

**Stress testing bank as tools of risk management, case of an individual
Algerian bank using Financial Projection Model**

اختبارات الضغط البنكية كأداة لتسيير المخاطر، حالة بنك جزائري واحد باستخدام نموذج الإسقاط المالي

Mehdi BOUCHETARA^{1*}, Sezer BOZKUŞ KAHYAOĞLU²

¹ Higher National School of Management ENSM, m.bouchetara@ensm.dz

² Izmir Bakırçay University, sezer.bozkus@bakircay.edu.tr

Date of receipt:30/10/2020 Date of revision: 18/11/2020 Date of acceptance:04/12/2020

Abstract

ملخص

In this paper, the major aim is to exercise stress testing for an individual bank in Algeria to highlight the bank's vulnerabilities in the face of the various shocks that are applied based on Financial Projection Model. Although the study includes the case of Algeria, the recommendations made in the context of international risk management standards and the methods applied for risk assessments constitute a global best practice example.

Keywords : Stress testing, Financial Projection Model, Credit Risk, Liquidity Risk,

الهدف من هذه الدراسة هو تطبيق اختبارات الضغط او الصلابة على بنك واحد في الجزائر لتسليط الضوء على نقاط الضعف في مواجهة الصدمات المختلفة التي يتم تطبيقها على أساس نموذج الإسقاط المالي. على الرغم من أن الدراسة تشمل حالة الجزائر فقط، إلا أن التوصيات المقدمة في سياق معايير إدارة المخاطر الدولية والأساليب المطبقة لتقييم المخاطر تشكل مثالا عالميا لأفضل الممارسات.

الكلمات المفتاحية: اختبار الضغط، نموذج الإسقاط المالي، خطر القروض، خطر السيولة.

*Corresponding Author: BOUCHETARA Mehdi, Email: m.bouchetara@ensm.dz

1. INTRODUCTION

The efficient allocation of funds in the financial system depends on an efficient functioning financial intermediary structure and the existence of competitive and sustainable financial intermediary institutions (Chorafas, 2008). Banks have a special importance and weight among financial intermediary institutions compared to others. It is a fact that financial markets are becoming more integrated every day and the interaction between markets has increased significantly with the effect of digitalization. This situation also makes the whole financial system, financial intermediaries, and banks in particular, more fragile and sensitive to risks. Fluctuations in international financial markets cause increased volatility for the banking sector. This is also considered as an issue that makes financial stability difficult for the national economies (CFA Institute, 2013).

There is a high volatility, increased fragility, and uncertainty in today's financial markets. In this regard, FSAP (Financial Sector Assessment Program) carried out by the IMF and the World Bank can be expressed as an important global initiative (Arslaner, 2014). In addition, there are some regulations related to minimum capital ratio of banks which have been constantly imposed by the Basel Committee, i.e. Basel I, Basel II, Basel III and Solvency Standards (Basel Committee, 2017a, 2017b and 2018; BIS, 2020). They are all aiming to contribute to the financial stability of the country's economies based on all these global efforts, which emphasize the importance of new standards and their measurement techniques to ensure the sustainability of methods. The most important of these methods is called "Stress tests" and it has been developed to test the resilience of the financial system and especially banks (BIS, 2020). Through stress tests, it is possible to define, measure and evaluate the weaknesses in the banks' balance sheets.

Stress tests are considered and applied as a valuable risk management tool in the banking system¹. On the other hand, stress tests are not the only way of risk management and there are various risk management tools available for banking sector (Bozkus Kahyaoglu and Kurt, 2020; Leo et al., 2019). The major list of available risk management tools used in the banking sector is given at Appendix 1 to support further studies in the literature.

Stress tests examine shocks that are unexpected under normal conditions and are not likely to occur but are not impossible (Bozkus Kahyaoglu, 2019). Since such shocks have a high potential to damage when they occur, measurements and analyzes are carried out to reveal the possible effects on various portfolios, financial institutions, or the financial system by applying stress tests.

¹ However, it should be noted that stress tests are not used as a policy tool and it is only the aggregate results shared with the public (BIS, 2020: 30). However, it should be noted that stress tests are not used as a policy tool and it is only the aggregate results shared with the public. It is a fact that disclosing disaggregated information could support better practice in the banking sector since it increases the confidence level by being more accountable. Unfortunately, communicating stress test results is not a widespread practice.

In this work, the banking system of Algeria is examined regarding the major risks exposed of banks operating in this sector. Alessandri and Drehmann (2010) and Drehmann et al. (2010) claim that measuring the liquidity and credit risks in stress test is the most important part of the analysis. In this context, the application process of stress tests in measuring the liquidity and credit risks is explained in detail through a sample of bank case.

The organization of the study can be summarized as follows. First, brief information about the relevant literature is presented to create awareness about the importance of the issue for the banking sector. The studies in the literature about how stress testing has become a necessity and application standards are briefly mentioned to guide the finance professionals and provide relevant information for further studies. Then, it is explained how this structure is carried out specifically in Algeria and brief information about the Algerian banking system is presented. Next, the data and method are explained. The method applied in this work is consistent and reliable which is based on a tool, namely Financial Projection Model, generated by the World Bank. In this context, the empirical findings obtained are given in tables with their comments. Then, within the framework of the findings obtained, it is tried to contribute to the literature by making policy recommendations.

2. LITERATURE REVIEW

With the accelerating effect of the shocks and economic crises in the financial markets, we can say that the first studies for the development of the stress test started at the international level in the 1990s. With the accelerating effect of the shocks and economic crises in the financial markets, we can say that the first studies for the development of the stress test started at the international level in the 1990s. It is observed that these studies have become effective, especially after the 2000s. After the "2008 global financial crisis" that took place in this period and left significant marks on the financial markets on a global scale, it was determined that the studies on this subject reached a significant level.

Wong and Hui (2009) argue that the banking systems are not immune to financial crises because of the three common features relevant for banking systems all over the world. First, banks' balance sheets are mostly exposed to "*common market risk factors*". This is because banks normally acquire similar financial assets and positions. For this reason, when there is any significant decline in the asset prices, let's assume to happen just in a single market, even this could expose many banks to considerable amount of losses arising from market risks (Cifuentes et al., 2005 ; and Adrian and Shin 2008a and 2008b). This situation is shown at Figure 1 which is indicating asset price shocks via different channels leading to liquidity risks for banks. International Accounting Standards Board (IASB)

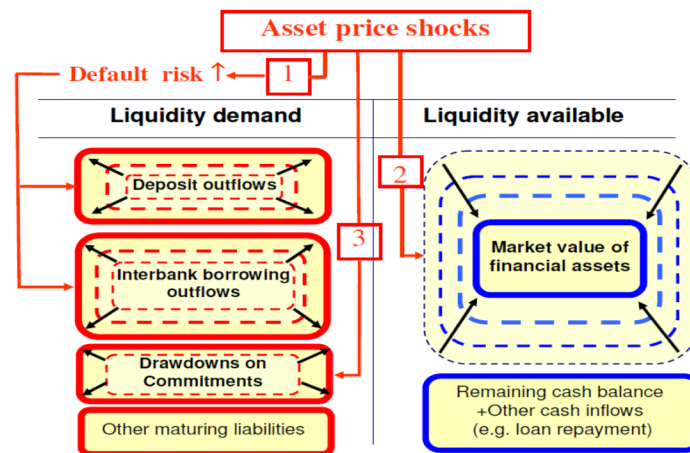
standards² are the essential part of regulations related to liquidity risks for banking sector.

Secondly, banks have a limited amount of capital which is used as a buffer against credit losses. It is a fact that banks mostly operate based on a high level of financial leverage. This situation leads to banking systems become vulnerable to multiple default risk during big market shocks (Matz and Neu, 2007 ; Duttweiler, 2009 ; Matz, 2011).

Thirdly, interbank markets are known to be sensitive regarding default risks and their sensitivity leads to significant increases in the default risk of banks. From this channel, interbank markets become tighter and as a result, this situation may create liquidity shortages at systemic level in the market (Cole, 2012).

Stress tests have started to be used as a basic tool in the management of the risk group defined as "*internal risk*" by financial institutions. As a result of the shocks that emerged over time and the increasing volatility, it has been widely applied by central banks and supervisory authorities based on the financial system under the leadership of international institutions. In applying stress tests, it can measure the possible effects of volatility in risk factors on the risks of financial institutions and / or the financial sector, such as liquidity risk, currency risk, interest risk, market risk and credit risk (Chorafas, 2008). This measurement method can be created to reveal all effects that occur separately (for individual bank) or together (for system-based) (Arslaner, 2014).

Figure 1: The effect of asset price shocks on the liquidity of a bank



Source: Wong and Hui, 2009.

² It should be noted that IAS/IFRS is not mentioning any specific discipline concerning the Liquidity Risk (apart from minor requirements on its disclosure) and hence, the interest of the study is based on both "IFRS 7 - Financial Instruments: Disclosures" and "IFRS 9 - Financial Instruments".

Stress tests are designed for monitoring the outcomes from the stressed scenarios relevant for financial markets (Bozkus Kahyaoglu, 2019). The major stressed scenarios involve impact analysis regarding the dynamics and directions of shocks and the magnitude of exposures on the bank's balance sheet under the predetermined figures of the key macroeconomic variables. BIS (2020) recommends various methodologies for stress testing implementations such as "multivariate econometric models", "replication of historical events" or "statistical rules applied to some or all variables in the scenario".

There are some data requirements for making a reliable credit risk assessment such as data on loans portfolio at categoric classification, loan loss provisions for commercial, consumer and mortgage loans at a bank level as well as credit portfolios time series data to analyze the historical information on defaults both at the bank and category levels respectively (Bozkus Kahyaoglu, 2019). In addition, there is a need for the individual bank information, like all-inclusive portfolio possessions by institution, and high frequency financial market data regarding the interest rates and exchange rates (Bozkus Kahyaoglu and Kurt, 2020). In this context, assessing the strength of diffusion mechanisms requires detailed analysis of the interbank exposure. It should be noted that although high frequency financial time series required for the sake of better analysis, the frequency of the financial market data used in the stress tests mostly depends on their availability. In this respect, there are various works indicating the methodological challenges of stress testing implementations in the literature (Schuermann, 2014; Dent et al., 2016 ; Baudino et al., 2018; and Kapinos et al, 2018).

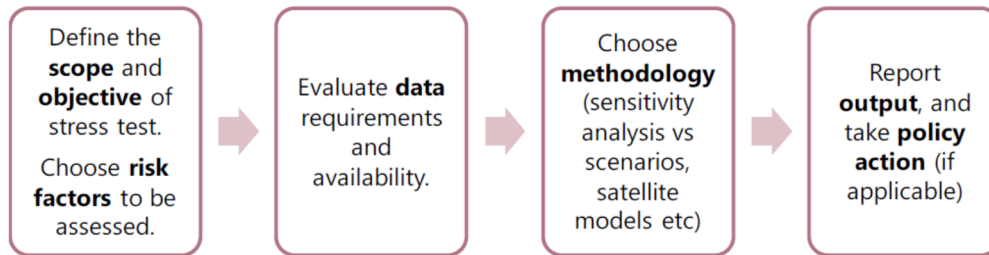
When the activities of banks are evaluated in general, loans among them are considered as one of their risky activities. Credit risk is the risk of loss that may arise if the borrower fails to meet the agreed terms for financial or other reasons. It is a fact that credit risk can be diversified, although it consists of the counterparty's failure to fulfill its obligations (Chorafas, 2008). It is claimed that the risk of default due to various reasons arises mostly from systematic risk. For this reason, it is difficult for banks to hedge this risk (risk aversion) (Wong and Hui, 2009; BIS 2019).

Due to credit risks, significant losses may be experienced reflected in banks' balance sheets (Illanes et al., 2016; BIS, 2020). In the distribution of these losses, banks will cover the expected losses with their reserves, and unexpected losses with provisions and equity (Buncic and Melecky, 2013). There are various approaches in quantitative modeling of the credit risks arising in the banking sector. For example, critical information can be provided by the coefficients via regressing the NPL ratio on macroeconomic variables. Using these coefficients, they can provide an important input for stress test analysis by giving an estimate of bank borrowers' sensitivity to relevant macroeconomic risk factors.

It is a fact that liquidity comes under stress and sometimes leads to liquidity risk because of commitments that are being and have been made by the banks (BIS,

2020). Particularly, the off-balance sheet items³ and their exposures may contribute significantly to liquidity risk in banking sector (Chorafas, 2008).

Figure 2: The Major Steps for Applying Stress Tests



Source: Perez and Trucharte, 2013 and BIS, 2020.

The major steps for the stress testing are indicated at Figure 2 and in the following sections, these steps are applied for the Algerian banking sector.

3. THE ALGERIAN BANKING SYSTEM AT PRESENT

The Algerian banking system is composed of twenty-nine (29) banks and financial institutions, including six (6) public banks, fourteen (14) private banks with foreign capital, and nine (9) financial institutions (BOUCHETARA 2018). In terms of deposit taking, bank activity is growing steadily, while lending by banks remains very weak. A large proportion of the loans granted by the latter are for leasing transactions (85.9%), whereas they are not authorized to collect deposits and manage means of payment. From 2014, the Algerian banking sector recorded a strong increase in bank assets (16.5% compared with 2013), while the assets of financial institutions are rising more moderately (7.4% compared with 2013) and represent only 0.6% of total banking sector assets. In total bank assets, public banks remain predominant with a relative share of 86.8% at end 2014 against 13.2% for private banks. Public banks represent the core of the Algerian banking sector (Bank_of_Algeria, Banking activity report according to the balance sheet 2014). More than 80% of the total assets of the banking system in 2018 are held by public banks. These banks provide important funds for privileged public investments. Algerian banks are capitalized, profitable and liquid (IMF 2018).

In order to strengthen the stability of the Algerian banking system, the monetary authority has put in place a set of prudential standards to be respected. Like the Basel regulations, Algerian prudential standards are progressing. In this context, we review new regulatory texts (Bank_of_Algeria, www.bank-of-algeria.dz 2014):

³ Basel Committee (2006) point out in the joint forum that: "Key off-balance sheet products that can give rise to sudden material demands for liquidity at banking sector during times of stress include: (1) Committed lending facilities to customers (2) Committed backstop facilities to commercial paper conduits, and (3) Committed back-up lines to special purpose vehicles."

- Regulation 14-01 of 16 February 2014 on solvency ratios applicable to banks and financial institutions.
- Regulation 14-02 of 16 February 2014 on large exposures and equity investments.
- Regulation 14-03 of 16 February 2014 on the classification and provisioning of receivables and commitments by signature of banks and financial institutions.

4. METHOD AND DATA

4.1. Data

We used the FPM 2.0 (Financial projection Model) (Arslaner 2014) set up by the World Bank as a tool for the tests. We fed the model by referring mainly to prudential statements and reporting models in order to extract the following elements from it:

- The bank's balance sheets and income statements,
- Off-balance sheet items,
- The breakdown of the bank's receivables and liabilities by sector of activity,
- The elements used to calculate regulatory, basic and supplementary capital,
- Elements for calculating weighted risks,
- Elements used to calculate liquidity.

We have opted to introduce these data in the format of FPM 2.0 (Directly through the "Mapped Data" sheet). The transcription of the data into the model format will enable us to highlight certain elements necessary for the analysis of the bank's initial situation, to follow the path of the calculations and will facilitate the interpretation of the test results.

Presentation of the bank's initial situation:

Table 1: Initial situation of Bank U: KDA

Indicators	Amount
Regulatory equity	38 958 962
Profit for the year	4,332,531
Cash and assets Bank of Algeria	134,091,097
Receivables	319,682,157
Provisions	36,034,222
Deposits	383,374,301
Solvency ratio %	12.4%
Liquidity ratio %	1163.3%

In terms of solvency, the bank has a general solvency ratio of 12.40%. This is above the regulatory limits, with a difference of 2.90%. The amount of credits granted by the bank amounts to 319.7 billion dinars. The provisions made on the totality of the credits are up to 36 billion dinars generating a net amount of credits of 283.7 billion dinars. Deposits are the main source of the bank's credits. The latter amounts to 383.3 billion dinars. The ratio between credits and deposits is

83%. In terms of liquidity, the bank presents a ratio of 1163.3%. The latter is above the set threshold. The cash and assets held by the bank with the Bank of Algeria (the most liquid assets) amount to 134 billion dinars covering 35% of total deposits.

Table 2: Breakdown of receivables by sector of activity U: KDA

Activity sectors	Amount of healthy loans	Amount of classified receivables	Total
Agriculture	11 134 630	4 844 174	15 978 804
Trade	77 652 460	23 561 604	101 214 064
Construction	5 646 652	3 048 421	8 695 073
Industry	96 496 108	29 216 905	125 713 013
Service	40 204 120	10 980 357	51 184 477
Real estate	6 843 914	1 733 254	8 577 169
Financial activity	1 194 404	634 552	1 828 957
Others	5 471 529	1 019 072	6 490 601
Total	244 643 818	75 038 339	319 682 157

Table 3: Breakdown of receivables classified by type and their provisioning U: KDA

Activity sectors	Credit with potential	problems High-risk	receivables Impaired receivables	Total	Provisions
Agriculture	1 758 705	762 871	2 322 597	4 844 174	3 095 744
Trade	4 677 778	5 416 872	13 466 953	23 561 604	10 276 513
Construction	456 201	546 359	2 045 862	3 048 421	2 109 960
Industry	7 574 706	7 816 563	13 825 637	29 216 905	13 627 508
Service	2 488 536	1 687 576	6 804 245	10 980 357	4 986 024
Real estate	444 572	264 888	1 023 795	1 733 254	853 011
Financial activity	132 270	180 117	322 166	634 552	104 129
Autres	271 585	135 484	612 003	1 019 072	981 332
Total	17 804 352	16 810 729	40 423 258	75 038 339	36 034 222

The total amount of classified receivables represents 23% of the total receivables. The amount of provisions set aside for this proportion is 48%. The breakdown of receivables by sector of activity shows a proportion of 87% allocated to the industry, trade and services sectors. The amount of classified receivables recorded by these three sectors amounts to 85% of total classified receivables. The provisioning of these receivables represents 80% of total provisions.

Table 4: Breakdown of deposits by type U: KDA

Type of deposit	Amount
DAV	278,454,591
DAT	70,383,903
Blocked receivables	25,930,826
Deposits per security	8,604,981
Total	383,374,301

The breakdown of deposits by type shows that sight deposits constitute 73% of the bank's main resources, followed by term deposits with a proportion of 18%. These results show that bank X allocates a significant proportion of short resources to long-term deposits.

4.2. Method

We have set up five series of sensitivity tests to stress two major risk categories: credit risk, liquidity risk.

4.2.1. Credit risk stress tests

- Test 01: General deterioration of the bank's credit portfolio.
- Test 02: Simultaneous deterioration of the credit portfolios of the three main sectors of activity.
- Test 03: Individual deterioration of the credit portfolios of the three main sectors of activity.

4.2.2. Liquidity risk stress tests

- Test 01: Massive withdrawals of deposits - 40% over 12 days.
- Test 02: Mass withdrawals of deposits - 50% over 8 days.

5. APPLICATIONS AND RESULTS

5.1. Stress testing of credit risk

5.1.1. Test 01: General deterioration of the bank's credit portfolio

For a first shock, we have hypothesized a deterioration of 20% of each category of loans, for all sectors of activity, over a time horizon of one year. The downgrading will be carried out as follows:

- Downgrading of 20% of sound receivables to potentially problematic receivables. These flows are provisioned for 20%.
- Downgrading of 20% of potentially problematic receivables to high-risk receivables. A provision of 30% has been set aside for these flows.
- Downgrading of 20% of high-risk receivables to impaired receivables. These flows are provisioned at 50%.

The rules for the provisioning of classified receivables set out in Article 5 of Regulation 14-03 should be recalled:

Table 5: Provisioning rules for classified receivables

Classified receivables	Amount	Duration of Outstanding	Provisioning rate
Potential problems		[90;180] days	20%
Very risky		[180;360] days	50%

Compromises	> 1 year	100%
-------------	----------	------

In order to observe the evolution of the different indicators, we have opted for quarterly projections. The shock will be spread evenly over the four quarters.

Table 6: Calculation of receivables flows (Test 1 - credit risk) U: KDA

Activity sectors	Secured receivables	Credit with potential problems	High-risk receivables	Impaired receivables
Agriculture	-2 226 926	2 226 926	351 741	152 574
Trade	-15 530 492	15 530 492	935 556	1 083 374
Construction	-1 129 330	1 129 330	91 240	109 272
Industry	-19 299 222	19 299 222	1 514 941	1 563 313
Service	-8 040 824	8 040 824	497 707	337 515
Real estate	-1 368 783	1 368 783	88 914	52 978
Financial activity	-238 881	238 881	26 454	36 023
Others	-1 094 306	1 094 306	54 317	27 097
Total	-48 928 764	48 928 764	3 560 870	3 362 146

Table 7: Calculation of provision flows (Test 1 - credit risk) U: KDA

Activity sectors	Prov. receivables with potential problems	Prov. high-risk receivables	Prov. compromised receivables	Total
Agriculture	445 385	105 522	76 287	627 195
Trade	3 106 098	280 667	541 687	3 928 452
Construction	225 866	27 372	54 636	307 874
Industry	3 859 844	454 482	781 656	5 095 983
Service	1 608 165	149 312	168 758	1 926 235
Real estate	273 757	26 674	26 489	326 920
Financial activity	47 776	7 936	18 012	73 724
Others	218 861	16 295	13 548	248 705
Total	9 785 753	1 068 261	1 681 073	12 535 087

The sudden shock is as follows:

Table 8: The shock to be applied (Test 1 - credit risk) U: KDA

Flux	Choc	Choc trimester
Flow of performing loans	-48 928 764	-12 232 191
Flow of potentially bad debts	48 928 764	12 232 191
Flows of high-risk receivables	3 560 870	890 218
Flow of impaired receivables	3 362 146	840 536
Flow of provisions	12 535 087	3 133 772

The application of this first test gives the following results:

Table 9: Results of Test 1 - credit risk

S: Scenario / T0: Initial situation / Tb: Basic scenario / Ts: Stress scenario

Indicator	T 0	S	Trim.1	Trim.2	Trim.3	Trim.4
Regulatory equity capital	34 958 962	Tb	37 178 839	38 424 568	39 732 775	41 149 464
		Ts	27 985 503	19 609 870	10 820 129	-2 042 712
Results	4 332 531	Tb	1 027 263	1 245 702	1 308 179	1 416 662
		Ts	-8 166 087	-8 375 660	-8 789 768	-9 212 998
RAC %	12,40%	Tb	12,20%	12,50%	12,60%	12,90%
		Ts	9,70%	7,10%	4,10%	-0,80%
Tier1 %	11,10%	Tb	11,00%	11,30%	11,50%	11,80%
		Ts	8,40%	5,80%	2,70%	-0,80%
Recapitalization needs	0	Tb	0	0	0	0
		Ts	0	6 577 182	14 371 489	25 587 524
Net cost of receivables %	3,50%	Tb	4,60%	3,70%	3,70%	3,70%
		Ts	17,80%	17,10%	17,20%	17,40%
spread between deposits and receivables %	2,90%	Tb	2,60%	2,60%	2,60%	2,90%
		Ts	2,60%	2,40%	2,30%	2,30%

The results of this test highlight bank vulnerabilities in the face of a gradual deterioration in its loan portfolio. Indeed, the bank's solvency is reached, from the second quarter, recording a solvency ratio below the threshold (7.10%). The latter reached a negative level (-0.80%) towards the end of the fourth quarter. The recapitalization needs amount to 25.5 billion dinars towards the end of the year. The bank initially had a solvency ratio of 12.40% and recorded an improvement in the latter in the case of the bank's development under normal conditions, i.e. a level of 13.00% towards the end of the fourth quarter.

The differences between the two scenarios, as well as between the initial situation and the final situation under stress conditions, are mainly due to the decrease in the bank's regulatory capital, i.e. flows of (-37,001,674 KDA). This decline is due to the cumulative negative results achieved over the four quarters. The main reason for the deterioration in the bank's results is the fall in interest income following loan defaults and the increase in provisions set aside for downgraded loans.

The impact of the increase in provisions is also reflected by the increase in the net cost of receivables (flow of provisions / net receivables) from 3.50% to 17.40% (the final level recorded under normal conditions is 3.70%). Another indicator reflecting the impact of the shock on the level of interest earned is the decrease in the spread between the cost of deposits and the yield on loans following the deterioration of the average yield on loans (a decrease of 0.6% between the initial situation and the final situation).

5.1.2. Test 02: Simultaneous deterioration of the credit portfolios of the three main sectors of activity

This test consists of reproducing the previous shock only on the loan portfolios of the three main sectors of activity, i.e. a 20% deterioration for each category of loans. Loans allocated to the three sectors account for 87% of the loans in the overall portfolio:

- The industry sector: 38% of the total receivables.
- The trade sector: 32% of the total receivables.
- The service sector: 17% of the total receivables.

Table 10: Calculation of receivables flows (Test 2 - credit risk) U: KDA

Activity sectors	Performing loans	Credit with potential problems	High-risk receivables	Impaired receivables
Commerce	-15 530 492	15 530 492	935 556	1 083 374
Industry	-19 299 222	19 299 222	1 514 941	1 563 313
Service	-8 040 824	8 040 824	497 707	337 515
Total	-42 870 538	42 870 538	2 948 204	2 984 202

Table 11: Calculation of provision flows (Test 2 - credit risk) U: KDA

Activity sectors	Credit with potential problems	High-risk receivables	Impaired receivables	Total
Commerce	3 106 098	280 667	541 687	3 928 452
Industry	3 859 844	454 482	781 656	5 095 983
Service	1 608 165	149 312	168 758	1 926 235
Total	8 574 108	884 461	1 492 101	10 950 670

The shock to be applied is as follows:

Table 12: The shock to be applied (Test 2 - credit risk) U: KDA

Flow	Choc	Choc/ trimester
Flows of performing loans and receivables	-42 870 538	-10 717 634
Flow of potentially problematic receivables	42 870 538	10 717 634
Flows of high-risk receivables	2 948 204	737 051
Flow of impaired receivables	2 984 202	746 051
Flow of provisions	8 574 108	2 143 527

The results of this test show the extent of the impact of the shock applied simultaneously on the three main sectors of activity and highlight the bank's vulnerabilities to the sectorial concentration of loans granted. The deterioration of the bank's solvency is reflected by the deterioration of the general solvency ratio, a decrease of 9.6% compared to the initial ratio (12.40%), generating recapitalization needs of 17.4 billion dinars. Compared to the impact of the first shock, this deterioration amounts to 73%.

The concentration of healthy and classified debts of these three sectors, implies a proportional concentration of the flows of provisions made, this is reflected by the increase in the net cost of debts going from 3.50% to 15.40%. The deterioration in the level of interest earned following the shock is reflected by the decrease in the spread between the yield on net receivables and the cost of deposits by 0.5%. This double impact generated a negative result of (-28,696,750 KDA) which in turn led to a total decrease in shareholders' equity of 27,504,040 KDA, being the main cause of the deterioration in solvency.

5.1.3. Test 03: Individual deterioration of credit portfolios in the three main sectors of activity

The third test consists in applying the same shock (20% deterioration of each class of claims) to the three main sectors of activity of the bank separately:

Table 13: Basic scenario (Test 3 - credit risk) U: KDA

Indicator	T0	Trim.1	Trim.2	Trim.3	Trim.4
Regulatory equity capital	34 958 962	37 178 839	38 424 568	39 732 775	41 149 464
Results	4 332 531	1 027 263	1 245 702	1 308 179	1 416 662
RAC %	12,40%	12,20%	12,50%	12,60%	12,90%
Tier1%	11,10%	11,00%	11,30%	11,50%	11,80%
Recapitalization needs	0	0	0	0	0
Net cost of receivables	3,50%	4,60%	3,70%	3,70%	3,70%

Spread between deposits and receivables %	2,90%	2,60%	2,60%	2,60%	2,90%
---	-------	-------	-------	-------	-------

The application of shocks gives the following results:

Table 14: Results of Test 3 - credit risk U: KDA

Indicator	T0	Sector	Trim.1	Trim.2	Trim.3	Trim.4
Regulatory equity capital	34 958 962	Industry	33 986 448	31 896 108	29 688 941	27 400 572
		Commerce	34 270 017	32 512 507	30 676 751	28 776 985
		Services	35 977 923	35 988 988	35 997 636	36 049 118
Results	4 332 531	Industry	-2 165 142	-2 090 367	-2 207 195	-2 288 396
		Commerce	-1 881 573	-1 757 538	-1 835 783	-1 899 794
		Service	-173 667	11 038	8 620	51 454
RAC%	12,40%	Industry	11,40%	10,70%	9,90%	9,30%
		Commerce	11,50%	10,90%	10,20%	9,70%
		Services	11,90%	11,80%	11,70%	11,60%
Tier 1%	11,10%	Industry	10,20%	9,50%	8,70%	8,00%
		Commerce	10,20%	9,70%	9,00%	8,40%
		Services	10,70%	10,60%	10,50%	10,40%
Recapitalization needs	0	Industry	0	0	0	700 282
		Commerce	0	0	0	0
		Services	0	0	0	0
Net cost of receivables %	3,5%	Industry	9,30%	8,40%	8,50%	8,60%
		Commerce	8,90%	8,00%	8,10%	8,10%
		Services	6,50%	5,70%	5,70%	5,80%
Spread between deposits and receivables %	2,90%	Industry	2,60%	2,50%	2,50%	2,70%
		Commerce	2,60%	2,50%	2,50%	2,72%
		Services	2,60%	2,50%	2,60%	2,80%

The results resulting from the application of the shock on credits allocated to the industrial sector show a final solvency ratio of 9.30%. The ratio recorded is slightly below the regulatory solvency threshold. The recapitalization needs generated amount to 700 million dinars. With regard to the trade sector, the impact

of the shock leads to a deterioration of the bank's solvency ratio from 12.40% to 9.70%. The latter is slightly above the regulatory threshold.

The results of the downgrading of receivables from the services sector show a decrease in the solvency ratio of 0.9%, recording a ratio of 11.60% towards the end of the year. This level is above the regulatory threshold. These results show an average sectorial concentration of credits allocated to the industry sector and a lesser degree of concentration for the commerce sector. In fact, the results for the year recorded in the case of the application of the shock to each of the two sectors are:

- Industry sector: -8,751,100 KDA.
- Trade sector: -7 374 688 KDA.

We recall that the result recorded in the case of consideration of the general portfolio is of 34,544,513 KDA. These results are proportional to the flow of downgraded receivables and their provisioning as well as the deterioration of interest receipts in the case of each sector. This impact is also reflected by the evolution of the two indicators:

- Net cost of receivables: an increase of 5.10% in the case of the industry sector and an increase of 4.60% for the trade sector.
- Spread between deposits and loans: a decrease of 0.20% for the industry sector and a decrease of 0.18% for the trade sector.

5.2. Stress testing of liquidity risk

5.2.1. Test 01: Massive withdrawals of deposits - 40% over 12 days

For a first liquidity shock, we opted for the simulation of a massive flight of liquidity resources from the bank. Massive withdrawals of deposits at a daily rate of 3.33% of total initial deposits for 12 days.

We opted for a withdrawal rate of 3.33% per day, i.e. a total withdrawal of 40% of the initial deposits over 12 days, in order to remain within the plausibility limits and to ensure a certain degree of severity of the test. It should be noted that the model used does not take into account the distribution of collected resources by term in the simulation of deposit leakage. The model considers that leakage affects all deposit categories. In addition to sight deposits, time deposits will be withdrawn under the assumption that even if customers are penalized by the reduction in interest, it favors the recovery of the capital deposited.

The following table shows the results of the application of the shock:

Table 15: Results of Test 1 - liquidity risk U KDA

Indicator	T0	J1	J2	J3	J4	J5	J6
Liquidity ratio	1163,30 %	1054,80 %	981,20 %	907,4 0%	833,70 %	760,00 %	686,30 %
Liquidity requirements	0	0	0	0	0	0	0
Asset coverage rate of deposits Liquids	47,90%	44,50%	42,50 %	40,40 %	38,10%	35,70 %	33,00 %
Indicator	T0	J7	J8	J9	J10	J11	J12
Liquidity ratio	1163,30 %	612,50%	538,70 %	465,0 0%	391,30 %	317,60 %	210,40 %
Liquidity requirements	0	0	0	0	0	0	0
Asset coverage rate of deposits Liquidity	47,90%	30,10%	27,00 %	23,50 %	19,70%	15,50 %	10,80 %

The results of this first simulation show a gradual decrease in the bank's liquidity ratio, which fell from 1163.30% to 210.40%, remaining above the regulatory threshold after the withdrawal of 40% of deposits over 12 days. The deterioration in the liquidity ratio is due to the decrease in the bank's liquid assets used to meet the demand for liquidity from depositors. The residual liquid assets can observe this decrease through the evolution of the coverage rate of deposits. The latter has an initial threshold of 47.9% and shows a decrease of 37.10% at the end of the twelfth day.

The following table shows the daily evolution of Bank X's internal sources of liquidity during the shock:

Table 16: Evolution of internal sources of liquidity (Test 1 - liquidity risk) U: KDA

		FLUX					
Indicator	T0	J1	J2	J3	J4	J5	J6
Initial cash flow		-10 100 776	-10 097 116	-10 097 733	-10 098 351	-10 098 971	-10 098 906
Bank of Algeria account	55 147 915	-10 100 776	-10 097 116	-10 097 733	-10 098 351	-10 098 971	-4 654 967
Loans Securities	34 896 997	0	0	0	0	0	-5 443 939

Securities (TDV+TDFT) ⁴	31 908 195	0	0	0	0	0	0
final Cash-flow		0	0	0	0	0	0
EUA - BA		0	0	0	0	0	0
Indicator		J7	J8	J9	J10	J11	J12
initial Cash-flow		-10 098 515	-10 098 732	-10 098 950	-10 099 378	-10 102 109	-10 104 847
Bank of Algeria account		0	0	0	0	0	0
Interbank loans		-10 098 515	-10 098 732	-9 255 811	0	0	0
Securities (TDV+TDFT)		0	0	-843 139	-10 099 378	-10 102 109	-10 104 847
Cash-flow final		0	0	0	0	0	0
EUA - BA		0	0	0	0	0	0

The results show that the bank's internal sources of liquidity were able to cover the massive withdrawals of deposits while remaining above the regulatory liquidity threshold. The free assets that the bank has with the Bank of Algeria are exhausted at the end of the sixth day, covering 46% of the total negative flows. Interbank loans are fully recovered at the end of the ninth day covering 29% of the negative flows. The proportion of the remaining negative flows is counter balanced by the sale of liquid securities held by the bank.

The Bank overcame the liquidity shock and was able to satisfy depositor demand only with its internal resources. The second simulation consists in implementing a more severe shock in order to test the limits of bank X's liquidity strength.

5.2.2. Test 02: Massive withdrawals of deposits - 50% over 8 days

The second liquidity shock consists in reproducing the first test with a higher degree of severity, by simulating massive withdrawals of deposits at a daily rate of 6.25% of the initial deposits (total withdrawal of 50%), over an 8-day horizon.

⁴ TAS: Titles Available for Sale.

SHTP: Securities Held for Trading Purposes

The application of the test gives the following results:

Table 17: Results of Test 2 - liquidity risk U kDA

Indicator	T0	J1	J2	J3	J4	J5	J6	J7	J8
Liquidity ratio %	1163,30	1024,8	886,40	748,00	609,50	471,00	332,50	157,60	83,70
Liquidity requirements	0	0	0	0	0	0	0	0	0
Coverage rate of deposits by liquid assets % of total deposits	47,90	44,40	40,50	35,90	30,60	24,30	16,80	7,50	-4,00

The results of the shock show that Bank X did not withstand the second liquidity shock recording a liquidity ratio below the regulatory threshold at the end of the eighth day (83.70%), i.e. a drop of 1079.60% compared to the initial situation. These results are confirmed by the rate of coverage of deposits by liquid assets, which fell from 47.90% to -4.00% over the eight days. This negative rate reflects the non-hedging of current liabilities by liquid assets.

These results are explained in the table showing changes in the bank's sources of liquidity:

Table 18: Changes in internal sources of liquidity (Test 2 - liquidity risk) U: KDA

Indicator	FLUX								
	T0	J1	J2	J3	J4	J5	J6	J7	J8
Initial Cash-flow		-18 980 017	-18 977 122	-18 978 508	-18 979 786	-18 979 986	-18 980 711	-18 984 981	-29 898 046
Bank of Algeria account	55 147 915	-18 980 017	-18 977 122	-17 190 775	0	0	0	0	0
Interbank loans	34 896 997	0	0	-1 787 733	-18 979 786	-14 129 477	0	0	0
Securities (TDV+TDFT)	31 908 195	0	0	0	0	-4 850 508	-18 980 711	-8 076 976	0
Cash-flow final		0	0	0	0	0	0	-10 908 005	-29 898 046

EUA - BA		0	0	0	0	0	0	10 908 005	29 898 046
-------------	--	---	---	---	---	---	---	---------------	---------------

The results show that the bank recorded a negative final cash flow of - 10,908,005 KDA at the end of the fifth day following the depletion of its internal liquidity resources. The latter were able to cover 75% of the total negative flows. The totality of the free assets at the Bank of Algeria was used during the first three days. Interbank loans are fully recovered at the end of the fifth day and the volume of liquid securities is exhausted during the seventh day. The remaining proportion is covered by refinancing with the Bank of Algeria.

The bank did not withstand the second liquidity shock. The latter had to resort to refinancing with the Bank of Algeria at the end of the seventh day in order to satisfy the massive liquidity demands and recorded a liquidity ratio below the regulatory threshold on the eighth day.

6. DISCUSSION AND CONCLUSION

The stress testing exercise that was put in place enabled us to highlight the bank's vulnerabilities in the face of the various shocks that were applied. In general, we found that the bank remains moderately exposed to a risk of sector concentration and presents a greater sensitivity of resource costs in relation to job yields to changes in interest rates. In terms of liquidity, the bank's overall situation is solid. The analysis of the results of the application of the three series of stress tests has enabled us to issue the following overall recommendations. The bank should:

- Implement rigorous and forward-looking tests to identify potential shocks that could have an adverse impact on capital or liquidity, possibly through changes in customer behavior.
- Test the scenarios developed on a periodic basis to ensure that its risk exposure remains consistent with defined risk limits.
- Ensure the collaboration of different categories of experts (market operators, treasury, finance, risk management, economists, etc.) in the implementation of stress tests in order to identify relevant shock scenarios and properly exploit the test results.
- Put in place contingency plans in the event of a crisis. These plans specify the strategy and procedures to be followed according to the different scenarios and ensure effective diversification of sources and forms of financing.
- Ensure that the criteria for allocating resources to jobs are stable over time in order to allow a relevant comparison of risks over different periods.
- Ensure that the maturity transformation mechanism contributes to an efficient allocation of resources and credit creation.
- Set appropriate limits in relation to the nature, size and adequacy of capital, as well as its capacity to assess and manage these risks.
- Develop a clear risk appetite statement approved by the governing body, implemented through a detailed framework of policies and procedures to limit and control its risk exposure.

The purpose of these tests is to draw the bank's attention to hidden sources of risk that could threaten its business in certain circumstances, to study the consequences and to measure the bank's ability to withstand such situations. At the national level, the series of stress tests implemented by the Bank of Algeria during the fourth quarter of 2018 testify to the regulator's willingness to align itself with international practices.

However, this concept remains little developed and little used at the level of banks. Banks should consider making the practice of stress tests common practice, and not only sensitivity tests. The ideal would be to apply tests that take into account all the major risks borne by the bank through the implementation of models that link macroeconomic variables and risk factors incurred by the bank.

It is essential to stress that the adoption of such an approach to risk management is very costly and complicated in practice, in addition to the costly procedures that it requires beforehand. While these measures are beneficial for the banks in the sense that they allow them to fine-tune their risk management processes, they are also beneficial for the national economy, since the banks are the pillars of the national economy.

REFERENCES

1. ALESSANDRI, P and M Drehmann (2010). An economic capital model integrating credit and interest rate risk in the banking book, *Journal of Banking & Finance*, vol 34, no 4, April, pp 730–42.
2. ALFARO, R. and A Sagner (2011). Stress tests for banking sector: a technical note, *Central Bank of Chile Working Papers*, no 610, February.
3. ADRIAN, T., Shin, H. S., (2008a), Liquidity and financial contagion, *Financial Stability Review*, Banque de France, 11. 1-7.
4. ADRIAN, T., Shin, H. S., (2008b), Liquidity and leverage, *Journal of Financial Intermediation*, doi:10.1016/j.jfi.2008.12.002.
5. Bank_of_Algeria. (2014). *Banking activity report according to the balance sheet*. Algiers: Bank of Algeria .
6. Bank_of_Algeria. (2014, 02 16). *www.bank-of-algeria.dz*. Consulted le 10 10, 2020
7. BASEL COMMITTEE ON BANKING SUPERVISION (2017a). Supervisory and bank stress testing: range of practices, December.
8. ——— (2017b). Stress-testing principles, Consultative Document, December.
9. ——— (2018): “Stress-testing principles”, October.
10. BAUDINO, P, R Goetschmann, J Henry, K Taniguchi and W Zhu (2018). Stress-testing banks – a comparative analysis, FSI Insights, no 12, November.
11. BIS-Bank for International Settlements (2020). Stress testing in Latin America : A comparison of approaches and methodologies. BIS Papers.No.108. Monetary and Economic Department February 2020.
12. BIS-Bank for International Settlements (2019). Ten years after the Great Financial Crisis : what has changed? June 2019. BIS Papers No 103.

13. BOUCHETARA, M. (2018). Financial stability and Solvency of Algerian banks, application of stress tests from 2012 to 2016. *Financial Markets, Institutions and Risks*, 2(4), 57-67. doi:[https://doi.org/10.21272/fmir.2\(4\).57-67](https://doi.org/10.21272/fmir.2(4).57-67).2018
14. BOZKUS KAHYAĞLU, S. (2019). Stres Testi ve Bankalarda Risk Entegrasyonu. Gazikitabevi. ISBN: 978-605-344-929-4.
15. BOZKUS KAHYAĞLU, S. and G. Kurt (2020). Future Expectations in Banking Risk Management. *MUFAD Journal*. (86): 267-287. ISSN: 2146-3042 DOI: 10.25095/mufad.710380
16. BUNCIC, D and M Melecky (2013). Macroprudential stress testing of credit risk: A practical approach for policy makers, *Journal of Financial Stability*, no 9, pp 347–70.
17. CIFUENTES, R., Shin, H. S., Ferrucci, G., (2005). Liquidity risk and contagion, *Journal of the European Economic Association*. 3, 556-566.
18. CHORAFAS, D. N. (2008). Risk Accounting and Risk Management for Accountants. CIMA and Elsevier Publishing. ISBN: 978-0-7506-8422-4.
19. CFA Institute (2013). Chartered Financial Analyst. Financial Reporting Disclosures. Investor Perspectives on Transparency, Trust and Volume.
20. COLE, C. J. (2012). Corporate Liquidity Disclosures: A Review. *The Journal of Corporate Accounting & Finance*. Volume24, Issue1, November/December 2012. Pages 65-77.
21. DENT, K, B Westwood and M Segoviano (2016). Stress testing of banks: an introduction, Bank of England, Quarterly Bulletin, Q3.
22. DREHMANN, M, S Sorensen and M Stringa (2010). The integrated impact of credit and interest rate risk on banks: A dynamic framework and stress testing application, *Journal of Banking & Finance*, vol 34, no 4, pp 713–29.
23. DUTTWEILER, R. (2009). Managing Liquidity in Banks – A Top Down Approach, Wiley.
24. ILLANES, G, A Pena and A Sosa (2016). A macroeconomic model of credit risk in Uruguay, *Revista Brasileira de Economia*, vol 70, no 4, pp 441–55.
25. IMF. (2018). *Financial Stability Assessment No. 14/161, Algeria*. WASHINGTON: International Monetary Fund .
26. KAPINOS, P., C. Martin and O. Mitnik (2018). Stress testing banks: whence and whither?, *Journal of Financial Perspectives*, vol 5, no 1.
27. MATZ, L. M., & Neu, P. (2007). (Edited by) Liquidity Risk Measurement and Management. A Practitioner’s Guide to Global Best Practices, John Wiley & Sons (Asia) Pte Ltd.
28. MATZ, L. M. (2011). Liquidity Risk Measurement and Management – Basel III and Beyond. Xlibris.
29. LEO, M., Suneel Sharma - K. Maddulety (2019). Machine Learning in Banking Risk Management: A Literature Review, MDPI, Basel, Switzerland. https://www.researchgate.net/publication/331538099_Machine_Learning_in_Banking_Risk_Management_A_Literature_Review
30. SCHUERMANN, T. (2014). Stress testing banks, *International Journal of Forecasting*, vol 30, no 3, pp 717–28.
31. WONG, E. and Hui, C. (2009). A liquidity Risk Stress-Testing Framework With Interaction Between Market And Credit Risks. Hong

Appendix 1. List of Risk Management Tools in the Banking Sector

<i>Tools</i>	<i>Market Risk</i>	<i>Credit Risk</i>	<i>Liquidity Risk</i>	<i>Operational Risk</i>
Risk Limits	√	√	√	
Credit Risk limits		√		
Value at Risk	√			
Earnings at Risk	√			
Expected Shortfall	√			
Economic Value Stress Testing	√			
Economic Capital	√	√	√	√
Risk Sensitivities	√			
Risk Assessment (RCSA)				√
Operational Risk Losses				√
Loss Distribution Approach				√
Scenario Analysis	√	√	√	√
Tail Risk Capture	√	√	√	√
Stress Testing	√	√	√	√
Scoring Models		√		
Rating Models		√		
Exposure		√		
- Probability of Default				
- Loss Given Default				
- Exposure at Default				
Back Testing	√	√	√	

Source: Bozkus Kahyaoglu and Kurt, 2020; Leo et al., 2019.