

## Original Paper

# Impact of Macroeconomic Shocks on the Individual Banks: Case of Madagascar

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### Abstract

*The successive financial crises have highlighted the interdependence between the financial system and the real economy. Prudential measures to limit the negative repercussions of the financial crisis, through the Basel I and Basel II agreements, have shown their limits and the Basel III agreements have consequently integrated the macro-prudential component which aims to ensure the stability of the financial sector as a whole within the economy. The financial stability assessment tool known as the “stress test” has also been developed in various forms and its application to the financial sector, particularly the banking sector, is strongly recommended by the Bank for International Settlements. Indeed, the purpose of this study is to assess the resilience of the Malagasy banking sector to macroeconomic shocks and to evaluate its impact on the capitalization of the banking system through the macroeconomic stress test tool. To do so, we used a dynamic panel model. Non-performing loan forecasts are used to obtain capital projections at both the banking system and bank levels under adverse scenarios. The results show that most banks were able to hold capital above the minimum regulatory threshold of 8% under Basel III standards. However, only one bank fails to meet the minimum capital adequacy threshold. Non-performing loan forecasts are used to obtain capital projections at both the banking system and bank levels under adverse scenarios.*

### Keywords

*Financial stability, stress test, capitalization, banking sector*

## 1. Introduction

The purpose of this study is to carry out a macroeconomic stress test of credit risk with the individual banks that make up the banking sector in Madagascar. More specifically, the study covers 6 out of 11 banks in the sector, which represent 95% of the assets of the banking sector in 2015. The financial

stability of these banks will subsequently be measured by the capital they hold after adverse macroeconomic scenarios, including the Capital Adequacy Ratio (CAR), which is the ratio of capital to risk-weighted assets.

This study is a continuation of the analyzes carried out with Rakotonirainy and Rasolomanana published in 2020 and drawn from the research work with Rakotonirainy in 2021. Indeed, in the assessment of the financial stability of a financial sector, the stress test of the global portfolio at the scale of the system should be supplemented by the calculation of the impacts of stress test scenarios at the level of each bank depending on the availability of micro-data (Foglia, 2008; Kapinos & Mitnik, 2016). In reality, due to the lack of data availability, most studies, other than those carried out by regulatory authorities, remain at the level of the banking system and others try to do a disaggregated analysis by carrying out a sector study by category of loans. Despite this, much work on financial stability tries to deploy the stress test both at the aggregate level of the banking system and at the individual bank level. Our study focuses on 6 individual Malagasy banks rated from A to F.

The organization of the study will be as follows: first we will focus on the presentation of methodology adopted for the assessment of the credit risk of individual banks under adverse macroeconomic scenarios. Then, we will present the results on the credit risk situation and the equity projections under adverse scenarios. A discussion of each bank's performance will also be highlighted at the end.

## **2. Method for the Assessment of the Credit Risk of Individual Banks under Adverse Macroeconomic Scenarios**

The objective of this section is to present the methodology adopted for the assessment of the credit risk of individual banks under adverse macroeconomic scenarios. As this is a study with each bank, the dynamic panel model approach is the most used to link economic and banking determinants with credit risk. The scenarios used in this assessment of individual banks are a negative shock to GDP corresponding to an economic recession, a positive shock to the real effective exchange rate, that is, a depreciation of the local currency, a positive shock to the price of oils as a global variable and a negative shock to the prices of agricultural commodities. The impacts on credit risks will then be transmitted to the banks's equity capital in order to assess their solidity.

The section will be organized as follows: the first paragraph will address the dynamic panel model. The second paragraph will describe the variables used with their respective sources. The third paragraph will show the stress test scenarios with each bank's equity projection process under adverse scenarios.

### *2.1 Dynamic Panel Model*

Following the recent literature on stress test studies of credit risk at the level of individual banks (Chaibi & Ftiti, 2015; Kosmidou & Moutsianas, 2015; Dimitrios et al., 2016), a dynamic panel approach is adopted to estimate the effect of macroeconomic variables and bank specific variables on the credit risk indicator, the non-performing loan ratio (NPL). The dynamic approach takes into account the persistence of time in the structure of the NPL ratio by including the lagged dependent variable as

an explanatory variable in the static fixed effects model (Louzis et al., 2012; Youssef, 2018).

The approach used is based on the methodology of Chaibi and Ftiti (2015).

Consider the dynamic panel model with fixed effects:

$$Y_{it} = \alpha_i + \mu(U_{it}) + \sum_{s=1}^k \phi_s(U_{it})Y_{i,t-s} + \beta(U_{it})'X_{it} + \gamma(U_{it})'Z_t \quad (1)$$

With  $i = 1, \dots, N$  and  $t = 1, \dots, T$ .  $i$  denotes the cross section and  $t$  the time dimension in the panel sample.

$Y_{it}$  is the endogenous variable, in our case the NPL credit risk indicator

$X_{it}$  is a vector of the time variables specific to each bank. ( $l \times 1$ )

The elements of the vector parameter are unknown functions which must be estimated.  $\theta(U)_{it} \equiv$

$[\mu(U_{it}), \phi_1(U_{it}), \dots, \phi_k(U_{it}), \beta_1(U_{it}), \dots, \beta_l(U_{it}), \dots, \gamma_1(U_{it}), \dots, \gamma_m(U_{it})] \theta_s: [0, 1] \rightarrow \mathbb{R}, s = 1, \dots, (1 + k + l + m)$

$\alpha_i$  represents specific fixed effects, assumed to be independent of the innovation process and is intended to control any unobserved cross-sectional heterogeneity (assumed to be invariant over time) not taken into account by the banking variables. ( $U_{it}$ ) $X_{it}$

$Z_t$  a vector of macroeconomic variables. ( $m \times 1$ )

Therefore, the dynamic panel model to be estimated is written as follows:

$$NPL_{it} = \alpha_i + \phi_{i,t}NPL_{i,t-1} + \beta'X_{i,t} + \gamma'Z_t + \mu_i + \varepsilon_{i,t} \quad (2)$$

With fixed effects  $\alpha_i$

$N$  denotes the number of banks and  $T$  denotes the dimension of the time series. With  $i$  the cross section going from bank 1 to bank 6; and  $t$  notes the chronological dimension going from 2005q2 to 2015q2.

$NPL_{it}$  the non-performing loan ratio (NPL) of bank  $i$  for period  $t$ .

$X_{i,t}$  the vector of banking variables, specific to each bank (return on equity, total loans on deposits, leverage ratio and size of banks).

$Z_t$  the vector of macroeconomic variables, common to all banks, describing the macroeconomic scenario.

$\phi_{i,t}$ , and are the vectors of coefficients to be estimated  $\beta' \gamma'$

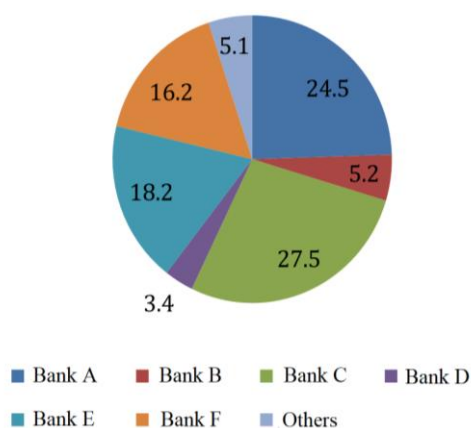
$\mu_i$  unobserved effects specific to each bank

$\varepsilon_{i,t}$  the error term

The dynamic panel models will be estimated using the generalized method of moments (GMM), in the context of Arellano and de Bond (1991).

## 2.2 Description of Data and the Banking Variables

To examine the impact of macroeconomic factors and asset quality on banks' credit risk, six (06) out of eleven (11) commercial banks of Madagascar were selected (banks A, B, C, D, E, F), representing approximately 95% of Madagascar's banking sector in terms of total assets in 2015. In accordance with the literature review, we retain two types of variables: bank-specific variables and macroeconomic determinants.



**Figure 1. Breakdown of Banking Sector Assets**

*Note.* The shares of assets are presented as a percentage. Source: BCM 2015, author

The literature on bank-specific credit risk analysis has noted that the determinants of NPLs should not be sought exclusively among macroeconomic variables, which are exogenous to the banking industry. The peculiarities of the banking sector and the political choices of each bank, in particular with regard to their efforts to improve efficiency and risk management, are likely to influence the evolution of NPLs (Berger & De Young, 1997; Salas & Saurina, 2002; Podpiera & Weill, 2008; Chaibi & Ftiti, 2015; Zheng et al., 2018; Moussa, 2018; Kiemo et al., 2019).

The following table presents the description of the banking variables.

**Table 1. Description of Banking Variables**

Variable	Definition	Corresponding hypothesis	References	Predicted signs
Return on equity	<i>Return on equity (ROE)</i> $ROE_{it} = \frac{Profits_{it}}{Total\ Equity_{it}}$	Mismanagement	Vuković (2014) Abid, et al. (2014)	-
Total loans over total deposits	<i>Loans to deposit Ratio (LtD)</i> $LtD_{it} = \frac{Loans_{it}}{Deposit_{it}}$	Moral hazard	Chaibi and Ftiti (2015) Makri, et al. (2014)	+
Leverage ratio	<i>Leverage Ratio (LR)</i> $LR_{it} = \frac{Total\ liabilities_{it}}{Total\ Assets_{it}}$	Too big to fail	Chaibi and Ftiti (2015)	+
Cut	<i>SIZE</i> $SIZE_{it} = \frac{Total\ Assets_{it}}{\sum_{i=1}^n Total\ Assets_{it}}$	Diversification	Kiemo, et al. (2019), Youssef (2018)	-

*Source:* adapted by the author

Louzis et al. (2012) conducted studies on the assumptions associated with each banking variable. The “mismanagement” assumption implies that low profitability is positively related to the increase in future non-performing loans. The “moral hazard” hypothesis implies that the low capitalization of banks leads to an increase in non-performing loans. Bank managers can also increase their portfolio risk by increasing the loan / deposit ratio (more loans not with deposits) and this leads to more non-performing loans. Similarly, the logic holds for the LLP ratio regarding this assumption. Finally, the “size” hypothesis suggests that the size of banks has a negative correlation with non-performing loans.

Variables used throughout the model with detailed data description and correlation assumptions are as follows:

- Leverage ratio (LR) for the capital structure is likely to affect credit risk. Highly leveraged capital leads to a tendency to take more risk due to the need to produce higher returns with lower capital. As financial risk increases with leverage, a positive relationship between a banking firm’s risk and leverage is expected.
- The loan-to-deposit ratio (LtD) examines bank liquidity by measuring funds used in loans from deposits collected. According to previous studies (Louzis et al., 2012; Vuković. 2014; Makri et al., 2014), this indicator should have a positive effect on the NPL.
- As a reminder, the ratios of non-performing loans (NPL) which are obtained by the provisions for loan losses, are considered as a means of controlling anticipated loan losses and make it possible to detect and cover large losses on receivables bank loans. Therefore, banks that anticipate high capital losses should build larger provisions to reduce earnings volatility (Hasan & Wall, 2004). Thus, high loan loss provisions indicate high NPL ratios.
- Return on equity (ROE). performance is negatively associated with increases in future bad debts. In addition, past performance may reflect the high quality of management (Louzis et al., 2012), which has resulted in a decrease in the number of non-performing loans. We expect bank profitability to have a negative impact on non-performing loans. ROE is defined as the amount of net profit expressed as a percentage of equity.
- Size (SIZE). under the presumption of “too big to fail”, big banks take excessive risks (Chaibi & Ftiti, 2015). Stern and Feldman (2004) claim that “too big to fail” has played an important role in several banking crises around the world over the past decades. They explain that the big banks tend to take more excessive risks because their creditors do not impose the discipline of the market, which expects the government to protect them in the event of bankruptcy. As a result, banks increase their indebtedness, increase their lending to “bad” borrowers and therefore have more NPLs.
- The Gross Domestic Product (GDP) is the macroeconomic variable of interest, making it possible to control the economic cycle. The variable is assumed to be negatively correlated with the NPL ratio. During times of economic expansion, both individual and private borrowers need sufficient funds to repay their debts, but in times of recession their ability to repay them decreases.

– The macroeconomic control variables are the Consumer Price Index (CPI) and the real effective exchange rate (Bitar et al., 2018). For the CPI, high inflation is generally associated with lower interest rates high, which increases the profitability of banks. In this study, we predict a positive relationship with inflation and bank profits. For the real effective exchange rate (REER) variable, the rise in this variable may have mixed repercussions. Empirical studies (Castro, 2013; Nkusu, 2011) include this variable to control external competitiveness. According to Fofack (2005), the appreciation of this variable can weaken the competitiveness of export-oriented firms and make them unable to service their debt. In addition, a real appreciation of the local currency results in higher costs for local goods and services. Nonetheless, an increase in the exchange rate can improve the ability of those who borrow in foreign currency to service their debt (Nkusu, 2011). In this context, the sign of the relationship between the exchange rate and NPLs can be positive or negative.

The banking variables are extracted from the database of the Central Bank of Madagascar, currently Banky Foiben'i Madagasikara (BFM) and the macroeconomic variables come from National Statistic Office of Madagascar (INSTAT). The variables cover the period from 2005q2 to 2015q2 following the availability of bank data only for this period. Thus, the panel data includes 6 banks with 240 observations over the period 2005q2 to 2015q2.

## 2.1 Stress Test Scenarios and Equity Projection

### 2.1.1 Projection of the NPLs under the Different Stress Test Scenarios

The results of the panel data estimates will then be used to submit each bank's NPL ratios under adverse macroeconomic scenarios.

In equation (2), the vector of macroeconomic variables, common to all banks, describes the macroeconomic scenarios resulting from an auxiliary model, in our case the GVAR model.  $Z_t$

$$NPL_{it} = \alpha_i + \phi_{i,t} NPL_{i,t-1} + \beta' X_{i,t} + \gamma' Z_t + \mu_i + \varepsilon_{i,t} \quad (2)$$

In a stress test exercise, the trajectories of macroeconomic factors are considered "exogenous", in the sense that banks' profits / losses are not passed on to the economy in general. However, in practice, the macroeconomic variables that go into a model are determined using a combination of expert judgment and the output of an auxiliary model and therefore try to implicitly take into account the feedback loop between financial conditions and macroeconomics (Covas et al., 2014).

In the present case, the adverse stress test scenarios come from the results of the GVAR model. In fact, in a stress test exercise, the scenarios are defined beforehand or come from an auxiliary model. Several stress test studies have used the same predefined scenarios such as the work of Covas et al. (2014) and Kapinos and Mitnik (2016) where they used in their stress test exercises the same macroeconomic scenarios that are determined using a combination of expert judgment and the results of a dynamic stochastic general equilibrium (DSGE) model for the mid and large US banks stress test exercise. These are, in fact, the same scenarios defined and used by the Federal Reserve for the periodic stress test exercises for the year 2013-2014.

As a reminder, the macroeconomic scenarios used for forecasting the ratios of non-performing loans for each bank are as follows:

- The base scenario or reference scenario consists of the expected evolution of the economic situation, that is to say the projection of the results of the GVAR model without causing any shock for the system.
- The adverse scenarios correspond to the result of the simulation of the impulse response functions of the GVAR model following a decrease or an increase of one standard deviation of the variable considered for the shock. For example:
  - The negative shock scenario of local GDP corresponds to the result of the generalized impulse response functions (GIRFs) of the GVAR model on local variables following a reduction of one standard deviation of local GDP.
  - The positive oil price shock scenario corresponds to the result of the generalized impulse response functions of the GVAR model on local variables following an increase of one standard deviation in the oil price.

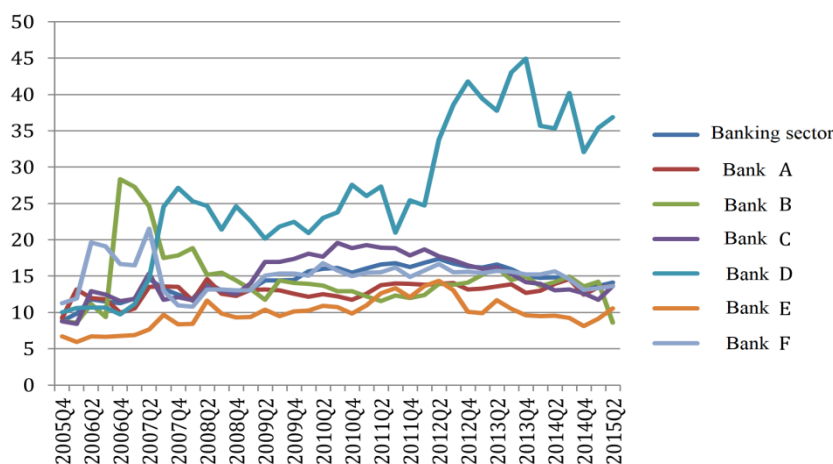
Adverse macroeconomic scenarios are mainly composed of results on local macroeconomic variables of the following shocks:

- a negative shock to GDP corresponding to a period of economic recession;
- a positive shock to the real effective exchange rate, ie a depreciation of the local currency;
- a positive shock to the price of oil as a global variable;
- and a negative shock to the prices of agricultural commodities.

#### 2.1.2 Projection on Banks's equity n under the conditions of adverse macroeconomic scenarios

Equity projections are calculated on the basis of changes in credit risk ratios under the conditions of adverse macroeconomic scenarios. The Capital Adequacy Ratio (CAR) for each bank will be calculated to verify the impact on banks of macroeconomic shock events. This indicator is obtained by the ratio of capital to risk-weighted assets.

The method of projecting equity with the scenarios is identical to the approach adopted to measure the capitalization of the aggregate banking sector. As a result, in addition to the measures of four macroeconomic shock scenarios, banks' risk-weighted assets are then increased by 16%. These two categories of scenarios are applied to banks's equity and then if the latter are still within the regulatory standard in terms of equity, despite the CAR ratios level of most banks are still above 8%. The figure below shows the evolution of the CAR ratio of each bank compared to the CAR of the aggregate sector.



**Figure 2. Evolution of Banks' Own Funds between 2005 and 2015**

Source: BCM 2015, author

### 3. Econometric Estimates and Results

The purpose of this section is to present the results of the various econometric estimates as well as the results of the implementation of the stress test on banks. The presentation of descriptive statistics of banking variables and macroeconomic variables used in the panel model is necessary before presenting the results of the different stages of the estimation of the panel model. Then, the reactions of banks' credit risks under adverse macroeconomic scenarios will be measured and will subsequently be reflected in the level of equity of each bank.

The data is processed using the Stata software.

#### 3.1 Descriptive Statistics

The table below presents the descriptive statistics (mean, minimum, maximum and standard deviation) of the banking variables and macroeconomic variables used in this study for the period from 2005 to 2015. The 6 banks which constitute the sample account for more than 95% of the total banking sector assets.

**Table 2. Descriptive Statistics of Specific Bank Variables and Macroeconomic Variables**

Bank variables					
	LR	LtD	NPL	ROE	SIZE
<b>All banks</b>					
Mean	0.932052	0.518897	0.12579	0.342479	0.162277
Maximum	0.963836	1.125314	0.471355	1.345581	0.316739
Minimum	0.878493	0.167206	0.029946	-0.27881	0.019172
Std. Dev.	0.017636	0.167995	0.082662	0.256454	0.092179
Observations	240	240	240	240	240



<b>Macroeconomic variables</b>			
	GDP	REER	CPI
Mean	6.410852	4.696734	5.552436
Maximum	6.524113	4.862846	5.908264
Minimum	6.262009	4.369736	5.118193
Std. Dev.	0.065179	0.161135	0.231119
Observations	240	240	240

Sources: BCM (2016), INSTAT, author

The analysis first concerns summary statistics for the entire sample. Regarding the level of credit risk, measured by the NPL ratio, the table shows an average of 12% for all banks. This shows the significant presence of credit risk for banks as a whole. The 8% standard deviation indicates slightly large variability in NPLs across banks.

With regard to the loan-to-deposit ratio (LtD), the average ratio is 0.51, which means that overall half of the deposits are mobilized as a loan.

For profitability (ROE), the table shows that the banking system is profitable with an average ratio of 0.34. This ratio also varies from one bank to another with standard deviation's value of 0.25.

Looking at the size of the banks, the average size is 0.16. The average prices is 5.5%.

The econometric results as well as the results of the stress test implementation provide more elements to analyze and relate the behavior and the situation of banks under the conditions of adverse macroeconomic scenarios.

### 3.2 Econometric Results: Regression of the Panel Model

Before undertaking any econometric analysis, preliminary panel data specification tests were performed.

#### 3.2.1 Stationarity Test

To determine the stationarity of the panel data, a panel unit root test was carried to the study variables. The panel unit root test involves solving in an autoregressive process AR (1) for the estimated equation (3).  $\rho_i$

$$Y_{it} = \rho_i Y_{it-1} + X_{it} \delta_{it} + \varepsilon_{it} \quad (3)$$

Where  $i = 1, 2, \dots, 6$  commercial banks, observed over the periods  $t = 2005, \dots, 2015$

$X_{it}$  represent all the explanatory variables used in the model,

$\rho_i$  autoregressive coefficients

$\varepsilon_{it}$  the error terms.

If, this means that the dependent variable was dependent on its own delay and that contains a unit root (not stationary) which can lead to erroneous results when testing the significance hypothesis of the explanatory variables  $|\rho_i| = 1$  (Gujarati, 2009).

The following table provides the summary of unit root tests of panel data:

**Table 3. Stationarity Test of the Variables of the Panel Model**

Variables	Test	Statistical value	p-value
NPL	Levin, Lin & Chu t	-7.80786	0.0000
	Im, Pesaran and Shin W-stat	-7.45259	0.0000
	ADF - Fisher Chi-square	75.8894	0.0000
	PP - Fisher Chi-square	148, 299	0.0000
ROE	Levin, Lin & Chu t	-7.70261	0.0000 *
	Im, Pesaran and Shin W-stat	-7.71818	0.0000
	ADF - Fisher Chi-square	79.1502	0.0000
	PP - Fisher Chi-square	88.0807	0.0000
LR	Levin, Lin & Chu t	-3.75211	0.0001
	Im, Pesaran and Shin W-stat	-4.91369	0.0000
	ADF - Fisher Chi-square	50.5465	0.0000
	PP - Fisher Chi-square	49.6856	0.0000
LtD	Levin, Lin & Chu t	-14.1399	0.0000
	Im, Pesaran and Shin W-stat	-12.5629	0.0000
	ADF - Fisher Chi-square	137, 922	0.0000
	PP - Fisher Chi-square	145, 208	0.0000
SIZE	Levin, Lin & Chu t	-15.2766	0.0000
	Im, Pesaran and Shin W-stat	-14.8691	0.0000
	ADF - Fisher Chi-square	165, 173	0.0000
	PP - Fisher Chi-square	179, 245	0.0000
GDP	Levin, Lin & Chu t	-1.78236	0.0373
	Im, Pesaran and Shin W-stat	-4.25833	0.0000
	ADF - Fisher Chi-square	38.9401	0.0001
	PP - Fisher Chi-square	42.2896	0.0000
CPI	Levin, Lin & Chu t	-12.3953	0.0000
	Im, Pesaran and Shin W-stat	-11.9616	0.0000
	ADF - Fisher Chi-square	130, 457	0.0000
	PP - Fisher Chi-square	136, 984	0.0000

\* Stationary variables at level. The p-value of Fisher's tests is calculated using an asymptotic chi-square distribution. All other tests assume asymptotic normality.

Source: author's calculations

Unit root test results are based on the tests of Levin-Lin-Chu (LLC), Im-Pesaran and Shin W-stat (IPS), Fisher-Chi Square (Fisher ADF), and Phillips-Perron Fisher-Chi Square-PP (Fisher PP). All these tests are based on the null hypothesis: the panel data are not stationary, and the alternative hypothesis: the data are stationary.  $\rho_i = 1$   $\rho_i \neq 1$

The LLC test assumes that the cross-sectional persistence parameters are common, i.e., for all  $i$ . This assumption takes into account the non-homogeneous cross-sectional effects in the generalized specified model, on the other hand for the tests of IPS, Fisher-ADF and Fisher-PP, all may vary from one section to another. The application of all these tests allows a comparison. In addition, the IPS test supplemented and confirmed the results of the LLC, ADF and PP tests.  $\rho_i = \rho$

According to the unit root tests of the panel data, the macroeconomic variables are stationary in first difference and the banking variables also except for the return on equity (ROE) variable which is stationary at level.

### 3.2.2 Diagnostic Test on Panel Data

Diagnostic tests will be performed to verify the use of the dynamic panel model.

a. Test for the presence of individual effects: the Fisher test

This test consists of verifying whether there is a presence of individual effects in the data. These effects are represented by an intercept specific to each individual. The null hypothesis to be tested is: there is only one common intercept, no individual effect in the following regression:  $H_0: u_i = 0$

$$Y_{it} = \rho_i Y_{it-1} + X_{it} \delta_{it} + u_i + \varepsilon_{it} \quad (4)$$

The result of the test is a Fisher F statistic shown in the following table:

**Table 4. Fisher Test Result for the Presence of Individual Effects**

Model specification	F Statistics	p-value (Prob> F)
Equation (4)	12.21	0.000

Source: author's calculations

The results show a p-value less than 5%, so  $H_0$  is rejected, i.e., the model includes individual effects.

We are now going to use the Hausman test: for the choice between fixed individual effect model or random individual effect

The Hausman test is used to determine the most appropriate model between the fixed effects model (FE) and the random effects model (RE). This implies estimating the two models in a particular order. The Hausman test is a specification test that determines whether the coefficients of the two estimates, fixed and random, are statistically different. Under the null hypothesis is that the appropriate model is the random effects versus the alternative fixed effects. The test result shown in the following table indicates the Chi-square test statistics and the corresponding p-value for the panel model equation.

**Table 5. Hausman Test Result**

Model specification	Statistics of Chi-square	p-value
Equation 4	325.10	0.000

Source: author's calculations

The Hausman test on the choice between the two models shows a p-value less than 5%. The null hypothesis of preference for the random effect model is rejected, so the fixed effect model is best suited for our analysis.

### 3.2.3 Heteroskedasticity Test

The Wald test is used to detect heteroskedasticity between individuals. The null hypothesis being homoscedasticity (Leblond & Belley-Ferris, 2004) and the statistic follows a law of degree of freedom  $N \cdot \chi^2$ . The table of results below shows the Chi-square statistic:

**Table 6. Wald Test**

Null hypothesis	Chi-square statistic (6)	p-value
for all $i \sigma_i^2 = \sigma^2$	139.98	0.0000

Source: author's calculations

The p-value the test is less than 5%, therefore the null hypothesis is rejected, which shows the presence of heteroskedasticity between individuals.

### 3.2.4 Autocorrelation Test

To test for the presence of correlation between the errors of individuals, we used the Wooldridge test. The null hypothesis of the test is the independence of the residuals between individuals.

**Table 7. Wooldridge Test**

Null hypothesis	Fisher statistic	p-value
Uncorrelated errors	19, 756	0.0067

Source: author's calculations

The results show a p-value less than 5%, the null hypothesis of independence of errors is rejected. So, the errors of individuals are therefore autocorrelated.

The conclusions of the above tests show the presence of fixed individual effects in the model, with the presence of heteroskedasticity and error correlation. The usual OLS model is therefore invalid. In that case, Arellano and Bond (1991) propose the estimator of the method of Generalized Moments (GMM). The model takes into account the problem of autocorrelation and the heteroskedasticity of the hazards of the difference model.

### 3.2.5 Instrument Validity Test

For models with individual fixed dynamic effects, the instrument validity test used is the Sargan-Hansen test and satisfies the null hypothesis: the instruments are not asymptotically correlated to the hazards. In GMM, it is fundamental that the instruments are not correlated to the vagaries of the model (Cadoret et al., 2004).

**Table 8. Sargan-Hansen Test Results**

Sargan-Hansen Statistics	p-value
8, 396	0.0150

Source: author's calculations

The p-value is greater than 5%,  $H_0$  is accepted. This implies that the instruments are valid.

The results of the various panel model specification tests above thus justify the choice of the dynamic panel model with fixed effects, by using the estimator of GMM.

### 3.3 Regression Results of the Dynamic Panel Model

The following table presents the coefficients of the GMM estimator of the dynamic specification with fixed effects according to the approach of Arellano-Bond (1991).

**Table 9. Results of the Estimation of the Dynamic Panel Model with Fixed Effects**

Dependent variable: Ratio of non-performing loans

Estimator: GMM

Variables	Coefficient (t-statistic)				Predicted signs
<i>Specific to banks</i>	(1)	(2)	(3)	(4)	
Lagged non-performing loan ratio $NPL_{t-1}$	0.25 * (4.65)	0.27 * (4.09)	0.25 * (3.72)	0.25 * (3.77)	+
Loan on Deposit Ration (LtD)	2.22 ** (2.27)	2.58 * (1.90)	2.34 ** (2.10)	2.11 *** (1.78)	+
Return on equity (ROE)	-0.62 * (4.60)		-0.45 * (5.69)	-0.61 * (4.14)	-
Leverage ratio (LR)	-5.75 * (4.20)			-4.67 * (3.09)	- / +
Bank size (SIZE)	-6.43 * (6.27)				+
<i>Macroeconomic variables</i>					
Gross Domestic Product GDP	-2.46 *** (1.61)	-2.55 *** (5.27)	-1.54 *** (2.07)	-2.20 *** (1.70)	-
Inflation (CPI)	-0.20 (0.12)	1.87 (1.46)	0.50 (0.41)	0.12 (0.07)	- / +
Exchange rate (REER)	-1.81 *** (1.76)	-1.29 (1.52)	-1.94 *** (1.75)	-1.97 *** (1.78)	- / +
Constant	2.77 (0.01)	4.94 (0.14)	3.6 (1.62)	2.77 (2.45)	

Absolute value of T-statistics in parenthesis. \*\*\* means p-value < 1%; \*\* p-value < 5% \* p-value < 10%.

Source: author's calculations

The incorporation of variables specific to each bank in the model does not change the impact of the macroeconomic variable of interest on the credit risk indicator. Indeed, the addition one by one of the banking variables does not modify the sign of the macroeconomic variable of interest and even that of the other variables as shown successively in columns (2), (3), (4) and (1). It also demonstrates the stability of the model.

The results in the above table highlight too that a part from sensitivity to macroeconomic conditions, the NPL ratio is also sensitive to specific bank factors. According to the results of the regression of the panel model, the explanatory variables, including the lagged dependent variable are all statistically significant, except for the CPI.

The estimated coefficients have the expected signs, compatible with the theoretical arguments of the literature. The period-lagged non-performing loan ratio coefficient (is positive and significant. An increase in NPL ratios during the last quarter will be followed by an increase in the current quarter.  $NPL_{t-1}$ )

The Loan-to-Deposit ratio (LtD) correlates positively with the credit risk indicator, which supports the moral hazard hypothesis. The capital performance ratio (ROE) is used to test bank mismanagement. The results show a significant negative relationship between ROE and NPL ratio, suggesting that ROE can significantly influence the level of NPL. The leverage ratio (LR) is a negative determinant of credit risk. Bank size (SIZE) negatively and significantly affects the credit risk indicator.

For macroeconomic variables, the coefficient of principal interest variable (GDP) is significant and negatively correlated with the ratio of Non-Performing Loans (NPL). The coefficient of the Consumer Price Index (CPI) has the expected negative sign. However, the CPI-variable does not have a significant impact on the ratio of non-performing loans. The exchange rate (REER) is a negative determinant of credit risk.

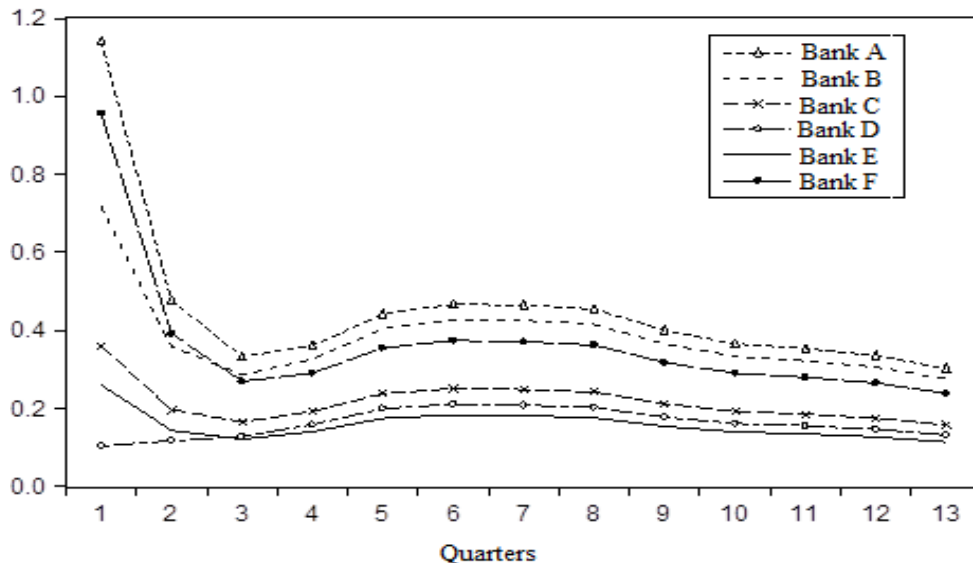
The discussion of the relationship between macroeconomic and banking variables and the indicator of banks' credit risk will be presented in paragraph 4.

### *3.4 Reaction of Credit Risk Indicators to Macroeconomic Shock Scenarios*

The results of the panel regression are then used to determine the change in the ratio of non-performing loans under the conditions of the macroeconomic stress test scenarios. The scenarios consist of the apparent changes in GDP after the shocks of the following macroeconomic variables: negative shock to GDP, positive shock to the real effective exchange rate, negative shock to the price of agricultural commodities and positive shock to the price of oil. The shock scenarios are obtained by the GVAR model. These scenarios are identical to the scenarios applied to the GVAR satellite model of aggregate banking sector credit risk. The impacts of macroeconomic scenarios on each bank's credit risk indicator are presented and discussed below.

The reactions of banks to adverse macroeconomic conditions are almost similar while the magnitude of the impact differs from bank to bank. All the reactions of the NPL ratio fall within the limits of the confidence interval.

The negative shock to GDP results in a sharp increase in the ratio of non-performing loans of all banks in the future horizons. Banks A, B and F are the most affected when looking at changes in the NPL ratio (Figure 3).



**Figure 3. Change in NPL Ratios of Banks Following a Negative Shock to GDP**

Source: Author's calculations

The following table (Table 10) shows that:

- The positive exchange rate shock, i.e., a depreciation of the local currency, has a low positive impact on credit risk indicators for all banks. The variation in the NPL ratio is below 1% for all banks.
- The positive shock of the oil price generates an increase of between 0.3% to 0.8% of the NPL ratios of the banks (Table below).
- Finally, a negative variation of one standard deviation in the price of agricultural commodities leads to a modest increase in the ratios of non-performing loans, with a variation of up to 0.68%. Banks A and F are the most affected by the commodity price shock.

In view of the reactions of NPL ratios, banks are more affected by GDP and oil price shocks compared to commodity price shocks and they are weakly affected by exchange rate variation. The following table summarizes changes in the NPL ratios following the various shocks compared to their base values, i.e., the ratio of non-performing loans in 2015q2.

**Table 10. Evolution of Banks' NPL Ratios after Macroeconomic Shocks**

Basic scenario		Adverse scenarios							
Banks	NPL 2015q2	Negative shock to GDP		Positive shock in the price of Oil		Negative shock in the price of agricultural commodities		Positive exchange rate shock	
		<i>h+4</i>	<i>h+8</i>	<i>h+4</i>	<i>h+8</i>	<i>h+4</i>	<i>h+8</i>	<i>h+4</i>	<i>h+8</i>
A	17.73	20.04 (2.31)	21.87 (4.14)	18.31 (0.58)	18.53 (0.80)	18.23 (0.50)	18.41 (0.68)	17.14 (-0.59)	18.24 (0.51)
B	15.59	17.28 (1.69)	18.95 (3.36)	16.12 (0.53)	16.31 (0.73)	15.61 (0.02)	15.78 (0.19)	15.48 (-0.11)	16.50 (0.91)
C	8.57	9.48 (0.91)	10.46 (1.89)	8.88 (0.31)	9.00 (0.43)	8.49 (-0.08)	8.59 (0.02)	8.59 (0.03)	9.21 (0.64)
D	6.85	7.35 (0.51)	8.18 (1.33)	7.11 (0.26)	7.21 (0.36)	6.52 (-0.33)	6.60 (-0.25)	7.14 (0.29)	7.66 (0.81)
E	6.14	6.81 (0.66)	7.52 (1.38)	6.37 (0.23)	6.46 (0.32)	6.21 (0.06)	6.13 (-0.01)	6.17 (0.03)	6.62 (0.48)
F	13.81	15.71 (1.91)	17.18 (3.37)	14.28 (0.47)	14.45 (0.64)	14.25 (0.45)	14.40 (0.59)	13.29 (-0.52)	14.18 (0.38)

*Note.* Changes in the NPL ratio are expressed as a percentage. *h* indicates the horizon of quarters after 2015q2. The values in brackets are the changes from the initial value of the NPL ratio in 2015q2.

*Source:* Author's calculations

### 3.5 Individual Bank Equity Projections

Since the last step of the stress test is to measure the ability of banks to absorb shocks through their equity, changes in the level of banks's credit risk are then reflected in equity through a projection. In fact, deteriorations in credit risk following shocks have an impact on and limit the capital adequacy ratio of banks, and can therefore compromise the system if their capital adequacy ratio falls below standards (Basel III, international standards).

The methods for calculating equity and the assumptions for adverse scenarios are the same as those adopted in the aggregate banking sector. Two adverse scenario assumptions are considered, the first encompasses the different macroeconomic shocks with banks's risk-weighted assets assumed constant, while the second assumes a 16% increase in risk-weighted assets in addition to adverse macroeconomic shocks.

The results on the equity projection under the different scenarios show the banks's credit risk absorption potential. Overall, most banks were able to meet the minimum capital threshold, i.e., the minimum capital ratio of 8%. For the first hypothesis of unfavorable scenarios, it is the negative shock



to GDP that has the greatest impact on the decrease in equity of all the banks, followed by the shock of the oil price. Indeed, these impacts stem from the magnitude of the consequences of these shocks on the deterioration of banks's credit.

For the negative GDP shock, it was banks A, C and F that suffered a sharp decrease in equity. Bank B is the only one that has a CAR ratio below 8% even though the magnitude of the impact of the GDP shock on this bank is less compared to the three previous banks. This is due to the fact that at the end of the second quarter of 2015, Bank B's capital ratio is just above the minimum with a CAR ratio of 8.59%.

The oil price shock also causes a fall in the capital ratio of banks but with a smaller variation compared to the GDP shock. The effects of shocks on the exchange rate and commodity prices on banks' capital ratios remain modest.

Looking at the impact of adverse scenarios with the assumption of a 16% increase in risk-weighted assets, banks's capital ratios experience a considerable drop for all types of shocks while the variation in this drop, compared to the decrease generated by the scenarios of the first hypothesis, differs from one bank to another. Indeed, with the increase in risk-weighted assets, the capital ratios of banks A, D and E are the most affected, followed by those of banks C and F. The capital ratio of bank B experiences less negative variation compared to other banks.

The following paragraph provides a discussion with respect to these adverse scenario results on banks.

#### **4. Discussions of the Results of the Stress Test on Bank Capitalization with Macroeconomic and Financial Variables**

##### *4.1 Relationship between the NPL Ratio and Macroeconomic Indicators*

###### **4.1.1 Negative relationship between NPL ratio and GDP**

The credit risk tends to increase when economic conditions deteriorate. This result aligns with various theories on the business cycle and credit risk that macroeconomic conditions affect the quality of banks's loans. This case demonstrates the vulnerability of some borrowers to macroeconomic shocks and therefore the deterioration of their ability to repay their debts in an unfavorable economic situation.

###### **4.1.2 Relationship between credit risk and control variables: CPI and REER**

The inflation rate (CPI) is negatively but not significantly correlated with the NPL ratio, which implies that the credit risk is insensitive to changes in the inflation rate. This negative relationship is explained by the fact that higher inflation weakens the ability of borrowers to service their debt by reducing their real income. This result is consistent with that of Castro (2013), who explains that inflation affects not only the real value of outstanding loans, but also the real income of borrowers. Thus, one effect is practically canceled by the other and the final impact of inflation on credit risk is canceled.

The negative relationship between the Real Effective Exchange Rate (REER) and the NPL ratio indicates that a depreciation (appreciation) of the local currency contributes to a fall (rise) in the ratio of non-performing loans. Indeed, the real depreciation of the local currency (increase in the REER)

promotes the competitiveness of exporting companies and thus improves their repayment capacity, thus reducing non-performing loan operations. This result is consistent with the conclusions found by many Beck, et al. (2013), Chaibi and Ftiti (2015) and Dua and Kapur (2017).

#### *4.2 Relationship between Credit Risk and Banking Variables*

##### *4.2.1 Relationship between NPL and NPL-1 Ratio*

The positive sign of the lagged NPL ratio means that NPLs are likely to increase when they increased in the previous year, this is due to amortization. The persistence of growth in the NPL ratio is also confirmed by previous work such as Sorge and Virolainen (2006), Beck et al. (2013).

##### *4.2.2 Positive Relationship between NPL and Loan-to-deposit Ratio LtD*

The credit-to-deposit ratio measures liquidity and reflects the attitude of banks towards risk; this ratio is also associated with the “moral hazard” hypothesis. The results which show a significant positive effect on the ratio of non-performing loans confirm the moral hazard hypothesis and align with the conclusions of Dimitrios et al. (2016) and Koju et al. (2018). The increase in the loan-to-deposit ratio indicates a preference for risk and is expected to lead to an increase in non-income producing loans. Indeed, in order to obtain more profitability, banks grant loans without maintaining the credit quality, which can reduce the quality of the loans and, consequently, increase the ratio of non-performing loans.

##### *4.2.3 Relationship between NPL, Leverage Ratio (LR) and Size (SIZE)*

The insignificant negative relationship between the NPL ratio and the leverage ratio does not support the “too big to fail” assumption on risk taking. This assumption predicts that the higher the liabilities relative to the total assets, the higher the probability of impaired loans should be. An explanation could be provided by the work of Louzis et al. (2012) which show that the relationship between the leverage ratio and credit risk is conditioned by the size of the banks. These results suggest that leverage tends to increase NPLs, but this effect only occurs up to a certain size threshold. After this threshold, leverage does not have a positive effect on NPLs, which means that among large banks there is no “too big to fail” effect on NPLs. That is, small banks tend to increase their leverage ratio by expanding loans to unreliable quality borrowers and hence have more non-performing loans. However, the banking sector is mainly made up of large banks, the four out of six banks in our sample hold more than 80% of total assets,

For the direct relationship between bank size and credit risk, the results show a significant negative effect. This is explained by the fact that unlike the results of other previous works such as Louzis et al. (2012), Asamoah and Adjare (2015) Chaibi and Ftiti (2015), only small banks take excessive risks by increasing their indebtedness and therefore have a higher ratio of non-performing loans. This result aligns with the conclusions of Lis et al. (2001) who also found a negative relationship between NPL and bank size. The explanation lies in the fact that the size reflects the strength and information asymmetry of the bank due to the availability of a highly skilled workforce and technological bases. In addition, the big banks regularly monitor loans, they have a better risk management policy and high diversification possibilities.

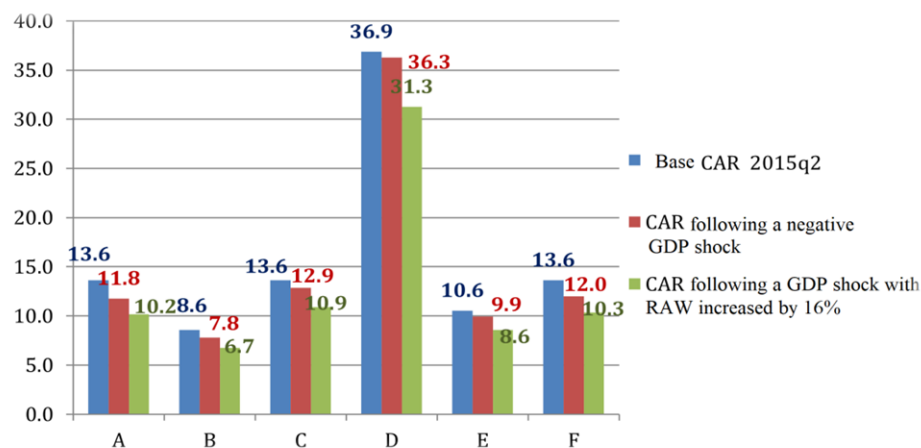
#### 4.2.4 Negative Relationship between NPL and Return on ROE Liabilities

The negative relationship between the performance indicator (ROE) and credit risk supports the hypothesis of “mismanagement” and aligns with the conclusions found by the work of Louzis et al. (2012), Makri et al. (2014) Dimitrios et al. (2016). Indeed, performance serves as an indicator of the quality of management. Banks that are characterized by high profitability are less likely to engage in dangerous activities, such as issuing risky loans, and are able to manage credit risk.

#### 4.3 Projection on Banks' Equity under Stress Test Scenarios

The results of stress test exercises on banks show that during the reference scenario, i.e., at the end of the second half of 2015, the banking system is well capitalized with regard to the capital adequacy system of Basel III which requires a capital ratio above the minimum threshold of 8%. On the other hand, during the stress test scenarios, a weakening of the banks' capital adequacy is observed. As a result, all credit institutions face a drop in their equity capital during periods of macroeconomic stress. Analysis of the distribution of capital levels revealed some divergence between banks. During the unfavorable macroeconomic scenarios, most banks have very good indicators with a capital ratio above 12% and some of them fall within a range between 8 and 12% and only one (bank B) is at a capital level below 8% (Figure 4).

By applying the scenarios with the 16% increase in risk-weighted assets, the majority of bank's own funds are concentrated between 8 to 12%. A bank's capital ratio is always below the minimum threshold (bank B) and only one bank has a capital adequacy ratio well above 12% (bank D).



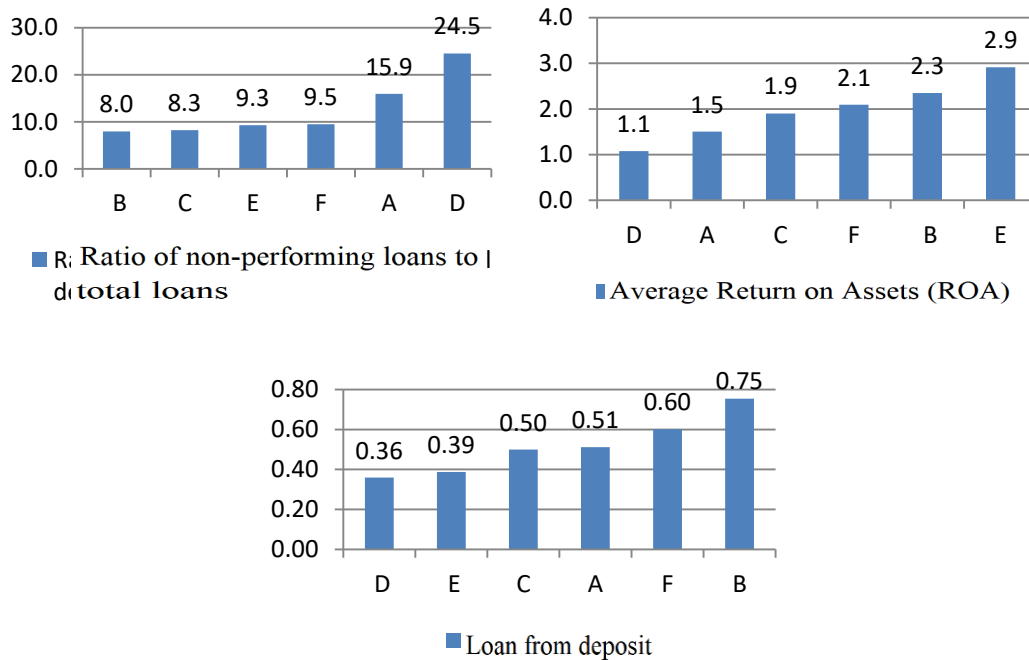
**Figure 4. Change Projection of Banks' Capital Adequacy Ratio (CAR) under Unfavorable Macroeconomic scenarios: Negative Shock to GDP**

*Note.* The y-axis shows the bank equity ratio after four quarters as a percentage. The x-axis shows the banks.

*Source:* author's calculations.

Banks that have the same characteristics after the macroeconomic shock scenarios (A, C, E and F) are those classified as large with assets between 16 to 27% of the total assets of the banking sector. The

other two banks (B and D) are characterized by their size which can be qualified as small compared to the other banks in the sample with a percentage of assets respectively around 5% and 3%. However, their behavior during bad times diverges completely. Figure 5, which shows the evolution of the average ratios of the banking variables, will be used as support for the explanation of the situations of the banks under the conditions of stress test.



**Figure 5. Average Ratios of Banking Variables between 2005 and 2015**

Source: BCM 2015, author's calculations

#### 4.3.1 Small Banks (D and B).

##### 4.3.1.1. Bank D

The equity projection presented in Figure 4 above shows a bank (D) that is characterized by an extremely high capital adequacy. This bank is among the small sample banks with assets of 3% of the total assets of the sector. Indeed, the capital adequacy ratio takes into account the size of banks. Banai et al. (2014) also noted that it is small banks that tend to hold a high capital adequacy ratio, as it would be very expensive for large banks to hold multiples of the required amount. The explanation for this strong capitalization also lies in the fact that despite the importance of the credit risk within Bank D compared to other banks (Figure 5, NPL), its borrowers are less affected by the deterioration of the macroeconomic environment and results on credit risks). In other words, most of this bank's loans are only granted to quality borrowers. This bank's low loan-to-deposit ratio also attests to this fact.

##### 4.3.1.2. Bank B

Unlike bank D, bank B which is below the minimum threshold after the shock scenarios, given that this

bank's credit risk is the lowest of all banks (Figure 5, NPL). This is due to the fact that this bank's loans are among the most exposed to macroeconomic shocks (see Figure 3 and the results on credit risks). In other words, bank B borrowers are more affected by unfavorable macroeconomic conditions. In addition, this weakness of resistance is also due to the size of the loans granted by this bank in relation to the deposit with a percentage of 75% (Figure 5, loan on deposit). In terms of risk-taking, the situation of this bank confirms the hypothesis of "moral risk". Indeed, the bank focuses above all on increasing profitability and to do this, it grants loans without maintaining the quality of the borrower, which reduces the quality of loans especially in times of distress and subsequently generates the increase the ratio of non-performing loans. Figure 5 shows that Bank B is among the most profitable compared to other banks by referring to Return on Assets (ROA) which measures the ratio of profit to total assets.

#### 4.3.2 Large Banks (A, C, F and E).

The more capitalized banks are those classified as large banks and hold equity between 8% and 12% after the shock scenarios (Figure 10). More precisely, three of these banks hold more than 10% of equity even after the extreme scenarios of hypothesis (A, C and F); for one of them (bank E), the capital ratio falls below 10% under the two shock hypotheses.

##### 4.3.2.1. Banks A, C and F

For banks A, C and F, half of their deposit is allocated to loans (see Figure 5, loan on deposit). As a result, during periods of recession, even if these banks are also exposed to credit risks during unfavorable macroeconomic situations, they manage to hold the necessary capital. These banks therefore diversify their activities by using the other half of the deposits to other income-generating activities such as transaction portfolios, investment portfolios and foreign currency operations; and consequently obtain various sources of non-interest income. These different sources of income allow these banks to be more resilient even during times of distress as their profits do not depend solely on loans.

Indeed, on the basis of the results on the reaction of credit risks, even if one of these banks (A) is the most exposed to risks during recessions while the other two are slightly affected, it manages to maintain a high capital adequacy ratio during periods of shocks. This more pronounced risk aversion is explained by the fact that the borrowers of this bank are sensitive to macroeconomic conditions on the one hand, and on the other hand, the quality of borrowers is lower compared to those of the other two (C and F). In other words, on the basis of 50% of their deposits turned into loans, on average 15% of Bank A's loans are non-performing while for the other two, this ratio is around 8% only. However, As for the other two banks (C and F), they can be considered as selective in terms of granting credit. Their borrowers are weakly sensitive to the deterioration of the macroeconomic situation. As a result, they manage to hold equity below the minimum threshold during adverse scenarios.

##### 4.3.2.2. Bank E

For bank E, which is one of the large banks, it differs from the three previous banks (A, C and F) by the fact that it has a capital ratio of less than 10% after the assumptions of macroeconomic shocks (Figure 4). Indeed, this bank is the least affected by credit risk in a period of macroeconomic shocks and which

also selects its borrowers such as banks C and F. Unlike the other two (C and F), it strongly favors other sources of income over financing the economy: only 38% of these deposits are converted into loans despite its size. This is how it is the most profitable in terms of return on assets (ROA) (see Figure 5). However, unlike the three big banks (A, C and F), it does not manage to hold as much equity in times of shocks, i.e., above 10%. This is explained by the fact that the equity ratio in normal periods of this bank is lower compared to that of other banks, with a percentage of 10.3% against 13.6% (Figure 10). Specifically, Bank E's capital and reserves are lower compared to those of the other three banks, or even half, and this consequently weakens the capital adequacy ratio in times of macroeconomic stress. 6% (Figure 4). Specifically, Bank E's capital and reserves are lower compared to those of the other three banks, or even half, and this consequently weakens the capital adequacy ratio in times of macroeconomic stress. 6% (Figure 4). Specifically, Bank E's capital and reserves are lower compared to those of the other three banks, or even half, and this consequently weakens the capital adequacy ratio in times of macroeconomic stress.

## 5. Conclusion

The application of the macroeconomic stress test on the banks of Madagascar was carried out in three stages. First, the relationship between the credit risk indicator of all banks with macroeconomic variables and banking variables are estimated using a dynamic panel model from the Allarano-Bond (1991) GMM estimator. Second, NPL ratios are subject to different macroeconomic shock scenarios. The scenarios used for the individual banks are identical to the shock scenarios applied to the aggregate banking sector, generated from the GVAR model. Third, the reactions of the NPL ratios are translated into the shareholders' equity of each bank in order to measure their resistance and resilience to the adverse scenarios.

The results of the macroeconomic stress test with individual banks showed that most banks remain capitalized after macroeconomic shocks. It should be noted, however, that banks' exposure to credit risk does not depend on their size. The different scenarios of macroeconomic shocks affect the credit risk of all banks, including the negative shock to GDP, but to a different degree. The results showed that among the banks most affected by credit risk during the occurrence of macroeconomic shocks are a large bank and a small bank. For the capitalization of banks under adverse scenarios, in addition to macroeconomic shock scenarios, another hypothesis of an increase in banks' risk-weighted assets was also considered. The results at the level of each bank showed that only one bank could not have a capital adequacy ratio higher than the regulatory minimum of 8% after the scenarios. This bank is among the most affected by credit risk. Among the other banks which manage to hold a level of capital higher than the minimum required, there is one which has a sufficiently large capital that although it is also sensitive to credit risk, it can manage to absorb shocks. Some of them, mainly composed by large banks, hold a capital ratio above 10% even after the severe scenarios of the second hypothesis. Indeed, Banks's exposure to credit risk depends in particular on the sensitivity of borrowers in an unfavorable economic situation. In other words, some banks lend the majority of their deposits while nonperforming loans are weakly sensitive in times of

economic contraction. Apart from the selection of the quality of loans to be granted, the solidity of banks is also explained by the fact that they diversify their activities to other sources of non-interest income, which allows them to have sufficient equity ratios after shock situations.

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