 2015).

the equation. The null hypothesis tested in each of the versions, are respectively: H2_0$_{(1)}$: $\beta_1 = 0$, H2_0$_{(2)}$: $\beta_2 = 0$, H2_0$_{(3)}$: $(\beta_1, \beta_2) = 0$.

Insert Table 4 here

Insert Figure 3 here

Based on the Hausmann test, we choose the fixed panel estimation technique as our main estimation technique. In each regression we include covariates X_{it-1} and Z_{t-1} that could also be associated with credit union risk, based on previous papers on the determinants of credit union risk. This aims at avoiding the bias coming from the omission of important variables. Recent studies on the determinants of credit union risk suggest that many factors explain the cross section of credit union risk. The list of these covariates is provided in the next subsection. In all equations estimated, the issue of endogeneity is reduced by the inclusion of predetermined covariates in the form of lags of the independent variables.[32]

4.2 Variables description

4.2.1 Variables of interest: The RBC and the LR

Our variables of interest are the new risk-based capital ratio (*RBC*) and the existing net-worth requirement (*LR*). Their formulas are the following:

$$\text{RBC} = \frac{\text{Capital or Net worth (adjusted*)}}{\text{Risk weighted assets (RWA)}}$$

$$\text{LR} = \frac{\text{Capital or Net worth}}{\text{Total assets}}$$

- **The numerator of the ratios: Capital or Net worth**

According to the "5300 call report" the net-worth is obtained as the sum of (a) undivided earnings, (b) regular reserves, (c) appropriation for Non-conforming investments (for state only credit unions), (d) other reserves (appropriation of undivided earning), (e) uninsured secondary capital (f) net income and (g) adjusted retained earnings acquired through business combinations.

[32] It makes sense to assume that contemporary shocks in the regression are uncorrelated with the lag of independent variables undertaking this regression, we are aware of potential endogeneity problems.

- **The denominators of the ratios: Total assets and the risk-weighted assets (RWA)**

Total assets are obtained straightforwardly from credit union balance sheets. The total risk weighted assets (*RWA*), the denominator of the risk-based capital ratio, deserves more description. We compute credit unions risk-weighted assets (*RWA*) based on credit unions historical balance sheet. It is obtained as a weighted sum of credit union asset categories. Asset categories and their corresponding risk weights can be found in Appendix A. We apply these risk weights to credit union historical balance sheet information, to reconstruct their historical *RWA*. We face many challenges in doing so.

- Firstly, the asset categories defined under the new risk-based requirement are not readily available from the historical balance sheet information submitted by credit unions (through the "5300 call report").
- Secondly, the historical information on credit union balance sheets lacks the detail needed to compute the exact RWA.
- Lastly, the "5300 Call report" used by credit unions to communicate their balance sheet, income statement and other accounting data has undergone many changes that we account for to make sure that we access the right information across time.

To circumvent these difficulties, we carefully identify information in the "5300 call report" that matches the asset categories in the new *RBC* requirement. Doing so, we consider changes in the call report forms to guarantee the consistency of the measure across time. Details on the matches can be found in Appendix A.

In general, three asset categories can be identified with the new risk-based capital requirement:

- Cash and cash-like securities (mostly backed by the government) have 0% risk weight;
- Investment securities (with weight varying between 20% and 300%). The riskiest are: (paid-in capital) Investments in corporate perpetual capital (300%) and publicly traded securities in non-CUSO[33] (150%);
- Loans categories (50-150%). Unsecured and junior loans receive higher risk weights;
- Off-balance sheet categories (50%-150%) of risk weights. Loan transferred with recourse receive the highest risk weight (150%).

We obtain the risk-based capital ratio by dividing credit union "Capital" or Net worth by the risk-weighted assets (*RWA*) computed previously. Unlike the existing net worth requirement (*LR*), the capital (numerator of the ratio) includes allowance for loan and lease losses, and goodwill.

[33] Credit union service organizations (CUSOs) are corporate entities owned by federally chartered or federally insured, state chartered credit unions.

Based on the RWA's calculation, we additionally compute the Risk-Weighted Asset Density (*Risk-Weighted Asset/Total Assets---RWAD)* representing the total assets risk per unit of assets.

4.2.2 Other variables

There might exist a delay between the deterioration in the performance of the credit union and the time when the failure is recorded. In this regard, we also add other measures of ex-post performance such as: the charge off rate (*CHOFF*), the non-performing loans or delinquent loans (*NPL*), the earnings (*ROA*) and the risk-adjusted earnings (*Z-score)*. A quick description of the dependent variables follows.

- The share of delinquent loans to total loans (*NPL*). Delinquent loans are loans for which the borrower is late on scheduled payments. Loans can be 30, 60- or 90-days delinquent. The total amount of delinquent loans used in this paper refers to all-maturity delinquency. Loans with higher risk of delinquency should receive higher risk weights.
- The Charge-off loans (*CHOFF*). Charge-off loans are loans that are deemed unlikely to be collected by the credit union for example because the borrower has been delinquent for a period. This does not however mean that the loan is a write-off since the borrower could repay the debt in the future via a collection agency for example.
- The return on assets (*ROA*) and the risk-adjusted return on assets (Z-*score*).

The credit union ROA is computed as the ratio of net income to the average assets. The Z-*score* can be defined as a distance to default that measures the number of standard deviations below the average *ROA* at which the institution would reduce its net worth[34]: Z-*score* = (ROA+LR)/σ_{ROA}. Köhler (2015) uses the Z-*score* as a measure of bank stability. Esho et al. (2005) use it as a risk measure of Australian credit unions. We consider the logarithm of the Z-*score* to bring it down to a smaller scale as did Köhler, 2015; Laeven and Levine, 2009; Demirgüç-Kunt et al., 2008 and Anginer et al., 2014.

We also add control variables that capture credit union individual and specific characteristics such as Liquid assets ratio, Non-deposit funds ratio, Loans to deposits ratio, Efficiency, Maturity, Charter and Common bond. Macroeconomic variables and economic condition are Unemployment rate, Real Gross Domestic product and Crisis dummy (value of 1 for years 2007-2009). The list of variables and computation is provided in Table 5. Descriptive statistics on main variables follow.

4.2.3 Descriptive statistics

- **Regulatory capital ratios (the leverage ratio and the risk-based capital ratio)**

Insert Figure 4 here

Both capital ratios decrease with credit union size. The average credit union holds a leverage or net worth ratio of 13.3% (above the 6% minimum requirement) compared to 29% (above the 10% minimum requirement) for the *RBC*. This suggests that credit unions hold important buffers on top of the minimum requirements (Jackson, 2007). The distribution of the capital ratio varies significantly (t-test and Wilcoxon test are performed) with credit union size, with large credit unions holding lower capital ratios compared to smaller ones. Large credit unions hold an *LR* of 10% and an *RBC* of 15% on average compared to 13% and 31.7% for small credit unions.

The dynamic of the ratio is also different across credit unions (see *Figure 4*). Capital ratio for medium and large credit unions are alike. Both capital ratios seem to decrease during the 2007 subprime crisis independently from credit union size. More interestingly, credit unions constantly increased their leverage ratio in the period preceding the crisis. This might have supported their activity during the crisis period. Credit unions lost around 200 basis points (from 16% to 14% for small credit unions and from 11% to 9% for large credit unions) during the crisis. Compared to large credit unions, the RBC exhibits an increasing trend that is very different from that of the leverage ratio. This finding provides support for the tailoring of the *RBC* measure to large credit unions. Our finding however suggests that medium-sized credit unions (with assets between $100 million and $500 million) should not have been exempted from the *RBC* measure since their behavior is very similar that of larger credit unions.

- **The risk-weighted assets (RWA) and the credit union performance measures**

Insert Table 2 here

The performance of the risk-based capital requirement will depend on the accuracy with which credit unions asset risk is measured. Therefore, it is important that the *RWA* capture (at least ex-ante) the riskiness of credit union business model (asset quality, management). We expect that credit unions

with comparable asset performance and size have comparable values of *RWAD* and consequently comparable capital requirements (Capital as of 10% of *RWA*).

The risk-weighted assets variable is reconstructed from credit union historical balance sheets using the risk weights from the new risk-based requirement. We compare the *RWAD* (i.e., the total assets risk per unit of assets) across the different size categories. We limit the analysis to the time period after 1998 since we lack enough granularity to compute the *RWA* for years preceding 1998. The *RWAD* for large credit unions amounts to 0.74. This suggests that for each dollar of assets, large credit unions should maintain a net worth of 7.4 cents (10% of $0.74). This is equivalent to a leverage ratio (*LR*) of 7.4%, well above the existing 6% minimum for the leverage ratio. Apart from their capital buffer, large credit unions that will be subject to the regulation are likely to be bound by it. The average value of the *RWA* per unit of assets is significantly different between large credit unions and the small credit unions (see Figure 5). We perform both the t-test and the nonparametric Mann and Whitney (1947) and Wilcoxon (1945) test to evaluate the significance of the difference between the distribution of our variables. Compared to large and medium credit unions, the risk-based capital requirement is equivalent to the 6% net worth requirement for small credit unions with an equivalent of 60 cents of assets per dollar of assets that would have been subject to the requirement, had they been regulated. We find evidence that the level of *RWAD* is significantly different between the credit union categories (in term of size).

Our previous analysis suggests that large credit union assets are on average riskier assets in terms of the risk per unit of assets (*RWAD*). Despite this, large credit unions' assets perform better than their small counterparts. While holding less risky assets (in terms of *RWAD*), small credit unions display higher charge off (*CHOFF*) and delinquency rates (*NPL*) per unit of assets. Delinquency rate in small credit unions is three times larger than the rate in large credit unions. This poor performance of assets in small credit unions leads to higher returns volatility combined with low return on assets (*ROA*) compared to large credit unions. Then, despite holding less risky assets, small credit unions are less stable with lower *Z-score* and higher failure rates. In conclusion, if the *RWAD* properly access the ex-ante risk of credit union assets, the ex-post performance of assets might vary with the asset risk management used by the credit unions. Proper risk management might explain why larger credit unions have fewer default loans (Frame et al., 2002).

Insert Figure 5 about here

The dynamic of the *RWAD* plotted in Figure 5 suggests that the *RWAD* varies positively with the business cycle. Positive trends are registered in prosperous times such as the period preceding the savings and loan crisis and the dot.com crisis and the pre-2007 financial crisis periods. This suggests that credit unions capital requirement will increase in booms and force credit unions to build enough capital that could serve to absorb losses during recessions and avoid excessive deleveraging that succeeded crisis episodes. As an illustration, large credit unions' average *RWAD* dropped by 15% from a peak of 0.8 in the pre-crisis period to a low of 0.68 at the heart of the crisis. The equivalent drop for small credit union is approximately 20%. The drop in the *RWAD* could be explained by deleveraging of assets substitution. We find similar patterns for the banking sector as illustrated in the second graph of Figure 5, Panel A. Community banks with total assets below $500 million have the lowest *RWAD*.

- **Determinants of ex-post assets performance**

Insert Table 3 here

As we developed previously, the ex-post performance of credit union assets should depend on their ex-ante asset risk (measured by the *RWAD*), their risk-management practice and the macroeconomic condition. Next, we provide descriptive statistics of factors (not related to asset risk) that could exogeneously affect the performance of credit unions. The findings are summarized in Table 3.

- Credit union bond (*SBOND*): Three types of field of memberships are distinguishable. A single common bond (for example the Navy Credit union, the largest credit union federate members from US army[35]), a multiple common bond or community common bond.[36] Single bond and community bond credit unions are supposed to have concentrated assets (in the same geographical area or the same company or business field). As expected, credit unions with a single bond (*SBOND*=1 for single bond credit union and 0 otherwise), despite holding lower regulatory asset risk (*RWAD*), are more subject to default certainly because of the concentration of their assets in the same member field. In addition, their assets are more volatile and have a higher non performing loan rates.

[35] Army, marine corps, navy air force, coast guard and veterans.

[36] As stated in Ely (2014), "a single common-bond credit union has a field of membership that consists of one group which has a common bond of occupation (employment by the same entity or related entities or a trade, industry, or profession) or association (members and employees of a recognized association)". In contrary, multiple common bond is a field of membership in which members have distinct bond and community common bond is formed by members "within a well-defined local community, neighborhood, or rural district" (NCUA, 2003).

- Maturity (*MAT*) also plays an important role in credit union performance. Mature credit unions (with age higher than the median age at any date) hold on average less risky assets and perform significantly better (in terms of chargeoff, non performing rates, return on assets (*ROA*) and return volatility). They also have higher Z-*score* and lower failure rate.
- On the regulatory side, US credit unions operate either under federal charter (for federally chartered credit unions) or under state laws for state chartered. Since federally insured credit unions can be either federal or state chartered, we include all the credit unions in our sample since they submit their balance sheet information to the NCUA, their insurance agency. Since some laws or regulation can be specific to a state, we introduce a dummy variable into the regression that capture whether a credit union is regulated at the federal level. *FCHART* takes a value of 1 if credit unions have a federal charter and 0 otherwise as in Frame et al. (2002).
- Macroeconomic conditions also affect credit union performance.

Since the financial and economic conditions of the different states[37] are different, we follow Ely (2014) and Wilcox (2007) in using state unemployment rate (*UEMPL*). We expect the unemployment rate in each state to influence the level and type of loan granted by credit unions; which would influence the level and risk-taking of credit unions. A high (low) unemployment rate reflects economic slowdown (growth).

There is significant difference between the asset risk (*RWAD*) under different macroeconomic condition, suggesting that the *RWAD* is less likely to fluctuate through the business cycle. However asset ex-post performance are worst during crisis period. This manifests through higher chargeoff and non performing loans, lower asset return and higher failure rate. Surprisingly, return volatilty is not higher in crisis period compared to normal one. This makes the Z-score less vulnerable to the crisis.

5. Results

5.1 The regulatory risk measure (RWAD) and CUs' performance

Insert Table 6 here

[37] Credit unions are distributed across states with nine states concentrating roughly half of credit unions. These states are TX (7.78%), PA (7.16%), NY (6.12%), CA (5.66%), OH (5.01%), IL (4.72%), MI (4.15%), NJ (2.94%) and MA (2.88%).

Our analysis (see Table 6) suggests that the new risk-based asset measure (*RWAD*) is significantly associated with future asset performance and thus validates our first hypothesis (H1). The charge-off, the non-performing and the return volatility are strongly and positively associated with the *RWAD*. Since banks are supposed to hold a level of net worth that is proportional to the *RWA*, our finding suggest that capital level based on the *RWA* will contribute to absorbing future losses. Considering the charge-off equation, we find that the relation between the loan charge-off rate and the RWAD is stronger for large credit unions. For the non-performing loans, it is more sensitive to the *RWAD* for small credit unions compared to large ones. Regarding the return on assets, we find that large credit union return on assets is negatively related to their *RWAD*, suggesting that holding complex or risky assets is neither profitable in terms of return nor in terms of financing cost for large credit union. Instead, smaller and medium credit union returns increase with their *RWAD*. The relationship between credit unions asset return volatility and the *RWAD* is not significant for small and large credit unions. This suggests that higher ex-ante asset risk does not necessarily traduce in more return volatility.

Another important takeaway from the analysis provided in Table 3 is that macroeconomic condition also affects credit union performance (*NPL*, *CHOFF* and *ROA*) but they are not fully captured by the *RWAD* as would have suggested our previous descriptive finding about the cyclical variation in credit unions *RWAD*. This suggests that the implementation of cyclical add-ons on the risk-based capital requirement will be interesting in making credit union capital more aligned with credit union performance.

5.2 Leverage ratio (LR), risk-based capital ratio (RBC) and solvency

Insert Tables 7, 8 and 9 here

We regress credit unions' *Z-score* on their 6-month lag capital measures (*RBC* and *LR*) to identify the capital ratio that matters the most in predicting the deterioration in credit union solvency (H2). Our analysis suggests that both capital ratios are significantly and positively associated with both *Z-score* (Table 7 and 8). The result holds when both capital ratios are kept in the same regression, especially with the "risk-adjusted" *Z-score* (Table 7 and 8). This suggests that both capital rules matter in predicting future solvency and that they have a complementary role. To test whether this finding is not compromised by the possible collinearity between the two ratios, we conduct additional robustness check analysis that are provided in the next section.

To further investigate the additional role of the *RBC*, we study the effect of the ex-ante level of risk-based capital ratio on credit union in the lower quartile of the leverage ratio distribution (Table 9). Our finding suggests that the contribution of the risk-based capital ratio is ex-ante higher for low-capitalized credit unions (in terms of the leverage ratio, *LR*). We find that an increase in the ex-ante *RBC* by 0.38 (its standard deviation) is associated with an increase in the future solvency ratio by 0.74[38] for "LR-poorly" capitalized credit unions (credit unions in the lowest quartile of the leverage ratio distribution, holding an average leverage ratio of 7%) compared to only 0.12 for "*LR*-well" capitalized credit unions (credit unions in the highest quartile of the leverage ratio distribution, holding an average leverage ratio of 21.29%). The effect of the *RBC* on the *LR*-poorly capitalized credit unions (0.74) is sizable when compared to the standard deviation of the *Z-score* that amounts 0.4. Interestingly we find similar results when we quantify the effect of the *LR* on credit unions based on their ranking according to their quartiles of the risk-based capital ratio. Compared to the *RBC* effect, we find that an increase of 0.026 (the standard deviation of the *LR*) in the *LR* is associated with an increase in the future *Z-score* by 0.228 (for *RBC*-poorly capitalized credit unions holding an average *RBC* of 10.6%) which is lower in size compared to the 0.74 induced by the *RBC* for *LR*-poorly capitalized credit unions.

Insert Figure 6 about here

This analysis suggests that both capital rules act as complements for credit union stability. To disentangle the constraints imposed by the ratios, we compute the level of the net worth that is required respectively under the *LR* and the *RBC*. We obtain the net worth as 6% of total assets and 10% of the *RWA*. We find (interestingly) that for large and medium-sized credit unions the risk-based capital ratio is the binding one through the whole data story. On the contrary, the *RBC* and the *LR* interchangeably bind for small credit unions (see *Figure 6*) with the *LR binding* only in the post crisis period. This suggests that the *RBC* if applied to small credit unions will be less effective in imposing higher capital requirement on them.

[38](=0.38*1.957) see Table 9, first column, 1.957 is the coefficient of the RBC variable in the Z-score regression.

6. Robustness checks

6.1 Alternative measure of solvency: Credit union failure

We provide evidence that the *RBC* is significant in predicting credit union solvency, whatever the credit union size and that it complements the existing *LR* ratio in strengthening credit union stability. Despite the contribution of the *RBC*, it is not clear whether it is necessary or not to maintain a risk-based capital ratio on top of the net-worth requirement. We deepen the analysis by testing directly the effect of the capital rules (*LR* and the *RBC*) on credit union failure. Despite the evidence that the *Z-score*, our proxy for the solvency, is highly correlated with the failure rate (see Figure 3), there is evidence that only three large credit union failed historically. Therefore, the equivalence between the failure risk and the *Z-score* is hard to establish for large credit unions.

To circumvent this issue and get insight about the potential contribution of the *RBC* for large credit unions, we use the sample of medium-sized credit unions[39] (credit unions with assets between $100 million and $500 million) that present similar characteristics with large credit unions (see Section 4.2.3). We perform a non-linear probit regression with the right hand side variables like those in Eq. 2. Surprisingly, we find only the simple leverage ratio (*LR*) matters in the prediction of observed failures for both the medium-sized credit unions (used as proxy for large credit unions) and the small credit unions. Since the *RBC* was on average the binding ratio for medium-sized credit unions, this finding suggests that the *LR* will serve to signal credit unions in distress whereas the *RBC* rule will increase the average level of capital held on credit unions balance sheets and would contribute to their relative solvency. This finding is in line with paper that documents that the *LR* is more powerful than the risk-based capital ratio in predicting distressed credit unions. (Aikman et al., 2014; Berger and Bouwman, 2013; Haldane and Madouros, 2012; Hogan et al., 2017 and Mayes and Stremmel, 2012).

Insert Table 10 and 11 here

Some may argue that the non-performance of the *RBC* is due to asset risk manipulation as complex ratios are more easily manipulated and exploited (Haldane and Madouros, 2012). This argument is less effective since credit unions were not yet regulated by the bank-like RBC prior to our analysis.

[39] Recall that in its first proposal, the limit to qualify a credit union as a large and complex institution is $100 million of assets holding.

An argument that could be considered is the artificial reconstruction of the risk-based capital ratio based on historical data, subject to Lucas (1976) critics. As the explanation of the non-performance of the *RBC* is not apparent for large credit unions, we analyze the effect of the *RBC* on the failure of "*LR*-poorly" capitalized credit unions.[40] Interestingly, we find that the *RBC* becomes significant in predicting the failure of "*LR*-poorly" capitalized credit unions (see Table 11).

Back to large credit unions, we observe that charge-off rates are very low for large credit unions compared to small ones during normal times, but the charge-off rate becomes very large during the last 2007 financial crisis. This suggests that during the crisis period, assets that were classified as less risky can quickly become non-performing which means that only the level of capital that backs total assets (irrelevant of their risk) is more precise in allowing credit unions to absorb losses that come from supposedly safe assets. Among others, asset performance measured through ex-ante ratio of non-performing loans is a good predictor of credit unions failure (see Wilcox, 2007 for similar findings). Other variables such as credit union liquid assets holding or stable funding holding also influence credit unions solvency as previously documented by Goddard et al. (2015).

6.2 Collinearity between the RBC and the LR

6.2.1 The combination of the risk-based and leverage ratio for large credit unions

In our previous analysis, we have considered the leverage and the risk-based capital ratio separately. However, the two capital rules are related since they share more or less the same numerator and related denominator.[41] According to Hessou and Lai (2019), the joint regulation of the *RBC* and the *LR* is equivalent to a simple leverage ratio regulation with a distorted limit as follows (see Appendix C for more details):

$$\begin{cases} LR \geq l & if\ \delta < \delta^* \\ LR \geq \delta c & if\ \delta > \delta^* \end{cases} \qquad (3)$$

[40] We pick the "LR-poorly" capitalized credit unions because of our previous finding suggesting the contribution of the risk-based capital ratio is ex-ante higher for low-capitalized credit union (Section 5.2). Mariathasan and Merrouche (2014) show that weakly capitalized banks report lower average risk weights when they are approved for either of Basel II's IRB approaches. Their results also suggest allocating more regulatory resources to weakly capitalized banks. This is not only because they are, by definition, more fragile, but because we have identified them as being more prone to under-reporting risk.

[41] Recall that risk-weighted assets are obtained as a weighted sum of total assets components.

where δ is the credit union's *'RWA density'* defined as credit union's *RWA* divided by its total assets. $\delta^* = \frac{l}{c}$ with c, l respectively the risk-based capital and leverage ratios limits set by the regulators. This result suggests that the two rules are not simultaneously binding for all credit unions and that their effect on their stability would have been different. For example, if the risk-based capital ratio were jointly regulated, credit unions with $\delta < \delta^*$ will be constrained by the leverage while the *RBC* binds for those with asset risk above the threshold holds $\delta > \delta^*$. We identify LR-constrained and *RBC*-constrained credit unions at each date and study how each of the ratio affects the respective banks. Doing so, we evaluate δ^* to 0.6 since the limit on the leverage ratio is *l*=6% and the one on the risk-based capital ratio is *c*=10%. Our findings suggest that controlling for the ratio that is the binding one doesn't affect our main results. We however document that the effect of the *RBC* is not material for large credit unions that are bound on the *LR*. This is coherent since credit unions that are bound on the *LR* are by construction insensitive to the *RBC* limit. On the contrary, the *LR* is significant for credit unions that are bound by the *RBC*. This suggests that the *LR* continues playing its backstop role even when the *RBC* is the most constraining one.

Insert Table 12 here

6.2.2 Alternative ways of dealing with the collinearity

We also control for the collinearity that arises when the two ratios are plugged into the same regressions in two other different ways. Firstly, we use an approach suggested by Wooldridge (2003, pp. 141 – 142) and use in Hogan et al. (2017) by including in the regression a new variable that is the sum of LR and RBC[42]. We also use the 2SLS approach by regressing the LR on the RBC and plugging the residual of the LR into our regression. The results reported in Table 13 are in line with our main findings.

Insert Table 13 here

[42] The new variable added is $(LR^*)_{it} = (LR)_{it} + (RBC)_{it}$ .Then, let's define $\boldsymbol{\theta = \beta 1 - \beta 2}$ as a new coefficient, where β1 is the coefficient of RBC and β2 is the coefficient of LR in equation 2. We include LR* and RBC in the same regression and remove LR. If **θ** is negative and significant this indicates that RBC is a better predictor of credit union risk. Second, if **θ** is positive and significant this indicates that LR is a better predictor of credit union risk. Third, if **θ** is not significant this indicates that RBC and LR are not significantly different from each other.

6.3 Alternative measures of the RBC

Our analysis fully relies on an "artificial" reconstruction of the risk-based capital ratio based on historical data. Therefore, our main findings are subject to Lucas (1976) critics that suggests that credit unions behavior (historical data) would have been different, should the *RBC* really be regulated prior to our analysis. To challenge our finding, we use the old net worth risk-based capital ratio "optionally reported" by credit unions with assets above $100 million[43] (see Section 2) under the PCA introduced in 2000. Our main finding about the complementary role of the RBC in predicting distress in LR-poorly capitalized CU holds (see Table 11, last column).

6.4 Testing for non-crisis episodes

Our findings would have been driven by the wave of failure that occurs during the last financial crisis. We test for this by dividing our sample into three sub periods: the pre-crisis (1994-2006), crisis period (2007-2010) and post crisis for years after 2010. We find that our main results hold except that the *RBC* is insignificant when the solvency measure used is the simple Z-score. Both ratios are strongly significant in the *Z-score-adjusted* version of our estimations (Table 14, Panel B).

Insert Table 14 here

6.5 Exclusion of outliers

Our findings could have been hindered by some outliers. Based on the exclusion suggested in the credit union literature (Goddard et al. 2008, among others), we exclude from the analysis, credit unions with the following characteristics: (a) credit unions close to default with negative net-worth ratio - these credit unions are certainly under regulatory (NCUA) pressure and scrutiny and their behavior could be different from common credit unions; (b) credit unions that are ultra-safe by holding more than 50% of net-worth ratio - these credit unions are less likely to hold capital level that match their risk level; (c) credit unions with uncommon asset structure - we exclude from the analysis, credit union half-year observations with loan-to-asset ratio below 5% or above 95%,

[43] From 2000 to 2015 credit unions with assets above $100 million were required to report their level of net worth risk-based capital ratio following the Prompt Corrective Action (PCA) introduced in 2000. Unlike the new risk-based capital ratio, the existing net worth risk-based capital ratio attributes specific net worth requirement to each asset categories with risky and complex assets subject to higher net worth requirement. The reported net worth risk-based capital ratio is the weighted sum of the asset categories weighted by their respective net worth risk-based requirement that varies between (0.04 to 0.2).

(following Goddard et al., 2015); (d) newly established credit unions, especially those with less than five years of existence (or ten half-year observations) - they are more likely to have uncommon asset and liability structure. Overall, these exclusions reduce our sample from 403,591 half-year observations to 375,239 half-year observations, corresponding to a reduction of less than 8% of our original sample. The finding supports our main results (see Table 12, last three columns).

6.6 Quantile regressions

On top of the exclusion of outliers, we test the robustness of our findings by running quantile regressions. It is well-known that outliers may have a much larger effect on the mean of the distribution than on the median (Aslanidis and Christiansen, 2014). The findings support our results regarding the complementary role of the *RBC* and *LR* in predicting future solvency (see Table 15).

Insert Table 15 here

6.7 Troubled Asset Relief Program (TARP)

Insert Table 16 here

In 2010, 48 credit unions received direct Troubled Asset Relief Program (TARP) funding called the Community Development Capital Initiative ("CDCI").[44] The goal of the program was to stabilize the financial market by providing financial services to communities underserved by traditional banks and financial services, such as low- and moderate- income, minority and other underserved communities (Bauer, 2012).[45] Bauer (2012) documents that TARP funding had no significant impact on whether the credit union failed, but find that of those credit unions surviving, TARP-funded institutions tended to have stronger performance. As that TARP capital injections may also be reflected on the level of capital (capital ratios), we check the robustness of our main results taking

[44] "The Community Development TARP's Capital Purchase Program bailout of 707 banks is well known, but there is a lesser known TARP bailout of 36 small banks and 48 credit unions called the Community Development Capital Initiative ("CDCI") that will likely continue until at least 2018'' (SPECIAL INSPECTOR GENERAL, QUARTERLY REPORT TO CONGRESS I APRIL 30, 2014).

[45] Bauer (2012) finds that TARP recipient credit unions were those credit unions with lower capital, stronger loan portfolios and/or those whose headquarters were in the districts of states of congressional committee members who supervised financial institutions. https://www.uvic.ca/iwfsas2016/assets/docs/Session6-Paper2-Bauer.pdf

into consideration the context of TARP. We employ two methods. We first insert in the regression a control variable "TARP" that indicates whether or not the credit union was offered the TARP funding. Second, we split our data into Non-TARP and TARP credit unions and run the regressions respectively. The results support our main findings with respect to our focal variables, the capital ratios (see Table 16).

7. Conclusions and policy implications

The National Credit Union Administration (NCUA) is introducing a new risk-adjusted capital measure (RBC) to complement the existing credit union (CU) industry required leverage ratio (LR). This new rule is expected to better gauge the build-up of excessive risk shown on credit union balance sheets. Using NCUA call reports from 1994 to 2015, this paper investigates whether this new RBC rule alongside the leverage ratio is relevant and informative in predicting credit union stability, had it been regulated. Our findings show that both capital ratios are positively related to credit union stability measured by their *Z-score* and "risk-adjusted" *Z-score*. However, when both capital ratios are included in the same regression, this result only holds with the "risk-adjusted" *Z-score*. This implies that the "risk-adjusted" *Z-score* better captures the complementary role of the capital ratios and suggests that both capital rules matter in predicting CU future solvency.

To dig further on the additional role of the *RBC*, we first examine the effect of both capital ratios on the *Z-score* of "*LR*-poorly" capitalized credit unions. Then, we analyze the impact of both capital ratios on large credit union failures measured by a binary variable. Our finding regarding the complementary role of the *LR* and the *RBC* on the *Z-score* is supported for credit unions that are "*LR*-poorly" capitalized, but the result on the credit union failure shows that the leverage ratio is more powerful during the last financial crisis. The finding on the failure confirms the results of Aikman et al. (2014), Berger and Bouwman (2013), Haldane and Madouros (2012), Hogan et al. (2017) and Mayes and Stremmel (2012) regarding the predictive value of the *RBC*. To explain the lack of significance of the *RBC* for large credit unions, we analyze the effect of the *RBC* on the failure of "*LR*-poorly" capitalized credit unions. Interestingly, we find that the *RBC* becomes significant in predicting the failure of "*LR*-poorly" capitalized credit unions.

Although subject to Lucas (1976) critics - that has been mitigated by way of robustness checks– our results reinforce the choice of the regulator to implement the new *RBC* as a complement to the leverage ratio only for large credit unions since they are on average less capitalized than small credit

unions and more importantly, they are on average bound by the *RBC* compared to the *LR*. In addition, our results indicate that while *RBC* regulation should not be a panacea to prevent credit union failure, CU asset quality measures do matter. Our analysis also suggest that regulators should care about membership concentration risk since single bond credit unions are more prone to failure than their multiple bond counterparts.

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Appendix A: On the computation of the total risk-weighted assets

This table presents the assets risk categories in the new risk-based capital requirement (first column) and their corresponding asset categories based on historical balance sheet information (second column). Asset categories that are not matched are signaled by the mention "Not available (N.A.)". We employ the simulator suggested by the NCUA to compute the historical risk-weighted assets of credit unions. While our number will be different from the one that will be effectively computed once the RBC will be activated, we expect the differences to be negligible.

Assets categories in the 2015 RBC	**Historical assets categories in the "5300 call report" form (use as proxies)**	**Risk weights (effective)**	**Comments**
Direct unconditional claims on the U.S. government	U.S. Government Obligations (Acct 741C)	0%	Data available
Debt instruments issued by NCUA and FDIC	Issued Guaranteed Notes (Acct 740 et Acct 740A)	0%	No data recorded on the Acct 740 et Acct 740A. No proxy created since it has a 0% weight
Federal Reserve Bank and Central Liquidity Facility stock	N.A.		
Agency obligations			
General obligation bonds issued by state or political subdivisions	Securities Issued by States and Political Subdivisions in the U.S. (Acct 745)	50%	No data available. We proxy this as half of the total government obligation (Acct_741c/2)
Federal Home Loan Bank stock	N.A.		
Funds containing only 703 compliant investments subject to a 0% - 20% risk weight	N.A.		
Agency and GSE residential MBS or ABS structured securities	Agency/GSE Mortgage-Backed Securities (Acct 742 C2)	20%	Available from 2008. Data from 1998 to 2008 are obtained by assuming that the average share of acct_742C2 to acct_742C (other Mortgage-Backed Securities) is constant.
Revenue bonds issued by state or political subdivisions	N.A. (assimilable to the Acct_745)		
Non-agency residential MBS structured securities	Non agency MBS (Acct 742C1)	50%	Available from 2008 to 2015. We obtain value for the period from 1998

			to 2008 as follows: (Acct 981- Acct 742C2) where Acct 981 is the total of the credit unions others MBS
Corporate non-perpetual capital (membership capital)	N.A		
Industrial development bonds	N.A		
Interest-only mortgage-backed securities strips	N.A.		
Mutual funds – Part 703 compliant	Mutual funds (Acct 743D)	100%	Only Acct_743C is available. It is the sum of the mutual and trust fund. Data are available from 1998 to 2008. Data from 2008 is obtained by assuming a constant Acct_743C to total investment ratio (Acct 799i)
General account permanent insurance	N.A.		
Non-subordinated tranche of any investment	N.A.		
Charitable donation accounts	N.A.		
GSE equity exposure or preferred stock	N.A.		
Corporate perpetual capital (paid-in capital)	Membership capital at corp. CUs/Nonperpetual Capital Account + Paid-in capital at corp. CUs/Perpetual Contributed Capital (Acct 769A+ Acct 769B) or 769	150%	Available from 1998. Acct_769 from 1998.1 to 1999.1 and acct_769a acct_769b from 1999.2
Separate account insurance	N.A.		
Publicly traded equity investment (non CUSO)	Trading securities (Acct 965)	300%	Available from 1998 to 2015
Fair value of mutual funds not compliant with Part 703.14(c)	Included in Acct_743C		

Non-publicly traded equity investment (non CUSO)	N.A.		
Loans (by general loan type)			
Government-guaranteed portions of outstanding loans (net from all loans below)	N.A.		
Share-secured loans (deposits held in-house)	N.A.		
Share-secured loans (deposits held in another financial institution)	N.A.		
Current secured consumer loans	Vehicle (new and used) loans Acct_370 and Acct_386. Since these loans are somewhere between current secured consumers loans (75%) and non-current consumers loans (150%), we attribute them a weight of 100%.	100%	
Current unsecured consumer loans	Small Amount Loans (STS) (Federal CU Only) Acct 397A	100%	Data not available. It is however included in the Category Acct 397 below
	Unsecured credit card loans + Other unsecured loans (Acct 396 + Acct 397)	150%	Available from 1994.
Current 1st-lien residential loans comprising less than 35% of assets	N.A		
Current 1st-lien residential loans comprising more than 35% of assets	N.A.		
Non-current 1st-lien residential real estate loans	Total 1st Mortgage Real Estate Loans/Lines of Credit (Acct 703)	100%	Data available from 1994. We assume that all the 1st mortgage real estate are non-current.
Current junior real estate loans comprising less than 20% of assets	N.A		
Current junior real estate loans comprising more than 20% of assets	N.A		
Non-current junior real estate loans	Total Other Real Estate Loans/Lines of Credit (Acct 386)	150%	Data available from 1994.

Portions of commercial loans secured by compensating balances	N.A		
Current commercial loans comprising less than 50% of assets	N.A		
Current commercial loans comprising more than 50% of assets	N.A		
Non-current commercial loans	N.A		
Loans to CUSOs (unconsolidated CUSOs only)	Total Amount loaned to CUSOs (Acct 852)	100%	Data are not available in the data collected
Equity investments in CUSOs (unconsolidated CUSOs only)	Total Value of Investments in CUSOs (Acct 851)	100%	Data are not available in the data collected
(optional if line above is classified as a non-significant equity exposure)			
Mortgage servicing assets (carrying value)			
All others assets			
Off-balance sheet assets			
Commercial loans transferred with recourse	Loans Transferred with Limited Recourse Qualifying for Sales Accounting (Acct 819)	100%	Data are available from 1998.
1st-lien residential real estate loans transferred with recourse	N.A		
Junior-lien real estate transferred with recourse	N.A		
All other secured consumer loans transferred with recourse	N.A		
All other unsecured consumer loans transferred with recourse	N.A		
Loans transferred to FHLB under the Mortgage Partnership Finance Program	N.A		

Unfunded commercial loan commitments	Total Unfunded Commitments for Business Loans (Acct 814E)	50%	Data is available from 1998 to 2012. It is obtained by the sum of acct_814 and acct_814a. Values from 2012 are obtained by assuming a constant acct_814b to acct_814 ratio.
Unfunded 1st-lien residential real estate loan commitments	Revolving Open-End lines secured by 1-4 Family (Acct 811)	5% risk weight	Data available from 1998
Unfunded junior-lien real estate loan commitments	N.A		
Unfunded secured consumer loans	N.A		
Unfunded unsecured consumer loans	Total Unfunded Commitments for Non-Business Loans less unfunded residential loans. Obtained as the sum of the following items: Acct 812+ Acct 813+ Acct 815+ Acct 822+ Acct 816	10% 10%	Data available from 1998
OTC interest rate derivative contract exposure	N.A		
Cleared transactions for interest rate derivatives	N.A		

Appendix B: Literature review synthesis

Panel A: Risk Based Capital ratio

	Credit Unions
Sollenberger and Schneckenburger (1994)	They propose a risk-weighting method for the assets of US credit unions, based on methods established for commercial banks.
	Banks
Avery et al. (1990)	The new 1992 risk-adjusted capital (RBC) measure for US banks is strongly associated with several performance measures (the standard deviation ROA, delinquency ratio, bankruptcy ...) of banks.
Aikman et al. (2014)	For the prediction of bank distress, insensitive risk measures (the capital ratio) most often outperform sensitive risk measures (risk-adjusted capital ratio).
Berger and Bouwman (2013)	Sensitive risk measures are more weakly related to the distress of banks compared to the capital ratio.
Haldane and Madouros (2012)	Unweighted capital measures outperform risk-adjusted capital measures in predicting the bankruptcy of US banks.
Mayes and Stremmel (2012)	The capital ratio outperforms the risk-adjusted capital measure in predicting the distress of US banks.
Cizel et al. (2017)	The metrics related to the risk-weighted asset calculation method are not significantly related to the distress of large banks that primarily use the IRB Internal Rating Based approach. On the other hand, there is a positive and significant relationship between these metrics and the distress of small banks (which do not use the IRB approach).

Estrella et al. (2000)	RBC ratio tend to perform better over longer horizons and LR predict better bank failure over one- or two-year-time horizons.
	Panel B: Credit union risk profiling and stability
Ely (2014)	Multiple bond credit unions and community bond credit union are more risky (Z-score and REG-Z) than single bond credit unions, all things being equal. Community bond credit union are more risky (Z-score and REG-Z) than multiple bond credit unions. The change of field of membership impact the risk of credit union.
Frame et al. (2002)	Among single bond credit union, those with an occupational field of membership have a low delinquency rate and a high Leverage Ratio (LR). Multiple bond credit union have a high loan to deposit ratio (LTD) and a high LR. The number of Selected Employee Groups owned by multiple bond credit union is positively related to LTD and LR.
Esho et al. (2005)	The risk of credit unions increases with a high concentration of income sources. Diversifying sources of income is therefore beneficial.
Kohers (1986)	He reports that occupational credit unions serving sponsors operating in unstable business-cycle environments experienced higher loan delinquency rates and held higher levels of liquidity
Goddard et al. (2008)	Credit unions with large non-interest income operate at greater risk using the standard deviation of return on assets and the standard deviation of return on equity (ROE) as risk measures.
Goddard et al. (2015)	The probability of a credit union surviving is increasing relative to its size but decreasing with respect to age. Also, a high capital ratio and a high total loan-to-asset ratio increase the probability of survival and a high liquid asset ratio, on the contrary reduces the likelihood of survival.

Wilcox (2005)	Credit unions that go bankrupt have a low capital ratio, a low level of total assets, hold a low level of investment in financial assets and have a low return on assets compared to credit unions that have not failed (survivor). As well, failing credit unions have a high loan-to-asset ratio, a high unsecured loan ratio, a high delinquent loan, a high loan loss provisions, a high charged-off rate, and high interest income.
Wilcox (2007)	Low total assets, high loan-to-asset ratios, allowance for credit losses, delinquent loans, commercial loans and non-traditional expenses, a capital ratio and a return on assets low, and a high unemployment rate per state, significantly increase the likelihood of bankruptcy of American credit unions and commercial banks.

Appendix C: Joint regulation of the risk-based capital ratio (RBC) and the leverage ratio (LR)

The risk-based capital ratio (RBC) and the Leverage ratio (LR) are two related capital rules:

$$\text{RBC} = \frac{\text{Capital or Net worth}}{\text{Risk weighted assets (RWA)}}$$

$$\text{LR} = \frac{\text{Capital or Net worth}}{\text{Total assets}}$$

Therefore, the understanding of the nexus between the two capital rules is important to figure out how banks will react to their joint regulation. To formalize the idea, we decompose the formula of the leverage ratio as follows:

$$\underbrace{\frac{\text{Capital or Net worth}}{\text{Total assets}}}_{\text{Leverage ratio (LR)}} = \underbrace{\frac{\text{Capital or Net worth}}{\text{Risk weighted assets (RWA)}}}_{\text{Risk based Capital (RBC)}} \times \underbrace{\frac{\text{Risk weighted assets (RWA)}}{\text{Total assets}}}_{\text{RWA density: } \delta} = \frac{Capital}{RWA} \times \delta \quad (1)$$

For now on, we assume that regulators are imposing a limit of *l* % on the leverage ratio and c % on the risk-based capital ratio (RBC). This translates to:

$$\begin{array}{l} \text{Leverage ratio: } \frac{Capital}{Assets} \geq l \\ \text{Capital ratio: } \frac{Capital}{RWA} \geq c \end{array}, \quad (2)$$

Plugging equation (1) in (2) and writing $\delta = \frac{RWA}{Assets}$ yields:

$$\begin{array}{l} \frac{Capital}{Assets} \geq l \\ \frac{Capital}{RWA} = \frac{Capital}{Assets \times \delta} \geq c \end{array} \quad \text{or} \quad \begin{array}{l} \frac{Capital}{Assets} \geq l \\ \frac{Capital}{Assets} \geq c \times \delta \end{array}. \quad (3)$$

We can clearly see from the above system of inequation that the risk-based capital ratio is transformed to a leverage ratio with a limit that depends on δ. Since both constrains are expressed in function of credit unions leverage ratio (LR), the question is then: which one the credit union must

[46] We mentioned in Section 4.2 that the capital measure used in the numerator of the risk-based capital ratio is slightly adjusted. For the analysis of the combination of the two ratios, we keep the same measures of capital only for comparison motives.

satisfy? The answer to this question depends on the choice of the level of the asset risk parameter $\delta = \frac{RWA}{Assets}$, qualified as the "RWA density" of the credit union. Two cases may arrive.

- (**First case**) We assume that $l < c \times \delta$. In that case, the leverage ratio limit that is constraining for the credit union is $\frac{Capital}{Assets} \geq c \times \delta$. This happens only if the credit union chooses δ such that $\delta > \delta^* = \frac{l}{c}$. Under this case, the limit on the leverage ratio is an increasing function of the credit union δ. In other words, one point increase in the credit union RWA density δ implies a marginal increase in the leverage constraint in a proportion of the capital ratio limit c. When a credit union's asset risk is in this region, the capital ratio limit acts as the binding minimum capital requirement.

- (**Second case)** We assume that $\geq c \times \delta$. In that case, the binding constraint is $\frac{Capital}{Assets} \geq l$. This happens only if the credit union chooses δ such that $\delta \leq \delta^* = \frac{l}{c}$. Under this assumption, the leverage ratio limit is independent of the credit union's asset risk movement proxied by its RWA density, hence, the leverage ratio limit acts as the binding minimum capital requirement. This marks a clear difference with the case where only the "risk-based" capital ratio regulation is in effect. Here, we observe that in absence of a leverage ratio limit, the minimum capital ratio does not bind, and the credit union can continue to either reduce the regulatory capital level or increase the asset size simply by adding more non-risk sensitive assets. This can be done by RWA arbitrage via securitization, hedging with derivatives and so on…

It follows from this analysis that the joint risk-based capital and leverage ratios can be reduced to a simple leverage ratio Lev with a dynamic "*hockey stick* shape" limit function of the "RWA density" δ.

Then the reduced form leverage limit is the following:

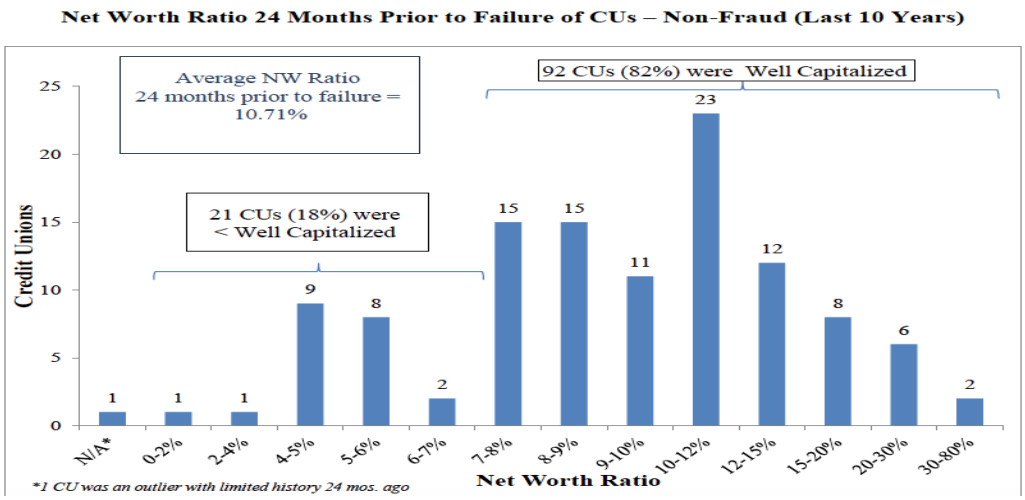
$$\begin{cases} LR \geq l & if\ \delta < \delta^* \\ LR \geq \delta c & if\ \delta > \delta^* \end{cases} \qquad (4)$$

Where δ is the credit union's 'RWA density' defined as credit union's RWA divided by its total assets. $\delta^* = \frac{l}{c}$ with c, l respectively the risk-based capital and leverage ratios limits set by the regulators. This result suggests that credit union's leverage under the joint risk-based and leverage ratios should be nonlinear in credit unions RWAD.

Appendix D: The list of CU that receive the TARP. The table is from Bauer (2012).

CU Number	CU Name	City	State	TARP Funds	% of Assets	Total Assets
15523	Tongass Federal Credit Union	Ketchikan	AK	1 600 000	3,09%	51 743 782
13852	Phenix Pride Federal Credit Union	Phenix City	AL	153 000	3,33%	4 593 899
24826	Pyramid Federal Credit Union	Tucson	AZ	2 500 000	3,24%	77 200 501
643	Butte Federal Credit Union	Biggs	CA	1 000 000	2,91%	34 327 327
4900	Cooperative Center Federal Credit Union	Berkeley	CA	2 799 000	3,26%	85 793 543
24506	Episcopal Community Federal Credit Union	Los Angeles	CA	100 000	2,07%	4 825 839
24687	Faith Based Federal Credit Union	Oceanside	CA	30 000	3,45%	868 689
23780	Northeast Community Federal Credit Union	San Francisco	CA	350 000	3,21%	10 909 385
64029	Santa Cruz Community Credit Union	Santa Cruz	CA	2 828 000	3,28%	86 095 980
23896	East End Baptist Tabernacle Federal Credit Union	Bridgeport	CT	7 000	2,76%	253 280
16411	D.C. Federal Credit Union	Washington	DC	1 522 000	3,34%	45 502 538
15051	Community First Guam Federal Credit Union	Hagatna	GU	2 650 000	3,31%	80 087 717
5628	Independent Employers Group Federal Credit Union	Hilo	HI	698 000	3,23%	21 589 706
20187	Prince Kuhio Federal Credit Union	Honolulu	HI	273 000	3,27%	8 355 087
24751	Community Plus Federal Credit Union	Rantoul	IL	450 000	3,16%	14 260 766
21550	North Side Community Federal Credit Union	Chicago	IL	325 000	3,09%	10 515 711
24781	Union Baptist Church Federal Credit Union	Fort Wayne	IN	10 000	3,14%	318 788
138	Vigo County Federal Credit Union	Terre Haute	IN	1 229 000	3,34%	36 794 163
9164	Carter Federal Credit Union	Springhill	LA	6 300 000	3,27%	192 865 323
11263	Shreveport Federal Credit Union	Shreveport	LA	2 646 000	2,99%	88 624 789
23540	Tulane-Loyola Federal Credit Union	New Orleans	LA	424 000	3,24%	13 092 321
20842	UNO Federal Credit Union	New Orleans	LA	743 000	3,40%	21 845 123
24829	Hope Federal Credit Union	Jackson	MS	4 520 000	3,38%	133 734 271
18983	Gateway Community Federal Credit Union	Missoula	MT	1 657 000	3,02%	54 796 168
68593	First Legacy Community Credit Union	Charlotte	NC	1 000 000	2,46%	40 592 915
64034	Greater Kinston Credit Union	Kinston	NC	350 000	2,40%	14 583 344
68195	Renaissance Community Development Credit Union	Somerset	NJ	31 000	3,41%	908 679
23283	Alternatives Federal Credit Union	Ithaca	NY	2 234 000	3,23%	69 085 087
19907	Bethex Federal Credit Union	Bronx	NY	502 000	3,15%	15 932 333
24642	Brooklyn Cooperative Federal Credit Union	Brooklyn	NY	300 000	2,93%	10 251 452
23495	Buffalo Cooperative Federal Credit Union	Buffalo	NY	145 000	3,22%	4 508 459
11380	Fidelis Federal Credit Union	New York	NY	14 000	3,27%	428 169
23848	Genesee Co-op Federal Credit Union	Rochester	NY	300 000	2,90%	10 353 127
24232	Lower East Side People's Federal Credit Union	New York	NY	898 000	3,43%	26 167 815
24589	Neighborhood Trust Federal Credit Union	New York	NY	283 000	3,47%	8 160 017
9107	Southern Chautauqua Federal Credit Union	Lakewood	NY	1 709 000	3,21%	53 246 159
11702	Union Settlement Federal Credit Union	New York	NY	295 000	3,35%	8 795 599
24772	Workers United Federal Credit Union	New York	NY	57 000	2,84%	2 006 059
20354	Hill District Federal Credit Union	Pittsburgh	PA	100 000	2,78%	3 599 194
24304	Border Federal Credit Union	Del Rio	TX	3 260 000	3,28%	99 439 970
14052	Liberty County Teachers Federal Credit Union	Liberty	TX	435 000	3,31%	13 141 331
68193	Southside Credit Union	San Antonio	TX	1 100 000	3,41%	32 215 942
24658	Fairfax County Federal Credit Union	Fairfax	VA	8 044 000	3,37%	238 343 943
11111	Freedom First Federal Credit Union	Roanoke	VA	9 278 000	3,54%	261 941 458
67251	Opportunities Credit Union	Burlington	VT	1 091 000	3,57%	30 539 596
68528	Thurston Union of Low-Income People (TULIP) Cooperative Credit U	Olympia	WA	75 000	3,38%	2 221 825
66637	Brewery Credit Union	Milwaukee	WI	1 096 000	3,28%	33 392 904
16009	Atlantic City Federal Credit Union	Lander	WY	2 500 000	2,95%	84 753 699

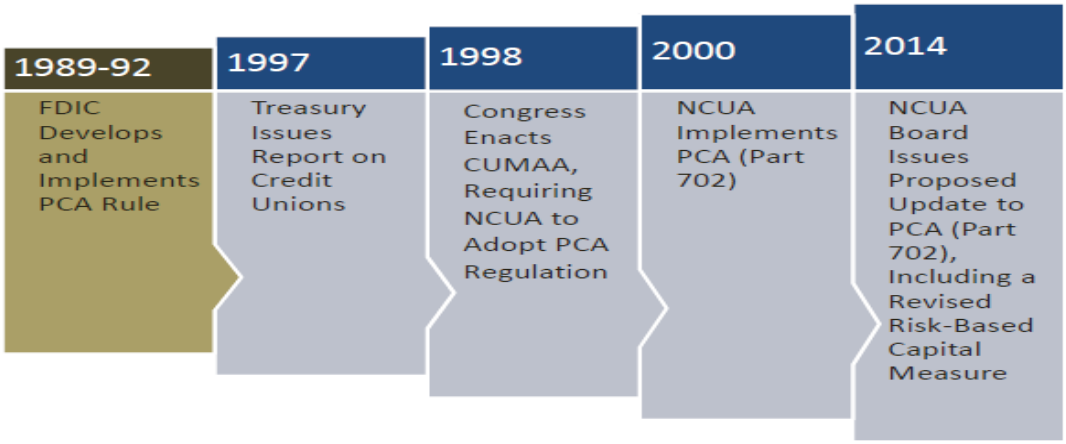
Figure 1: Distribution of failures according to the 24 months leverage ratio during the 1995-2015 period



Source: NCUA 2015[47]

Chart 1: The history of capital regulation in US credit unions

This figure shows that the implementation of a formal capital rule by the NCUA only starts in 2000, more than ten years after its implementation by the FDIC for banks



Source: NCUA (2015)[48]

[47] https://www.cuna.org/Legislative-And-Regulatory-Advocacy/Regulatory-Advocacy/Regulatory-Topics/RBC-Resources-from-NCUA/

[48] https://www.ncua.gov/Legal/Documents/RBC/RBC-webinar-slides.pdf

Table 1: Credit union distribution by size in % of the total number of credit unions

This table presents the distribution of credit union by size and subperiods. We provide descriptive statistics for the whole sample period (1994.1–2015.2) and three subperiods: the pre-crisis period (1994.1 to 2008.1), the crisis period (2008.2–2009.2) and the postcrisis period (2010.1–2015.2). Small credit unions have assets smaller than 100K$, medium credit unions have assets between 100K and 500K and large credit unions have assets above 500K.

	Pre-crisis	Crisis	Post-crisis	Whole sample
Small	84.31	77.68	75.92	82.15
Medium	12.11	15.88	16.87	13.34
Large	3.58	6.44	7.20	4.51
Total	100	100	100	100

Table 2: Descriptive statistics of the RWAD and credit union performance measures

This table presents the descriptive statistics of the credit union performance measures and the regulatory measure of assets risk (LR, RBC), the risk weighted assets density (RWAD). The measures of the credit union performance are: The total non performing loans (NPL), the chargeoff rates (CHOFF), the return on assets (ROA) and the return on assets volatility (SdROA). Additional variables are the Z-score and the variable Failure (Credit Union that fails). We test the difference between credit union size (small versus medium and large credit unions). We conduct both the parametric t-test (The null hypothesis (H0) tests the equality of means) and the non parametric Wilcoxon-Mann-Whitney (H0 tests the equality of the medians). . ***, ** and * denote statistical significance at 1%, 5%, 10%, respectively.

	Small	Medium	Large sample	Whole sample	Large vs Small Rank-sum test (T-test)	Large vs Medium Rank-sum test (T-test)
RBC	0.139	0.105	0.109	0.133	74.61***	15.05***
LR	0.317	0.172	0.156	0.290	51.94	13.30***
RWAD	0.598	0.705	0.740	0.625	49.23***	-13.45***
CHOFF	0.120	0.109	0.118	0.118	-4.15***	9.46 ***
NPL	0.649	0.318	0.278	0.589	55.99***	14.51***
ROA	0.216	0.323	0.400	0.238	35.03***	22.70 ***
Z-score	2.956	3.197	3.275	3.000	61.73***	20.32 ***
SdROA	0.878	0.489	0.432	0.808	67.505***	22.880***
Failure	0.100	0.052	0.016	0.094		

Table 3: Regulatory asset risk (RWAD) and the credit union performance measures by bond type, maturity and macro economic conditions

This table presents and test the difference between mean values of credit union performance measures (the risk weighted assets density (RWAD), the total non-performing loans (NPL), the chargeoff rates (CHOFF), the return on assets (ROA) and the return on assets volatility (SdROA), the Failure dummy variable (takes one if the credit union fails in a given year). We test the means difference between bond types (single versus non single (multiple or community)), maturity (mature= 1 for age above the median credit union age and zero otherwise) and macroeconomic condition (crisis versus non crisis periods). The column Sign. reports the outcome of the difference test performed using the t-test and the Wilcoxon test. ***, ** and * denote statistical significance at 1%, 5%, 10%, respectively.

	Common bond			Maturity			Macro condition		
	Single Bond	Multiple Bond	Difference Sign.	Mature	New	Difference Sign.	Crisis	Non crisis	Difference Sign.
RWAD	0.60	0.65	***	0.61	0.63	***	0.62	0.62	
CHOFF	0.12	0.12		0.11	0.12	***	0.13	0.11	***
NPL	0.64	0.52	***	0.52	0.65	***	0.59	0.58	**
ROA	0.25	0.22	***	0.24	0.23	***	0.11	0.26	***
Z-score	3.00	2.99	***	3.10	2.89	***	3.07	2.98	***
SdROA	0.87	0.74	***	0.70	0.92	***	0.77	0.81	***
Failure	0.13	0.05	***	0.06	0.12	***	0.14	0.08	***

Table 4: Distribution of the number of credit unions failures by year and by credit union size
This table present the number of credit unions that are liquidated by the NCUA during each year from 1994 to 2015 by credit union size.

	Number of failed credit unions Failure		
Year	Small	Medium	Large
1994	7	0	0
1995	6	0	0
1996	12	0	0
1997	24	1	0
1998	23	1	0
1999	25	3	0
2000	18	0	2
2001	20	1	0
2002	13	0	0
2003	8	0	0
2004	9	0	0
2005	13	0	0
2006	13	0	0
2007	15	2	0
2008	17	3	0
2009	18	8	0
2010	23	6	0
2011	17	1	0
2012	24	2	0
2013	16	0	1
2014	13	1	0
2015	16	0	0
Total	**350**	**29**	**3**

Figure 2. Number of failed credit unions per year

This figure shows the distribution of the number of failed (or liquidated) credit union independently of their size.

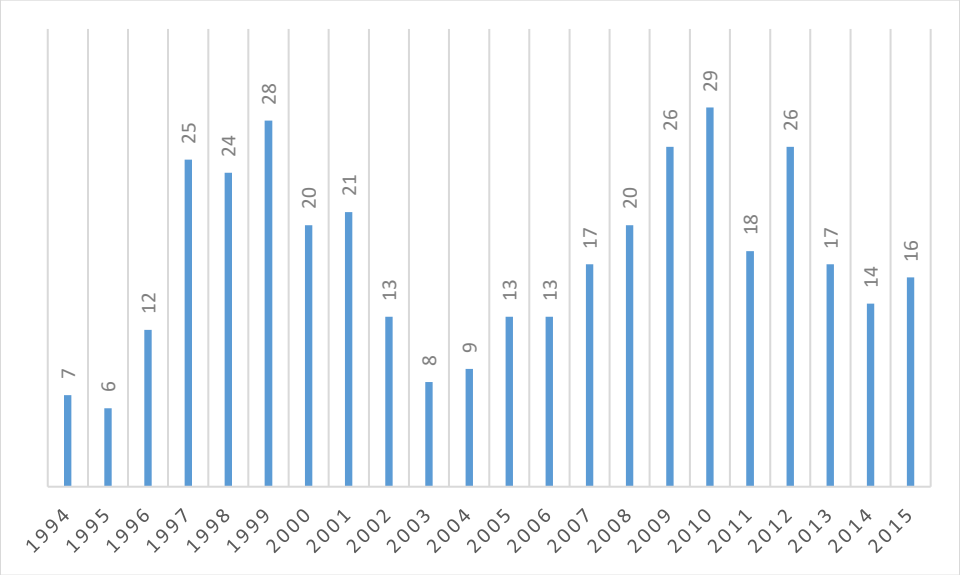


Table 5: Variables definition

	Variables	Computation	Calculation formulae based on the "5300 Call report items"
Dependent variables	NPL	*Non-performing loans= Total delinquent loans / Loans*	acct_041b / acct_025b
	CHOFF	*Charge-off= Total loans charged-off / Total Loans*	acct_550 / acct_025b if time=Year.h1 d.acct_550 / acct_025b if time=Year.h2
	ROA	*Return on assets = Net Income / Average assets*	(acct_661a+ acct_388) / [(Lag.acct_010 +acct_010) /2] if time=Year.h1 d.(acct_661a+ acct_388) / [(Lag.acct_010 +acct_010) /2] if time=Year.h2
	Failure	*Dummy for credit union that failed*	1 if credit union has failed in period (half-year) T otherwise 0
	Z-score	*Log [(LR + ROA) / Sd(ROA[49])] or* *Log [(RBC + RORWA) / Sd(RORWA[50])]*	
Variables of interest	RBC	*Risk-based capital ratio= Net worth (adjusted)[51] / RWA*	See appendix A
	LR	*Leverage ratio=Total Capital / Total Asset*	(acct_931+ acct_668+ acct_925+ acct_658+ acct_940+ acct_602) / acct_010 before 2000h2 and acct_997/ min (acct_010, acct_010 (a, b or c) after 2000h2
Control variables	SIZE	*Log (Total Asset)*	Log (acct_010)
	LIQ_A	*Asset Liquidity=Cash / Total Asset*	(acct_730a + acct_730b+ acct_730c) / acct_010 or + acct_730 / acct_010
	LIQ_L	*Non-deposit funds= Non deposits funds / Total liability*	(acct_860c + acct_825 + acct_820a + acct_820) / acct_860c + acct_825 + acct_820a+ acct_820
	LOTA	*Loan-to-assets= Total Loans / Total Asset*	Acct_025b / acct_010
	EFF	*Efficiency= Operating expenses / Interest income*	acct_671 / d. (acct_115 + acct_100) if time=Year.h1 d.acct_671 / d. (acct_115 + acct_100) if time=Year.h2
	MAT	*Maturity= Log (current year - opened year)* *Dummy variable*	1 if the credit union age is above the median age of credit union at a given date.
	FCHART	*Dummy for federally chartered credit unions*	1 if credit union have federal charter and 0 otherwise.
	SBOND	*Dummy for single bond credit unions*	1 if the credit union is of single bond and 0 otherwise.
Macroeconomic variables	UEMPL	*Unemployment rate by state*	Provided by the Bureau of Labor Statistics
	RGDP	*Real Gross Domestic product* [52]	Provided by the FED St. Louis

[49] We computed the standard deviation of the credit union ROA, using all it recorded historical data. Doing so we have one value by credit union. Also used as a dependent variable.

[50] We computed the standard deviation of the credit union RORWA (Net Income/average RWA), using all it recorded historical data. Doing so we have one value by credit union.

[51] The numerator of the RBC and its denominators includes both the Net worth (used as numerator of the NWR) and others additional capital elements such as the allowance to loan losses minus the deposits to the NCUSIF (the credit union deposits insurance fund), goodwill and other intangible assets.

[52] According to the FED St Louis (https://fred.stlouisfed.org/series/A191RL1Q225SBEA , July 10, 2019), "Gross domestic product (GDP) is the value of the goods and services produced by the nation's economy less the value of the goods and services used up in production. GDP is also equal to the sum of personal consumption expenditures, gross private domestic investment, net exports of goods and services, and government consumption expenditures and gross investment. Real values are inflation-adjusted estimates—that is, estimates that exclude the effects of price changes".

Figure 3: Average log of Z-score: Failed versus survived credit unions

This figure plots the average value of the Z-score of failed and survived credit unions.

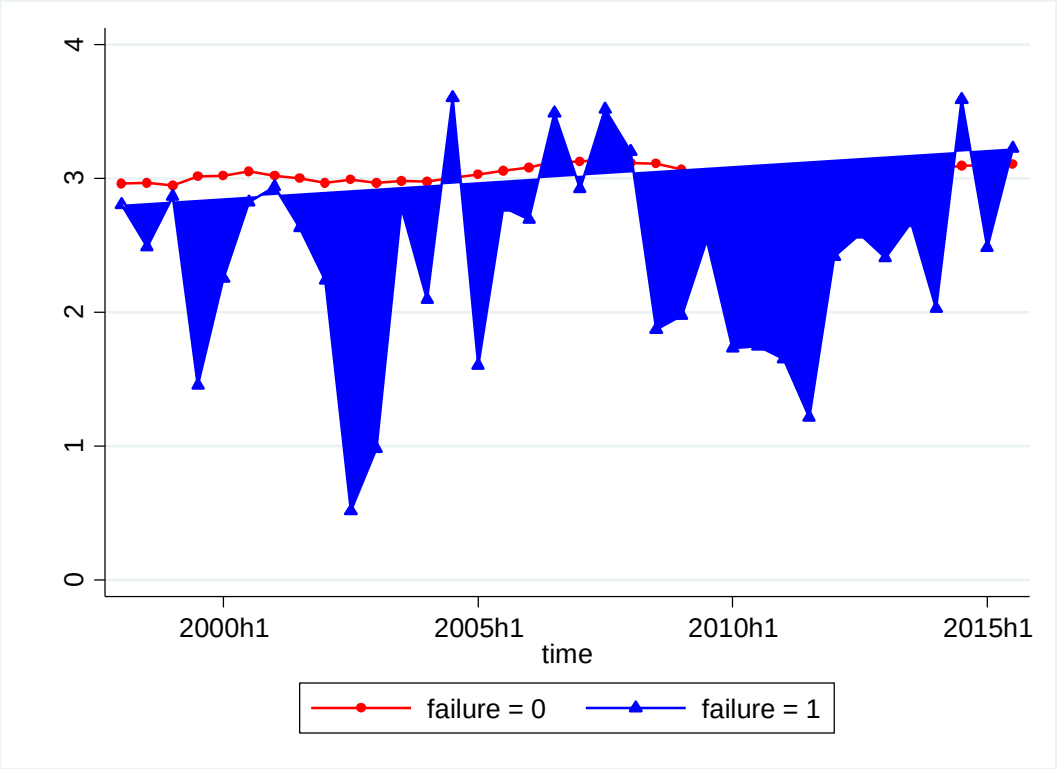


Table 6: Performance measures and the new asset risk measure (RWAD)

This table reports the results from the regression of credit union performance measures on the risk-weighted assets density (RWAD). The RWAD is obtained as the ratio of risk weighted assets (RWA) to total assets (Assets). The measures of the credit union performance are: The total non-performing loans (NPL), the charge off rates (CHOFF), the return on assets (ROA) and the return on assets volatility (SdROA). The analysis is based on half-annual data from 1998 to 2015 and include different size of credit union: large credit unions (with equivalent[53] assets above 500 million), medium credit unions (with assets between $500 million and $100 million) and small credit unions (with assets below $100 million). Capital ratios (LR and RBC) are the variables of interest. Control variables include : Credit unions bond type captured by SBOND (a dummy variable that takes one if the credit union if of single bond), credit unions maturity dummy MAT that takes one if the credit union age is above the median age of credit union at a given date. Macroeconomic condition is jointly captured by the crisis dummy (years 2007-2010) and the state by state employment rate (UEMPL). ***, ** and * denote statistical significance at 1%, 5%, 10%, respectively. Prefix "L." on a variable X denotes that we include in the regression the lag of the variable X. A lag corresponds to a 6-month period.

	Non performing loans (NPL)			Charge Off Rate (CHOFF)			Return on assets (ROA)			ROA volatility (SdROA)		
VARIABLES	Small	Medium	Large	Small	Medium	Large	Small	Medium	Large	Small	Medium	Large
RWAD	**0.561*** **	**0.424*** **	**0.361*** **	**0.0870*** **	**0.146*** **	**0.178*** **	**0.401*** **	**0.0605** **	**-0.187*** **	**-0.103***	**0.168*** **	**-0.0378**
	(0.0174)	(0.0263)	(0.0445)	(0.00366)	(0.00889)	(0.0145)	(0.0135)	(0.0275)	(0.0528)	(0.0536)	(0.0645)	(0.0884)
SBOND	0.0196*	-0.000656	-0.0219*	0.00757***	0.0109***	0.00263	0.00382	0.00410	-0.00183	0.0633***	0.0121	0.0203
	(0.0100)	(0.0122)	(0.0122)	(0.0019)	(0.00311)	(0.00482)	(0.00687)	(0.0109)	(0.0147)	(0.0150)	(0.0164)	(0.0172)
MAT	0.0219	0.0316	-0.0718	0.0101*	0.00914	-0.00249	0.0841***	0.0210	0.0328	-0.236***	0.0348**	0.000837
	(0.0271)	(0.0259)	(0.0543)	(0.00526)	(0.00961)	(0.0167)	(0.0188)	(0.0301)	(0.0321)	(0.0146)	(0.0146)	(0.0204)
UEMPL	0.0220***	0.0472***	0.0654***	0.00743***	0.0151***	0.0219***	-0.0674***	-0.0362***	-0.0266***			
	(0.00157)	(0.00236)	(0.00406)	(0.000344)	(0.000709)	(0.00147)	(0.00133)	(0.00189)	(0.00251)			
CRISIS	0.0353***	0.0520***	0.0563***	0.00676***	0.0155***	0.0204***	-0.0300***	-0.0964***	-0.144***			
	(0.00578)	(0.00685)	(0.00996)	(0.00119)	(0.00199)	(0.00299)	(0.00431)	(0.00746)	(0.0116)			
CONST	0.120***	-0.298***	-0.336***	0.0131***	-0.101***	-0.154***	0.298***	0.503***	0.728***	1.107***	0.345***	0.457***
	(0.0217)	(0.0342)	(0.0633)	(0.00449)	(0.0118)	(0.0217)	(0.0165)	(0.0326)	(0.0515)	(0.0441)	(0.0528)	(0.0721)
Observations	249,863	42,451	15,085	249,863	42,451	15,085	249,863	42,451	15,085	18,825	2,462	828
R-squared	0.023	0.129	0.277	0.010	0.130	0.262	0.059	0.068	0.096	0.015	0.005	0.002
NB CUS	9,906	1,412	500	9,906	1,412	500	9,906	1,412	500	18,825	2,462	828
FE	YES	YES	YES	YES	YES	YES	YES	YES	YES			

[53] We compute for each year preceding 2015 the equivalent of $500 million assets based on a 2% half-annual average asset growth rate.

Table 7: Z-score and the capital ratios (LR and RBC)

This table reports the results from the regression of Z-score on RBC, LR and both ratios. The analysis is based on half-annual data from 1998 to 2015 and include large credit unions (with equivalent[54] assets above $500 million). Control variables include the asset liquidity (LIQ_A) obtained as the ratio of liquid assets to total assets, liability liquidity (LIQ_L) obtained as the ratio of non-deposit funds other than capital to total liabilities, the efficiency ratio (EFF) obtained as the ratio of operating expenses over operating income, the delinquent loans ratio (NPL). Macroeconomic variable is the employment rate ratio by state (UEMPL). Credit union (CU) specific characteristics include (SBOND) a dummy for single bond credit unions and their maturity that takes one if the credit union age is above the median age of CU at a given date. ***, ** and * denote statistical significance at 1%, 5%, 10%, respectively. Prefix "L." on a variable X denotes that we include the lag of the variable X. A lag corresponds to a 6-month period.

	Regression of Z-score on the RBC				Regression of Z-score on the LR				Regression of Z-score on both the LR and RBC			
VARIABLES	Small	Medium	Large	Whole sample	Small	Medium	Large	Whole sample	Small	Medium	Large	Whole sample
LIQ_A	-0.00863	0.0214	-0.0265	-0.00284	0.0229***	0.0950***	0.105***	0.0252***	0.0229***	0.0964***	0.0976***	0.0255***
	(0.00938)	(0.0260)	(0.0472)	(0.00896)	(0.00501)	(0.0137)	(0.0218)	(0.00479)	(0.00500)	(0.0136)	(0.0215)	(0.00478)
LIQ_L	0.308***	0.0114	-0.155*	0.0728	0.218***	0.107**	-0.0634	0.142***	0.222***	0.105**	-0.0515	0.144***
	(0.0686)	(0.0826)	(0.0886)	(0.0492)	-0.0439	(0.0419)	(0.0429)	(0.0303)	(0.0438)	(0.0422)	(0.0448)	(0.0302)
EFF	-0.0998***	-0.0776***	0.0206	-0.0894***	-0.0749***	-0.00862**	0.0377***	-0.0647***	-0.0754***	-0.00791**	0.0359***	-0.0649***
	(0.00511)	(0.00972)	(0.0145)	(0.00454)	(0.00260)	(0.00387)	(0.00629)	(0.00230)	(0.00260)	(0.00396)	(0.00654)	(0.00231)
NPL	-2.402***	-12.78***	-15.08***	-2.890***	-3.076***	-8.616***	-10.61***	-3.338***	-3.077***	-8.638***	-10.62***	-3.344***
	(0.191)	(1.118)	(1.888)	(0.192)	(0.119)	(0.722)	(1.378)	(0.119)	(0.119)	(0.725)	(1.385)	(0.119)
RBC	**0.126*** **	**0.831*** **	**1.197*** **	**0.133*** **					0.00249	-0.0177	0.0847	0.000283
	(0.00674)	(0.184)	(0.260)	(0.00688)					(0.00261)	(0.0228)	(0.0904)	(0.00262)
LR					**5.553*** **	**7.461*** **	**7.813*** **	**5.684*** **	**5.555*** **	**7.490*** **	**7.686*** **	**5.690*** **
					(0.0439)	(0.139)	(0.190)	(0.0428)	(0.0440)	(0.133)	(0.204)	(0.0430)
UEMPL	-0.00778***	-0.0122***	-0.0132***	-0.0102***	-0.0121***	-0.00884***	-0.00553***	-0.0123***	-0.0121***	-0.00880***	-0.00565***	-0.0123***
	(0.000587)	(0.000876)	(0.00145)	(0.000497)	(0.000317)	(0.000490)	(0.000909)	(0.000272)	(0.000316)	(0.000492)	(0.000965)	(0.000271)
SBOND	0.0249***	0.0156**	0.0184**	0.0236***	0.00589***	0.00371	0.00550**	0.00663***	0.00607***	0.00368	0.00599**	0.00678***
	(0.00436)	(0.00673)	(0.00875)	(0.00369)	(0.00213)	(0.00293)	(0.00278)	(0.00179)	(0.00212)	(0.00292)	(0.00285)	(0.00178)
MAT	0.0187	0.0150	0.0200	0.0153	0.00521	0.00176	0.00501	0.00518	0.00511	0.00163	0.00597	0.00512
	(0.0129)	(0.0181)	(0.0260)	(0.0109)	(0.00583)	(0.00573)	(0.00997)	(0.00486)	(0.00583)	(0.00574)	(0.0101)	(0.00486)
CONST.	3.054***	3.215***	3.188***	3.112***	2.324***	2.457***	2.482***	2.380***	2.324***	2.457***	2.483***	2.379***
	(0.00869)	(0.0328)	(0.0452)	(0.00771)	(0.00711)	(0.0168)	(0.0215)	(0.00666)	(0.00709)	(0.0165)	(0.0218)	(0.00664)
Observations	248,567	42,246	14,981	305,794	248,599	42,246	14,981	305,826	248,567	42,246	14,981	305,794
R-squared	0.048	0.224	0.326	0.054	0.502	0.637	0.669	0.510	0.503	0.637	0.670	11,788
Nb CUs	9,877	1,412	499	11,788	9,878	1,412	499	11,789	9,877	1,412	499	0.511
FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

[54] We compute for each year preceding 2015 the equivalent of $500 million assets based on a 2% half-annual average asset growth rate.

Table 8: Z-score adjusted and the capital ratios (LR and RBC)

This table reports the results from the regression of "risk adjusted" Z-score (computed with the RBC and ROA_adjusted) on RBC, LR and both ratios. The analysis is based on half-annual data from 1998 to 2015 and include large credit unions (with equivalent[55] assets above $500 million). Control variables include the asset liquidity (LIQ_A) obtained as the ratio of liquid assets to total assets, liability liquidity (LIQ_L) obtained as the ratio of non-deposit funds other than capital to total liabilities, the efficiency ratio (EFF) obtained as the ratio of operating expenses over operating income, the delinquent loans ratio (NPL). Macroeconomic variable is the employment rate ratio by state (UEMPL). Credit union (CU) specific characteristics include (SBOND) a dummy for single bond credit unions and their maturity that takes one if the credit union age is above the median age of CU at a given date. ***, ** and * denote statistical significance at 1%, 5%, 10%, respectively. Prefix "L." on a variable X denotes that we include the lag of the variable X. A lag corresponds to a 6-month period.

	Regression of Z-score_adjusted on the RBC				Regression of Z-score_adjusted on the LR				Regression of Z-score_adjusted on both the LR and RBC			
VARIABLES	Small	Medium	Large	Whole sample	Small	Medium	Large	Whole sample	Small	Medium	Large	Whole sample
LIQ_A	0.245***	0.330***	0.355***	0.259***	0.337***	0.513***	0.612***	0.351***	0.270***	0.381***	0.406***	0.282***
	(0.0132)	(0.0472)	(0.0728)	(0.0125)	(0.0155)	(0.0340)	(0.0564)	(0.0147)	(0.0127)	(0.0444)	(0.0729)	(0.0121)
LIQ_L	-0.820***	-0.710***	-0.527***	-0.941***	-0.986***	-0.857***	-0.824***	-0.998***	-0.875***	-0.645***	-0.484***	-0.887***
	(0.0908)	(0.117)	(0.135)	(0.0646)	(0.0892)	(0.0858)	(0.114)	(0.0614)	(0.0804)	(0.0904)	(0.122)	(0.0558)
EFF	0.0879***	0.0474***	0.0673***	0.0890***	0.173***	0.159***	0.125***	0.169***	0.108***	0.0948***	0.0737***	0.109***
	(0.00686)	(0.0146)	(0.0224)	(0.00609)	(0.00738)	(0.0112)	(0.0182)	(0.00647)	(0.00630)	(0.0150)	(0.0215)	(0.00555)
NPL	-3.997***	-9.530***	-7.492***	-4.328***	-5.837***	-8.542***	-5.300***	-6.022***	-4.491***	-6.626***	-5.658***	-4.667***
	(0.233)	(1.246)	(1.915)	(0.229)	(0.253)	(0.947)	(1.443)	(0.245)	(0.213)	(0.898)	(1.575)	(0.208)
RBC	**0.600*** **	**2.190*** **	**2.871*** **	**0.620*** **					**0.498*** **	**1.613*** **	**2.414*** **	**0.508*** **
	(0.0175)	(0.401)	(0.785)	(0.0177)					(0.0165)	(0.342)	(0.792)	(0.0165)
LR					**4.969*** **	**7.757*** **	**6.770*** **	**5.144*** **	**3.972*** **	**5.085*** **	**3.162*** **	**4.135*** **
					(0.0813)	(0.200)	(0.380)	(0.0775)	(0.0736)	(0.548)	(0.571)	(0.0709)
UEMPL	0.00807***	0.00132	0.00234	0.00607***	0.00662***	0.00699***	0.00904***	0.00621***	0.00507***	0.00361***	0.00546***	0.00465***
	(0.000714)	(0.000998)	(0.00159)	(0.000590)	(0.000754)	(0.00107)	(0.00155)	(0.000609)	(0.000632)	(0.000983)	(0.00179)	(0.000516)
SBOND	0.0396***	0.0144*	0.00715	0.0339***	0.0282***	0.00339	-0.0119	0.0225***	0.0263***	0.00626	0.00203	0.0218***
	(0.00559)	(0.00748)	(0.00781)	(0.00472)	(0.00585)	(0.00697)	(0.0109)	(0.00483)	(0.00477)	(0.00570)	(0.00718)	(0.00398)
MAT	-0.0110	-0.0194	-0.0386	-0.0184	-0.0169	-0.0406	-0.0719**	-0.0241*	-0.0202	-0.0285	-0.0444*	-0.0254**
	(0.0165)	(0.0231)	(0.0274)	(0.0142)	(0.0160)	(0.0257)	(0.0339)	(0.0136)	(0.0139)	(0.0196)	(0.0253)	(0.0119)
CONST.	2.903***	3.166***	3.203***	3.006***	2.340***	2.577***	2.874***	2.433***	2.382***	2.651***	2.913***	2.476***
	(0.0115)	(0.0643)	(0.118)	(0.0104)	(0.0159)	(0.0314)	(0.0513)	(0.0144)	(0.0134)	(0.0289)	(0.0662)	(0.0123)
Observations	247,933	42,269	14,982	305,184	247,942	42,269	14,982	305,193	247,933	42,269	14,982	305,184
R-squared	0.217	0.438	0.521	0.218	0.199	0.390	0.333	0.209	0.303	0.541	0.558	0.311
Nb CUs	9,871	1,412	499	11,782	9,871	1,412	499	11,782	9,871	1,412	499	11,782
FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

[55] We compute for each year preceding 2015 the equivalent of $500 million assets based on a 2% half-annual average asset growth rate.

Table 9: The effect of risk-based capital ratio on Z-score: Analysis by quantiles of the leverage ratio

This table reports the analysis of each capital rule effect on the Z-score based on subsample based on the quartile of the other capital rule. The first four columns of result display the effect of the risk-based capital ratio (RBC) for their different level of leverage ratio (LR) capitalization. The last four columns are the corresponding regressions for different quartiles of the RBC distribution. The analysis is based on half-annual data from 1998 to 2015 and include only large credit unions (with equivalent[56] assets above $500 million). Capital ratios (LR and RBC) are the variables of interest. Control variables include the asset liquidity (LIQ_A) obtained as the ratio of liquid assets to total assets, liability liquidity (LIQ_L) obtained as the ratio of non-deposit funds other than capital to total liabilities, The efficiency ratio (EFF) obtained as the ratio of operating expenses over operating income, the delinquent loans (NPL) obtained as the ratio of delinquent loans to total loans. Macroeconomic conditions are captured by the employment rate ratio by state (UEMPL). Credit union specific characteristics include their bond type (SBOND) a dummy for single bond credit unions and

their maturity that takes one if the credit union age is above the median age of credit union at a given date. ***, ** and * denote statistical significance at 1%, 5%, 10%, respectively. Letter "l" denote that the variable is a lag (6 month).

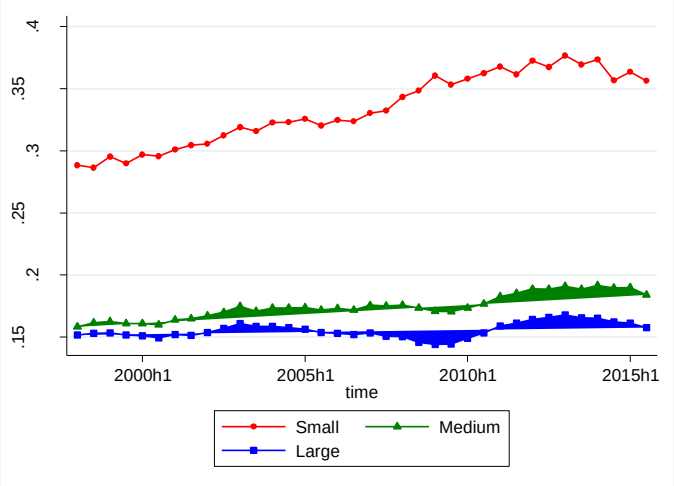
	Z-score				Z-score			
VARIABLES	LR (Q4=1)	LR (Q4=2)	LR (Q4=3)	LR (Q4=4)	RBC (Q4=1)	RBC (Q4=2)	RBC (Q4=3)	RBC (Q4=4)
LIQ_A	0.0296	-0.0539	-0.00754	-0.495***	0.176***	0.0411*	0.0137	-0.0965**
	(0.0602)	(0.0416)	(0.0531)	(0.103)	(0.0335)	(0.0235)	(0.0403)	(0.0419)
LIQ_L	0.196*	0.0159	-0.00957	0.171	-0.129**	0.0430	0.268***	-0.364
	(0.111)	(0.0693)	(0.109)	(0.216)	(0.0582)	(0.0556)	(0.0662)	(0.464)
EFF	0.0213	-0.0604***	-0.0992***	-0.168***	0.0519***	0.00890	-0.0186*	-0.0316
	(0.0176)	(0.0109)	(0.0212)	(0.0475)	(0.00963)	(0.00800)	(0.0105)	(0.0332)
NPL	-15.05***	-4.618***	-1.806	0.149	-11.27***	-4.506***	-1.737	-26.54*
	(1.627)	(0.822)	(1.831)	(3.670)	(1.505)	(1.120)	(1.924)	(14.44)
RBC	**1.957*** **	**0.672*** **	**0.685*** **	**0.322*** **				
	(0.402)	(0.210)	(0.103)	(0.0649)				
LR					**8.804*** **	**6.709*** **	**5.888*** **	**5.318*** **
					(0.372)	(0.183)	(0.210)	(0.792)
UEMPL	**-0.0160*** **	**-0.0144*** **	**-0.00942*** **	**-0.0104** **	**-0.00609*** **	**-0.00738*** **	**-0.00685*** **	**-0.00573**
	(0.00183)	(0.00105)	(0.00172)	(0.00510)	(0.00132)	(0.000981)	(0.00115)	(0.00758)
SBOND	0.0185*	0.0151*	-0.00806	0.0593***	-1.82e-05	0.0106**	0.000412	-0.0149
	(0.0102)	(0.00784)	(0.0124)	(0.0114)	(0.00379)	(0.00466)	(0.00622)	(0.0183)
MAT	0.0393	0.0208	0.0822***	NA	0.0148	0.0185***	0.0292**	0.00848
	(0.0460)	(0.0238)	(0.0213)		(0.0161)	(0.00655)	(0.0146)	(0.0109)
CONST.	2.951***	3.372***	3.443***	3.547***	2.370***	2.659***	2.742***	2.672***
	(0.0526)	(0.0388)	(0.0280)	(0.0588)	(0.0354)	(0.0233)	(0.0307)	(0.136)
Observations	5,795	6,132	2,529	525	8,026	4,625	1,879	451
R-squared	0.347	0.281	0.254	0.442	0.608	0.648	0.696	0.611
Nb CUs	354	402	225	44	382	338	144	31
FE	YES	YES	YES	YES	YES	YES	YES	YES

[56] We compute for each year preceding 2015 the equivalent of $500 million assets based on a 2% half-annual average asset growth rate.

Figure 4: The leverage ratio and the risk-based capital ratio by credit union size

We plot the dynamic of the average value of credit unions' leverage (LR) and risk-based capital ratio (RBC) for different credit union size: small credit unions (with total assets below $100 million), medium CU (with total assets between $100 million and $500 million) and large credit unions (with assets above $500 million). The RBC ratio is obtained as the ratio of credit union capital or net worth to total assets risk measured by the risk-weighted assets. The net worth capital or leverage ratio is obtained as the ratio of credit union capital or net worth to total assets.

Panel A: The risk-based capital ratio (RBC)



Panel B: The leverage or the net worth ratio (LR)

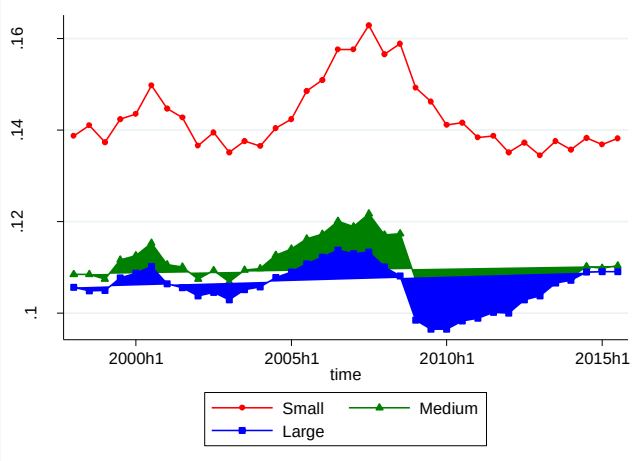
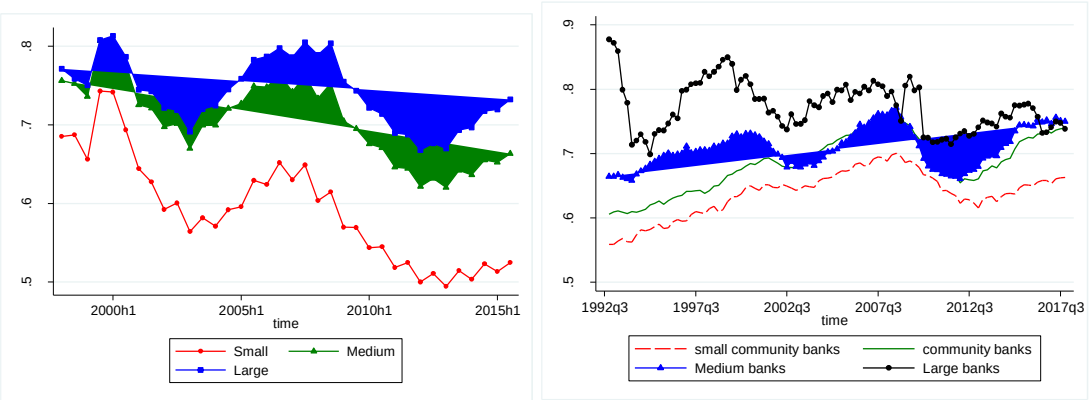


Figure 5: CU asset risk to total assets ratio (RWAD) and performance measures

We plot the dynamic of the RWAD and others performance variables for credit union. The RWAD is obtained as the ratio of risk weighted assets to total assets. The measures are computed for different credit union size: small credit unions (with total assets below $100 million), medium CU (with total assets between $100 million and $500 million) and large credit unions (with assets above $500 million). Regarding the RWAD, we make a comparison with the banking sector[57] by looking at the RWAD by bank size. *Small community banks* are banks with total assets below $500 million, *community banks* have total assets between $500 million and $2 billion, medium banks have total assets between 2 billion and 50 billion and large banks' assets exceed 50 billion.

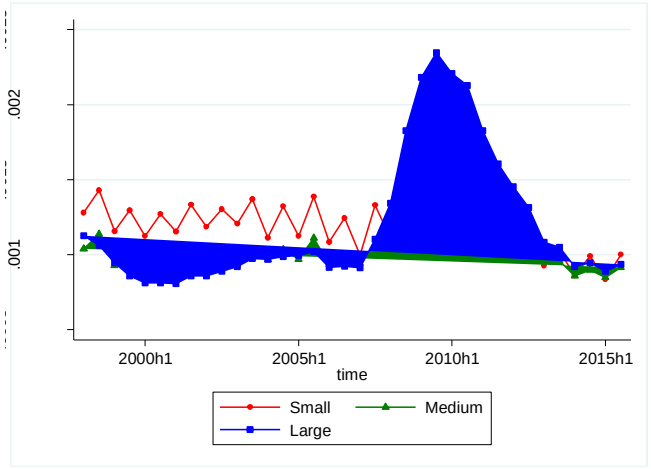
Panel A: The risk weighted assets density (RWA/Total assets) for credit unions



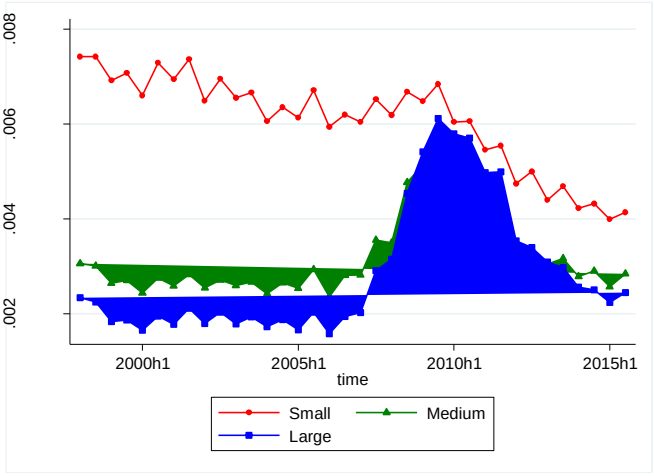
[57] The Database on banks "call reports" span the period from 1996Q1 to 2017Q4 and is obtained using quarterly information on Consolidated Reports of Condition and Income (a "Call Report") filed by financial institutions (national bank, state member bank, insured state non-member bank and savings association) insured by the FDIC agency.

Panel B: Credit unions performance measures

- **The charge off rates (CHOFF)**

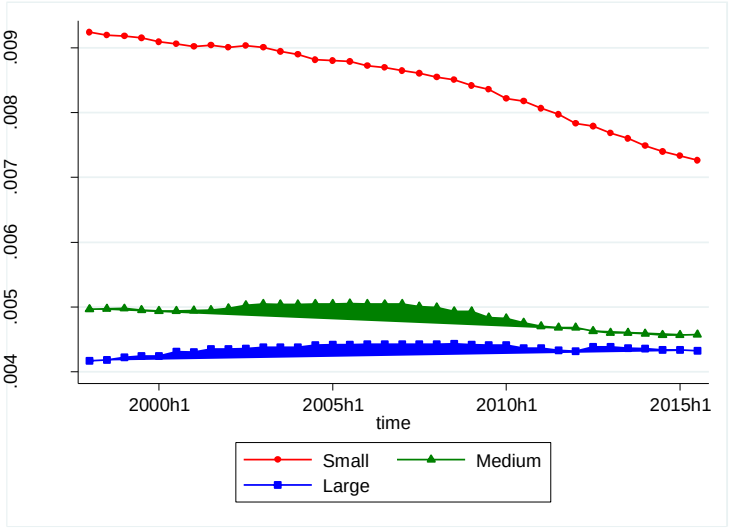


- **The Non-performing loans (NPL)**



- **The earning volatility (SdROA)**

  The earning volatility is obtained as the standard deviation of the return on the whole sample



- **The return on assets (ROA)**

Figure 6: Required capital level under both the LR and the RBC

This graph plots the average value of the minimum regulatory amount of capital by credit union size. We plot the average value for both the net worth capital ratio requirement (LR) and the risk-based capital requirement (RBC). The data cover the half-annual period from 1998 to 2015. We obtained the minimum required capital under the LR (req_netwoth_LR) by multiplying the total assets of the credit union by 6%. The minimum capital requirement for the RBC (req_netwoth_RBC) is obtained by multiplying the risk weighted assets amount by 10%. Obs_networth_LR and Obs_networth_RBC are respectively the observed net worth of the LR and the observed net worth of the RBC.

Panel A: Small credit unions with total assets below $100 million

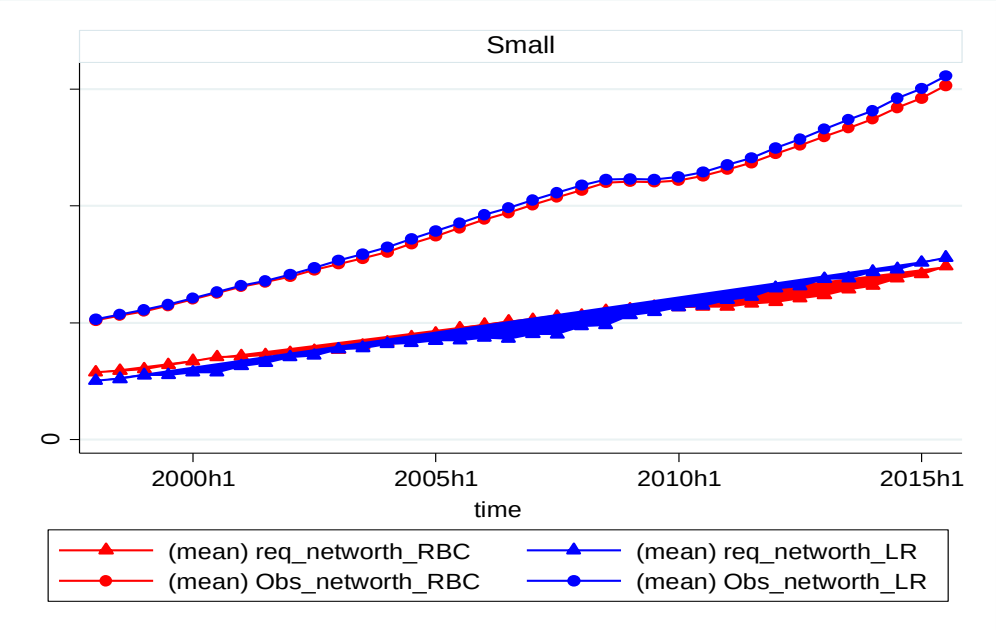


Figure 6, Panel B: Medium-size credit unions with assets between $100 million and $500 million

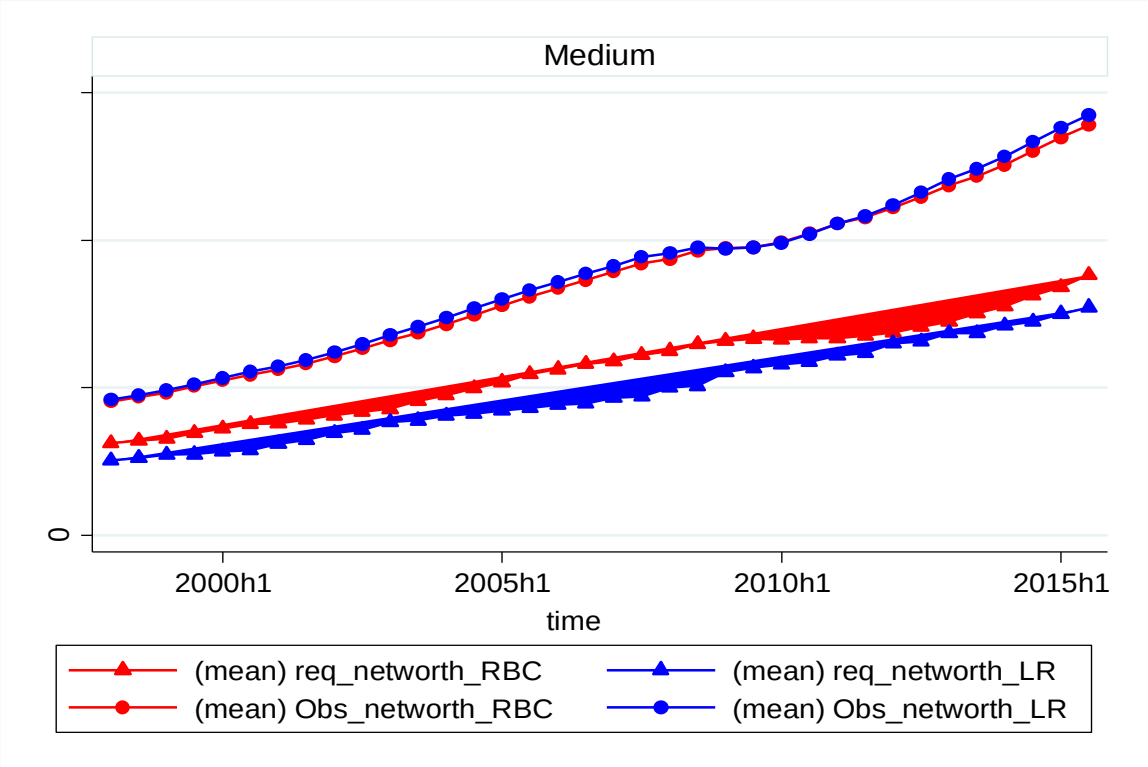


Figure 6, Panel C: Large credit unions with assets greater than $500 million

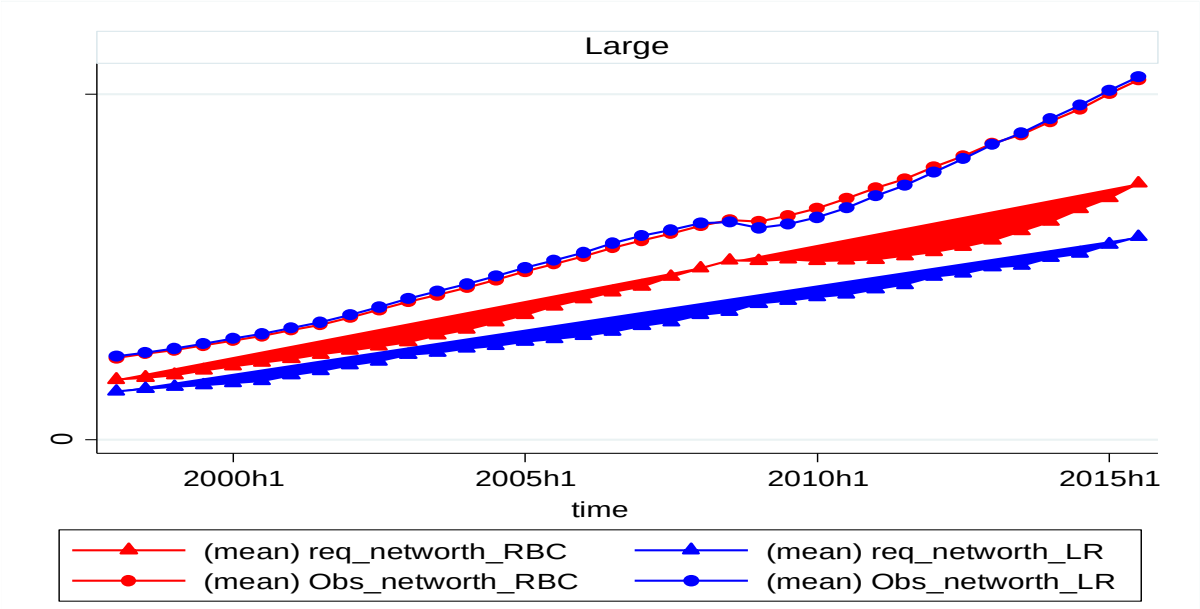


Table 10: RBC and LR effect on CU failures

This table reports the regression of capital ratios (RBC and LR) on the probability of CU failure. Capital ratios (LR and RBC) are the variables of interest. Control variables include the asset liquidity (LIQ_A) obtained as the ratio of liquid assets to total assets, liability liquidity (LIQ_L) obtained as the ratio of non-deposit funds other than capital to total liabilities, the efficiency ratio (EFF) obtained as the ratio of operating expenses over operating income, the delinquent loans (NPL) obtained as the ratio of delinquent loans to total loans. Macroeconomic conditions are captured by the employment rate ratio by state (UEMPL). Credit union specific characteristics include their bond type (SBOND) a dummy for single bond credit unions and their maturity that takes one if the credit union age is above the median age of credit union at a given date. ***, ** and * denote statistical significance at 1%, 5%, 10%, respectively. Letter "l" denote that the variable is a lag (6 month).

	Before crisis			Crisis			Post crisis		
VARIABLES	RBC	LR	Both	RBC	LR	Both	RBC	LR	Both
LIQ_A	-4.348	-4.418*	-4.395	-6.678**	-6.722**	-6.395**	-0.864	-2.422	-2.954
	(2.686)	(2.614)	(2.695)	(2.978)	(3.078)	(2.894)	(4.539)	(4.110)	(4.070)
LIQ_L	2.249	2.680	2.175	0.919	0.615	0.968	-4.742	-4.531	-4.234
	(2.574)	(2.482)	(2.595)	(2.229)	(2.849)	(2.765)	(4.227)	(7.033)	(7.515)
EFF	-1.471***	-1.122***	-1.505***	-0.333	-1.073*	-0.869	1.474***	2.236***	2.435***
	(0.458)	(0.307)	(0.453)	(0.458)	(0.586)	(0.550)	(0.292)	(0.562)	(0.604)
NPL	-25.32	-21.52	-25.52	59.09***	47.10***	47.13***	70.02***	54.50**	53.37**
	(28.87)	(25.12)	(29.77)	(6.331)	(6.653)	(6.596)	(18.99)	(22.49)	(22.57)
RBC	-2.754		-4.343	-2.112		**0.839****	**-7.981***		**2.832*****
	(2.357)		(3.340)	(4.062)		(0.366)	(4.552)		(0.501)
LR		-3.229	4.308		**-26.54*****	**-27.31*****		**-61.17*****	**-71.70*****
		(3.241)	(3.712)		(6.668)	(6.799)		(9.694)	(11.26)
UEMPL	0.0516	0.0347	0.0578	0.0339	0.0181	0.0134	-0.0934	-0.134	-0.134
	(0.0720)	(0.0698)	(0.0704)	(0.0336)	(0.0452)	(0.0448)	(0.0867)	(0.104)	(0.104)
SBOND	-0.106	-0.119	-0.105	0.213	0.219	0.199	0.0750	-0.0401	-0.0691
	(0.230)	(0.229)	(0.228)	(0.188)	(0.202)	(0.202)	(0.321)	(0.373)	(0.394)
MAT	-0.00200	-0.00657	-0.0162	0.0269	-0.0495	-0.0728	-0.502**	-1.012***	-1.081***
	(0.232)	(0.231)	(0.229)	(0.226)	(0.238)	(0.237)	(0.219)	(0.270)	(0.280)
CONST.	-2.246***	-2.408***	-2.476***	-2.955***	-0.0865	-0.233	-3.674***	-0.302	-0.0710
	(0.511)	(0.479)	(0.521)	(0.711)	(0.737)	(0.730)	(0.240)	(0.575)	(0.617)
Observations	21,985	21,985	21,985	9,294	9,294	9,294	11,009	11,009	11,009
FE	YES	YES	YES	YES	YES	YES	YES	YES	YES

Table 11: RBC effect on CU failures: The effects of the LR

This table reports the regression of the RBC on the probability of CU failure for different quartiles of the LR distribution. The first three columns report the finding for the first three quartile of the new RBC ratio. No CU in the fourth quartile of the LR failed. The fourth column reports the results for the existing (old) RBC introduced under the PCA (Prompt Corrective Action). Capital ratios (LR and RBC) are the variables of interest. Control variables include the asset liquidity (LIQ_A) obtained as the ratio of liquid assets to total assets, liability liquidity (LIQ_L) obtained as the ratio of non-deposit funds other than capital to total liabilities, The efficiency ratio (EFF) obtained as the ratio of operating expenses over operating income, the delinquent loans (NPL) obtained as the ratio of delinquent loans to total loans. Macroeconomic conditions are captured by the employment rate ratio by state (UEMPL). Credit union specific characteristics include their bond type (SBOND) a dummy for single bond credit unions and their maturity that takes one if the credit union age is above the median age of credit union at a given date. ***, ** and * denote statistical significance at 1%, 5%, 10%, respectively. Letter "l" denote that the variable is a lag (6 month).

VARIABLES	LR (Q1)	LR(Q2)	LR(Q3)	LR(Q1) with old RBC
LIQ_A	-2.082	-3.155	-26.01*	-5.727**
	(2.459)	(3.059)	(14.76)	(2.789)
LIQ_L	2.602	1.570	-42.62***	2.147
	(2.154)	(3.984)	(8.944)	(2.164)
EFF	-0.0569	-1.779***	-1.515***	0.0161
	(0.474)	(0.535)	(0.322)	(0.430)
NPL	64.17***	2.084	-523.2***	67.80***
	(6.755)	(8.709)	(174.4)	(6.823)
RBC	-11.35**	-8.756*	0.0829	-0.00190***
	(4.928)	(4.585)	(0.201)	(0.000644)
UEMPL	0.0743**	-0.0340	0.257***	0.0659**
	(0.0330)	(0.0676)	(0.0955)	(0.0321)
SBOND	0.193	-0.170	-0.938***	0.142
	(0.183)	(0.273)	(0.129)	(0.160)
MAT	-0.265	0.0766		-0.152
	(0.168)	(0.331)		(0.181)
CONST.	-2.788***	-0.894	-2.320***	-3.879***
	(0.611)	(0.745)	(0.409)	(0.444)
Observations	15,259	15,345	6,702	33,588
FE	YES	YES	YES	YES

Table 12: RBC-constrained CU versus LR-constrained CU and Sample without outliers

This table reports the analysis of each capital rule effect on the Z-score for RBC-constrained credit union versus LR-constrained credit union and for the sample without outliers. Capital ratios (LR and RBC) are the variables of interest. Control variables include the asset liquidity (LIQ_A) obtained as the ratio of liquid assets to total assets, liability liquidity (LIQ_L) obtained as the ratio of non-deposit funds other than capital to total liabilities, The efficiency ratio (EFF) obtained as the ratio of operating expenses over operating income, the delinquent loans (NPL) obtained as the ratio of delinquent loans to total loans. Macroeconomic conditions are captured by the employment rate ratio by state (UEMPL). Credit union specific characteristics include their bond type (SBOND) a dummy for single bond credit unions and their maturity that takes one if the credit union age is above the median age of credit union at a given date. ***, ** and * denote statistical significance at 1%, 5%, 10%, respectively. Letter "l" denote that the variable is a lag (6 month).

	RBC-constrained CU			LR- constrained CU			Sample without outliers		
VARIABLES	Small	Medium	Large	Small	Medium	**Large**	Small	Medium	**Large**
LIQ_A	0.0776***	0.0150**	**0.130*** **	0.0198	0.0984***	**0.000621**	0.0212***	0.0982***	**0.103*** **
	(0.00734)	(0.00678)	**(0.0158)**	(0.0181)	(0.0225)	**(0.0331)**	(0.00467)	(0.0135)	**(0.0228)**
LIQ_L	0.189***	0.274***	**0.100** **	0.216**	-0.0205	**0.00449**	0.193***	0.101**	**-0.0591**
	(0.0476)	(0.0849)	**(0.0459)**	(0.0986)	(0.0452)	**(0.122)**	(0.0425)	(0.0423)	**(0.0473)**
EFF	-0.0534***	-0.0755***	**0.00610**	-0.0464***	0.0318***	**0.00828**	-0.0775***	-0.00707*	**0.0376*** **
	(0.00438)	(0.00339)	**(0.00485)**	(0.00719)	(0.00687)	**(0.0123)**	(0.00252)	(0.00394)	**(0.00694)**
NPL	-4.126***	-1.900***	**-10.05*** **	-2.347***	-10.90***	**-9.256*** **	-3.177***	-8.510***	**-10.43*** **
	(0.164)	(0.159)	**(0.776)**	(0.664)	(1.475)	**(3.481)**	(0.117)	(0.720)	**(1.352)**
RBC	5.830***	5.049***	**7.434*** **	6.031***	7.238***	**6.638*** **	5.614***	7.518***	**7.723*** **
	(0.0590)	(0.0585)	**(0.178)**	(0.188)	(0.192)	**(0.305)**	(0.0397)	(0.132)	**(0.214)**
LR	0.0258***	0.00846***	**0.349*** **	0.0418*	0.683***	**0.0511**	-0.00325	-0.0343	**0.0232**
	(0.00778)	(0.00269)	**(0.117)**	(0.0251)	(0.0792)	**(0.0504)**	(0.00236)	(0.0218)	**(0.129)**
UEMPL	-0.0133***	-0.00973***	**-0.00880*** **	-0.0101***	-0.00640***	**-0.00462** **	-0.0121***	-0.00885***	**-0.00584*** **
	(0.000470)	(0.000408)	**(0.000614)**	(0.000691)	(0.000973)	**(0.00228)**	(0.000309)	(0.000489)	**(0.000898)**
SBOND	0.00688**	0.00348	**0.00326**	-0.000332	0.00538*	**0.00934**	0.00598***	0.00353	**0.00582** **
	(0.00283)	(0.00322)	**(0.00307)**	(0.00578)	(0.00295)	**(0.0109)**	(0.00210)	(0.00292)	**(0.00285)**
MAT	0.00713	0.00786	**0.00360**	0.0274	0.0123	**-0.0155**	0.00582	0.00146	**0.00541**
	(0.00994)	(0.00796)	**(0.00736)**	(0.0227)	(0.0135)	**(0.0120)**	(0.00560)	(0.00573)	**(0.0101)**
CONST.	2.284***	2.367***	**2.408*** **	2.618***	2.459***	**2.620*** **	2.329***	2.455***	**2.489*** **
	(0.00983)	(0.00999)	**(0.0186)**	(0.0303)	(0.0204)	**(0.0420)**	(0.00650)	(0.0164)	**(0.0237)**
Observations	130,433	118,134	**31,857**	10,389	12,224	**2,757**	244,561	42,027	**14,905**
R-squared	0.471	0.480	**0.627**	0.624	0.667	**0.662**	0.513	0.638	**0.672**
N CU	8,684	7,976	**1,341**	785	481	**230**	9,424	1,362	**475**
FE	YES	YES	**YES**	YES	YES	**YES**	YES	YES	**YES**

Table 13: Tackling multicollinearity alternative approaches

This table reports the results from the regression of Z-score on RBC and LR with control of multicollinearity. The analysis is based on half-annual data from 1998 to 2015 and include large credit unions (with equivalent[58] assets above $500 million). Control variables include the asset liquidity (LIQ_A) obtained as the ratio of liquid assets to total assets, liability liquidity (LIQ_L) obtained as the ratio of non-deposit funds other than capital to total liabilities, the efficiency ratio (EFF) obtained as the ratio of operating expenses over operating income, the delinquent loans ratio (NPL). Macroeconomic variable is the employment rate ratio by state (UEMPL). Credit union (CU) specific characteristics include (SBOND) a dummy for single bond credit unions and their maturity that takes one if the credit union age is above the median age of CU at a given date. ***, ** and * denote statistical significance at 1%, 5%, 10%, respectively. Prefix "L." on a variable X denotes that we include the lag of the variable X. A lag corresponds to a 6-month period.

VARIABLES	LR* = LR + RBC			LR*= LR - (a+bRBC)		
	Small	Medium	Large	Small	Medium	Large
LIQ_A	0.0229***	0.0964***	0.0976***	0.0229***	0.0964***	0.0976***
	(0.00500)	(0.0136)	(0.0215)	(0.00500)	(0.0136)	(0.0215)
LIQ_L	0.222***	0.105**	-0.0515	0.222***	0.105**	-0.0515
	(0.0438)	(0.0422)	(0.0448)	(0.0438)	(0.0422)	(0.0448)
EFF	-0.0754***	-0.00791**	0.0359***	-0.0754***	-0.00791**	0.0359***
	(0.00260)	(0.00396)	(0.00654)	(0.00260)	(0.00396)	(0.00654)
NPL	-3.077***	-8.638***	-10.62***	-3.077***	-8.638***	-10.62***
	(0.119)	(0.725)	(1.385)	(0.119)	(0.725)	(1.385)
RBC	-5.552***	-7.508***	-7.601***	0.139***	0.166***	0.273***
	(0.0444)	(0.135)	(0.253)	(0.00268)	(0.0230)	(0.0886)
LR*	5.555***	7.490***	7.686***	5.555***	7.490***	7.686***
	(0.0440)	(0.133)	(0.204)	(0.0440)	(0.133)	(0.204)
UEMPL	-0.0121***	-0.00880***	-0.00565***	-0.0121***	-0.00880***	-0.00565***
	(0.000316)	(0.000492)	(0.000965)	(0.000316)	(0.000492)	(0.000965)
SBOND	0.00607***	0.00368	0.00599**	0.00607***	0.00368	0.00599**
	(0.00212)	(0.00292)	(0.00285)	(0.00212)	(0.00292)	(0.00285)
MAT	0.00511	0.00163	0.00597	0.00511	0.00163	0.00597
	(0.00583)	(0.00574)	(0.0101)	(0.00583)	(0.00574)	(0.0101)
CONST.	2.324***	2.457***	2.483***	3.026***	3.403***	3.455***
	(0.00709)	(0.0165)	(0.0218)	(0.00406)	(0.00742)	(0.0173)
Observations	248,567	42,246	14,981	248,567	42,246	14,981
R-squared	0.503	0.637	0.670	0.503	0.637	0.670
NB CUS	9,877	1,412	499	9,877	1,412	499
FE	YES	YES	YES	YES	YES	YES

[58] We compute for each year preceding 2015 the equivalent of $500 million assets based on a 2% half-annual average asset growth rate.

Table 14: Z-score and the capital ratios (LR and RBC) over the economic periods

This table reports the analysis of each capital rule effect on the Z-score (Panel A) and the "risk adjusted" Z-score (Panel B) by economic periods. We report result for the pre-crisis (1998h1-2006h4), crisis period (2007h1-2010h2) and post crisis period (2011h1-2015h2). The Z-score_adjusted is a version of the traditional Z-score with the total assets variable replaced by the total risk weighted assets variable. Capital ratios (LR and RBC) are the variables of interest. Control variables include the asset liquidity (LIQ_A) obtained as the ratio of liquid assets to total assets, liability liquidity (LIQ_L) obtained as the ratio of non-deposit funds other than capital to total liabilities, The efficiency ratio (EFF) obtained as the ratio of operating expenses over operating income, the delinquent loans (NPL) obtained as the ratio of delinquent loans to total loans. Macroeconomic conditions are captured by the employment rate ratio by state (UEMPL). Credit union specific characteristics include their bond type (SBOND) a dummy for single bond credit unions and their maturity that takes one if the credit union age is above the median age of credit union at a given date. ***, ** and * denote statistical significance at 1%, 5%, 10%, respectively. Letter "l" denote that the variable is a lag (6 month).

Panel A: Z-score

	Small credit unions			Medium credit unions			Large credit unions		
VARIABLES	Before crisis	Crisis	After Crisis	Before crisis	Crisis	After Crisis	Before crisis	Crisis	After Crisis
LIQ_A	0.0133**	0.00655	-0.0200	0.0539***	0.0490	0.0325	0.0383*	0.255***	-0.0624
	(0.00570)	(0.0138)	(0.0144)	(0.0144)	(0.0535)	(0.0216)	(0.0203)	(0.0774)	(0.0560)
LIQ_L	0.225***	0.288***	0.321**	0.142***	0.145*	0.0625	0.0831	0.491***	-0.0324
	(0.0573)	(0.0731)	(0.132)	(0.0545)	(0.0831)	(0.0704)	(0.0514)	(0.128)	(0.0766)
EFF	0.0148***	-0.0733***	-0.0560***	0.0634***	-0.0855***	-0.0351***	0.0610***	0.120**	-0.0167
	(0.00462)	(0.00767)	(0.00657)	(0.00704)	(0.0248)	(0.00965)	(0.00960)	(0.0481)	(0.0185)
NPL	-2.735***	-3.017***	-2.791***	-7.502***	-12.19***	-5.680***	-8.701***	-11.92***	-7.895***
	(0.140)	(0.252)	(0.272)	(1.054)	(1.272)	(0.897)	(1.701)	(1.748)	(2.204)
LR	**4.928*** **	**3.967*** **	**3.978*** **	**7.039*** **	**5.170*** **	**6.384*** **	**7.122*** **	**6.174*** **	**6.309*** **
	(0.0631)	(0.112)	(0.125)	(0.171)	(0.258)	(0.184)	(0.213)	(0.511)	(0.321)
RBC	0.000913	0.0132*	0.00577	0.0339	0.0604	0.0313	0.0891	0.169	0.548
	(0.00302)	(0.00747)	(0.00616)	(0.0358)	(0.149)	(0.0202)	(0.0597)	(0.172)	(0.335)
UEMPL	-0.0150***	-0.0200***	-0.00113*	-0.00655***	-0.0144***	-0.00471***	-0.00387***	-0.0110***	-0.00230
	(0.000638)	(0.000470)	(0.000602)	(0.000950)	(0.000937)	(0.000861)	(0.00123)	(0.00155)	(0.00188)
SBOND	0.00404**	-0.00503	0.0128	0.00337	0.00443	0.0123	0.00505**	-0.0376	-0.00573
	(0.00206)	(0.0144)	(0.0124)	(0.00256)	(0.0288)	(0.0113)	(0.00256)	(0.0354)	(0.00855)
MAT	0.00382	0.00296	-0.0750***	0.0216	0.00176	-0.0130***	-0.0200***	0.00291	0.0206**
	(0.0126)	(0.00868)	(0.0247)	(0.0149)	(0.00788)	(0.00193)	(0.00771)	(0.0254)	(0.00878)
CONST.	2.340***	2.643***	2.560***	2.418***	2.806***	2.604***	2.543***	2.585***	2.590***
	(0.0111)	(0.0218)	(0.0233)	(0.0226)	(0.0601)	(0.0273)	(0.0225)	(0.0800)	(0.0618)
Observations	146,374	50,256	51,937	21,975	9,270	11,001	7,486	3,351	4,144
R-squared	0.332	0.318	0.177	0.507	0.487	0.396	0.586	0.548	0.563
Observations	9,721	6,788	5,829	1,347	1,209	1,153	463	442	434
FE	YES	YES	YES	YES	YES	YES	YES	YES	YES

Panel B: "Risk adjusted" Z-score

	Small credit unions			Medium credit unions			Large credit unions		
VARIABLES	Before crisis	Crisis	After Crisis	Before crisis	Crisis	After Crisis	Before crisis	Crisis	After Crisis
LIQ_A	0.283***	0.231***	0.278***	0.326***	0.118*	0.350***	0.202***	0.456***	0.143**
	(0.0148)	(0.0324)	(0.0310)	(0.0577)	(0.0631)	(0.0787)	(0.0418)	(0.102)	(0.0659)
LIQ_L	-0.879***	0.00553	-0.411**	-0.519***	-0.0563	-0.495***	-0.193**	0.173	-0.258***
	(0.102)	(0.104)	(0.175)	(0.141)	(0.0938)	(0.153)	(0.0877)	(0.110)	(0.0986)
EFF	0.0707***	-0.0110	0.0569***	-0.00983	-0.0499*	0.0288	-0.0329*	0.132***	-0.00873
	(0.0102)	(0.0167)	(0.0132)	(0.0126)	(0.0261)	(0.0270)	(0.0170)	(0.0505)	(0.0220)
NPL	-3.272***	-2.401***	-3.378***	-5.817***	-6.718***	-4.973***	-6.904***	-2.755*	-4.853***
	(0.247)	(0.366)	(0.531)	(1.475)	(1.352)	(0.929)	(1.664)	(1.513)	(1.449)
LR	**3.582*** **	**2.583*** **	**3.236*** **	**4.621*** **	**1.699*** **	**4.595*** **	**2.206*** **	**1.360** **	**1.922*** **
	(0.102)	(0.137)	(0.202)	(0.864)	(0.359)	(0.684)	(0.370)	(0.533)	(0.572)
RBC	**0.336*** **	**0.230*** **	**0.295*** **	**1.701*** **	**1.691*** **	**0.885** **	**3.142*** **	**2.063*** **	**3.045*** **
	(0.0192)	(0.0382)	(0.0338)	(0.630)	(0.320)	(0.444)	(0.356)	(0.702)	(0.462)
UEMPL	0.0119***	0.00368***	0.000691	0.0113***	-0.00228*	0.00655***	0.0122***	-0.000171	0.0128***
	(0.00137)	(0.000735)	(0.00121)	(0.00181)	(0.00122)	(0.00172)	(0.00211)	(0.00151)	(0.00222)
SBOND	0.0221***	0.00626	0.0356	0.00609	0.0322	0.0136	0.0120**	0.116***	-0.0191
	(0.00456)	(0.0189)	(0.0317)	(0.00481)	(0.0246)	(0.0489)	(0.00569)	(0.0383)	(0.0121)
MAT	0.0315	0.00657	-0.0679	-0.0286	-0.00974	-0.0610***	-0.0217	0.00320	0.0353***
	(0.0302)	(0.0114)	(0.0459)	(0.0287)	(0.0160)	(0.00605)	(0.0155)	(0.0225)	(0.00958)
CONST.	2.394***	2.766***	2.786***	2.699***	3.117***	2.961***	2.920***	2.967***	2.959***
	(0.0209)	(0.0292)	(0.0451)	(0.0368)	(0.0652)	(0.0533)	(0.0355)	(0.0733)	(0.0482)
Observations	145,998	50,153	51,782	21,981	9,280	11,008	7,486	3,352	4,144
R-squared	0.160	0.075	0.118	0.447	0.238	0.249	0.556	0.222	0.513
Nb CUs	9,713	6,780	5,819	1,347	1,209	1,153	463	442	434
Country FE	YES	YES	YES	YES	YES	YES	YES	YES	YES

Table 15: Quantile regressions

This table reports the analysis of each capital rule effect on the Z-score and the "risk adjusted" Z-score using quantile regression. The Z-score is computed with the ROA and LR and the Z-score adjusted with the RBC and ROA_adjusted (Total income divided by Risk Weighted Assets). The analysis is based on half-annual data from 1998 to 2015. Capital ratios (LR and RBC) are the variables of interest. Control variables include the asset liquidity (LIQ_A) obtained as the ratio of liquid assets to total assets, liability liquidity (LIQ_L) obtained as the ratio of non-deposit funds other than capital to total liabilities, The efficiency ratio (EFF) obtained as the ratio of operating expenses over operating income, the delinquent loans (NPL) obtained as the ratio of delinquent loans to total loans. Macroeconomic conditions are captured by the employment rate ratio by state (UEMPL). Credit union specific characteristics include their bond type (SBOND) a dummy for single bond credit unions and their maturity that takes one if the credit union age is above the median age of credit union at a given date. ***, ** and * denote statistical significance at 1%, 5%, 10%, respectively. Letter "l" denote that the variable is a lag (6 month).

	Z-score			Z-score_adjusted		
VARIABLES	Only RBC	Only LR	Both	Only RBC	Only LR	Both
LIQ_A	0.0183	-0.0185	-0.0893***	0.00452	0.328***	0.0856***
	(0.0177)	-0.0117	(0.0112)	(0.0267)	(0.0213)	(0.0217)
LIQ_L	-0.0525	-0.0171	0.00471	-0.290***	-0.371***	-0.213*
	(0.0817)	(0.0562)	(0.0608)	(0.101)	(0.102)	(0.109)
EFF	-0.271***	-0.385***	-0.390***	-0.606***	-0.384***	-0.592***
	(0.0220)	(0.0112)	(0.0101)	(0.0270)	(0.0353)	(0.0253)
NPL	-2.915***	-7.991***	-8.217***	-13.58***	-13.66***	-12.21***
	(0.300)	(0.294)	(0.298)	(0.452)	(0.404)	(0.410)
RBC	**0.150*** **		**-0.0182*** **	**5.240*** **		**2.463*** **
	(0.0152)		(0.00668)	(0.185)		(0.110)
LR		**5.559*** **	**5.828*** **		**5.758*** **	**2.225*** **
		(0.0795)	(0.0857)		(0.141)	(0.145)
UEMPL	-0.0198***	-0.0273***	-0.0330***	-0.0416***	-0.0345***	-0.0479***
	(0.00672)	(0.00274)	(0.00265)	(0.00464)	(0.00457)	(0.00430)
SBOND	0.0101*	-0.0115***	-0.0129***	-0.0382***	0.0138**	-0.00929
	(0.00579)	(0.00369)	(0.00387)	(0.00655)	(0.00705)	(0.00621)
MAT	0.0549***	0.0985***	0.0658***	0.105***	0.121***	0.0460***
	(0.0172)	(0.0109)	(0.0100)	(0.0164)	(0.0248)	(0.0149)
Observations	305,794	305,826	305,794	305,184	305,193	305,184
Nb CUs	11,788	11,789	11,788	11,782	11,782	11,782
FE	YES	YES	YES	YES	YES	YES

Table 16: Credit union solvency and capital ratios: TARP versus Non TARP CU

This table reports the analysis of each capital rule effect on the Z-score and the "risk adjusted" Z-score with TARP as a control variable. The analysis is based on half-annual data from 1998 to 2015. Capital ratios (LR and RBC) are the variables of interest and the variables for which results are presented. Control variables include TARP a dummy variable for credit unions that received funding by 2010, the asset liquidity (LIQ_A) obtained as the ratio of liquid assets to total assets, liability liquidity (LIQ_L) obtained as the ratio of non-deposit funds other than capital to total liabilities, The efficiency ratio (EFF) obtained as the ratio of operating expenses over operating income, the delinquent loans (NPL) obtained as the ratio of delinquent loans to total loans. Macroeconomic conditions are captured by the employment rate ratio by state (UEMPL). Credit union specific characteristics include their bond type (SBOND) a dummy for single bond credit unions and their maturity that takes one if the credit union age is above the median age of credit union at a given date. ***, ** and * denote statistical significance at 1%, 5%, 10%, respectively. Letter "l" denote that the variable is a lag (6 month).

Panel A: Analysis with TARP as control variable

	Z-score			Z-score_adjusted		
VARIABLES	Only RBC	Only LR	Both	Only RBC	Only LR	Both
LIQ_A	-0.00293	0.0252***	0.0254***	0.259***	0.351***	0.282***
	(0.00895)	(0.00479)	(0.00478)	(0.0125)	(0.0147)	(0.0121)
LIQ_L	0.0609	0.135***	0.137***	-0.947***	-0.995***	-0.889***
	(0.0491)	(0.0303)	(0.0303)	(0.0646)	(0.0613)	(0.0558)
EFF	-0.0898***	-0.0649***	-0.0651***	0.0888***	0.169***	0.109***
	(0.00455)	(0.00230)	(0.00231)	(0.00609)	(0.00647)	(0.00556)
NPL	-2.891***	-3.338***	-3.344***	-4.328***	-6.022***	-4.667***
	(0.191)	(0.119)	(0.119)	(0.229)	(0.245)	(0.208)
RBC	**0.133*** **		**0.000355**	**0.620*** **		**0.508*** **
	(0.00689)		(0.00262)	(0.0177)		(0.0165)
LR		**5.684*** **	**5.689*** **		**5.144*** **	**4.135*** **
		(0.0428)	(0.0430)		(0.0775)	(0.0709)
TARP	0.0813***	0.0487***	0.0469***	0.0375	-0.0194	0.0112
	(0.0273)	(0.0139)	(0.0139)	(0.0419)	(0.0445)	(0.0365)
UEMPL	-0.0102***	-0.0123***	-0.0123***	0.00605***	0.00621***	0.00464***
	(0.000497)	(0.000271)	(0.000271)	(0.000590)	(0.000609)	(0.000515)
SBOND	0.0237***	0.00668***	0.00683***	0.0339***	0.0225***	0.0218***
	(0.00369)	(0.00179)	(0.00178)	(0.00472)	(0.00483)	(0.00398)
MAT	0.0152	0.00509	0.00502	-0.0185	-0.0241*	-0.0254**
	(0.0109)	(0.00486)	(0.00486)	(0.0142)	(0.0136)	(0.0119)
CONST.	3.112***	2.380***	2.380***	3.006***	2.432***	2.476***
	(0.00771)	(0.00666)	(0.00664)	(0.0104)	(0.0144)	(0.0123)
Observations	305,794	305,826	305,794	305,184	305,193	305,184
R-squared	0.054	0.510	0.511	0.218	0.209	0.311
Nb CUs	11,788	11,789	11,788	11,782	11,782	11,782
FE	YES	YES	YES	YES	YES	YES

Panel B: TARP Credit Union vs Non-TARP Credit Unions

This table reports the analysis of each capital rule effect on the Z-score and the "risk adjusted" Z-score for TARP and Non-TARP credit unions. The Z-score is computed with the ROA and LR and the Z-score adjusted with the RBC and ROA_adjusted (Total income divided by Risk Weighted Assets). The analysis is based on half-annual data from 1998 to 2015. Capital ratios (LR and RBC) are the variables of interest and the variables for which results are presented. Control variables include the asset liquidity (LIQ_A) obtained as the ratio of liquid assets to total assets, liability liquidity (LIQ_L) obtained as the ratio of non-deposit funds other than capital to total liabilities, The efficiency ratio (EFF) obtained as the ratio of operating expenses over operating income, the delinquent loans (NPL) obtained as the ratio of delinquent loans to total loans. Macroeconomic conditions are captured by the employment rate ratio by state (UEMPL). Credit union specific characteristics include their bond type (SBOND) a dummy for single bond credit unions and their maturity that takes one if the credit union age is above the median age of credit union at a given date. ***, ** and * denote statistical significance at 1%, 5%, 10%, respectively. Letter "l" denote that the variable is a lag (6 month).

	Z-score		Z-score_adjusted	
VARIABLES	TARP	Non-TARP	TARP	Non-TARP
LIQ_A	0.0641	0.0256***	0.246	0.283***
	(0.185)	(0.00478)	(0.216)	(0.0121)
LIQ_L	-0.370	0.144***	0.249	-0.892***
	(0.462)	(0.0303)	(0.547)	(0.0561)
EFF	-0.0574	-0.0650***	0.131*	0.109***
	(0.0554)	(0.00231)	(0.0666)	(0.00556)
NPL	-4.525	-3.342***	-5.507	-4.661***
	(2.782)	(0.119)	(3.408)	(0.208)
RBC	**3.539*** **	**5.691*** **	**0.260***	**0.508*** **
	(0.0627)	(0.00262)	-0.145	-0.0165
LR	**3.539*** **	**5.691*** **	**2.447*** **	**4.136*** **
	(0.614)	(0.0430)	-0.799	-0.071
UEMPL	0.00961*	-0.0123***	0.0275**	0.00461***
	(0.00507)	(0.000271)	(0.0125)	(0.000516)
SBOND	0.181**	0.00680***	0.203*	0.0218***
	(0.0676)	(0.00178)	(0.105)	(0.00398)
MAT		0.00497		-0.0255**
		(0.00486)		(0.0119)
CONST.	2.057***	2.380***	1.819***	2.477***
	(0.109)	(0.00665)	(0.206)	(0.0123)
Observations	534	305,260	532	304,652
R-squared	0.133	0.512	0.138	0.311
Nb CUs	47	11,786	47	11,780
FE	YES	YES	YES	YES

Table 17: Correlation Matrix

This table presents the Pearson correlation statistics on the dependent variables, variables of interest, some credit union-specific (control) variables and macroeconomic variables. Dependent variables are: The Z-score (computed with LR and total assets) and the Z-score_adj (computed with RBC and Risk Weighted Assets), the chargeoff rates (CHOFF), the total non performing loans (NPL), the return on assets (ROA) and the return on assets volatility (SdROA). The variables of interest are: Capital ratios (LR and RBC), the risk-weighted assets density (RWAD). Control variables include the asset liquidity (LIQ_A) obtained as the ratio of liquid assets to total assets, liability liquidity (LIQ_L) obtained as the ratio of non-deposit funds other than capital to total liabilities, The efficiency ratio (EFF) obtained as the ratio of operating expenses over operating income. Macroeconomic conditions are captured by the employment rate ratio by state (UEMPL). * denote correlation values significant at the 1% level.

	Z-score	Z-score_adj	CHOFF	NPL	SDROA	ROA	RBC	LR	RWAD	LIQ_A	LIQ_L	EFF	UEMPL
Z-score	1												
Z-score_adj	0.8292*	1											
CHOFF	-0.2604*	-0.2528*	1										
NPL	-0.2986*	-0.3373*	0.2756*	1									
SDROA	-0.7274*	-0.6237*	0.1715*	0.3087*	1								
ROA	0.2286*	0.1869*	-0.3257*	-0.1779*	-0.1115*	1							
RBC	0.0180*	0.0755*	-0.0544*	0.0424*	0.2228*	-0.0263*	1						
LR	0.2720*	0.1900*	-0.0264*	0.0975*	0.2366*	0.0724*	0.4575*	1					
RWAD	-0.0661*	-0.1971*	0.1122*	0.0892*	-0.0456*	0.0850*	-0.4937*	-0.1951*	1				
LIQ_A	-0.1389*	-0.0991*	0.0448*	0.1087*	0.2002*	-0.1153*	0.2034*	0.1641*	-0.3527*	1			
LIQ_L	-0.0395*	-0.0399*	0.0431*	0.0182*	0.0287*	-0.0025	-0.0494*	-0.0653*	0.0417*	-0.0462*	1		
EFF	-0.1583*	-0.0647*	0.1071*	0.0094*	0.1024*	-0.4259*	0.0346*	-0.0287*	-0.2754*	0.2873*	0.0825*	1	
UEMPL	-0.0233*	0.0486*	0.0599*	-0.0076*	-0.0033	-0.1396*	0.0520*	-0.0097*	-0.1737*	0.1539*	0.0281*	0.3178*	1