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October 2016

TECHNICAL NOTE—STRESS TESTING THE BANKING SYSTEM

This Technical Note on Stress Testing the Banking System for Morocco was prepared by a staff team of the International Monetary Fund. It is based on the information available at the time it was completed on September 2016.

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STRESS TESTING THE BANKING SYSTEM

Prepared By
Monetary and Capital Markets Department, IMF

This Technical Note was prepared in the context of a joint IMF-World Bank Financial Sector Assessment Program (FSAP) mission in Morocco during April 2015 led by Ms. Jianping Zhou, IMF and Mr. Gabriel Sensenbrenner, World Bank, and overseen by the Monetary and Capital Markets Department, IMF, and the Finance and Private Sector Development Vice Presidency, World Bank. The note contains the technical analysis and detailed information underpinning the FSAP assessment's findings and recommendations. Further information on the FSAP program can be found at http://www.imf.org/external/np/fsap/fssa.aspx.

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BU	Bottom-up (stress test)
BAM	Central Bank of Morocco
CAR	Capital Adequacy Ratio
CPI	Consumer Price Index
EaD	Exposure at Default
EBIT	Earnings before Interest and Taxes
EL	Expected Loss
EM	Emerging Markets
FSAP	Financial Sector Assessment Program
FSSA	Financial System Stability Assessment
FX	Foreign Exchange
GDP	Gross domestic product
HQLA	High Quality Liquid Assets
LCR	Liquidity Coverage Ratio
LGD	Loss Given Default
MoU	Memorandum of Understanding
NSFR	Net Stable Funding Ratio
NIIP	Net International Investment Position
NPL	Nonperforming Loan
OBS	Off-balance (sheet)
PD	Probability of default
PiT	Point-in-time
RAM	Risk Assessment Matrix
ROE	Return on Equity
RWA	Risk-weighted Assets
SME	Small- and Medium-sized Enterprises
STeM	Stress Test Matrix (for FSAP stress tests)
TD	Top-down (stress test)
TTC	Through-the-Cycle
UMP	Unconventional Monetary Policy
WEO	World Economic Outlook

EXECUTIVE SUMMARY[1]

The FSAP stress testing exercise took place at a time of deep structural changes for the Moroccan financial system that create opportunities but also bring about potential risks. First, Moroccan banks have expanded both domestically and regionally since the global financial crisis, taking advantage of the opportunities afforded by retreating European banks, and with proactive support from BAM. Second, Morocco's insurance sector has expanded strongly in recent years, with close links with the banking sector. In addition, some features of the banking system increase its vulnerability to shocks. These include: rapid expansion abroad, and high concentration risks. Moreover, several shocks experienced during the recent years as a result of external and domestic macroeconomic conditions brought about liquidity pressures and a rising rate of NPLs.

The design of the stress tests incorporated main potential external risks. These risks arise mostly from a protracted period of slower growth in advanced economies, particularly in Europe, which would affect the Moroccan economy through lower exports, FDI, and remittances. Moreover, a surge in global financial market volatility could increase interest rates, raise funding costs and indirectly affect external demand and FDI. Finally, heightened risk of fragmentation/state failure in the Middle East would lead to a sharp rise in oil prices, with negative spillover on the global economy and on Morocco's external accounts. While the latter risk was considered by the FSAP mission to be a medium-risk event, the first two were deemed to be high risk `events.

The test also incorporated potential key domestic risks. First, slower-than-needed pace of fiscal, financial and structural reforms in Morocco would prevent potential growth from picking up and might result in a slowdown in FDI inflows, a medium-risk event. Second, bad weather conditions could cause poor harvests that might affect the overall economy, in a similar way to the last shock observed in 2007, but this admittedly constitutes a low risk event.

The stress tests examined the resilience of the Moroccan banking system to *solvency*, *liquidity*, and *contagion* risks. The stress tests included TD and BU exercises based on macroeconomic scenarios and sensitivity analyses. The tests based on macroeconomic scenarios assessed the impact of these extreme but plausible external and domestic shocks on the economy over a three-year horizon (2015-2017), based on data available through December 2014. The effects of these shocks on individual banks' profitability and capitalization were assessed using satellite models and methodologies developed by the authorities and Fund staff. In addition, sensitivity stress tests assessed vulnerabilities of the banking system to individual shocks. The TD liquidity tests assessed the capacity of banks to withstand large withdrawals of funding, using a maturity ladder analysis and supervisory information. The contagion tests covered domestic interbank exposures, interlinkages between banks and insurers, market data-based contingent claim analysis and cross-border contagion.

[1] This Technical Note has been prepared by Mr. Cyril Pouvelle, Ms. Kay Chung, Messrs. Dale Gray and Ben Huston, all Monetary and Capital Markets Department of the IMF.

The results of the solvency stress tests testify to the resilience of the banking system. In the V-shaped adverse macroeconomic scenario including a severe recession during the first year, one bank, representing 6.1 percent of the banking system, becomes undercapitalized, with the banking system's capitalization shortfall being estimated at 0.2 percent of 2014 GDP, with similar results in a severely negative adverse scenario.

Credit risk is the main vulnerability. Loan quality is found to be very sensitive to real interest rate and, to a lesser extent, to GDP growth and capital inflows through the liquidity channel: real interest rates increase the debt burden and deteriorate loan quality, GDP growth is associated with higher income which increases borrowers' debt payment capacity; and capital inflows increase the liquidity of the banking system, allowing banks to distribute more credit, which makes the NPL ratio decline mechanically as new loans are by definition performing. In the negative scenario, bank loan loss provisions would rise in parallel with higher NPL ratios, with negative effects on profitability. Sensitivity tests confirm the predominance of credit risks and also indicate that these risks are exacerbated by the high concentration of loan portfolios, with the failure of the three largest exposures causing undercapitalization of every bank.

The global liquidity stress tests reveal that most banks in the system would be exposed to liquidity risks in the event of large deposit withdrawals, under a more severe scenario than the Basel III LCR metrics, or of a dry-up of unsecured wholesale funding.

Banks are found to be less vulnerable to direct contagions risks through bilateral exposures. The contagion risk analysis reveals that the risks stemming from domestic interbank exposures are very limited. However, the analysis also shows that several Moroccan insurance companies would be vulnerable to bank failures but not the other way round as Moroccan insurance companies' exposure to Moroccan banks is high with regard to their capital whereas banks are little exposed to insurers. Cross-border contagion risk analysis revealed that Moroccan banks have adequate level of capital to absorb the severe loss from the subsidiaries, and have capacity to implement an orderly resolution that minimizes the impact on regional financial stability.

BAM should encourage further refinement of banks' stress testing methodologies. As banks are only used to conducting sensitivity analysis, they lack robust credit risk models. Consequently, they were provided with NPL projections in three scenarios corresponding to the average results between the IMF and BAM credit risk models. Although the BU stress testing methodology developed by BAM is robust, banks need very detailed guidelines for the conduct of bottom-up stress tests and appear to use mainly expert judgment to undertake stress tests.

Table 1. Morocco: Recommendations on Banking Stress Testing and Financial Stability	
Risk analysis	**Time[1]**
Carry out stress tests on a consolidated basis in addition to solo basis	NT
Carry out more extreme macro stress tests in BAM regular Top-Down stress tests	NT
Satellite models of banking credit risks could be improved by disaggregating the non-performing loan ratio by sector and including explanatory variables related to external liquidity (capital flows)	NT
Make better use of the data available at the credit registry in order to compute historical default rates and Probabilities of Defaults once time series are long enough	MT
Collect data on provisions by asset classification category and asset/liability repricing gap in the foreign subsidiaries of Moroccan banks	NT
Develop macro stress test for insurance companies and add sensitivity tests based on housing price shocks into the insurance sector stress testing framework	MT
Financial sector policy	
Reduce banks' exposures to large enterprises by developing collateral requirements or developing the domestic bond market	NT

[1] "I-Immediate" is within one year; "NT-near-term" is 1–3 years; "MT-medium-term" is 3–5 years.

INTRODUCTION

1. The FSAP stress testing exercise took place at a time of deep structural changes for the Moroccan financial system that create opportunities but also bring about potential risks. In addition, some features of the banking system increase its vulnerability to shocks. These include: rapid expansion abroad, and high concentration risks. Moreover, several shocks experienced during the recent years as a result of external and domestic macroeconomic conditions brought about liquidity pressures and a rising rate of NPLs.

2. Morocco's banking sector is open, concentrated, rapidly expanding and dominates the domestic financial system. The total banking sector assets amount to 134 percent of GDP (see Table 2), which is high compared to peers. The top eight banks control 90 percent of system assets (Table 2 and Figure 1). By end-2014, foreign (mainly of French-origin) financial institutions were majority stakeholders in seven banks, while the government's holdings in the banking sector have declined to 16 percent in 2014 (from 23 percent in 2007 and 40 percent in 2002) with the sale of stakes in major banks.

3. Traditional banking dominates the sector's activities. Loans make up an overwhelming part of banking sector assets (72 percent), while banks fund themselves mainly through customer deposits and bond issuances. The profitability of Moroccan banks is high due to a large interest rate margin, amounting to 4 percentage points on average. However, concentration credit risks are a concern.

4. Banks maintain large and high quality capital. Capital Adequacy Ratio (CAR) for the banking system stands at 12.9 percent in December 2014, above the new national regulatory minimum of 12 percent (which exceeds the Basel III minimum of 8 percent). With the exception of one medium-sized bank, every bank in the system met the regulatory CAR minimum at December 2014. Tier 1 capital makes up 85 percent of total capital, a high ratio even by emerging market standards. NPL ratios vary from 6.4 percent to 14.3 percent on a consolidated basis.

5. Fiscal and liquidity buffers may become tight in the event of severe stress. So far fiscal and liquidity instruments have been amply sufficient to support the system. The central bank has provided banks with liquidity support, helping the system to withstand the global financial crisis and the decline in transfers from Moroccans living abroad quite well. However, BAM now has less room to further broaden the range of eligible collateral. Moreover, fiscal buffers are now smaller than they used to be before the 2008/2009 global financial crisis.

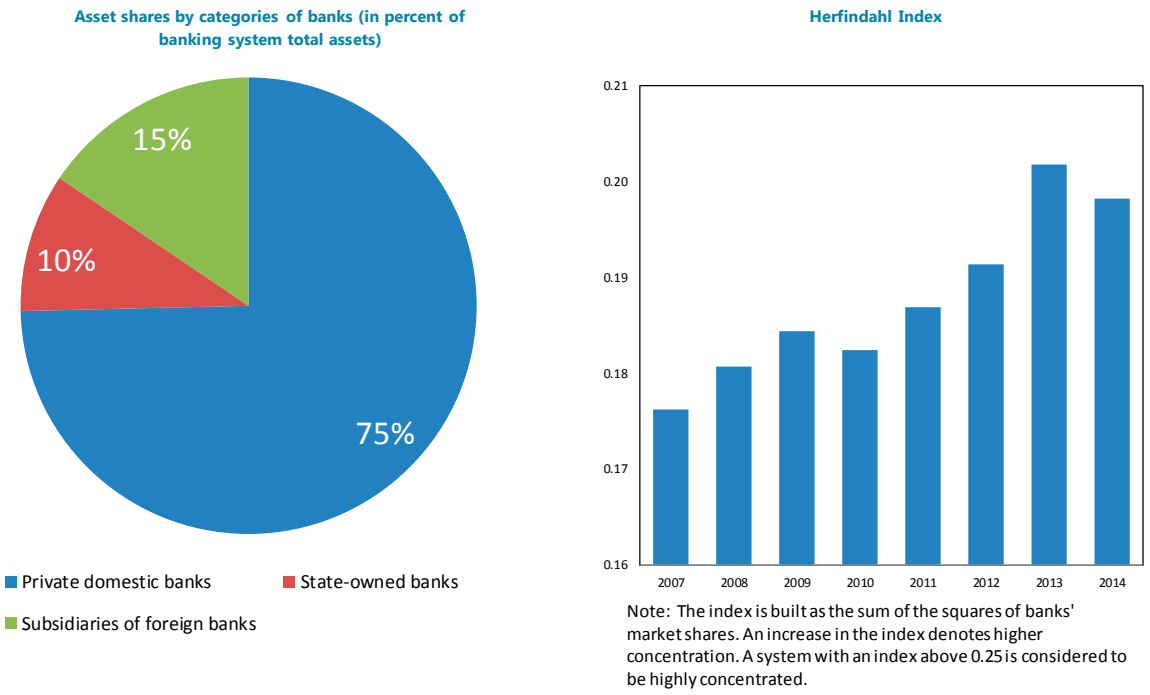
Table 2. Morocco:

Structure of the Banking System FSAP Sample - December 2014

	Total	Private domestic banks	State-owned banks	Subsidiaries of foreign banks
Number of banks	8	3	2	3
Asset share (as a percentage of total banking sector assets)	90.0	74.6	9.8	15.5
Assets as percent of GDP	140.0	104.5	13.8	21.8
of which: Loans	100.7	72.3	10.4	18.0
Total deposits as percent of GDP	94.6	70.7	9.1	14.8
Capital adequacy ratio (in percent of RWAs)	12.9	12.5	12.4	14.7

Sources: BAM and IMF staff estimates.

Figure 1. Morocco: Structure of the Banking System



Sources: BAM and IMF staff calculations.

6. In general, the objective of the FSAP stress testing exercise is to assess the capacity of the banking system to withstand *extreme* but *plausible* macroeconomic shocks. The tests are meant to explore weaknesses in a financial system and the channels through which adverse shocks are transmitted. FSAP stress tests can help to identify priorities for policy actions, such as those aimed at reducing specific exposures or building capital and liquidity buffers. The FSAP stress testing

process can also help authorities to identify informational and methodological gaps, and assess their preparedness to deal with situations of financial distress.

7. FSAP stress test may differ from stress tests conducted by central banks, including those previously undertaken by BAM. The authorities and the FSAP tem estimated separate credit risk models but common assumptions were provided to the banks. The authorities carried out the tests in close cooperation with the FSAP team and provided access to detailed supervisory and macroeconomic data.

8. Although stress tests are useful to explore weaknesses in a financial system, results must be interpreted with caution. In all countries, the implementation of stress tests is conceptually challenging. Among other limitations, stress tests use macroeconomic and satellite models to calculate the impact of adverse scenarios or shocks on banks.[2] These models are estimated using historical data and are subject to estimation uncertainty. These limitations can be mitigated, but not eliminated, by using state-of-art techniques. Choices must also be made regarding the severity of shocks. In adverse scenarios, the economy is typically affected by a combination of external and domestic shocks that (ex ante) have a very low probability of occurrence – and could possibly materialize once every 20-40 years.[3] Hence, by construction, adverse scenarios should not be interpreted as macroeconomic "forecasts."

9. The stress tests examined the resilience of the banking system to *solvency*, *liquidity*, and *contagion* risks (Figure 2). The stress tests included TD and BU exercises based on macroeconomic scenarios and sensitivity analyses. The tests based on macroeconomic scenarios assessed the impact of combined external and domestic shocks on the economy over a three-year horizon (2015-2017), based on data available through December 2014.[4] The effects of these shocks on individual banks' profitability and capitalization were assessed using satellite models and methodologies developed by the authorities and Fund staff. In addition, sensitivity stress tests assessed vulnerabilities of the banking system to individual shocks. The TD liquidity tests assessed the capacity of banks to withstand large withdrawals of funding, using a maturity ladder analysis and supervisory information. The contagion tests covered domestic interbank exposures, interlinkages

[2] Satellite models map the variables projected in the macroeconomic scenarios into credit, market, and other risk factors that determine individual banks' gains or losses.

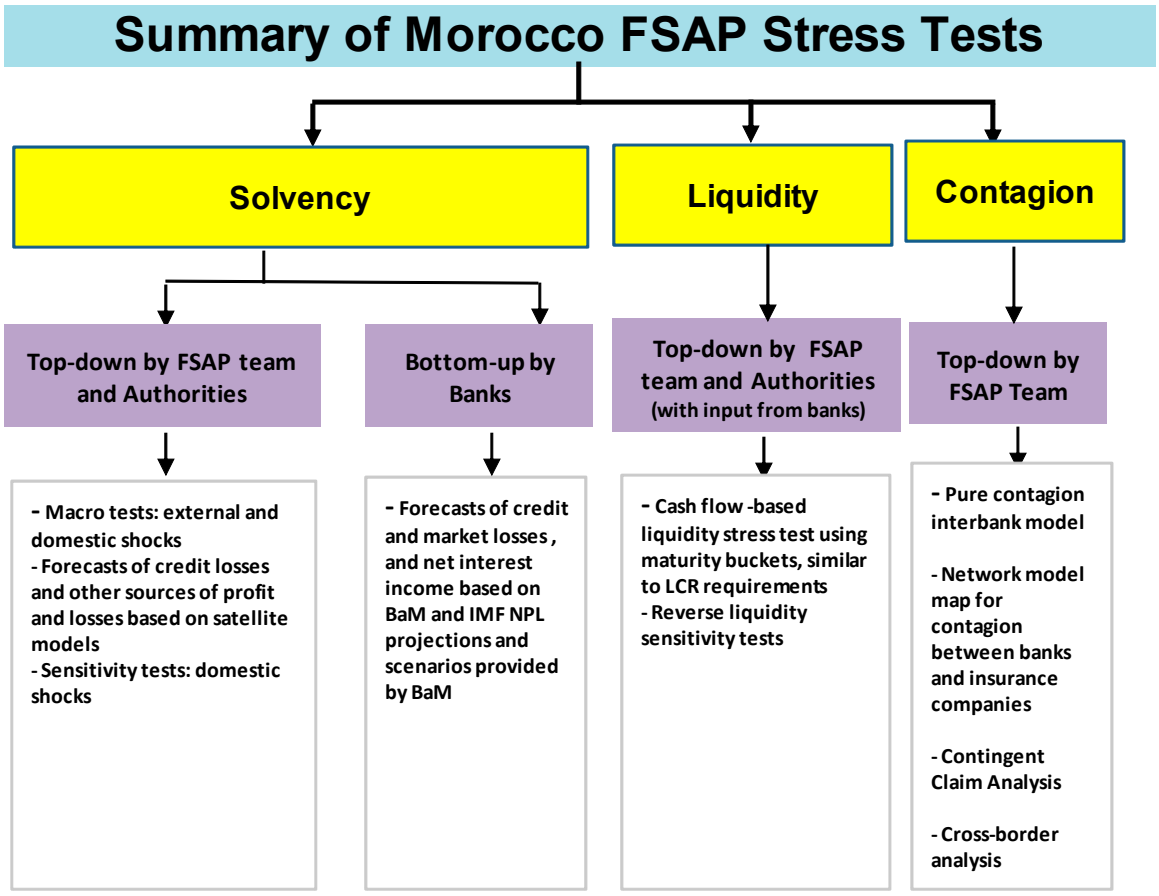
[3] The selection of "relevant" historical episode and the length of data series used to construct adverse are among the choices that must be made in the design of stress tests. There is often a temptation to dismiss the validity of historical episodes because structural changes alter the way in which economies function. For instance, the adverse scenarios for Morocco described in this note might be considered extreme given that Morocco has recorded only positive growth rates during the last 17 years. Valid stress tests, however, should not fail to incorporate long ago history. As pointed out by Haldane (2009), stress testing exercises conducted before the global financial crisis failed to play a useful "early warning" role (in part) due to reliance on short data series – the tests underestimated true macroeconomic and financial volatility by failing to incorporate information contained in long data series, which undermined their validity and usefulness.

[4] It is common practice in FSAPs to implement the stress tests over a two- to five-year horizon. A two-year horizon is used in countries subject to a high degree of macroeconomic uncertainty at the time of the exercise. A five-year horizon is appropriate for countries subject to moderate or low macroeconomic uncertainty.

between domestic banks and insurers, and cross-exposures between Moroccan banks and their foreign subsidiaries.

10. The insurance sector stability was analyzed through its interlinkages with the domestic banking sector. Due to limited resources, the mission did not carry out a full-fledged stress test on the insurance sector. The domestic insurance supervisor regularly conducts a sensitivity stress test based on equity prices and interest rates and ran a housing price-based stress test for the first time in 2015. The 2014 financial stability report indicates that in case of a 25 percent decline in equity prices, five insurers out of eighteen would face capital shortfalls. One insurer would be negatively affected by a 25 percent decline in real estate prices. However, the sector would be able to withstand a 100 basis point increase in interest rates. The supervisor does not run any stress test based on macroeconomic scenarios.

Figure 2. Morocco: Summary of Morocco FSAP Stress Tests



Sources: BAM and IMF staff.

11. The TD and BU stress tests covered 8 banks that make up 90 percent of assets in the system. As of December 2014, these 8 banks include 3 private domestic banks (75 percent of

assets), 2 state-owned domestic banks (10 percent of assets), and 3 subsidiaries of French banks (16 percent of assets).

12. The remainder of this technical note (TN) is structured as follows. The second section presents the different components of the solvency stress tests based both on macroeconomic scenarios and sensitivity analysis: their description, design, methodology for implementation, and results. The following sections present the stress tests of liquidity risk, and the analysis of contagion risks.

SOLVENCY STRESS TESTS

13. The FSAP solvency stress tests covered the main risks faced by the banking sector. They included Top-Down and Bottom-Up exercises based on macroeconomic scenarios and sensitivity analyses. The tests based on macroeconomic scenarios assessed the impact of combined external and domestic shocks on the economy over a three-year horizon (2015-2017), using data available through December 2014. The TD and the BU stress tests included the 8 largest banks covering 90 percent of total banking sector assets.

14. The regulatory framework that was applied was the Moroccan national framework, as defined by national law and BAM regulation. Therefore, the hurdle rates for total regulatory capital and for Tier 1 capital were set at, respectively, 12% and 9% (including the conservation buffer), i.e., at a higher level than the Basel 2 framework rules.

15. The effects of the shocks on individual bank's profitability and capitalization were assessed using the results of satellite models and methodologies developed by the authorities and Fund staff. In addition, sensitivity stress tests assessed vulnerabilities of the banking system to individual shocks. Sub-section A presents the main macrofinancial risks, the baseline and the macro scenarios that were applied for the conduct of the solvency stress test. Sub-section B describes the estimation of credit risks. Sub-section C sets out the analysis of market risks in the scenario analysis. Sub-section D provides the global results of the solvency stress tests based on scenario analysis. Sub-section E presents the results of the market risk sensitivity analysis. Sub-section F discusses the concentration risk analysis.

A. Macrofinancial Risks and Macroeconomic Scenarios

16. Although the country's external position has improved, the Moroccan financial sector is exposed to several external risks. The risks that are the most likely to materialize are the following (see also Risk Assessment Matrix in Appendix I):

- *Protracted period of slower growth in advanced economies, due to negative developments in potential growth.* A protracted period of slow growth in advanced economies, in particular Europe, would affect the economy through lower exports, FDI, and remittances.

- *Heightened risk of fragmentation/state failure in the Middle East,* leading to a sharp rise in oil prices, with negative spillover on the global economy. Morocco's dependence on oil imports, which amounted to about 10.2 percent of GDP in 2014, is another source of vulnerability: a reversal of the current fall in oil prices could significantly and rapidly widen the current account deficit again.

- *Sustained tensions in Russia/Ukraine that depress business confidence and heighten risk aversion, amid disturbances in global financial, trade, and commodity markets.* Such events could worsen the current account deficit through an increase in world energy prices and undermine the country's external position.

- *Surge in global financial market volatility as investors reassess underlying risk.* This would increase interest rates, raise funding costs and indirectly affect external demand and FDI.

- *Slower-than-needed pace of fiscal, financial and structural reforms* would prevent potential growth from picking up and might result in a slowdown in FDI inflows.

17. Several features of the banking sector also increase its vulnerability to shocks:

- *High risks posed by large exposures.* Large single-party and industry concentration of banks' loan portfolios are a serious vulnerability of the banking system. Gross exposure to the largest counterpart represents more than 30 percent of total regulatory capital at one bank and amounts to 20 percent for the banking system on average, while gross exposure to the 3 largest counterparts exceeds 60 percent of regulatory capital at 2 banks.

- *Additional credit and operational risks resulting from the international development of Moroccan banks' activities in North and Sub-Saharan Africa.* This international expansion enables Moroccan banks to increase their profitability and diversify their income sources but at the same time requires adequate supervision.

18. Several shocks experienced during the recent years as a result of external and domestic macroeconomic conditions brought about the following tensions:

- *Increasing pressures on bank liquidity.* The liquidity of the banking system has decreased markedly since the onset of the global financial crisis, leading banks to increase their reliance on central bank facilities. Against this background, a surge in global financial volatility associated with the Fed exit from unconventional monetary policy might limit Moroccan banks' funding resources and increase their funding costs, especially if accompanied by a rise in domestic sovereign spreads.

- *Rising credit risks.* The increase in the non-performing loan ratio should be closely monitored given the risks to the economic outlook resulting from the protracted weakness in the euro area economy and the downward pressures on real estate prices.

19. Given the risks and vulnerabilities described above, the stress test examined a baseline macroeconomic scenario and one *extreme but plausible* adverse scenario. All scenarios stretch over a three-year forecasting period.[5] The first year of the shock would then be 2015 and the scenario would run until 2017. The baseline macroeconomic scenario is based on the projections of the IMF staff included in the April 2015 WEO. It forecasts that real GDP growth will increase, starting in 2015, and stabilize over the medium term in the 5-5½ percent range, while the external position should continue to improve. The adverse scenario was developed jointly by the FSAP team and the Moroccan authorities using simple econometric regressions and expert judgment.[6] It reflects downside external risks calibrated to magnitudes close to those observed during past crises such as the 2008/2009 global financial crisis, and domestic shocks such as the domestic 1995 agriculture production shock and (see Table 3 for an outlook of international and domestic indicators during these two past episodes). Moreover, it is in line with the scenarios applied to comparable countries that have recently had FSAPs (see Table 4 for the external and domestic assumptions chosen for the adverse scenario).[7]

20. For the design of the macroeconomic scenarios, the following domestic variables had to be calibrated over a 3-year horizon: real GDP growth, CPI inflation rate, the nominal Treasury bill rate, the dirham nominal effective exchange rate, the growth in FDI and remittances from Moroccans living abroad. The adverse scenario (see Figure 3 and Table 5) features a V-shaped scenario characterized by a growth of -2 percent in 2015, and +2.4 and +5.2 percent in 2016 and 2017 respectively, translating into a cumulative decline of GDP equivalent to 2 standard deviations (9.7 percentage points, calculated based on data covering 1980-2013) relative to the baseline over three years. This scenario is caused by a sharp rise in international investors' risk aversion and the surge in global financial market volatility associated with the exit from unconventional monetary policy in the United States, leading to economic and financial stress in emerging countries. This higher volatility would bring about a sharp rise in CDS premia and interest rates in international capital markets for the financing of emerging countries, would reduce Morocco's external funding capacity and would trigger a drying-up of liquidity as well as a high increase in funding costs in the domestic banking system. This instability would be associated with a recession in the euro area of the same magnitude as that observed in 2009, due to the world trade contraction linked to the large emerging countries' crisis.[8] This would reduce the demand for Moroccan exports, slow down

[5] A three-year projection was chosen because, at the time of the FSAP, forecast errors appeared too large over periods longer than three years.

[6] Bank-al-Maghrib is in the process of strengthening its macro modeling capacity following a TA mission provided by MCM and a team led by RES. However, the process was not complete at the time of the FSAP and robust models were not available for macro projections.

[7] The shocks assumed in the FSAP stress tests and the shocks assumed for Precautionary and Liquidity Line access calibration purposes are not completely aligned with each other as they have different focuses: PLL access calibration is about external financing whereas FSAPs deal with financial stability risks and focus on tail risks; however, external factors are common to the two sets of projections.

[8] Moreover, the elasticity coefficient of the Moroccan GDP growth to the euro area GDP growth is estimated at 0.4. The application of this coefficient to the growth rate experienced by the euro area in 2009, last year of a large crisis, gives a growth rate of the Moroccan GDP under an extreme shock of -1.8 percent.

remittances from abroad, tourism revenues and FDI inflows, and would exert downward pressures on the central bank's international reserves. The recession in the euro area and emerging countries would bring about a fall in oil prices of the same magnitude as that observed in late 2014/early 2015, which would translate into a sharp decline in the inflation rate in Morocco. This scenario is based on risks # 1 and 4 of the Risk Assessment Matrix published in the 2014 Article IV report.

Table 3. Morocco: International Factors and Domestic Indicators during Two Past Crises

(in percent)	1995 (agricultural shock)	2009 (global financial crisis)	Average
International factors			
Euro area GDP growth	2.9	-4.5	-0.8
Oil price change	7.9	-36.3	-14.2
Food price change	4.5	-13.2	-4.4
Germany 10-year rate	6.9	3.2	5.0
Moroccan indicators			
Real GDP growth	-6.6	4.8	-0.9
CPI inflation rate	6.1	1.0	3.5
Treasury bill rate	n.a.	3.8	n.a.
NEER change	1.5	1.8	1.6
FDI stock change	n.a.	-9.7	n.a.
Remittances stock change	n.a.	-5.4	9.7

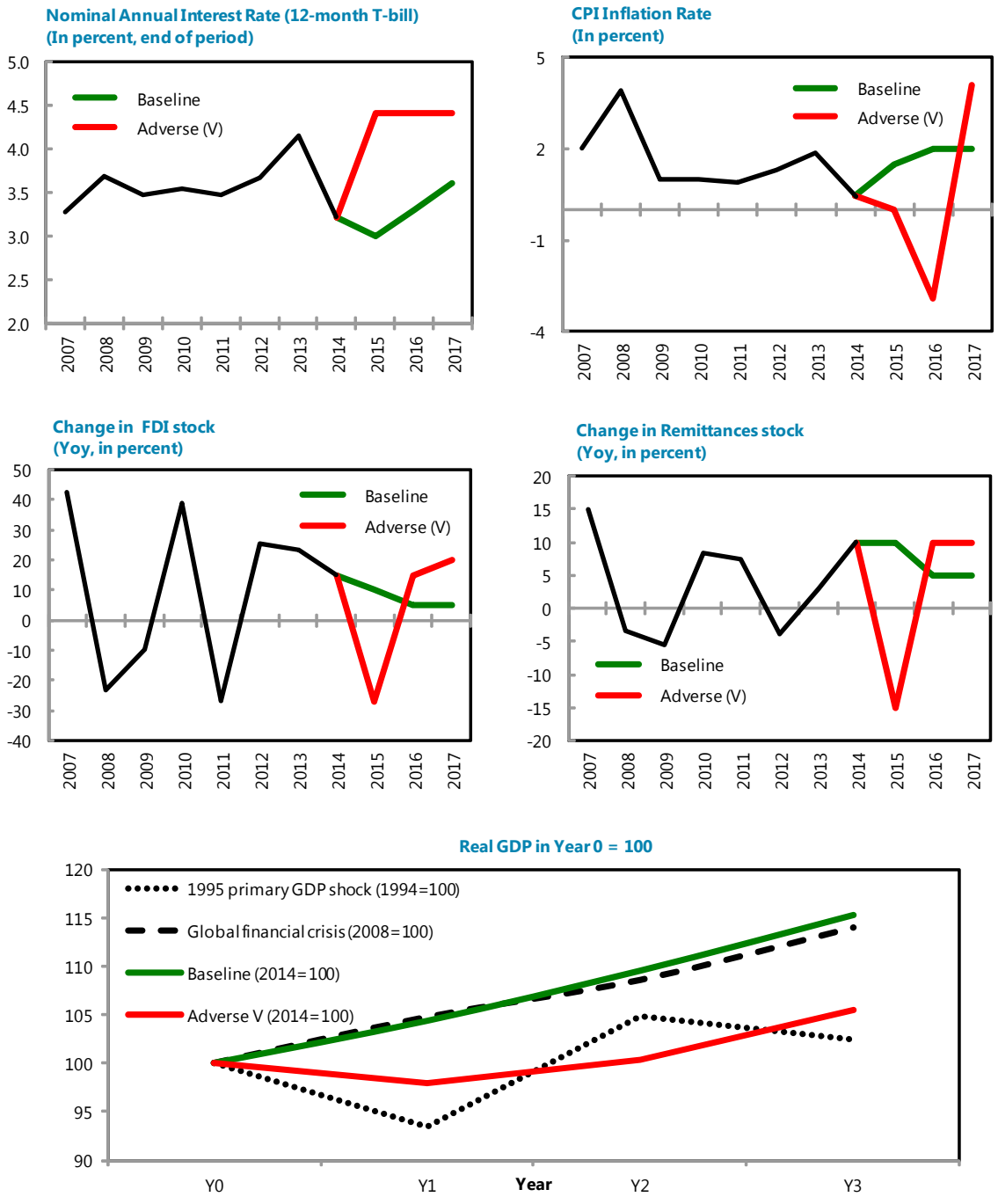
Source: WEO database.

Table 4. Morocco: External and Domestic Assumptions Chosen for the Adverse Scenario

	2015	2016	2017
V-shaped scenario (combined shocks)			
Euro area GDP growth	-4.5%	0.5%	1.0%
Inflation rate in the euro area	-2.0%	0.0%	0.2%
Change in brent oil price per barrel (in USD)	-75%	-15%	7%
Food price change	-13.0%	2.0%	4.0%
Emerging countries CDS premium (in bp)	450	420	400

Source: IMF staff.

Figure 3. Morocco: Macroeconomic Baseline and Stress Scenarios



Sources: BAM and IMF estimates.

Table 5. Morocco: Macroeconomic Scenarios for Stress Tests: Assumptions for Macroeconomic and Financial Variables

(In percent)

	Est.	Projections		
	2014	2015	2016	2017
Real GDP growth				
	2.9			
Baseline	2.9	4.4	5.0	5.3
Adverse (V)	2.9	-2.0	2.4	5.2
Adverse (L)	2.9	-2.0	0.0	0.0
CPI Inflation rate				
	0.4			
Baseline	0.4	1.5	2.0	2.0
Adverse (V)	0.4	0.0	-2.9	4.1
Nominal effective exchange rate annual change				
	0.6			
Baseline	0.6	-2.0	2.5	2.5
Adverse (V)	0.6	-4.0	2.0	2.5
Nominal annual interest rate (12 month T-bill)				
	3.2			
Baseline	3.2	3.0	3.3	3.6
Adverse (V)	3.2	4.4	4.4	4.4
Adverse (L)	3.2	3.3	5.5	5.5
FDI annual change				
	15.0			
Baseline	15.0	10.0	5.0	5.0
Adverse (V)	15.0	-27.0	15.0	20.0
Remittances annual change				
	10.0			
Baseline	10.0	10.0	5.0	5.0
Adverse (V)	10.0	-15.0	10.0	10.0

Sources: WEO database and IMF staff.

B. Credit Risks in the Scenario Analysis

Credit Risks in the Loan Book

21. Credit risk in the loan book constitutes the largest risk factor for the banking system. Total loans represent 72 percent of total banking sector assets.

22. The transmission of macroeconomic shocks to NPL ratios and loan loss provisions of individual banks was assessed by estimating specific satellite models of credit risks. Due to the lack of data related to risk parameters such as default probabilities (PDs) and loss-given-default (LGDs) as banks in Morocco operate under the Basel II standardized approach, the ratio of NPLs (in percent of total loans) was used to assess credit risk in the loan portfolio. Losses related to credit risk were then computed based on the increase in provisions resulting from the loan migration associated with the increase in NPLs under stress.[9] BAM and the FSAP team developed panel data models to project bank-specific NPL ratios. For the estimation of the credit risk satellite model and the conduct of the solvency stress test, the FSAP team had access to a full set of supervisory data, both at the individual bank level, on solo and consolidated basis, and data at the banking system level (Table 6).

Table 6. Summary of FSAP Team Access to Supervisory Data 1/

	Fully available	Partially available	Not available
Data at the individual bank level	✓		
Data aggregated along groups of banks	✓		
Data aggregated at the banking system level	✓		

Source: IMF staff.

1/ This table only describes the availability of supervisory data for the stress tests conducted by the FSAP team, but does not present an assessment of data quality.

23. The NPL ratios for each bank were projected at the global level of the economy as no bank-by-bank sectoral breakdown of NPLs was available. The NPL ratio was modeled as a function of the macroeconomic and financial variables that were included in the stress test scenarios. As a result, the determinants of NPL ratios include the lagged dependent variable, GDP growth rate, the real Treasury bill rate, the change in the stock of FDI and remittances, and bank fixed effects aimed at capturing unobserved bank-specific characteristics. GDP growth rate is expected to have a negative effect on the NPL ratio because it is associated with higher income, which increases borrowers' debt payment capacity. Real interest rates are expected to have a

[9] This framework models the behavior of NPLs, i.e., loans classified in categories 3, 4 and 5 ("pre-doubtful," "doubtful," and "loss" respectively) together. Moreover, the stress test assumes that the proportion of loans classified in each of these three (non-performing) categories remains the same before and after the shock.

positive effect on the NPL ratio as they increase the debt burden and deteriorate loan quality. Finally, capital inflows are expected to have a negative effect through the liquidity channel because they increase the liquidity of the banking system, allowing banks to distribute more credit, which makes the NPL ratio decline mechanically as new loans are by definition performing. As the NPL ratio series was found to be non-stationary, it was decided to estimate the year-on-year change in the NPL ratio, taken as a flow variable used as a proxy for the change in the probability of default.[10] The dependant variable of our model was thus the following:

$$Y = NPL_{it} - NPL_{it-4} \quad (1)$$

This variable is then assumed to be a linear function of the different exogenous macroeconomic and financial factors mentioned above. Therefore, the estimated model can be expressed as:

$$Y_{i,t} = \alpha + \mu_i + \rho Y_{i,t-1} + \beta X_{t-s} + \varepsilon_{i,t} \qquad for\ t = 1, \cdots, T \quad and \quad i = 1, \cdots, N \quad (2)$$

where $Y_{i,t}$ is the first difference of the NPL ratio for bank i at time t, X_t is a vector of macroeconomic and financial variables, s denotes time lags, μ_i denotes bank-specific fixed effects, $\varepsilon_{i,t}$ is an independent and identically distributed error-term, and α, ρ, and vector β are parameters to be estimated.

More specifically, the model of NPL ratios has the following form:

$$Y_{i,t} = \alpha + \mu_i + \rho_1 Y_{i,t-1} + \beta_1 \Delta GDP_{t-4} + \beta_2 ir_t + \beta_3 \Delta fcapital_{\ t} + \delta + \varepsilon_{i,t} \quad (3)$$

where ΔGDP denotes the year-on-year real GDP growth rate in logarithm lagged by four periods, *ir* is the real 12-month Treasury bill rate deflated by the consumer price index, $\Delta fcapital$ is the year-on-year change in the stock of FDI and remittances in logarithm, aimed at capturing the liquidity channel.

Then, the NPL ratio under stress in percent was computed according to the following formula:

$$NPL_{i,t}^{stress} = NPL_{i,t-4}^{initial} + \alpha + \rho Y_{i,t-1} + \beta X_{t-s} \quad (4)$$

24. Nonperforming loan ratios were projected by bank using quarterly data over the period 2003Q1-2014Q4 and estimating a dynamic panel fixed-effect OLS model. The coefficients of the explanatory variables are presented in Table 7.[11] The lagged dependent variable and real interest rate are found to have the largest effects. More specifically, real interest rate is

[10] An alternative option would have been to detrend the NPL ratio series by using a Hodrick-Prescott filter. However, the estimation of this detrended variable within the framework of our credit risk satellite model did not provide very significant results.

[11] As a robustness check, an alternative, cointegration model was estimated using the logit transform of the NPL ratio variable as the dependent variable. The resulting projections of the NPL ratio were close to those resulting from the dynamic panel fixed-effect OLS model.

found to have a positive and significant effect on credit risk, that is, a 1 percentage point rise in real interest rate increases the NPL ratio by 0.38 percentage points. A one percentage point decline in real GDP growth results in a rise in the NPL ratio by 0.07 percentage points. Finally, a 1 percentage point decline in the growth of FDI and remittances stock is associated with a 0.01 percentage point rise in the NPL ratio.

25. Potential credit risk losses in the loan book represent the largest vulnerability of the banking sector. Top-down stress test results suggest that banks are likely to experience large increases in NPLs under the adverse scenario (see Figure 4), in contrast with the baseline scenario in which NPL ratios are declining. The combined effects of higher interest rates and the decline in GDP and FDI and remittance growth increase the banking system's NPL ratio from 7.1 percent in 2014 on a solo basis to 9.7 percent in 2015, 14.8 percent in 2016 and 13.5 percent in 2017 in the V-shaped scenario, according to IMF model results.

26. The rise in NPL ratios requires additional provisions that deteriorate bank profitability in the adverse scenario. Credit losses in the loan book amount to 39.9 bn dirham in the V-shaped adverse scenario, equivalent to 2.9 percent of total banking system assets, as a result of the credit risk increase caused by the severe macroeconomic conditions. By contrast, in the baseline scenario, the flow of new provisions is projected to be negative, amounting to -14.8 bn dirham.

Issuer Default Risk

27. Stress tests also included an assessment of credit risk on fixed income holdings. In addition to testing for credit risk-related losses in the loan book, top-down stress tests entailed the computation of expected losses on debt instrument holdings in the banks' balance sheet. Credit risk losses on these holdings derive from the potential default by the issuer of these instruments (i.e., "issuer default risk") in the stress scenario. Box 1 describes the methodology used in the top-down stress tests to estimate such losses. These debt instrument holdings include domestic government and corporate bonds, in all three available-for-sale (AFS), held-for-trading (HFT), and held-to-maturity (HTM) portfolios. The exposures to the domestic securities make up quite a significant share of assets, representing altogether 11½ percent of total assets. It should be noted that expected losses on these holdings related to other risk factors (such as valuation changes due to interest or exchange rate movements) are treated separately, and are described in the "Market Risk" section.

28. Banking sector credit losses due to fixed income instrument exposures remain very limited. The expected losses from the implicit increase in the credit spreads of the domestic government and corporate bonds are relatively small. In the V-shaped adverse scenario, the expected losses resulting from the increase in the probability of sovereign and corporate distress due to the overall macroeconomic outlook deterioration are equal to 80 mn dirham, contributing by 1 percentage point to the growth in provisions over the period.

Table 7. Morocco: Results from the Estimation of the IMF Credit Risk Satellite Model (Equation [3])

(Dependent variable: Year-on-year change in the NPL ratio)

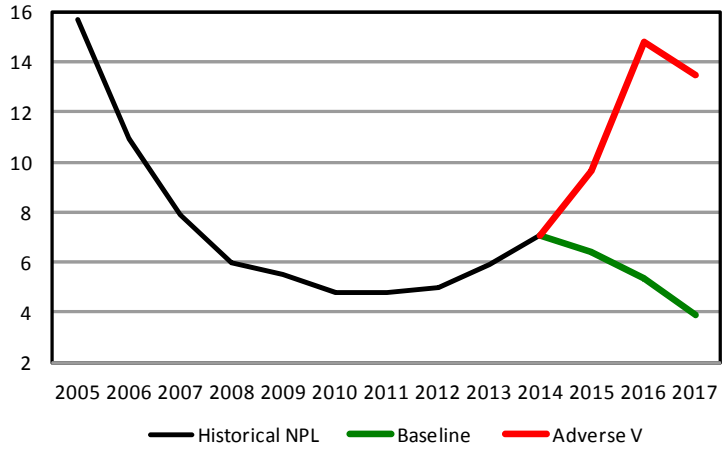
Lagged dependent variable (t-1)	0.6062***
	(6.95)
Real GDP growth (t-4) (in log)	-7.2322***
	(-3.70)
Real Treasury bill rate (in percent)	0.3809**
	(2.77)
Change in capital from abroad (in log)	-1.1988**
(FDI and remittances)	(-2.76)
Constant	-0.6980*
	(-1.97)
R-square	0.74
# of observations	320
p-value of the Fischer test	0.00

Source: IMF staff calculations.

t-statistics in parentheses.

*Denotes significance at the 10 percent level; ** at the 5 percent level; and *** at the 1 percent level.

Figure 4. Morocco: Non-Performing Loan Ratio in the Baseline and Adverse Macroeconomic Scenarios – IMF Model



Sources: BAM and IMF staff calculations.

Box 1. Morocco: Computation of Potential Losses due to Issuer Default Risk

For sovereign bond holdings in the available for sale, held for trading and held to maturity portfolios, there is an implied expected loss which in principle should be covered by provisions. In order to estimate these expected losses, the corresponding risk parameters (PD, LGD and EAD) have to be estimated.

According to Moody's, Morocco's current sovereign rating is in the "Ba" level category, with a corresponding default probability of 0.63 percent over a 12-month period. This level was chosen as a starting point in the FSAP stress test (i.e., PD_0=0.0063).

Based on a panel regression analysis,[12] the following elasticity was estimated:

$$\gamma = \frac{\Delta \log it(PD_t)}{\Delta drgdp_t}$$

where $drgdp_t$ is the year-on-year growth rate of real GDP, and logit denotes the logistic transform. The above expression can thus be rearranged as:

$$PD_t = \frac{\left(\frac{PD_{t-1}}{1-PD_{t-1}}\right) * \exp\{\gamma \Delta drgdp_t\}}{1+\left(\frac{PD_{t-1}}{1-PD_{t-1}}\right) * \exp\{\gamma \Delta drgdp_t\}}$$

Hence, based on the elasticity mentioned above and the change in real GDP growth under each scenario, the implied probability of default for the sovereign was computed. In terms of LGD, based on the 2015 World Bank Doing Business report, the recovery rate in Morocco is 27.9 percent, which was then used in the computation of expected losses in the stress tests.[13]

As regards expected losses due to issuer risk for corporate bond holdings, the same methodology was used. The stress tests assume that Morocco's corporate sector rating is the same as that of the sovereign, implying an initial corporate default probability of 1.08 percent. Using the same elasticity γ above, the corporate default probabilities were obtained for the different scenarios.

C. Market risks in the Scenario Analysis

29. Stress tests also assessed the resilience of banks when facing different sources of market risk. In addition to credit risk related losses, banks can experience large losses due to

[12] This panel regression includes a sample of 117 countries with a total of 2,120 observations. Panel fixed effects were used for the estimation of γ. This elasticity γ was estimated to be -0.088792. See also the July 2015 Technical Note on Banking Sector Stress Testing of the Bosnia and Herzegovina FSAP (IMF Country Report No. 15/213).

[13] It has to be noted that the World Bank recovery rate is used a loose proxy for claims on the sovereign as the World Bank rates concern claims on the private sector.

changes in market variables (for instance, exchange rates and interest rates). These losses – or gains- might be due to the existence of "open positions" in the banks' balance sheets (due to e.g., currency, maturity, time-to-repricing mismatches between asset and liabilities) or to valuation changes in the different securities (Available for Sale and Held for Trading) held by the banks. Interest and exchange rate risks were the two market risks included in the stress tests. Risks related to equity investments were not dealt with, as equity investments make up a negligible part of banks' assets and capital.

Interest Rate Risk

30. The impact of interest rate risk was assessed using time-to-repricing buckets. Different interest rate sensitive assets and liabilities are grouped together in different buckets depending on their time-to-repricing. For instance, a loan and a deposit whose effective interest rate can change within the next month would be placed in the same bucket; their difference would represent the "time-to-repricing gap."[14] The expected losses – or gains – on interest income are simply computed as the product of this gap and the changes in the interest rate. This particular analysis only deals with the direct effect of interest rate risk. Indirect effects, that is through credit risk and the effect on asset quality in the loan portfolio, were dealt with in the credit risk section.

31. In the scenario analysis, banks gain or lose net interest income depending on the scenario. Banks are usually exposed to a rise in interest rates because they are performing maturity transformation. Banks' net interest income is a main source of profits for banks and is sensitive to changes in interest rates, as these could reduce the interest margin depending on the time to asset and liability repricing. Therefore, a maturity ladder approach was used to project net interest rate income in the baseline and adverse macroeconomic scenarios. Among the 8 banks composing our stress test sample, two display a negative time-to-repricing gap (i.e., liabilities are repriced faster than assets), leading them to lose interest income when interest rates rise. Indeed, equal increases in deposit and lending rates raise banks' interest payments by a larger amount and faster than interest receipts. However, at the aggregate level for the 8 banks the repricing gap amounts to 31.5 bn dirham as of December 2014, meaning that the banking system as a whole gains interest income when interest rates rise. In the V-shaped scenario, the aggregated gain directly due to the change in interest rates amount to 344 mn dirham, resulting in a minimal contribution to the change in the CAR.

32. The increase in net interest income in the adverse scenarios stems from two effects. First, a base effect is taking place as Moroccan banks in aggregate have a larger amount of assets than liabilities which are repriced within one year; this is due to the large share of non interest-bearing current accounts held by non-financial customers in banks' liabilities. Second, a price effect occurs because Moroccan banks were deemed to have a high mark-up power and lending rates were estimated to be highly correlated with banks' funding costs and the domestic sovereign rate.

[14] Data were available for the following time-to-repricing buckets: less than 3 months; 3 to 6 months; 6 to 12 months; and more than 12 months. Conservatively, the largest net losses on any gap with a time-to-repricing less than 12 months were considered as representing the "instantaneous loss" due to the interest rate shock.

Therefore, the rise in the sovereign rate in the adverse scenarios translates into higher lending rates, increasing banks' interest income. This effect fades out from the second year of the scenario when the non-performing loan ratio starts increasing.

33. Interest rate risk through valuation effects on debt instrument holding was also assessed. The other potential source of gains or losses related to changes in interest rates are valuation changes on domestic government and corporate bond holdings. First, the duration of each of these holdings is computed. Second, for each portfolio, the average duration is calculated as the weighted average of the individual durations weighted by the amount (in dirham) of each individual bond holding. Finally, using a modified duration approach, the expected gains or losses due to valuation changes are computed as the product of the size of the bond portfolio, its average modified duration, and the change in the relevant interest rate (i.e., the bond yield). An increase in interest rates translates into a valuation loss in the bond portfolio, and vice versa.

34. Potential valuation losses on fixed income instruments remain limited. Owing to their moderate exposure regarding debt instruments and the reasonable duration of their bond portfolios (3.2 years in average), the implied valuation changes in the adverse scenario are fairly small. Domestic fixed income securities make up a share comprised between 7.8 and 14 percent of total assets. In the V-shaped adverse scenario, losses due to a decline in the price of domestic sovereign and corporate securities in the AFS and HFT portfolios amount to 3.1 bn dirham, contributing by 0.3 percentage points to the decline in the CAR.

Foreign Exchange Rate Risk

35. The direct effects of exchange rate risks were assessed based on the banks net open FX positions. Data on net open FX positions were available by currency along the following three categories: USD, EUR, and "other currencies." The implied gains or losses on these positions were computed as the product of the net open position and the expected change of the dirham exchange rate in each of the scenarios.[15]

36. The positive net foreign exchange position at the banking system level means that the banking system experiences direct market gains in the case of a dirham depreciation. Assets denominated in foreign currency outweigh liabilities denominated in foreign currency in five out of the eight banks. The net open FX position for the banking system amounts to 3.2 bn dirham, equivalent to 0.25 percent of assets and 1.7 percent of capital. The limited size of net foreign exchange positions results from financial account restrictions and tight prudential regulation.

37. Losses on banks' net foreign exchange position are small in the adverse scenario. In the V-shaped scenario, the dirham is expected to rise in nominal effective terms over the whole period, which results in a small aggregated loss of 20.4 mn dirham.

[15] The path for the NEER was used.

D. Results of the Solvency Stress Tests based on Macro Scenarios

38. In the adverse scenario, the materialization of risks affects the banking system through several channels. The relative importance of the different channels described above can be seen in terms of their contributions to the changes in CAR in Figures 6 and 7.

39. In all the scenarios, a number of initial adjustments and assumptions were made to track the change in individual banks' balance sheets and profits over time.

- *Adjustment of provisions and initial capital.* The stress test was based on the national loan classification system. The corresponding "nominal" provisioning rates are as follows: performing assets (0 percent), watch assets (10 percent), pre- doubtful assets (20 percent), doubtful assets (50 percent), and loss assets (100 percent).

  Effective provisioning rates, however, differ from nominal rates because the former are obtained by applying the latter to loan values net of collateral. Effective provision rates differ across banks and loan types due to differences in the type of assets that collateralize loan. Before adjustments, provisions are calculated as follows:

  Provisions = Nominal provisioning rate x (Loan value – Collateral value)

  where collateral values are discounted by 20 percent relatively to face values for guarantees provided by other credit institutions, and by 50 percent relatively to market values for real estate and cars, according to BAM regulation. No haircut is applied to guarantees provided by the Moroccan government or to securities issued or guaranteed by the Moroccan government.

  There was no evidence of under-provisioning by banks. However, in the stress test, an additional adjustment was made to collateral valuation after application of regulatory haircuts in order to take account of the estimated recovery rate of 27.9 percent in Morocco according to the World Bank and of concerns about collateral valuation rules in the calculation of loan loss provisions for guarantees provided by other credit institutions and Moroccan government bonds. Therefore, collateral values were further reduced by 13 percent to increase the haircuts on all types of collateral. Thus, the adjusted collateral value was calculated as follows:

  $$Adjusted\ \ collateral\ \ value = Collateral\ \ value\ \ after\ \ regulatory\ \ haircuts \times 0.87$$

  Adjusted effective provisioning rates were calculated as follows:

  $$Adjusted\ effective\ \ provisioning\ \ rate = No\min al\ \ provisioning\ \ rate \times \left(1 - \frac{Adjusted\ \ collateral\ \ value}{Loan\ \ value}\right)$$

  However, this adjustment resulted only in a reduction in banks' capital by 0.1 percent or 0.01 percent of RWAs and little changed the results.

- *Growth of banks' balance sheets.* Banks' balance sheet size was projected to grow in line with nominal GDP, with a zero growth floor. Thus, the size of the banking system in terms of assets remains constant relative to the size of the economy. This assumption has two advantages. First,

it guarantees that banks do not meet capital requirements simply by shrinking their balance sheets – which could also reduce their RWAs (i.e., the denominator of the CAR ratio) – in adverse scenarios. Second, it ensures that banks that pass the tests remain sufficiently capitalized to support lending in a severe downturn. For this reason, this assumption reduces the need to quantify the second round effects triggered by banks' behavioral responses to the initial shocks. It should be noted that in adverse scenarios, the growth of net assets (total assets net of loan loss provisions) is usually lower than the growth of total assets because provisions are higher.

- *Projection of risk-weighted assets.* As banks in Morocco operate under Basel II standardized approach, risk weights are constant for each type of exposure in the balance sheet across the forecasting period. The structure/composition of assets is assumed to remain constant over time in each scenario. Thus, RWAs must be adjusted only by nominal GDP growth and provisions for the purpose of calculating post-stress CAR ratios. This was the approach followed in the main stress test. In an alternative, more risk-sensitive approach, risk weights were projected through a Morocco-specific econometric model estimating the ratio between risk-weighted assets and total assets in order to capture the effect of credit rating migration and asset classification change across the economic cycle.[16]

- *Evolution of profits.* As regards the income statement, non-interest profit items and lines, such as operational and administrative expenses, and net fee and commission income, were projected to grow in line with nominal GDP. However, it was assumed that income from extraordinary items did not recur again during the 2015-2017 period in the baseline and the adverse scenarios. Moreover, NPLs were assumed not to provide any interest income. The 2012-2014 period was taken as the initial pre-shock benchmark for the profit projection in order to smooth the effect of the exceptional character of market income earned by Moroccan banks in 2014.

- *Distribution of dividends*. Banks satisfying capital requirements during the whole period of the stress test in a given scenario were assumed to distribute two-thirds of their after-tax profits. Undercapitalized banks in any year of a given scenario were not allowed to distribute dividends.

40. As a result of the materialization of the different risks set out above, the banking system would remain adequately capitalized (Figure 5), and only one bank would become undercapitalized in the adverse scenario (Figure 6). In the baseline scenario banks' profitability and capitalization increase, and every bank stays above the 12 percent capital requirement minimum. In the V-shaped scenario, one bank representing 6.1 percent of the banking system total assets, would see its CAR fall below the regulatory minimum to 10.0 percent of its RWA, with similar

[16] Real GDP growth, the change in the NPL ratio and the lagged dependent variable were used as explanatory variables in a panel OLS fixed-effects model estimating the RWAs-to-total assets ratio, with a coefficient of real GDP growth estimated to be -0.95, a coefficient of the change in the NPL ratio estimated to be -0.64, and an autoregressive coefficient of 0.53, using quarterly data over 2007-2014. The projection of stressed RWAs barely changed the global stress-test results in the adverse scenario, with the total capital shortfall increasing from 0.15 to 0.25 percent of GDP, but caused an additional small bank to become undercapitalized in terms of total CAR (CAR of 10.3 percent in 2017).

(continued)

results in a severely negative adverse scenario. The banking system's capitalization shortfall (relative to a common 12 percent capital adequacy threshold for all banks) is estimated at 0.2 percent of 2014 GDP (Table 8). The undercapitalization of this bank under the adverse scenario stems from two factors: 1/ its initial undercapitalization, and 2/ its higher exposure to credit and to interest rate risks due to a negative repricing gap between interest rate sensitive assets and liabilities.[17] In an alternative approach in which cross-border exposures are treated as if they were domestic exposures, that is the NPL ratio on a consolidated basis evolves in the same proportion as the NPL ratio on a solo basis, one more bank would become slightly undercapitalized, with a total capital shortfall estimated at 0.3 percent of GDP.

41. Undercapitalization in the adverse scenario, measured in terms of Tier 1 capital, is similar (Figure 7). In the Moroccan system, Tier 1 capital represents 85 percent of total capital. In the baseline scenario, no bank turns out to be undercapitalized. In the V-shaped scenario, the same bank as before, representing 6.1 percent of the system's assets, would have its Tier 1 capital ratio falling below the 9 percent hurdle rate including the conservation buffer, but above the recapitalization threshold of 6.5 percent as the Tier 1 capital ratio would amount to 7.5 percent.

Table 8. Morocco: Results of the Solvency Stress Tests Based on Macro Scenarios – IMF Results

	Peak of the aggregate NPL ratio (in percent)	Number of undercapitalized banks (total CAR)	As a percent of banking system's assets	Number of insolvent banks	Capital shortfall (as a percent of 2014 GDP)
National regulation					
Baseline	6.4	0	-	0	0
V-shaped negative scenario	14.8	1	6.1	0	0.2
National regulation + stressed RWAs					
Baseline	6.4	0	-	0	0
V-shaped negative scenario	14.8	2	9.8	0	0.3

Sources: BAM and IMF staff calculations.

42. One caveat that should be borne in mind is that our credit loss estimates and solvency projections in the adverse scenario may be biased in one way or another. First, credit loss estimates may be biased because the credit risk satellite model was estimated using NPL ratios on a solo basis due to data limitations, in particular the absence of a long enough time series of NPLs on a consolidated basis. In the main approach, we projected the NPL ratio on a solo basis and assumed that credit risks and provisions change during the scenario only in Morocco, and not in the host countries in which Moroccan banks' subsidiaries operate (the latter make up 18 percent of the

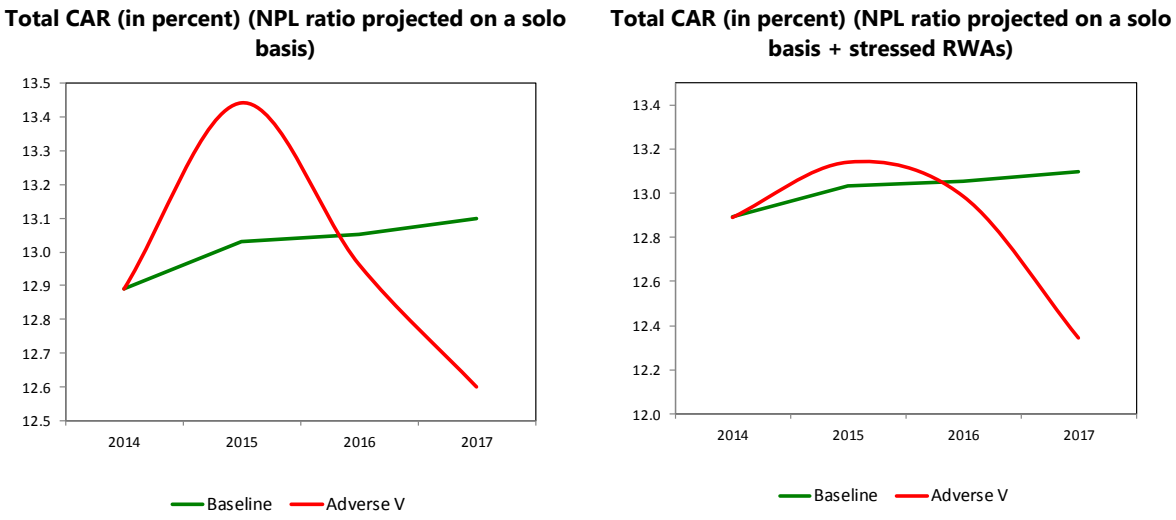
[17] These results would be sensitive to changes in assumptions regarding the size of the additional haircut on collateral valuation and the interest rate shock pass-through to lending rates (a one-for-one pass-through of shocks to Treasury rates has been assumed both for deposit and lending rates).

consolidated activity). In the second approach, the elasticity estimated by the model was applied to the latest NPL ratio and balance sheet items on a consolidated basis. Therefore, this procedure implicitly treats cross border credit risk exposures as if they were domestic exposures but without designing specific macro scenarios for host countries.[18] Moreover, no account was taken of write-offs.

43. Top-down credit risk losses in the loan book are larger than the bottom-up losses estimated by the banks. Commercial banks used different NPL ratio projections based on a range of models for the computation of their own credit losses in the different scenarios, and ad-hoc assumptions given by the authorities for the projection of commission and market income, and operational expenses.[19] Then, different collateral valuations were applied in the Bottom-Up and the Top-Down stress tests as banks applied the regulatory haircuts to their collateral valuation whereas the IMF team further decreased the collateral valuation from banks by 13 percent. Moreover, in the bottom up results, the net interest income remains very high, pushing up the solvency ratios even under the negative scenario in some cases. Finally, in line with the national regulation, banks carried out their stress tests on a pure solo basis, in contrast with the hybrid approach followed by the FSAP mission.

Figure 5. Morocco: Post-Shock Capital Adequacy Ratio at the Banking System Level

(In percent)



Source: IMF staff calculations.

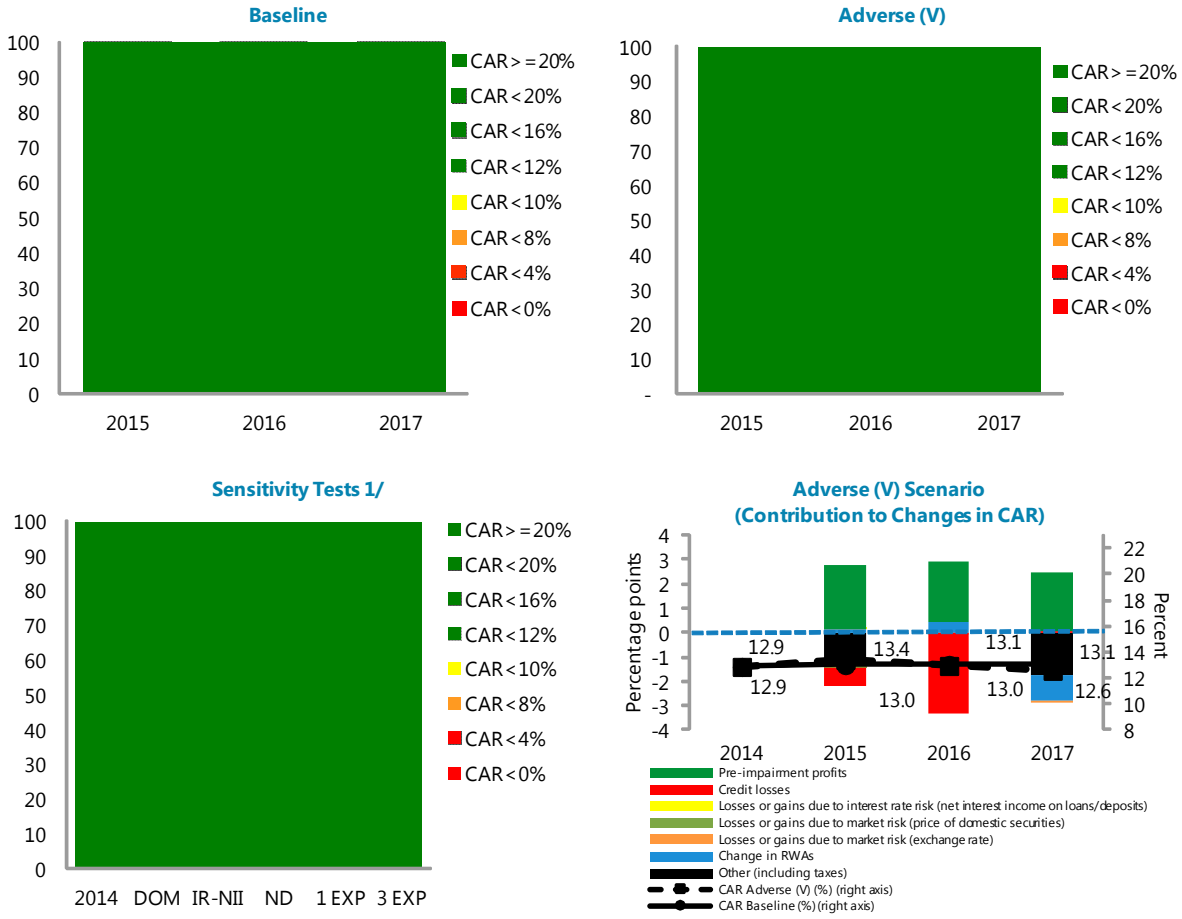
Note: The initial rise in the total CAR in the adverse scenario is due to the decline in RWAs and the growth in net interest income resulting from the interest rate increase, before impairment costs rise in the second year.

[18] The authorities considered this approach to be unrealistic as it implicitly relies on a very severe macroeconomic deterioration in all the host countries in which Moroccan banks' subsidiaries operate.

[19] It was decided to use this option in the conduct of the BU stress tests because commercial banks in Morocco apply Basel 2 standard approach and indicated that they did not have appropriate models available in-house to estimate credit losses under different scenarios. They usually conduct sensitivity analysis stress tests only.

Figure 6. Morocco: Bank Solvency Stress Test Results, CAR Ratios

(In percent of total banking system assets)

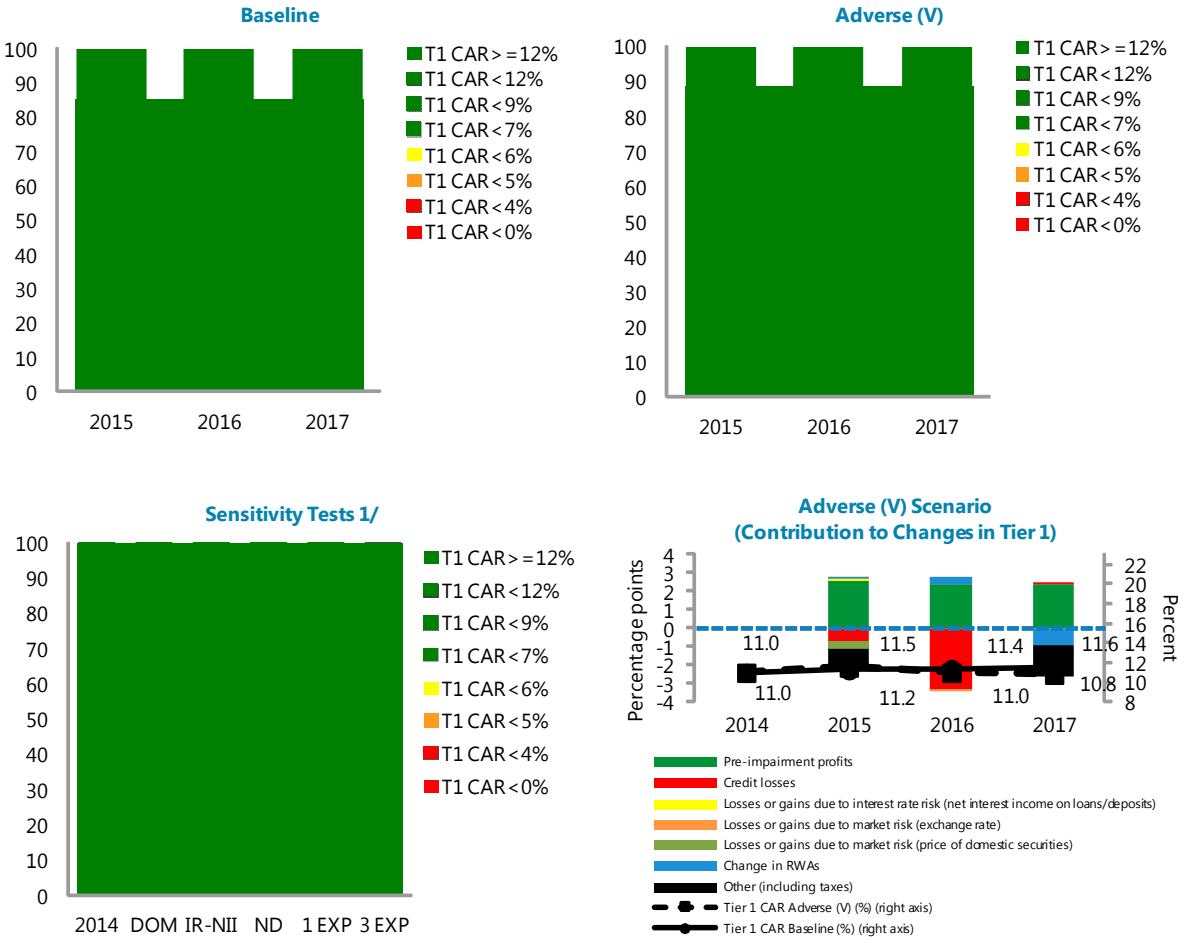


1/ Note: DOM = increase in domestic bond yield (300 bp); IR-NII = increase in interest rates (300 bps), effect on net interest income; ND = nominal depreciation (30 percent), effect on banks' net open FX positions; 1 EXP = failure of largest exposure; 3 EXP = failure of 3 largest exposures.

Sources: BAM and IMF staff estimates.

Figure 7. Morocco: Bank Solvency Stress Test Results, Tier 1 Ratios

(In percent of Total Banking System Assets)



1/ Note: DOM = increase in domestic bond yield (300 bp); IR-NII = increase in interest rates (300 bps), effect on net interest income; ND = nominal depreciation (30 percent), effect on banks' net open FX positions; 1 EXP = failure of largest exposures; 3 EXP = failure of 3 largest exposures.

Sources: BAM and IMF staff estimates.

E. Market risks based on Sensitivity Analysis

44. In addition to stress scenario analysis, sensitivity stress tests assessed vulnerabilities of the banking system to key individual shocks. These included: a decline in the prices of domestic securities; an increase in interest rates that affects banks' net interest income; an increase in interest rates that deteriorates the credit quality of bank loans; and a depreciation of the dirham nominal effective exchange rate that triggers direct gains or losses in banks with net open FX positions. Indirect effects of a nominal depreciation of the dirham on credit quality were not assessed because

the share of foreign currency lending in total loans is very low in Morocco (less than 4 percent) and FX borrowers have to be hedged in foreign currencies according to national regulation. Unlike macroeconomic stress tests, sensitivity tests are static: they assessed the instantaneous impact of different shocks on the banks' balance sheet positions as of December 2014. In all the sensitivity tests, banks' risk-weighted assets are assumed to stay constant after the application of the shocks, except for the concentration risk stress test.

A Decline in the Prices of Domestic Securities

45. Sensitivity tests assessed the impact of increases in domestic yields by type of instruments on exposures in the trading book. The tests assessed the sensitivity of banks' domestic bond AFS and HFT portfolios (excluding short-term Treasury bills) to a 300 bp increase in interest rates. Losses were calculated using a modified duration approach as the product of the size of the bond portfolio, its average modified duration, and the change in the interest rate.

46. The results show that Moroccan banks are exposed to domestic bond risks. The partial impact of domestic bond portfolio losses would be significant. Specifically, three banks in the system representing 57 percent of total assets would become slightly undercapitalized, and the CAR in the system would decline by 0.8 percentage points due to these losses taken in isolation (assuming that no other shocks trigger simultaneous losses for these banks). The main results, in terms of cross-bank distribution of CARs and Tier 1 capital ratios, are presented in Figures 6 and 7.

Interest Rate Risk: Net Interest Income Effects

47. A sensitivity test based on a maturity ladder (gap) analysis suggests that the banking system would gain net interest income in the event of an interest rate increase. The gap analysis assesses the effect of an increase in interest rates by 300 basis points on banks' net interest income, taking into account the maturity transformation performed by banks. Changes in net interest income stem from the temporal dynamics of deposits, loans, and securities with maturities of up to one year. In the analysis, deposits maturing within one year must be rolled over at higher deposit rates, implying higher bank interest payments. Loans with maturities of less than one year are also renewed at higher interest rates, increasing bank interest income. Finally, treasury instruments with maturities of less than one year are reinvested at higher yields, earning higher interest income for the part of the year. This shock, taken in isolation would worsen the undercapitalization of a bank, but would increase the total banking system's net interest income by 945 mn dirham, due to a positive repricing gap.

Interest Rate Risk: Effects on Credit Quality

48. An increase in domestic interest rates could deteriorate the credit quality of dirham-denominated loans, with a noticeable effect on bank capitalization. A tightening of domestic monetary conditions may be required to contain inflationary pressures or prevent capital outflows. Sensitivity tests based on credit risk models, developed by the IMF team (also used in the tests based on macroeconomic scenarios), suggest that a 300 basis point increase in domestic real interest rates would increase the NPL ratio in the system by 1.6 percentage points – from 7.1 percent

to 8.7 percent. This would result in a significant loss of CAR in the system (1.0 percent), and cause undercapitalization in four banks representing 81 percent of the banking sector total assets. The large impact of this shock on bank credit losses may be attributed to the relatively high interest rate elasticity of loans – as noted above, a 1 percentage point increase in the real interest rate brings about a 0.38 percentage point increase in the NPL ratio.

49. This result shows only the partial impact of changes in interest rates on credit quality and bank capitalization. This test assumes that banks earn no-pre-impairment profits under stress; also, the increase in interest rates is sustained for one year and only affects banks' NPL ratios and credit losses directly, with output assumed to stay constant.[20] By definition, it may be limited as a measure of overall impact as banks are likely to continue earning positive (or negative) pre-impairment profits that are not included in the analysis. This test also ignores second-round effects through which higher interest rates could be transmitted to banks. For instance, a monetary tightening could help contain deposit or capital outflows; it could also slowdown output growth in the short term, exacerbating credit losses in the banking system.

Foreign Exchange Rate Risk: Direct Effects on Banks with Net Open FX Positions

50. A separate sensitivity test assessed how banks would be affected by *market* risk in a scenario with dirham depreciation. Setting the effect of the dirham depreciation on credit losses aside, separate sensitivity tests were undertaken to assess how profits would be affected as a result of banks' net open foreign currency exposures. Liabilities denominated in foreign currency outweigh foreign currency- denominated assets in 3 of the 8 banks. However, for the banking system as a whole, the net open FX position is positive and equivalent to 0.25 percent of assets. The test indicates that a 30 percent depreciation of the dirham nominal effective exchange rate would increase the CAR in the system by 0.1 percentage points. This shock, taken in isolation, would worsen the undercapitalization in one bank.

51. Market risk losses are broadly in line in both top-down and bottom-up stress tests. Unlike the estimated credit risk losses on the loan book, losses related to market risk factors are roughly similar in the top-down and bottom-up stress tests. Most of the differences in the estimated losses are mainly explained by the way in which individual banks translated the assumptions into effective risk parameters used in their stress tests.

F. Concentration Risk: Failure of a Number of Large Corporate Exposures

52. Name concentration risk was tested by assessing the impact of the default of the largest exposures. Supervisory data on the largest bank exposures were used to perform this sensitivity analysis type of stress test. The test assesses the impact of the hypothetical default of the

[20] We noted above that, in contrast to macroeconomic tests, sensitivity tests are "static." However, the credit risk model used to assess the effect of a rise in interest rates on NPL ratios is dynamic and estimated based on quarterly data. This implies that the interest rate effects are fully transmitted to NPL ratios only with the passage of time. These tests are still considered "static" because banks' balance sheets do not adjust over time, and are taken as observed in December 2014.

(continued)

1 to 3 largest borrowers, and computes the implied losses for various assumptions on the recovery rate.[21] In our first scenario, we used a recovery rate of 27.9 percent, taken from the latest World Bank "Doing Business" report, but alternative assumptions were also made.

53. Sensitivity test shows that credit concentration remains one of the largest risks in the banking system. On average, the size of the gross largest exposure (after application of the conversion factors) is moderate at 12.2 percent of total regulatory capital. Typically, the largest exposures are state-owned enterprises which do not provide collateral because they are deemed to benefit from the implicit guarantee from the government. However, the stress test results show that the losses in case of defaults at the system level would be significant. Under the 27.9 percent recovery rate assumption on collateral, the default by the largest exposure of each bank in the system would cause undercapitalization in four banks, and imply a capital shortfall of 6.6 bn dirham (0.7 percent of GDP). With a simultaneous default by the three largest exposures in each bank, every bank would become undercapitalized. The total capital shortfall in this case would amount to 22.3 bn dirham, equivalent to 2.4 percent of GDP or 17.1 percent of the banking system's capital. In terms of Tier 1 capital, no bank would have a ratio below the regulatory intervention threshold of 6.5 percent in the event of the failure of the largest exposure and two banks would be below 6.5 percent in the event of the failure of the three largest exposures.

54. Under the most extreme scenario with a zero recovery rate, the results would not change much. The default of the largest exposure of each bank in the system would cause four banks to become undercapitalized, implying a capital shortfall of 6.9bn dirham (0.8 percent of GDP). Following a simultaneous default by the three largest exposures in each bank, the total capital shortfall would amount to 27.1 bn dirham, equivalent to 3.0 percent of GDP or 20.8 percent of the banking system's capital. In terms of Tier 1 capital, no bank would have a ratio below the regulatory intervention threshold of 6.5 percent in the event of the failure of the largest exposure and three banks would be below 6.5 percent in the event of the failure of the three largest exposures. Although banks' loan portfolios exhibit a very high degree of concentration that exacerbates credit risks, the haircut of 100 percent on collateral valuation in stress periods results in an admittedly very conservative scenario but is in line with international practices in the area of large exposures.[22]

55. Top-down concentration risks risk losses calculated by the IMF are larger than the bottom-up losses estimated by the banks. Indeed, banks took into account the impact of the change in their provisions on their large exposures on their tax payment, which was not done in the IMF sensitivity test.

[21] In line with Basel II framework but in contrast with the other sensitivity tests conducted for this FSAP, the provisions on large exposures were deducted from the RWAs for the concentration risk sensitivity test as the Moroccan regulation requires impaired large exposures to be full provisioned (provisioning rate of 100 percent).

[22] See Basel Committee on Banking Supervision (2013), "Supervisory framework for measuring and controlling large exposures" (Consultative Document), June

(continued)

LIQUIDITY STRESS TESTS

56. Liquidity stress tests were based on Basel III Liquidity Coverage Ratio (LCR). The LCR measures the bank's ability to meet its liquidity needs in a 30 calendar day liquidity stress scenario by using a stock of unencumbered high-quality liquid assets (HQLA).[23] Banks should maintain an LCR above 100 percent. Specific deposit run-off rates, roll-off rates for cash inflows and assets haircuts are included to simulate stressed conditions in three different scenarios.

57. Top-down liquidity stress tests were conducted jointly by the FSAP team and BAM staff. Cash-flow based liquidity stress tests were implemented through a Top-Down approach, using supervisory information on maturity structures of assets and liabilities at December 2014. The tests were carried out at the aggregate level, i.e., combining every currency including the dirham, as foreign currency-denominated liabilities make up a small part of total liabilities (6.2 percent). These tests assessed banks' resilience to strong shocks characterized by run-off rates on funding sources calibrated by type, and liquidation of assets subject to valuation haircuts. Specifically, the exercise captured (i) a bank's liquidity need derived from outflows, (ii) its available standby liquidity from inflows, and (iii) its buffers available to counterbalance liquidity gaps. The analysis also included an alternative more severe scenario in terms of deposit withdrawals and a third scenario featuring a dry-up of unsecured wholesale funding. It should be noted that common practice in FSAPs is to implement the liquidity tests assuming an underlying environment in which funding pressures are sizeable but limited to a number of banks (not systemic).[24]

58. Liquidity stress tests assumed various deposit run-off rates, roll-off rates for cash inflows and asset haircuts. These rates, together with the assumed asset haircuts, are presented in Table 9. Potential sources of funding pressures for banks consist mainly of deposits from individuals, businesses, and large corporations. Cash outflows are generated by the need to pay contracted and contingent liabilities under specific assumptions regarding the capacity of banks to re-issue liabilities in adverse conditions. The funding structure of the banking system (excluding capital and including contingent credit lines), can be described as follows:

- 45 percent of funding comes from retail sight and time deposits (due with physical persons);
- 27 percent is funding due with legal entities, in particular with small businesses (8 percent), and nonfinancial corporate, sovereigns, central banks, multilateral development banks (4.9 percent);
- 11.4 percent of funding is accounted for by undrawn but committed credit and liquidity facilities;
- 3 percent of other deposits.

[23] See Basel Committee on Banking Supervision (2013), "Basel III: The Liquidity Coverage Ratio and liquidity risk monitoring tools", January

[24] The underlying environment in which a bank's resilience to liquidity shocks is tested should affect the calibration of deposit run-off rates and asset haircuts. Under generalized banking panics – bank runs affecting many banks, including important ones - the scramble for liquidity usually results in fire sales of assets, and hence, larger haircuts. Similarly, run-off rates on deposits should be higher when a panic sets in and triggers widespread bank runs.

59. Funding pressures were captured through specific time profiles of run-off rates for different funding sources. A set of general principles guided the choice of run-off rates for the computation of the Basel III LCR. First, more informed and sophisticated depositors withdraw funding more rapidly than less informed ones, that is why run-off rates applied to wholesale funding sources are higher than those applied to retail funding sources. Second, run-off rates on secured funding sources are lower than those applied to unsecured funding sources.

Table 9. Morocco: Liquidity Stress Test Assumptions on Run-off, Roll-off Rates and Haircuts (in percent)

	LCR - Basel III	FSAP scenario with larger deposit withdrawals	Dry-up of unsecured wholesale funding
Run-off rates on potential *outflows*			
Deposits: Households	5-10	10-15	5-10
Deposits: Corporates	5-40	10-60	5-100
Deposits: Interbank	100	100	100
Non-deposit liabilities maturing in 1 month	25-100	25-100	100
Total contingent commitments	5-100	5-100	5-100
Roll-off rates on cash *inflows*			
Level 1 assets	0	5	0
Level 2a assets	15	30	15
Level 2b assets	25-50	50-100	25-50
Margin lending backed by all other collateral	50	75	50
All other assets	100	100	100
Other inflows, by counterparty			
Retail counterparties	50	75	50
Nonfinancial wholesale counterparties	50	100	50
Financial institutions and central banks	100	100	100
Haircuts on liquidity *buffers*			
Cash	0	0	0
Central bank instruments	0	0	0
Government securites eligible as collateral	15	15	15
Required reserves on deposits	0	0	0
Interbank claims with less than 1 month maturity	100	100	100
Loans (performing) maturing in 1 month	50	50	50
Monthy repayments on loans with maturities greater than 1 month	50	50	50
Other assets maturing in 1 month	50	50	50

Sources: BCBS (2013) and IMF proposals.

60. Banks' standby liquidity inflows stem mostly from maturing loans, deposits and credit facilities. Assets that can generate cash inflows over one month include: maturing loans from retail counterparties (35 percent), and level 1 assets (16 percent).

61. For different assets and maturity buckets, specific roll-off rates were applied to convert the maturing amounts into cash inflows. Specifically, 50 percent rates were applied to inflows from retail and nonfinancial wholesale counterparties, i.e., to performing loans to non-financial customers, and 100 percent rates were applied to maturing loans to financial institutions. These represent the cash inflows that a bank can generate under the going concern assumption: its actions do not compromise banking relations with important borrowers and cause no significant business disruptions.

62. Banks can counterbalance negative funding gaps by using their cash holdings and the standing facilities of BAM. Banks' ability to convert dirham government securities into cash is limited due to the imperfectly liquid nature of the secondary market. In the tests, banks were allowed to cover negative balances of cash inflows relative to cash outflows by using their sovereign securities as collateral to obtain liquidity through the standard BAM lending facilities – weekly repo operations or the more expensive overnight loans. At the banking system level, liquid assets make up 11 percent of total assets (including both on- and off-balance sheet items).

63. The global liquidity stress tests reveal that two banks in the system would be exposed to liquidity risks in the event of large deposit withdrawals (Table 10 and Figure 8). Liquidity stress test results suggest that aggregate LCR using the Basel III methodology is 124 percent at end-December 2014. Every bank passed the 60 percent hurdle rate, which is the initial rate imposed by national regulation in 2015 according to the LCR phase-in agenda. If a hurdle rate of 100 percent is taken as a benchmark, two banks, making up 24.1 percent of the banking system's assets, present a liquidity shortfall amounting to 1.9 bn dirham, equivalent to 0.8 percent of these banks' assets. These results compare with an LCR calculated according to the national regulation of 130 percent at end-December 2014. The differences with the FSAP liquidity stress test result from slight differences in the treatment of money market mutual fund shares in the calculation of liquid assets.

64. In the first alternative more adverse scenario, six banks would see their LCR fall below 100 percent. Higher run-off rates were applied in this scenario, especially to retail deposits, as well as higher roll-off rates for cash inflows. Indeed, the LCR standard establishes a minimum level of liquidity, but national authorities may impose higher minimum requirements. However, it should be noted that the parameters of this scenario are very severe with regard to the low volatility of deposits in Morocco historically, even for non-guaranteed deposits. Under this adverse scenario, banks lose 10 to 15 percent of their retail deposits, including sight deposits and term deposits with a residual maturity below 30 days, and 10 to 60 percent of their non-financial corporate deposits in a month. The results of this adverse liquidity stress test suggest that aggregate LCR would fall to 69 percent. Six banks, making up 89 percent of the system's assets (including both on- and off-balance sheet items), would present a liquidity shortfall amounting to 53.7 bn dirham, equivalent to 5.9 percent of these banks' assets.

65. The second adverse scenario including a dry-up of unsecured wholesale funding provides similar results. Banks were assumed to face 100 percent run-off rates on unsecured wholesale funding, including corporate deposits other than from SMEs. The results show that 7 banks, making up 95 percent of the system's assets, would experience a shortfall of liquid assets in such an aggressive withdrawal of liquidity. The aggregate LCR would fall to 67 percent. The total liquidity shortfall would amount to 56 bn dirham, equivalent to 5.7 percent of these banks' assets.

Table 10. Morocco: Summary of the Liquidity Stress Test Results

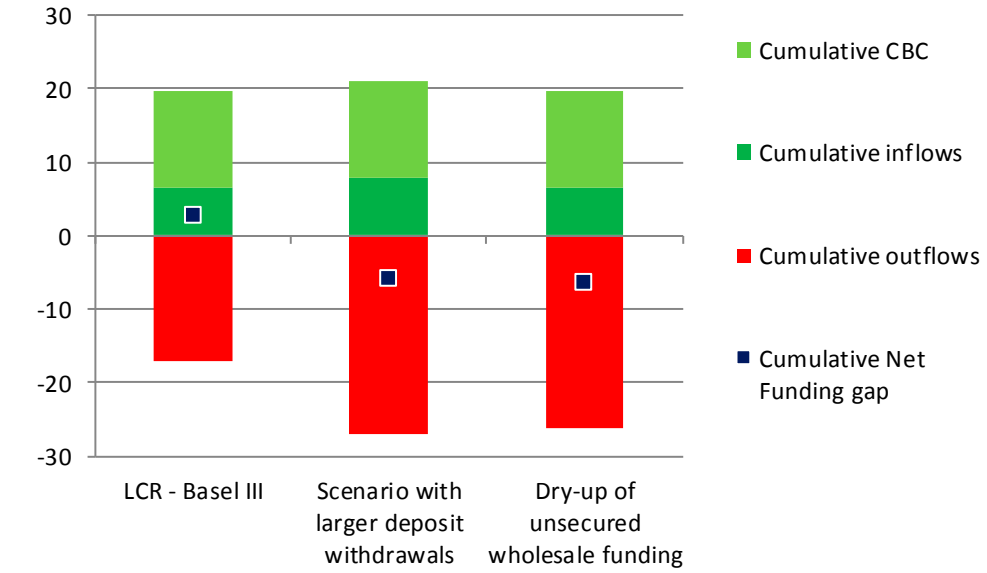
(in billions of dirhams, unless otherwise stated)

	LCR - Basel III	Scenario with larger deposit withdrawals	Dry-up of unsecured wholesale funding
Liquid assets	113.9	113.9	113.9
Potential net outflows	92.0	165.9	169.6
System-wide LCR (in percent)	124	69	67
Liquidity shortfall 1/	1.9	53.7	56.0
Number of banks with LCR<100 percent	2	6	7

Sources: IMF staff and BAM calculations.
Note: 1/ Liquidity shortfall is the amount required so that the LCR in each bank in the system be equal to or above 100 percent.

Figure 8. Morocco: Bank Liquidity Stress Test Results, Cumulative Inflows, Outflows, Net Funding Gap, and Use of Counterbalancing Capacity

(In percent of Outstanding Non-Equity Liabilities)



Sources: BAM and IMF staff

CONTAGION RISKS

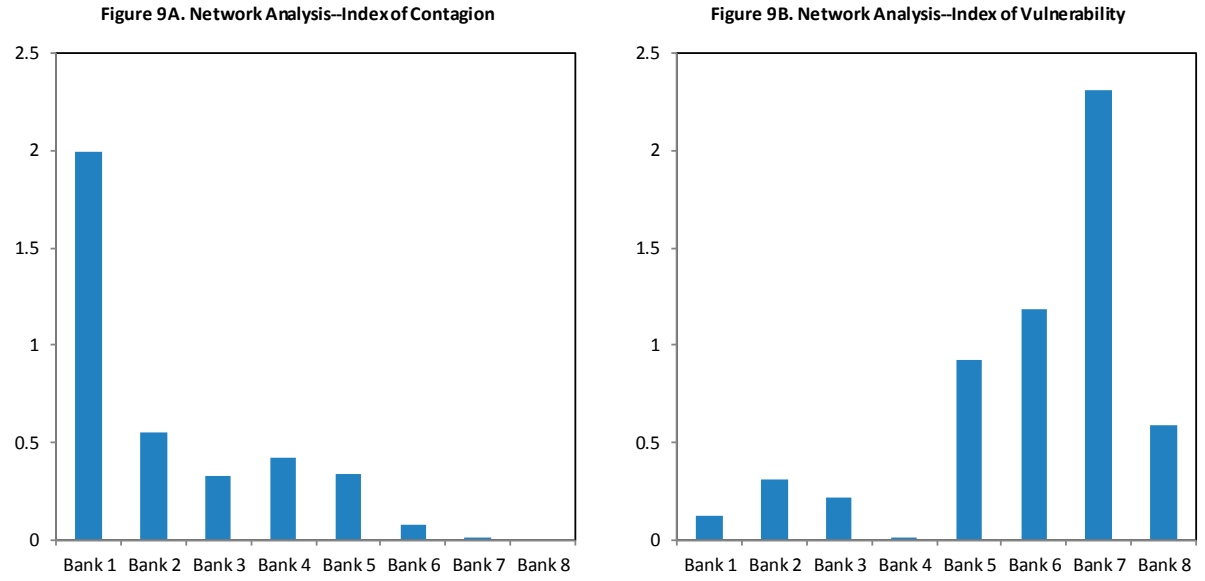
A. Domestic Interbank Contagion Risks

66. Domestic interbank contagion risks were assessed using a network model of contagion based on Espinosa-Vega and Solé (2010). The analysis is based on a matrix of bilateral domestic interbank gross exposures to the 8 banks composing our sample, with information as of end-December 2014.[25] Interbank exposures are composed of overnight unsecured positions, repo transactions and term deposits. The analysis includes pure contagion arising from default of institutions – whereby failure of a bank triggers direct credit and capital losses in other banks. The stress test assumes the hypothetical default of each bank, one at a time, on all its interbank obligations, and assesses the impact on other banks. If the default of any given bank on its interbank obligations implies the default of another bank in the system, a subsequent round must be calculated in order to assess the impact of the second bank's default on all other banks, and so on (i.e., "cascade effects"). The analysis also considered the possibility of contagion stemming from the combined effects of default and the subsequent fire sales caused by funding shocks. In this case, in addition to the direct loss of capital, a bank needs to replace a fraction of the funding lost due to the default. It does so by selling other assets at deep discounts in the market, and these fire sales cause further losses of capital.

67. The analysis reveals that contagion risks stemming from domestic interbank exposures are very limited. In Morocco, domestic interbank positions are found to be small, especially compared to banks' capitalization. For every bank in the system, the sum of all its domestic interbank exposures is smaller than its regulatory capital. No single failure of a domestic bank would trigger the failure of another bank, and thus no" cascade effect" would take place through the interbank market (Figure 9). As of end-December 2014, only one of the 8 banks of the sample is found to be slightly undercapitalized with regard to the regulatory minimum after a shock on one or several of its domestic interbank exposures. If the possibility of contagion stemming from the combined effects of default and the subsequent fire sales caused by funding shocks is introduced (assuming a 50 percent haircut in the fire sale of assets and a 65 percent roll-over ratio of interbank debt), the picture is little changed.

[25] In a system with 8 banks, the interbank exposure matrix is a square matrix of size 8x8.

Figure 9. Morocco: Bank Network Model Results (No Funding Shock)



Sources: BAM and IMF staff estimates based on Espinosa-Vega and Sole (2010).

B. Domestic Bank-Insurer Contagion Risks

68. An additional contagion stress test was carried out based on the interlinkages between Moroccan banks and insurance companies. In order to assess the degree of vulnerability of the largest Moroccan financial institutions stemming from the interconnectedness within the financial system, the analysis was complemented by the computation of a matrix of bilateral domestic gross exposures between the 8 previous banks and the 5 largest Moroccan insurance companies, including data on capital cross-participation, bonds, credit and deposits. As before, the analysis included pure contagion arising from default of institutions – whereby failure of a financial institution triggers direct credit and capital losses in other institutions.

69. The analysis shows that several Moroccan insurance companies would be vulnerable to bank failures but not the other way round. Whereas for every bank in the system, the sum of all the domestic exposures to both other banks and insurance companies is smaller than its regulatory capital, this sum is higher than capital for the five insurance companies. The isolated failure of six domestic banks would trigger the failure of one to three insurance companies, with four insurance companies being at risk of failure, but only one contagion round would take place through the financial system. By contrast, no single failure of a domestic insurance company would trigger the failure of another financial institution. The index of contagion, corresponding to the average percentage of loss of other institutions due to the failure a single institution, ranges between 0 and 4.46 percent, the highest index of contagion being associated with a bank. Moreover,

the index of vulnerability, which is the percentage of loss at a single institution due to the default of all other institutions, ranges between 0 and 39.5 percent, the highest index of vulnerability being associated with an insurance company. The higher vulnerability of insurance companies to interconnectedness and the higher systemic importance of banks stem from the fact that the exposures of insurance companies to banks are much larger relatively to their balance sheets (17 percent of total assets approximately) than the exposures of banks to insurance companies (0.2 percent of banks' total assets). As a consequence, as of end-December 2014, only one of the 8 banks of the sample is found to be slightly undercapitalized with regard to the regulatory minimum after a shock on one or several of its domestic exposures to insurance companies.

70. The introduction of the combined effects of default and funding shocks leads two more banks to become undercapitalized following the failure of an insurance company. In this case, assuming again a 50 percent haircut in the fire sale of assets and a 65 percent roll-over ratio of interbank debt, the index of contagion of three insurance companies would increase significantly, but the index of contagion would remain on average much higher at banks, and the index of vulnerability much higher at insurance companies (Figure 10).

Figure 10. Morocco: Bank- Insurance Companies Network Model Results (Combined Effects of Defaults and Funding Shocks)

Figure 10A. Network Analysis--Number of Induced Failures

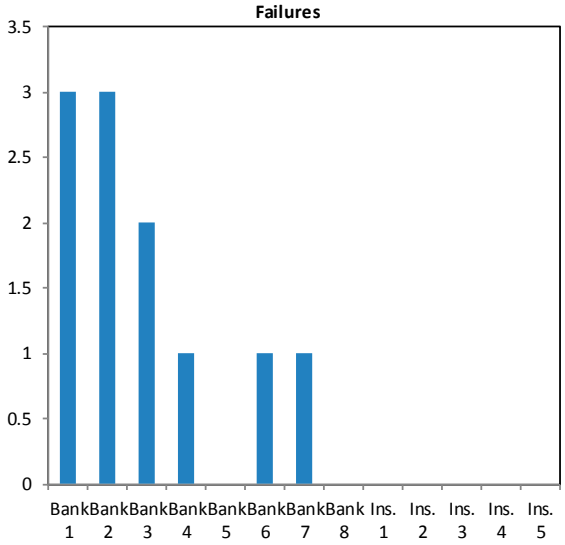


Figure 10B.Network Analysis--Vulnerability Level

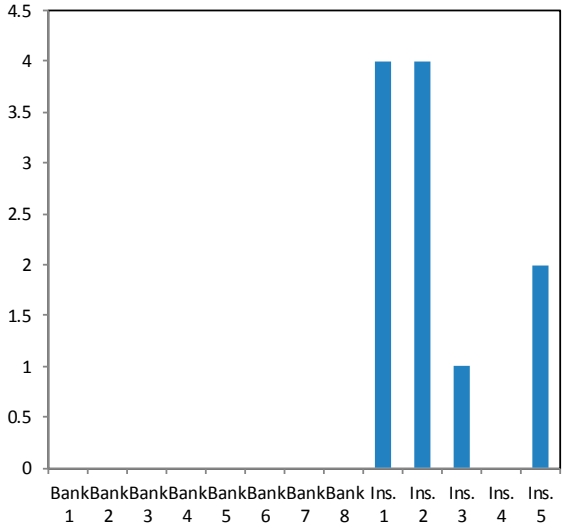


Figure 10C. Network Analysis--Index of Contagion

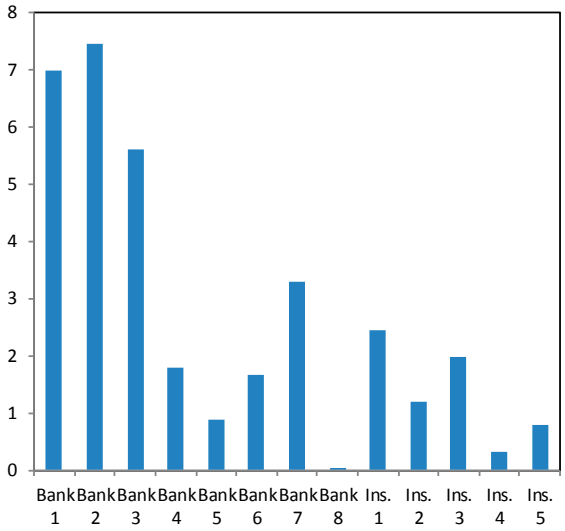
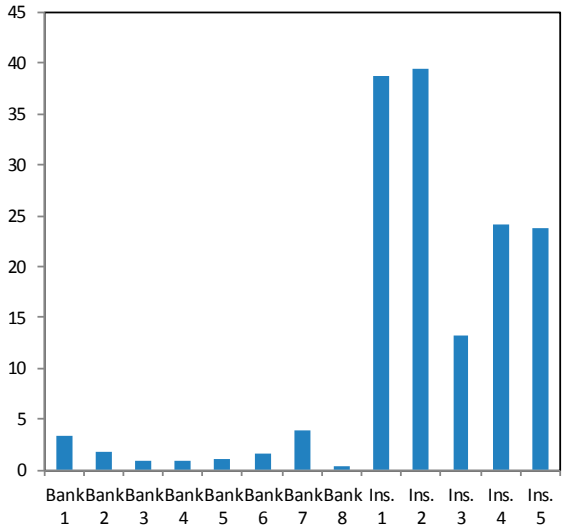


Figure 10D. Network Analysis--Index of Vulnerability



Sources: BAM and IMF staff estimates based on Espinosa-Vega and Sole (2010).

C. Market Price-Based Stress Test Using Contingent Claims Analysis (CCA)

71. CCA can be used to calculate the implied market value of assets, asset volatility and expected default probabilities. Equity and equity volatility are consensus forecasts of market participants and this provides forward-looking information. For the calibration of the risk adjusted balance sheet, the market value of equity, the volatility of equity, and the default barrier (calculated from book liabilities) are used as inputs into two equations in order to calculate the two unknowns, the implied asset value and implied asset volatility. Once the market value of assets and asset volatility are estimated the default probabilities and expected losses can be calculated. Moody's CreditEdge is a database that uses this mapping process to calculate expected default frequencies (EDFs) for tens of thousands of firms and financial institutions in 60 countries. This data was used for the five Moroccan banks and four insurers (See Appendix IV for details on CCA).

Linking Macro Variables to Financials Institutions' CCA Outputs – Methodology

72. EDFs for Morocco's five largest banks and four largest insurances companies are estimated using macro variables. The macro variables are interpolated to monthly using quadratic match sum method. The analysis used the monthly average of the EDF, obtaining a sample at the size of 127 observations at the minimum and 133 at the maximum (2004M1-2014M12). The macro variables considered were the GDP growth (log level of real GDP), inflation (log level of CPI), BAM's one-year Treasury interest rate (annual rates), foreign direct investment (level), remittances (level) and the one month lag of EDF. To avoid forecasting negative value of EDF, Distance to distress (DD) is estimated in econometric analysis and forecast and then transformed to EDF using returns at a one-tailed probability from the standardized Normal distribution. The analysis used least squares regression estimation procedure to link the macro factors to the EDFs of banking and insurance sectors. Three different levels of EDF are estimated based on Baseline scenarios and adverse scenario (*V- shaped GDP growth*). The results show:

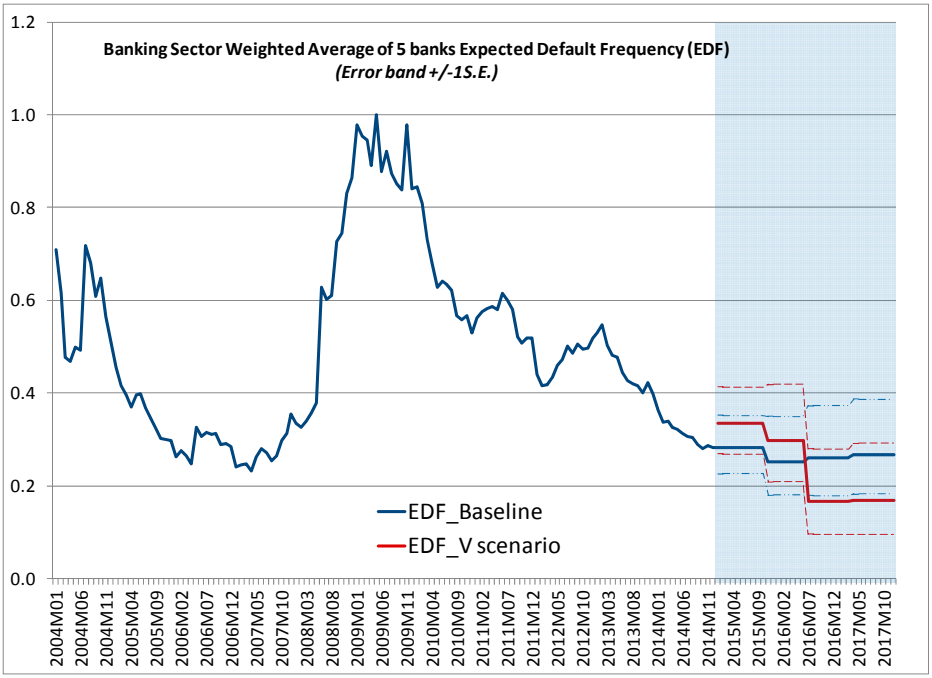
Banking Sector Changes in EDF

73. An increase in EDF is positively associated with inflation and remittances, and coefficients are statistically significant. Higher inflation with higher EDF seems convincing, while the positive relation between EDF and remittances needs further investigations, but the coefficient for remittances is very small. Increase in one-year Treasury bill rate is associated with higher EDF, which economically makes sense, however it is statistically insignificant. Increase in real GDP and FDI are associated with lower EDF, which seems sensible and coefficients are significant for real GDP. Banking sector EDF changes estimated from *adverse scenario* seem to move in the valid directions. Strong significance of the one month lagged value of dependent variable (distance to distress) indicates some degree of market memory and strong measure of persistence in the model. Market value assets were used to calculate the weighted average of five banks and the EDFs were projected for all five banks until the end of 2017, for baseline and one stress scenario. A one-standard-error-of-the prediction confidence interval was calculated for each institution forecast. EDF and ratings are related and less than 0.57 percent of EDF is considered *safe zone* as investment grade (Appendix V. Table 3). Morocco's analysis suggests that upper bounds of adverse scenarios are

around 0.4 percent, borderline between investment and noninvestment grade, largely indicating a pretty resilient system.

Figure 11. Morocco: Banking Sector Weighted Average of 5 Banks Expected Default Frequency (EDF)

(Error band +/-1S.E.)



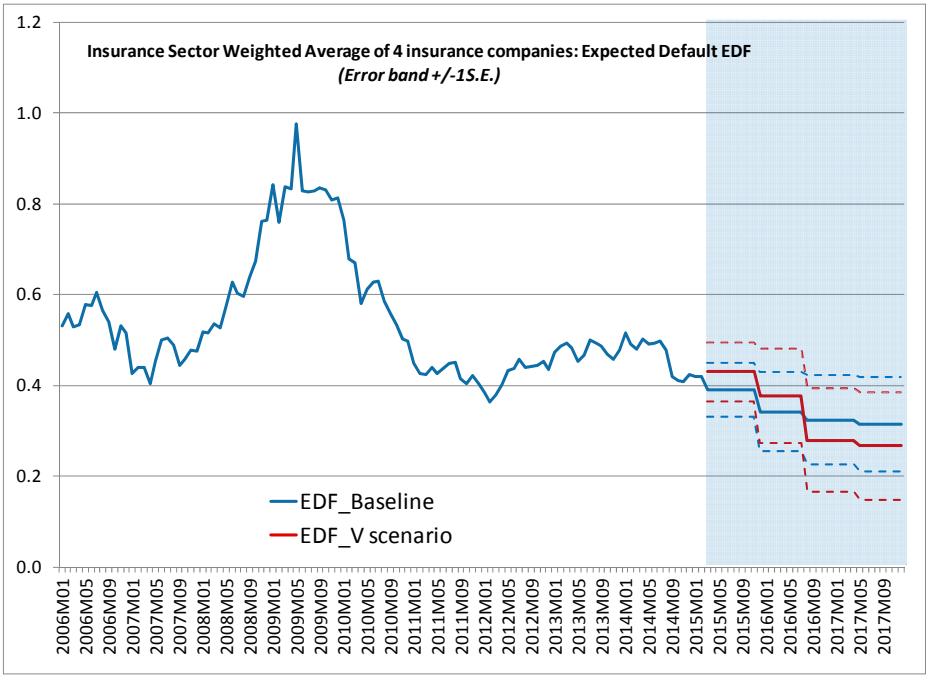
Source: IMF staff calculations.

Insurance Sector Changes in EDF

74. An increase in insurance sector's EDF is positively associated with inflation and FDIs, and coefficients are statistically significant for inflation. Higher inflation with higher EDF seems convincing, while coefficient for FDI is small and statistically insignificant. Increase in one-year Treasury bill rate is associated with higher EDF, which makes sense, however it is statistically insignificant. Increase in real GDP and remittances are associated with lower EDF, which seems sensible and coefficients are significant for real GDP while the effect of remittances is insignificant. Insurance sector EDF changes estimated from *adverse scenario* until 2017 seem to move in the compelling directions. Strong significance of the one month lagged value of dependent variable (distance to distress) indicates some degree of market memory and strong measure of persistence in the model. Market value assets were used to calculate the weighted average of four insurance companies and the EDFs were projected for all four insurers until the end of 2017, for baseline and one stress scenario. A one-standard-error-of-the prediction confidence interval was calculated for each institution forecast. EDF and ratings are related and less than 0.57 percent of EDF is considered *safe zone* as investment grade (Appendix V. Table 3). Morocco's case suggests that upper bounds of

adverse scenarios are around 0.49 percent, borderline between investment (BBB-) and noninvestment grade (BB+), indicating a largely resilient system.

Figure 12. Morocco: Insurance Sector Weighted Average of 4 Insurance Companies' Expected Default Frequency (EDF)
(Error band +/-1S.E.)



Source: IMF staff calculations.

75. Stress tests using the CCA balance sheets and EDFs come with some caveats. The CCA stress tests rely on historical relationships of macro data to EDF. Such relationships may not be representative of future relationships (i.e., there is model risk). The EDF estimates incorporate forward looking equity information but there may be instances of less than liquid equity markets or over/under shooting. Going forward, improvements and refinements in CCA stress testing procedures should be continued.

76. Interconnectedness between banks and insurers can be assessed using CCA. The approach proposed here is a market-based network model which assesses the directionality of network connectivity by applying bivariate Granger-Causality tests to the (first differenced) pairs of default probabilities for a given time period. The default probabilities for the five banks and four insurers in Morocco come from the CCA model described below. Granger-Causality tests are performed on first differenced time series in order to satisfy a prerequisite stationary hypothesis that is posited in the mathematical theory underlying the test. The attractive feature of using Granger-

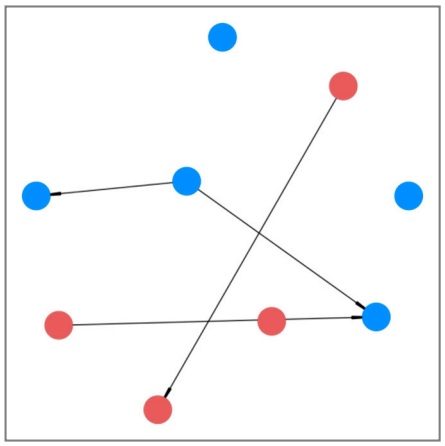
Causality tests is that their results can be asymmetric (i.e., Institution A may "granger-cause"[26] Institution B, but not necessarily vice versa), thereby allowing one to assign a direction to the "granger-causation." This asymmetry is simply not true of correlation-based tests because correlation is, by definition, a two-way street. The Granger-Causality tests will be performed for specific time periods. During the financial crisis period, the number of connections increases sharply for both the default probability and asset volatility networks. Banks affect insurers and vice versa. Patterns between the default probability and volatility networks are similar. Post crisis the interconnections are still relatively high as compared to pre-crisis. Banks and insurers appear to affect each other. This could be due to indirect connection.

77. Granger Causality networks were estimated between Moroccan banks and insurers. This analysis is traditional granger-causality and translated in graphs for both the EDF Expected Default Probability and the CCA asset volatility time series for each of three historical time periods. The time periods are: pre-global financial crisis: 5/2005 - 5/2008, the global financial crisis period: 6/2008 - 6/2011, and the recent period: 7/2011 - 12/31/2014. Monthly data was used. A significance level of 5 percent and a lag order of 2 were used for all tests. Monthly changes in the EDF and the asset volatilities were used. The one way arrows show that one institution's EDF affects ("granger causes") the other institutions' EDF at the point of the arrow. If there are two arrow points on the line, there is two-way bivariate granger causality. And a lag order of 2 months was used for all GC graphs with significance of 5 percent. A lag order of 2 was specifically chosen because this appeared to produce the best information criteria scores for the underlying VARs used in the tests. The results for the three time periods are shown in the six graphs in Figure 13.

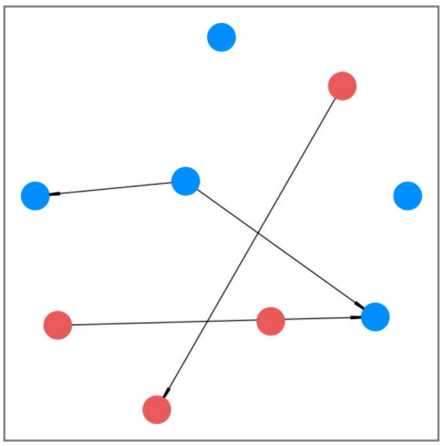
[26] In the context of this technical note, this relationship can intuitively be interpreted in the following manner: when a sector is granger-causing another sector, past information about the behavior of the first sector can help predict the future behavior of the second sector. When two sectors mutually granger-cause each other (exhibit feedback), this is a special case in which the flow of predictive information runs in both directions.

Figure 13. Morocco: Granger Causality Networks Between Moroccan Banks and Insurers

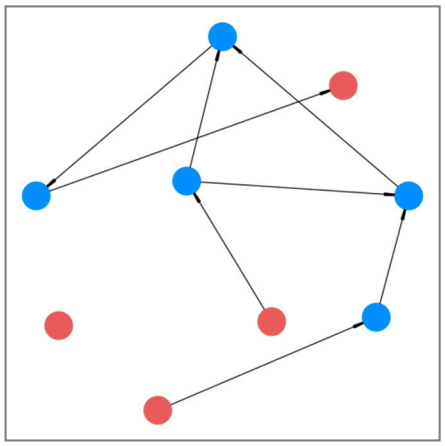
Period 1. GC Default Probability Network
5/2005 - 5/2008



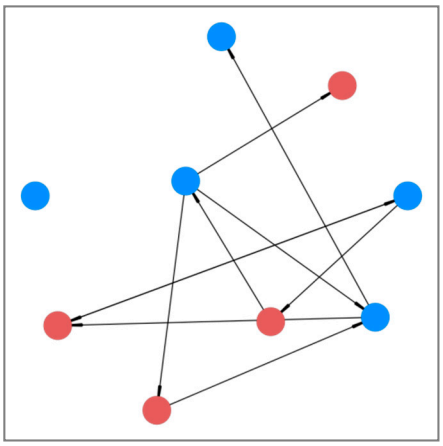
Period 1. GC Volatility Network
5/2005 - 5/2008



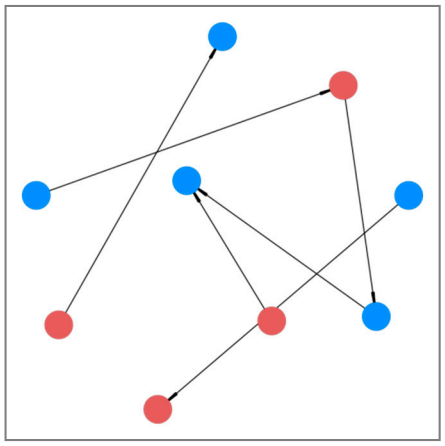
Period 2. GC Default Probability Network
6/2008 – 6/2011



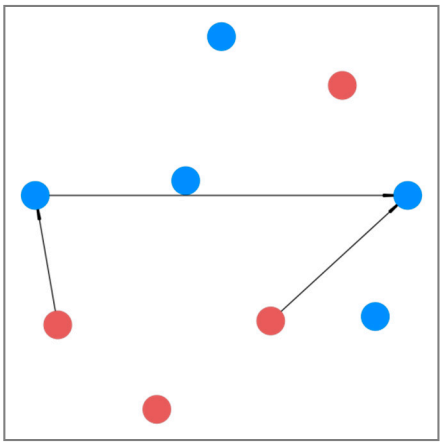
Period 2. GC Volatility Network
6/2008 – 6/2011



Period 3. GC Default Probability Network
7/2011 – 12/2014



Period 3. GC Volatility Network
7/2011 – 12/2014



Sources: CreditEdge and authors' estimates.

D. Cross-Border Contagion Risks

78. This section examines how cross-border contagion would impact the stability of the Moroccan banking system. For the simulation of the scenarios, two separate initial conditioning events (shocks) were considered:

- ***European banks' impact on their subsidiaries in Morocco*:** Global liquidity strains with tight credit market in Europe spill over to a Moroccan subsidiary facing a reduced funding from Europe and trigger potential fire sales of assets to obtain liquidity.

- ***African subsidiaries' impact on their parent banks in Morocco*:** Moroccan banks' subsidiaries in Africa experience severe stress (political crisis, sudden fall in commodity prices- cacao and oil) and default on their loans from Moroccan parent banks.

Stress Test Modalities

79. Stress test examined the direct bilateral exposure between the parent banks and the subsidiaries through the channel of capital, deposits and credits (Cihak (2007) and Espinosa-Vega and Solé (2010)). To examine the impact from the Moroccan banks' exposure to Europe, the test looked at the funding flows from Europe to Moroccan subsidiaries to identify any looming liquidity risks. To examine the impact from the Moroccan banks' exposure to Africa, the test looked at the direct credits from Morocco to each African subsidiary to discover any imminent credit risks.

80. The liquidity risk test simulates a forced sale by a bank of part of its assets when liquidity is tight and in the absence of alternative sources of funding, in order to restore its balance sheet stability. A bank is able to replace only a fraction of the lost funding and its assets trade at a discount (i.e., their market value is less than their book value). We exclude the possibility of institutions raising new capital, and assume that the loss induced by a funding shortfall is absorbed by the bank's capital. Therefore, a bank's vulnerability not only stems from its direct credit exposures to other institutions, but also from its inability to roll over (part of) its funding from abroad, thus having to sell assets at a discount in order to re-establish its balance sheet identity.

81. The credit risk test assumes that if a bank's capital stays above the regulatory hurdle of 12 percent after iteration, the bank does not fail and remains able to repay all its intra-group obligations. By contrast, if its capital falls below prudential requirements, it fails and does not repay its obligations. The calculation can be made more realistic by estimating a more complex mapping between the capital adequacy ratio, nonperforming loans level and the bank's probability of failure, but this analysis did not apply that mapping due to the data limitations at this stage. To keep the calculations straightforward, we assume here that the impact of shocks (losses) is deducted directly from capital. The stress test is run in several iterations, as the contagion-induced failures ("first iteration") can induce failures in other subsidiaries ("second iteration"), which can lead to further failures ("third iteration"), and so on. Then the test examined the bilateral direct exposure between the subsidiaries to check the cascade impact to identify any systemic risk in the region.

Findings

82. European banks' impact on their subsidiaries in Morocco: there will be minimum impact on the Moroccan banking system from potential funding and contagion stress based on network analysis. Under the strong emphasis to keep the funding locally from French banking system principles, Moroccan banks' funding is locally generated mostly based on local deposits in domestic currencies and Moroccan banks do not depend on cross-border funding. Even when parent banks experienced liquidity difficulty during the liquidity crisis in Europe, the Moroccan banks' funding was not affected from the global liquidity crisis. Data suggested that two French subsidiaries have no funding flows from parent banks and only one bank shows small deposits from its parent bank, as a form of subordinate loans, which comprises 1.8 percent of total deposits. Therefore, the test did not find any bank under liquidity distress nor detect systemic imminent liquidity risks.

83. African subsidiaries' impact on their parent banks in Morocco: the risks of cross-border spillovers into Morocco from the direct exposure from the African region appear limited. The network contagion analysis finds that there is marginal direct exposure between Moroccan banks and African subsidiaries in terms of credits or deposits. The results suggest that the risk that Africa's severe distress affecting the Moroccan banks is marginal. The impact amounts to around 1 percent of regulatory capital of three banks, and the impact on the capital adequacy ratio (CAR) is negligible. There is very little cross-border exposure between the subsidiaries in Africa at the moment, thus the analysis suggests no systemic impact in the region when one country or region experiences severe stress from political crisis or commodity price fall. Based on the volume of transactions, Tunisia and Ivory Coast appear to have the most impact on the Moroccan banks on average. Stress test also examined other spillover channel of direct capital loss from failed subsidiaries. When the test simulated a scenario where Moroccan banks step up to provide 50 percent capital loss of three major subsidiaries for each bank, impacts are still limited since capital invested in each subsidiary is a small fraction in their total capital. Only one bank will have CAR declined from 12.2 percent to 11.9 percent when Moroccan parent bank steps up to provide 50 percent of capital loss in failed subsidiary. This test revealed that Moroccan banks have adequate level of capital to absorb the severe loss from the subsidiaries, and have capacity to implement an orderly resolution that minimizes the impact on regional financial stability.

Caveats

84. This analysis looked only at direct bilateral exposure between the parent banks and subsidiaries due to the data limitation at this stage. However, according to the preliminary data collection and discussions with BAM, the indirect exposure through offshore banks is larger than direct exposure. Collecting data on indirect exposure, contingent liabilities, each parent bank's provisioning rate and risk weight on cross-border lending,[27] subsidiaries' CAR, nonperforming loans,

[27] Under BAM's supervision, each bank currently calculates provisioning rates for cross-border lending, reflecting specific country risk, borrower's capacity to repay, past actual experiences and overdue status, etc.

largest single borrower information, and host countries' macroeconomic time series and mapping them is likely to indicate a more precise picture for contagion than the initial calculation presented here. Moreover, with increasing cross-border operations in insurance sector, the FSAP team believes it is essential to include a thorough assessment of insurance sectors' cross-border financial services into the supervisory practice to mitigate any future risks.

CONCLUSION

85. Stress test assessed the stability of the banking sector in Morocco. Top-down stress test performed by the FSAP team and BAM staff assessed the solvency and liquidity positions of the overwhelming part of the banking system. These stress tests were complemented by bottom-up stress tests, carried out by eight banks operating in the country, using their own internal methodology, guidelines received from BAM, expert judgment applied to the macroeconomic scenarios provided by the FSAP team and BAM, and NPL projections provided by the two institutions.

86. The quantitative analysis included macroeconomic scenario-based stress tests, complemented by sensitivity analysis. Scenario-based stress tests used two full-fledged macroeconomic scenarios (one baseline and one adverse scenario) to assess the solvency of the banking system. These stress tests included comprehensive risk coverage, analyzing risk factors such as: credit risk in the loan book, market risk effects on interest income and valuation effects on the debt instrument holdings, and exchange rate related risks, among others. Sensitivity analysis to assess potential concentration risks, and risk of contagion through the interbank market, between banks and insurers, and between Moroccan banks and their foreign subsidiaries were also performed. Finally, liquidity stress tests were carried out to assess the overall liquidity positions of the banks.

87. The main results of the stress tests are the following:

- The solvency stress test results testify to the resilience of the banking system. Despite a sharp downturn in growth under the adverse scenario, only one bank (representing 6.1 percent of banking system assets) would see its CAR and Tier 1 capital ratio falling to 10.0 percent and 7.5 percent, respectively. These positive results, even in a more severe adverse scenario (with no growth in two years following the downturn), reflect mainly the relatively comfortable initial capitalization and profitability.

- Still, credit risk in the loan book is by far the most significant risk factor on the banks' balance sheets. Loan quality is found to be very sensitive to real interest rates and, to a lesser extent, to GDP, FDI and remittances growth, with the NPL ratio expected to rise by 7.7 percentage points to 14.8 percent in 2016 under the V-shaped negative scenario.

- Liquidity tests show that most banks in the system would be exposed to liquidity risks in the event of large deposit withdrawals, in a more severe scenario than the Basel III LCR metrics, or of a dry-up of unsecured wholesale funding.

- Banks are vulnerable to the default risk of their largest exposures, with capital shortfall estimated at 3.0 percent of GDP in the event of a default by the three largest exposures under a zero recovery rate assumption.

- The results show that Moroccan banks are exposed to domestic bond risks, especially sovereign bonds in case of a 300 basis point interest rate increase, with three banks becoming slightly undercapitalized.

- By contrast, interest rate risk to net interest income seems to be limited as banks would gain net interest income in the event of an interest rate increase which would have limited effects on bank capitalization.

- Moreover, the direct effects of a 30 percent dirham depreciation on banks' net open FX positions would be small and even slightly positive for the banking system as a whole due to the globally positive net open FX position.

- The contagion risk analysis reveals that the risks stemming from domestic interbank exposures are very limited. However, the analysis also shows that several Moroccan insurance companies would be vulnerable to bank failures but not the other way round.

- Cross-border contagion analysis reveals that Morocco's cross-border direct bilateral exposure is not likely to be a source of systemic contagion risks. Direct bilateral exposure through credits, deposits, and capital channel appears to be limited, thus it would have no significant impact on the capital adequacy ratio of these banks.

- Finally, market-price based stress tests also confirm the resilience of the banking system.

88. In conclusion, the Moroccan banking system appears to be resilient but with pockets of vulnerabilities. On the basis of the supervisory data used, one medium-sized bank seems to be weaker than the other seven; and credit and concentration risks could pose serious threats to the banking sector stability. The weaker bank is not highly interconnected with the other banks within the system, suggesting that any potential losses are likely to have limited direct spillovers to the rest of the banking system. However, indirect contagion risks (through for example reputational risks), not assessed in the stress tests, might entail significant risks to the system stability. Moreover, given significant exposures of Moroccan insurers to Moroccan banks, the insurance sector could face large losses in case of a banking crisis. As a next step, the IMF team will attempt to look at different channels of risks transfer in cross-border financial operations. Models will try to explore the impact from indirect exposures, cross-border activities from insurance sector, corporate and household, specific industry's linkages to find the source of potential vulnerability of cross-border financial network.

The market-based stress tests, the network interconnection model and the cross border banking risk analysis complement the traditional balance sheet stress testing. BAM should expand its capabilities and analytical tools to link financial sector, corporate, household risk into its macroeconomic modeling and to enhance assessment of cross-border risk transmission.

Appendix I. Morocco: Risk Assessment Matrix

Nature/Source of Main Threats	Overall Level of Concern	
	Likelihood of Severe Realization of Threat in the Next 1–3 Years *(high, medium or low)*	**Expected Impact** *(high, medium or low)*
1. A structurally weak growth in advanced economies (Euro area)	**High** • Weak demand and persistently low inflation from a failure to fully address crisis legacies and appropriately calibrate macro policies, leading to a "new mediocre" rate of growth.	**High** • Slow growth in Europe would reduce the demand for Moroccan exports, slow down remittances from abroad, tourism revenues and FDI inflows, and would exert downward pressures on the central bank's international reserves.
2. Heightened risk of fragmentation/state failure/security dislocation in the Middle East, leading to a sharp rise in oil price volatility, and migrant flows, with negative global spillovers	**Medium** • Geopolitical tensions in the Middle East could cause disruptions in oil supply and push prices up but persistently low energy prices may be triggered as well by supply factors, reversing only gradually, and weaker demand.	**High** • The current account deficit in Morocco remains relatively large and the country is highly dependent on oil imports.
3. Increased volatility of energy prices due to uncertainty about the persistence of the oil supply shock and the underlying drivers of the price decline	**Medium**	**Medium** • Oil and energy supply disruptions could raise oil prices, with consequences for fiscal and external positions.
4. Tighter and more volatile global financial conditions, as investors reassess underlying risk	**High** • Prices of risky assets drop abruptly as investors reassess underlying risk and move to safe assets, associated with a rise in actual and expected volatility. Global growth would be impacted negatively as some countries face a tight policy mix, given higher financing costs and fiscal sustainability concerns, and constraints on	**Medium** • Financial volatility, triggered by the prospective exit from unconventional monetary policy in certain advanced countries, would result in an increase in Morocco's borrowing costs. This could result in cutback of growth-enhancing expenditure, jeopardize growth prospects and bring about a reduction in domestic banking liquidity,

	accommodative monetary policies.	as well as a rise in banks' funding costs and lending rates.
5. Slower-than-needed pace of reforms	**Medium** • Political risks have receded with the recent appointment of a coalition government, but regional socio-political tensions could continue to affect the ability to sustain the delivery of an ambitious reform program.	**Medium** • A stop in the sustained implementation of reforms would endanger the economic resilience and would affect potential growth.

Appendix II. Morocco: Stress Test Matrix (STeM) for the Banking Sector: Solvency, Liquidity, and Contagion Risks

Domain		Assumptions		
		Bottom-up by banks	Top-down by Authorities	Top-down by FSAP Team
BANKING SECTOR: SOLVENCY RISK				
1. Institutional Perimeter	Institutions included	• 8 banks	• 8 banks	• 8 banks
	Market share	• 90 percent of the banking sector's assets	• 90 percent of the banking sector's assets	• 90 percent of the banking sector's assets
	Data and baseline date	• Bank proprietary data • Baseline date: end-December 2014 • Bank solo level data	• Supervisory data • Baseline date: end-December 2014 • Stress tests used bank-by-bank balance sheet, income statement and prudential data on a solo basis as of December 2014.	• Supervisory data • Baseline date: end-December 2014 • Stress tests used bank-by-bank balance sheet, income statement and prudential data on a consolidated basis as of December 2014. Due to time series data limitations, credit risk satellite models were estimated using data on solo basis • Market-data

2. Channels of Risk Propagation	Methodology	• Guidelines issued by the FSAP team	• Satellite models developed by the Authorities	• Satellite models developed by the FSAP team • Balance sheet-based approach • Contingent Claim Analysis
	Satellite Models for Macro-Financial linkages	• NPL projections under 3 scenarios provided by BAM	• Methodology to calculate credit losses in response to changes in macroeconomic conditions	• Methodology to calculate losses from bonds and money market instruments (sovereign and other issuers). Haircuts are calculated based on a modified duration approach. • Net fee income and commission income, and operating expenses, projected based on nominal GDP growth • Impact of increased NPL ratio on net interest income taken into account.
	Stress test horizon	• 3-years (2015/2017)	• 3 years (2015/2017)	• 3 years (2015/2017)
3. Tail shocks	Scenario analysis	• Scenario-based tests, which assess the impacts on the entire portfolio including the loans and, if applicable, the trading book, were conducted in the TD exercise. • Variables in the scenarios include domestic macro- financial variables (e.g., GDP, inflation), world GDP, and GDP for key trading partners, and interest rates.		

		• In the V-shaped adverse scenario, the GDP growth rate declines in 2015 to -2 percent, recovers in 2016 and 2017 to +2.4 percent and +5.2 percent. • A set of market shocks, including large and sudden changes in interest rates and exchange rates, is calibrated to magnitudes close to those observed in 2008/2009.		
	Sensitivity analysis	• Sensitivity analyses were conducted in the BU and TD exercises • They evaluate *domestic* shocks: direct effects of interest rate shocks; interest rate shock on credit quality; direct effects of exchange rate shocks; a decline in the prices of domestic bonds; and failure of the largest, 2 and 3 largest corporate exposures.		
4. Risks and Buffers	Risks/factors assessed.	• Credit risk on the banking book and trading book; loan migration • Market risk and bond losses: direct effects of interest rate shocks; direct effects of exchange rate shocks; shocks to domestic bond yields.	• Credit losses • Losses from bonds and money market instruments (sovereign and other issuers) in the banking and trading books. • Funding costs • Market risk, including foreign exchange risk	• Credit losses • Losses from bonds and money market instruments (sovereign and other issuers) in the banking and trading books. • Funding costs • Market risk, including foreign exchange risk
	Behavioral adjustments	• Constant balance sheet assumption aimed at making results more comparable between banks and at avoiding balance sheet optimization across years.	• Balance sheet grows with nominal GDP with a floor at 0. • Dividends are paid out by banks that remain adequately capitalized throughout the stress.	• Balance sheet grows with nominal GDP with a floor at 0. • Dividends are paid out by banks that remain adequately capitalized throughout the stress.

5. Regulatory and Market-Based Standards and Parameters	Calibration of risk parameters	• Point in time risk parameters for credit risk parameters or proxies	• Point in time risk parameters for credit risk parameters or proxies	• Point in time risk parameters for credit risk parameters or proxies
	Regulatory/Accounting and Market-Based Standards	• National regulation for total regulatory capital and Tier 1 capital • Basel II Standardized approach		
6. Reporting Format for Results	Output presentation	• System-wide capital shortfall • Number of banks and percentage of banking assets in the system that fall below certain ratios.		

BANKING SECTOR: LIQUIDITY RISK			
1. Institutional Perimeter	Institutions included	• n.a.	• 8 largest banks in the system
	Market share	• n.a.	• 90 percent of banking sector's assets
	Data and baseline date	• n.a.	• Latest data: December 2014. • Source: supervisory data • Scope of consolidation: perimeter of individual banks
2. Channels of Risk Propagation	Methodology	• n.a	• Basel III-LCR type proxies, cash-flow based liquidity stress test using maturity buckets by bank
3. Risks and Buffers	Risks	• n.a.	• Funding liquidity (liquidity outflows) • Market liquidity (price shocks)
	Buffers	• n.a.	• Counterbalancing capacity • Central bank facilities
4. Tail shocks	Size of the shock	• n.a.	• Run-off rates calculated following historical events and LCR rates • Bank run and dry up of wholesale funding markets, taking into account haircuts to liquid assets
5. Regulatory and Market-Based Standards and Parameters	Regulatory standards	• n.a.	• Basel III standards (revision as of January 2013). See Committee on Banking Supervision (2013), "Basel III: The Liquidity Coverage Ratio and liquidity monitoring tools," Basel, January 2013
6. Reporting Format for Results	Output presentation	• n.a.	• Liquidity gap by bank, and aggregated. • Survival period in days by bank, number of banks that can still meet their obligations

BANKING SECTOR: CONTAGION RISK			
1. Institutional Perimeter	Institutions included	n.a.	• 8 banks • 5 insurance companies
	Market share	n.a.	• 90 percent of total banking system assets
	Data and baseline date	n.a.	• Latest data: December 2014. • Source: supervisory data • Scope of consolidation: perimeter of individual banks
2. Channels of Risk Propagation	Methodology	n.a.	• Network interbank model by Espinosa-Vega and Solé (2010)
3. Tail shocks	Size of the shock	n.a.	• Pure contagion: default of institutions
4. Reporting Format for Results	Output presentation	n.a.	• Number of undercapitalized and failed institutions, and their shares of assets in the system

Appendix III. Morocco: Contributions to the Changes in CAR – Adverse Scenarios

Changes over time in the capital adequacy ratio $CAR = \frac{Capital}{RWA}$ can be expressed as follows:

$$\Delta CAR_{t+1} = CAR_{t+1} - CAR_t = \frac{\Delta Capital_{t+1}}{RWA_t} - \frac{\Delta RWA_{t+1} * CAR_t}{RWA_{t+1}} - \frac{\Delta Capital_{t+1} * \Delta RWA_{t+1}}{RWA_t * RWA_{t+1}}.$$

In the last expression, the first term on the right indicates the (partial) contribution of changes in capital (numerator) to variations in the CAR ratio; similarly, the second term is the contribution of changes in RWA (denominator). The third term captures the 9joint) contribution of changes in RWA and capital to changes in the CAR ratio. The latter term is (very) small in size and can be added to the contributions of RWA, capital, or both. For the construction of the decomposition chart, we add the joint effect (third term) to the contribution of changes in capital (numerator), as follows:

$$Contribution\ of\ \Delta Capital\ to\ \Delta CAR = \frac{\Delta Capital_{t+1}}{RWA_t} * \left(1 - \frac{\Delta RWA_{t+1}}{RWA_{t+1}}\right)$$

$$Contribution\ of\ \Delta RWA\ to\ \Delta CAR = -\frac{\Delta RWA_{t+1} * CAR_t}{RWA_{t+1}}$$

Assuming no capital injections in the period, the evolution of capital over time can be further decomposed as follows:

$$\Delta Capital_{t+1} = Capital_{t+1} - Capital_t = \Pr ofit\ before\ losses_{t+1} - Losses\ due\ to\ stress_{t+1} - Dividends_{t+1} - Taxes_{t+1}$$

X=source of change in capital (numerator)	Contribution of X to changes in CAR
- Pre-impairment profits - Losses or gains due to interest rate risk (net interest income) - Credit losses - Losses/gains due to market risk (exchange rate) - Losses/gains due to market risk (domestic bonds) - Taxes	$\frac{X_{t+1}}{RWA_t} * \left(1 - \frac{\Delta RWA_{t+1}}{RWA_{t+1}}\right)$
Changes in risk weighted assets	$-\frac{\Delta RWA_{t+1} * CAR_t}{RWA_{t+1}}$

Appendix IV. Morocco: Contingent Claims Analysis (CCA)

1. Contingent claims analysis is a generalization of the option pricing theory pioneered by Black-Scholes (1973) and Merton (1973). Since 1973, option pricing methodology has been applied to a wide variety of contingent claims. Contingent claims analysis is used to construct risk-adjusted balance sheets and is based on three principles: (i) the values of liabilities (equity and debt) are derived from assets; (ii) liabilities have different priority (i.e., senior and junior claims); and (iii) assets follow a stochastic process. Assets (present value of income flows, proceeds from assets sales, etc.) are stochastic and over a horizon period may be above or below promised payments on debt which constitute a default barrier.

2. Uncertain changes in future asset value, relative to the default barrier, are the driver of default risk which occurs when assets decline below the barrier. The CCA model assumes that the total market value of assets, *A*, at any time, *t*, is equal to the sum of its equity market value, *E*, and its risky debt, *D*. Asset value is stochastic and may fall below the present value of promised payments on debt, which constitute a default barrier, *B*.[1] The value of risky debt is equal to default-free debt minus the present value of expected loss to creditors due to default. Default occurs when *A*<*B*. Equity value is the value of an implicit call option on the assets, with an exercise price equal to default barrier. The expected loss to bank creditors can be calculated as the value of an implicit put option, *P*, on the assets with an exercise price equal to *B*. The equity value, *E*, can be computed as the value of a call option.

3. Several widely-used techniques have been developed to calibrate the CCA models using a combination of balance sheet information and forward-looking information from equity markets. The market value of assets of corporations and financial institutions cannot be observed directly but can be implied using financial asset prices. From the observed prices and volatilities of market-traded securities, one can estimate the implied values and volatilities of the underlying assets in financial institutions. In the traditional Merton (1974) model, the calibration requires knowledge about value of equity, *E*, the volatility of equity, σ_E, and the distress barrier as inputs into equations $E = A_0 N(d_1) - Be^{-rT} N(d_2)$ and $E\sigma_E = A\sigma_A N(d_1)$ in order to calculate the two unknowns, the implied asset value *A* and implied asset volatility σ_A.[2]

4. In practice, it is common to use the distance-to-default (market value of assets minus the default point, divided by asset volatility) and map this to a comprehensive database on defaults. Moody's CreditEdge is a database that uses this mapping process to calculate default probabilities for tens of thousands of firms and financial institutions in 60 countries. The ratio of market capital to assets (CCA capital ratio) is tightly linked to the default probability. Default

[1] MKMV defines this barrier equal to total short-term debt plus one-half of long-term debt based on empirical studies.

[2] See Merton (1974, 1977, 1992), Gray, Merton, and Bodie (2008), as well as Gray and Malone (2008).

probabilities are closely tied to credit ratings. Investment grade rating is considered to be BBB- and higher corresponding to a default probability of 0.5 percent or lower. Investment grade is considered a low-risk rating. So a default probability of 0.5 percent or lower is considered a "safe zone."

5. Banks and insurers used in this analysis are the following:

Sample:

Bank 1: ATTIJARIWAFA BANK

Bank 2: BANQUE MAROCAINE DU COMMERCE EXTERIEUR

Bank 3: BANQUE MAROCAINE POUR LE COMMERCE ET L'INDUSTRIE SA

Bank 4: CREDIT DU MAROC SA

Bank 5: BANQUE CENTRALE POPULAIRE

Insurer 1: WAFA ASSURANCE SA

Insurer 2: ATLANTA

Insurer 3: AGMA LAHLOU TAZI INTERMEDIAIRE D'ASSURAN

Insurer 4: SAHAM ASSURANCE SA

Table 1. Morocco: Banking Sector EDF Forecast Model: Statistics Description

Dependent Variable: DD
Method: Least Squares

Sample (adjusted): 2004M02 2014M12
Included observations: 131 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.278737	0.350620	-0.794984	0.4281
LOG(GDPCP_B)	0.393333	0.116450	3.377690	0.0010
LOG(CPI_B)	-1.050509	0.317416	-3.309566	0.0012
SECTBILLRATE_B	-0.002980	0.033292	-0.089509	0.9288
FDI_B	4.11E-06	2.49E-06	1.653503	0.1008
REMITTANCES_B	-2.86E-06	1.39E-06	-2.052163	0.0423
DD(-1)	0.912635	0.027729	32.91268	0.0000

R-squared	0.951207	Mean dependent var	2.604338
Adjusted R-squared	0.948846	S.D. dependent var	0.133539
S.E. of regression	0.030203	Akaike info criterion	-4.109810
Sum squared resid	0.113114	Schwarz criterion	-3.956174
Log likelihood	276.1926	Hannan-Quinn criter.	-4.047381
F-statistic	402.8936	Durbin-Watson stat	2.014504
Prob(F-statistic)	0.000000		

Source: IMF staff calculations.

Table 2. Morocco: Insurance Sector EDF Forecast Model: Statistics Description

Dependent Variable: Distance to Distress
Method: Least Squares

Sample (adjusted): 2004M03 2015M02
Included observations: 132 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.351872	0.269930	-1.303568	0.1948
LOG(GDPCP_B)	0.198654	0.087886	2.260370	0.0255
LOG(CPI_B)	-0.467893	0.233433	-2.004398	0.0472
SECTBILLRATE_B	-0.008935	0.023957	-0.372941	0.7098
FDI_B	-3.29E-07	1.57E-06	-0.209067	0.8347
REMITTANCES_B	1.57E-07	9.08E-07	0.172948	0.8630
DD(-1)	0.953022	0.020977	45.43155	0.0000

R-squared	0.971941	Mean dependent var	2.510430
Adjusted R-squared	0.970595	S.D. dependent var	0.137756
S.E. of regression	0.023622	Akaike info criterion	-4.601668
Sum squared resid	0.069752	Schwarz criterion	-4.448792
Log likelihood	310.7101	Hannan-Quinn criter.	-4.539547
F-statistic	721.6604	Durbin-Watson stat	2.271882
Prob(F-statistic)	0.000000		

Source: IMF staff calculations.

Table 3. Morocco: Expected Default Frequency and Ratings

Credit Category	Median EDF (1 yr)	Bound Range Lower	Bound Range Upper	Credit Category	Median EDF (1 yr)	Bound Range Lower	Bound Range Upper
AAA	0.03%	0.01%	0.03%	BB	0.89%	0.71%	1.22%
AA+	0.04%	0.03%	0.04%	BB-	1.67%	1.22%	2.28%
AA	0.04%	0.04%	0.04%	B+	3.13%	2.28%	4.28%
AA-	0.05%	0.04%	0.05%	B	5.87%	4.28%	6.74%
A+	0.06%	0.05%	0.07%	B-	7.80%	6.74%	9.11%
A	0.08%	0.07%	0.10%	CCC+	10.76%	9.11%	12.88%
A-	0.12%	0.10%	0.14%	CCC	15.66%	12.88%	16.16%
BBB+	0.16%	0.14%	0.20%	CCC-	16.70%	16.16%	17.91%
BBB	0.24%	0.20%	0.29%	CC	19.34%	17.91%	21.95%
BBB-	0.37%	0.29%	0.46%	C	25.27%	21.95%	35.00%
BB+	0.57%	0.46%	0.71%	D	35.00%	35.00%	35.00%

Source: IMF staff calculations.

References

Basel Committee of Banking Supervisors (2013), "Basel III: The Liquidity Coverage Ratio and liquidity risk monitoring tools", Basel, January.

See Basel Committee on Banking Supervision (2013), "Supervisory framework for measuring and controlling large exposures" (Consultative Document), June.

Čihák, Martin (2007), "Introduction to Applied Stress Testing", IMF Working Paper No. 59, March.

Espinosa-Vega, Marco, and Julian Solé (2010), "Cross-border Financial Surveillance: A Network Perspective", IMF Working Paper No. 105, April.

Foglia, Antonella (2009), "Stress Testing Credit Risk: A Survey of Authorities Approaches", *International Journal of Central Banking*, Vol. 5 No. 3, September.

Gray, D., M. Gross, J. Paredes, M. Sydow (2013), "Modeling Banking, Sovereign, and Macro Risk in CCA Global VAR", IMF Working Paper 13/218, Washington D.C.

Gray, D. and S. Malone (2008), *Macrofinancial Risk Analysis,* New York: Wiley.

Gray, D. F., and A. A. Jobst (2013), "Systemic Contingent Claims Analysis –Estimating Market-Implied Systemic Risk" IMF Working Paper 13/54 (Washington: International Monetary Fund).

Haldane, Andrew G. (2009), "Why Banks Failed the Stress Test", speech delivered as executive Director of Financial Stability at the Bank of England, Marcus-Evans Conference on Stress Testing, London, February.

Merton, R. C, (1973), "Theory of Rational Option Pricing," Bell *J. Econ. Manag. Sci.*, 4 (Spring), pp. 141–83.

_____ (1974), "On the Pricing of Corporate Debt: The Risk Structure of Interest rates," *J. Finance* 29 (May), pp. 449–70.

Merton, Robert C., Monica Billio, Mila Getmansky, Dale Gray, Andrew W. Lo, and Loriana Pelizzon (2013), "On a New Approach for Analyzing and Managing Macrofinancial Risks", Financial Analysts Journal, vol. 69, no 2.

Schmieder, Christian, Claus Puhr, and Maher Hasan (2011), "Next Generation Balance Sheet Stress Testing", IMF Working Paper No. 83, April.