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Sweden: Financial Sector Assessment Program Update—Technical Note on Stress Testing of the Banking Sector

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FINANCIAL SECTOR ASSESSMENT PROGRAM UPDATE

SWEDEN

STRESS TESTING OF THE BANKING SECTOR

TECHNICAL NOTE

SEPTEMBER 2011

INTERNATIONAL MONETARY FUND
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GLOSSARY

AIRB	Advanced internal-ratings-based
BCBS	Basel Committee on Banking Supervision
CAR	Capital adequacy ratio
CD	Certificate of deposit
CEBS	Committee of European Banking Supervisors
DCF	Discounted cash flow
DSGE	Dynamic stochastic general equilibrium
EADs	Exposures at default
ECB	European Central Bank
EDF	Expected Default Frequency
EL	Expected loss
EU	European Union
FI	Finansinspektionen
FSAP	Financial Sector Assessment Program
FX	Foreign exchange
GDP	Gross domestic product
ICAAP	Internal Capital Adequacy Assessment Process
IMF	International Monetary Fund
LGD	Loss given default
Liquidatum	A fee-based commercial database
LTV	Loan-to-value
MTM	Mark-to-market
NPLs	Nonperforming loans
PD	Probabilities of default
RB	Riksbank
RWA	Risk-weighted assets
SEB	Skandinaviska Enskilda Banken
SEK	Swedish krona
SME	Small and medium-sized enterprises
SPV	Special purpose vehicles
U.K.	United Kingdom
U.S.	United States
VAR	Vector autoregression
WEO	World Economic Outlook

I. EXECUTIVE SUMMARY[1]

1. **Sweden has recovered from the financial crisis and the authorities have already initiated exit measures from crisis response policies.** The crisis had a sizeable impact on the banking sector stemming from strains in the funding markets and cross-border exposures in the crisis-hit Baltic region. Banks' funding pressures were exacerbated by their significant reliance on short-term wholesale markets—partly in foreign currency—to fund mortgage lending in Swedish krona. Since mid-2009, economic recovery took hold with real GDP growth reaching 5½ percent in 2010. Public finances also remain the strongest amongst advanced economies.

2. **The Financial Sector Assessment Program (FSAP) Update undertook a financial stability analysis of the banking sector, including a comprehensive stress-testing exercise of banks' solvency and liquidity positions.**

- **Solvency.** The analysis focused on the estimated impact of a sharp deterioration in the economic environment on banks' loan losses and solvency. In addition to a baseline scenario, three adverse scenarios were tested simulating sharp double-dip recessions and slow growth scenarios. The stress scenarios were assumed to be catalyzed by external drivers, such as a derailed global growth affecting Swedish exports, and jeopardizing consumer and business confidence, while the internal ones were assumed to be driven by a correction in house prices. The latter would impact household balance sheets and debt service capacity owing to their already high indebtedness with variable rate loans. Bank losses could then materialize through an increase in nonperforming loans.

- **Liquidity.** The stress tests also focused on the impact on banks' liquidity positions of dislocations in the funding markets, in particular wholesale. Funding pressures could be triggered by a debt restructuring in fiscally strained countries, leading to a flight to high-quality sovereigns, an outflow of deposits, which would be refinanced by costlier funding, and/or a structural shift to longer-term funding to comply with the Basel III liquidity requirements.

3. **While the banking sector appears resilient to credit risk stress tests, liquidity stress test results reveal some weaknesses.** The credit risk stress tests show that banks should be able to maintain adequate capital in the face of severe macroeconomic shocks, owing to high profits and capital buffers, and high-quality loan portfolios. However, against the backdrop of continuing house-price increases, the high and rising indebtedness of

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[1] Prepared by Nada Oulidi and Stephanie Stolz, with significant input from staff at the Riksbank (RB) and Finansinspektionen (FI). The authors are grateful to Messrs. Hovick Shahnazarian, David Forsman, Kristian Jonsson, Martin Liljeblad, Anders Nordberg, and Olof Sandstedt for their analytical insights, open discussions, and cooperation with data. The authors would like to thank Paul Kupiec for his guidance on credit risk modeling.

households, increasing loan-to-value ratios, and the significant share of housing-related loans in banks' portfolio, the performance of mortgage and property companies' loans are key to the stability of the banking sector. Regarding liquidity, the stress tests show some concerns owing to banks' heavy reliance on wholesale funding, in particular short-term, to finance relatively illiquid mortgages in SEK. In fact, banks' current funding structure exposes them to dislocations in the various segments of the wholesale market. Disruptions could lead to an increase in banks' funding costs with an impact on banks' profits and solvency if the increase cannot be passed through to borrowers.

4. **The technical note is structured as follows.** Section II of this note describes the salient features of the financial sector and analyzes banks' exposures as regards asset allocations and funding structure, and evaluates their financial soundness. Section III summarizes the key assumptions, methodologies, caveats, and results of the stress tests, and Section IV concludes with key recommendations.

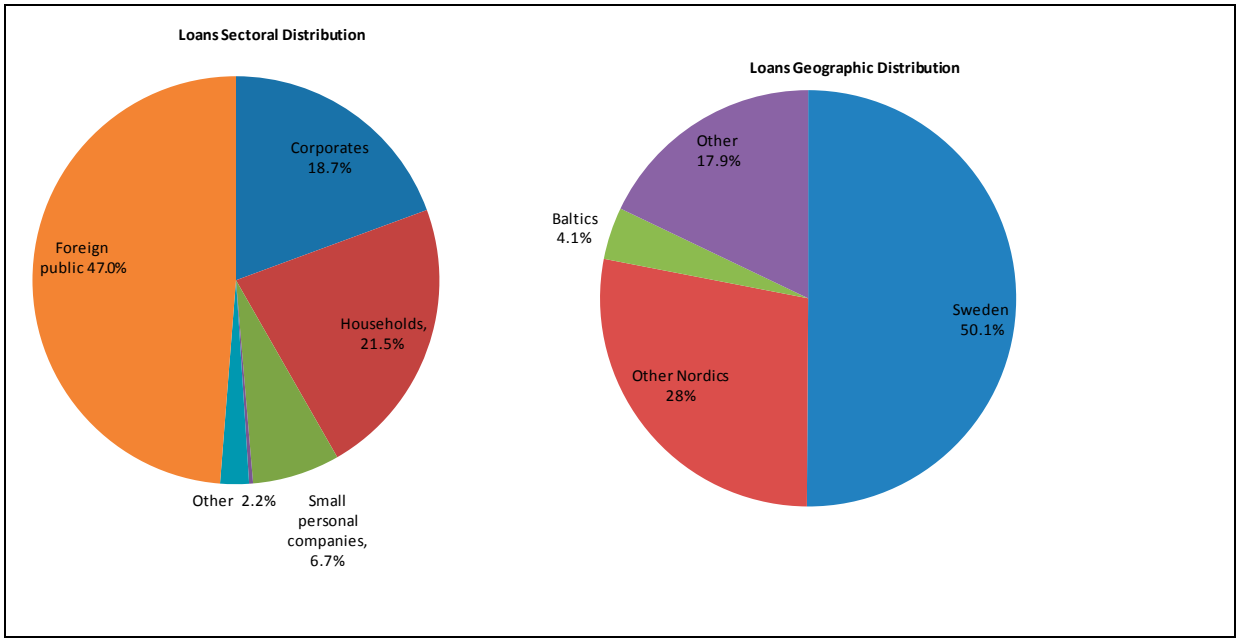
II. Structure and Soundness of the Banking Sector

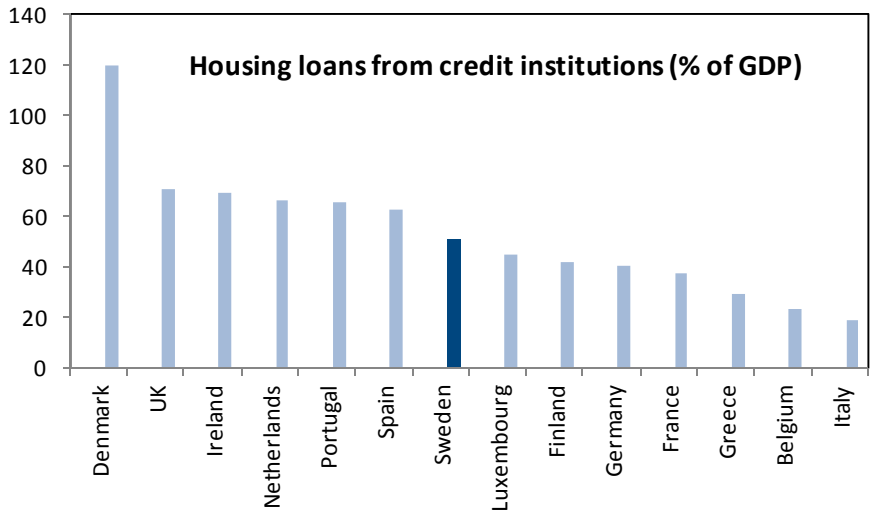
5. **The Swedish financial sector is large relative to gross domestic product (GDP), and the banking sector is concentrated.** The financial system's assets account for 550 percent of GDP, of which 65 percent belong to four large banking groups—Swedbank, Nordea, Skandinaviska Enskilda Banken (SEB), and Handelsbanken. These four systemically important banking groups have extensive cross-border activities, mostly in the Nordic and Baltic regions. Insurance companies, in particular life insurance, form an important part of the financial sector accounting for 16 percent of total assets. In addition, there are mortgage companies and other consumer credit market companies, some of which are bank subsidiaries that also extend credit.

6. **Swedish banks engage in significant cross-border lending, mostly in the Nordic region.** Bank assets consist mainly of loans, which account for 71 percent of total balance sheets, making credit risk the most important risk in banks' assets. Government bond holdings are relatively marginal at 5 percent of assets, and Swedish banks' direct sovereign exposures to vulnerable European countries are limited. Most of banks' lending is in Sweden (50 percent) and other Nordic countries (28 percent), while Baltic countries account for only 4.1 percent of total loan exposures (Figure 1). Swedbank and SEB have the largest exposures to the Baltics at 10 percent of total loans. The largest share of banks' loan exposures are in mortgages and loans to property developers, which, respectively, account for approximately 40 percent and 20 percent of total loans. Housing loans in Sweden are at comparable levels to other European countries, although they have markedely increased in recent years. The increase was attributed to demand and supply factors, including a strong macroeconomic environment, low interest rates, tax deductibility, and the development of the covered bond

market.[2] Commited facilities for trade finance constitute the bulk of banks' off-balance sheets, while exposures to special purpose vehicles (SPVs) are limited.

Figure 1. Sweden: Banks' Asset Allocation



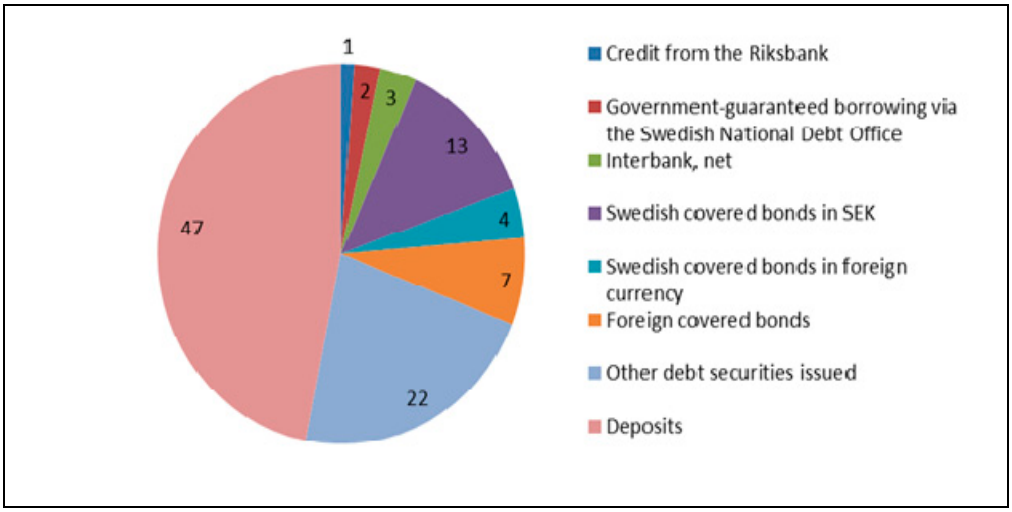


Sources: Riksbank, European Central Bank.

[2] See Sweden FSAP Update: Technical Note on Household Indebtedness Implications on Financial Stability (2011)

7. **As regards funding, banks rely heavily on the wholesale markets to finance lending, which makes them vulnerable to market disruptions and liquidity risk (Figure 2).** Wholesale market reliance is considered amongst the highest in Europe,[3] with a high loan-to-deposit ratio of 200 percent for the sector. This ratio is even higher at banks with significant mortgage lending. Banks' mortgage lending is mostly funded through the covered-bond market (mostly in Swedish krona (SEK)), which continued functioning during the crisis, albeit at higher spreads. A considerable part of the issues were also held as repo-collateral at the Riksbank (RB). Banks seize arbitrage opportunities by contracting cheaper foreign exchange (FX) debt in the wholesale markets, which they then convert to SEK to finance mortgage lending. Approximately 25 percent of foreign funding is swapped to SEK to lend to Swedish borrowers. Interest-rate and cross-currency swaps are used to hedge against interest rate and exchange rate risks associated with FX borrowing. This funding structure presents vulnerabilities to the banking sector if the wholesale funding and swap markets dry out or their cost increases dramatically following a drastic shift in investors' risk appetite.

Figure 2. Sweden: Major Swedish Banks Funding Structure



Source: Riksbank.

8. **The aggregate capital adequacy ratio (CAR) of the four major banks is well above the regulatory minimum, at 12 percent as of September 2010.** Regulatory capital is composed predominantly of common equity Tier 1 capital, which was further strengthened following major rights issues in late 2008 and 2009 (Table 1). Moreover, retained earnings continued to support banks' capitalization. However, the capital-to-assets ratio is low at 4.5 percent, reflecting the concentration of bank assets in low risk-weighted assets (RWA) such as mortgages. QIS results suggest that the four largest banks are in compliance with Basel III capital requirements. Data available on common equity Tier 1 ratios based on the

[3] See October 2010, International Monetary Fund (IMF) Global Financial Stability Report (Chapter 1).

new Basel capital and RWA definitions suggest that Swedish banks are well prepared for Basel III.

9. **Banks' profits rebounded from 2009 lows.** Profits had declined in 2009 in banks with Baltic exposures due to substantial increases in loan-loss provisions. One bank registered significant losses consequently, but returned to profits in 2010 owing to provisions reversals. Most of the provisions were booked in 2009, and further reversals are reportedly expected with prospects for improved macroeconomic conditions in the Baltics. While subsiding credit growth alongside low interest rates put pressures on banks' net interest margins (the largest contributor to banks' profitability), the release of loan-loss provisions maintained banks' profitability in 2010. The two small banks for which data were provided exhibit adequate capitalization and profitability levels, and a relatively healthy loan portfolio with low nonperforming loans (NPLs).

10. **Loan quality is among the highest in Europe (Figure 3).** The NPL ratio is among the lowest in Europe, at 2 percent as of September 2010. The highest credit risk, as illustrated by reported probabilities of default (PDs) and loss given default (LGDs), stems from corporate lending, mostly commercial real estate (real estate developers). Conversely, mortgage lending has historically exhibited low default rates owing to the nonspeculative nature of mortgage borrowing in Sweden (loans contracted mostly for primary residence), full recourse from lenders, generous social benefits for the unemployed,[4] and, so far, stable housing prices**.**

11. **Since the height of the crisis, market price developments point to decreasing risk for both individual banks and the banking system (Figure 4).** Banks' share prices have strongly rebounded and credit default swap (CDS) spreads have shrunk, although banks with a high exposure to the Baltic region lag behind others. In addition, the probability that all four large banks default, a measure of extreme tail risk, has declined significantly. Finally, the Banking Stability Index, which indicates the number of banks that would be expected to default given that any other bank defaults, has also declined, although remaining at an elevated level.[5]

III. Top-Down Banking Stress Tests

12. **In close cooperation with the authorities, the FSAP mission team carried out a wide range of stress tests covering credit, liquidity, contagion, and concentration risks.** For credit risk, both the FSAP mission team and the RB carried out the stress tests and the results were cross-checked against each other for robustness of the conclusions on solvency. Given the different approaches and data sources, the results differed, but were qualitatively

[4] Unemployment benefits cover up to three years.

[5] The joint probability of default and the Banking Stability Index were derived using methodologies developed by Segoviano (2006) and Segoviano and Goodhart (2009).

similar. Owing to data confidentiality, the mission team relied on the RB's stress tests for liquidity, contagion, and concentration risks. The stress tests covered the four largest banks accounting for 90 percent of the banking sector assets.

A. Macro Stress Tests

13. **The macro stress tests covered several risk factors.** These include (i) credit risk; (ii) market risk from the repricing of sovereign bonds (held in the banking and trading books) resulting from an upward shift in the long-term yield curve; and (iii) funding cost risk associated with a run on deposits and a dry-out in the wholesale funding markets. Credit, sovereign, and funding risks were modeled as functions of the macroeconomic scenarios, which were devised by the FSAP mission and the RB. The remainder of this section describes the different building blocks of the macro stress testing exercise.

Macroeconomic scenarios

a. Macro credit-risk stress tests spanned five years (2011 to 2015) and covered four macroeconomic scenarios (Figure 5):

- a baseline scenario in line with the October 2010 World Economic Outlook (WEO) projections for GDP growth of 2.56 percent in 2011 and 3.00 percent in 2012, as well as conservative projections for unemployment and interest rates;

- a double-dip scenario (adverse Scenario 1) implying an increase in unemployment and interest rates, and assuming deviations in GDP growth by 2.7 percent in 2011 and 3.2 percent in 2012 compared to the WEO baseline; This scenario assumes a confidence shock, which affects demand worldwide, and a European Union (EU)-specific shock to the yield curve following a sovereign-debt crisis and a deterioration in fiscal outlooks. This was translated into a common upward shift in long-term sovereign-bond yields for all countries, in addition to a shift associated with country-specific risks. The increase in yields was in turn translated into losses on Swedish banks' sovereign-bond holdings held both in the trading and banking book. A linear return to baseline was assumed for the three outer years (2013 to 2015).

- a more severe double-dip scenario (adverse Scenario 2) assuming twice the deviations from baseline for all variables except long-term interest rates. For these, only the country risk increase was doubled, and yield calibrations for vulnerable European countries were updated based on recent bond-market developments.

- A prolonged low growth (adverse Scenario 3), which was developed together with the RB. This scenario was calibrated to illustrate the combined effect of concomitant adverse shocks including: (i) an external demand shock; (ii) a house-price crash inducing a decline in domestic consumption; and (iii) an oil-price shock. This scenario was calibrated to be similar to the 2008/09 downturn, but with a more persistent path and no return to baseline in 2015. RB calibrated this scenario using their DSGE RAMSES model.

Credit risk models

14. **To ensure the robustness of the overall results of the top-down stress tests**, **the scenario conditions were translated into bank losses using two models:** (a) a mission-devised model, which includes features from the methodology used in the July 2010 Committee of European Banking Supervisors (CEBS) stress test exercise and uses bank-by-bank supervisory data; and (b) RB's credit-risk model, adapted to the needs of the FSAP, using Moody's KMV data. Details of the two models are presented in Appendix 1. The two methodologies are complementary in nature (not necessarily comparable) and were used for consistency checks of the overall solvency conclusions.[6] Each has its strengths and caveats, which are highlighted in this note. The results of the two approaches, however, converged in terms of their overall conclusions on the solvency of the banking sector. While the assessment is wide-ranging, it is not all-encompassing.

Sovereign risk losses

15. **Upward shifts in the long-term yield curves of Eurozone countries, the United Kingdom, and the United States (U.S.) were assumed.** The shifts simulate an aggravated sovereign-debt crisis and mounting market concerns over the fiscal solvency in many Eurozone countries. A common upward shift was applied to each country, which was compounded by an additional country-specific upward shift reflecting fiscal situations and/or market perceptions. Shocks were assumed to phase out linearly in the three outer years (2013–15). The mission broadly followed a discounted cash flow (DCF) methodology in the calculation of bond haircuts under the four scenarios (Appendix 2).

Profits and funding costs

16. **The stress tests also assumed a funding cost increase associated with a run on deposits and a dry-out in wholesale funding markets.** The impact was assessed on net interest margins and gross operating profits. The funding cost increase could be triggered by a debt restructuring in fiscally strained countries, leading to a flight to high-quality sovereigns, an outflow of deposits which would be refinanced by costlier funding, and/or a structural shift to longer-term funding to comply with the Basel III liquidity requirements. In this test, it was assumed that all market debt maturing within three months would be refinanced at higher cost (using short-term interest rate shocks from the macro scenarios). The additional cost was not assumed to be entirely passed through to borrowers in the form of increased lending rates. This is a conservative assumption insofar as Swedish banks have traditionally managed to entirely pass through historical increases in their funding cost,

[6] The FSAP and RB stress tests produced different results quantitatively. This was due to differences in data sources, satellite models, and methodologies used in the calculation of loan losses and RWA. Supervisory data were used by FSAP, while market implied data were used by RB. In addition, two different satellite models were used by the FSAP team and RB, respectively, to translate the macro scenarios into bank losses, and assumptions on payout ratios and balance sheet growth also varied.

essentially owing to the predominance of floating rate loans and the oligopolistic nature of the banking sector. The additional funding cost was then added to the interest expense and deducted from operating profits.

17. **Profit assumptions were based on market consensus projections.** No viable model to forecast earnings was available. Hence, market consensus projections were used for the rest of the income-statement items. Haircuts to net commissions and other income were applied. Earnings assumptions are summarized in Table 2.

Dividend payout

18. **Dividend payout ratios typically depend on firms' shareholders, target payouts, investment opportunities, and regulatory restrictions (if any).** The mission model assumed zero payout. The RB's model assumptions are more conservative than Basel III (Appendix I) and are based on banks' historical as well as currently disclosed target payout ratios, which range between 40 percent and 50 percent for the four largest banks.

Macro credit stress-test results

19. **The macro scenario stress tests underscore the importance of credit risk. Nevertheless, under both the RB and FSAP mission models, banks are found to be resilient to severe shocks (Table 5, Figure 6):**

- Under adverse Scenarios 1 and 2, banks' capital adequacy ratios remain above the regulatory minimum. Despite weak growth, high unemployment, and subsequent increases in bank losses during the crisis years, banks' capital ratios remain well above the 4 percent Tier 1 regulatory minimum, 6 percent CEBS Tier 1 threshold, and the 8 percent total CAR regulatory minimum. Increases in loan losses and RWAs from credit risk are the main negative drivers of the results under the stress scenarios. Profits and reversals in provisions provide significant buffers against credit risk (Figure 7). Shocks to sovereign-bond portfolios and funding costs do not have a major impact, given banks' limited exposures to the vulnerable European countries, and the pass-through of increased funding cost. [1] Moreover, post-shock credit losses are not significant owing to banks' high-quality loan portfolios and low initial values of credit-risk measures. Strong operating profits and large loan-loss provisions built-up during the crisis serve as first line buffers against the losses. Assuming full pretax profit retention (and even with a 40 percent dividend payout assumed under the RB model), Tier 1 and total capital ratios under both IMF and RB methodologies remain above the regulatory minima.

- Even under the prolonged low-growth scenario, banks are found to be resilient. Low growth and high unemployment paths are persistent under this scenario, and bank losses and increases in RWA are significant, with no recovery in the outer years (unlike Scenarios 1 and 2). However, no bank is projected to breach the regulatory minimum either for Tier 1 or the total CAR in any given year, under both the mission and the RB's models.

- Conducting similar tests against the Basel III capital requirements suggest that all banks are resilient. Banks' common Tier 1 capital ratios remain above the minimum required under Basel III using the new common Tier 1 capital and RWA definitions and applying the phased in deductions from 2014–15.

B. Liquidity Risk Stress Tests

20. **Owing to data confidentiality, the mission used the RB's framework for liquidity risk.**[7] The authorities use Liquidatum (a fee-based commercial database) to run liquidity stress tests. FI has recently initiated a liquidity data collection exercise using a more detailed supervisory template. However, this supervisory data is reportedly not yet suitable for stress-testing purposes. RB conducted the stress tests, and presented the results and methodology to the mission team. The stress tests covered the four major Swedish banks and a group of large European banks, which served as a benchmark.

21. **Two measures similar to the Basel III liquidity coverage ratio and net-stable-funding ratio were calculated: the first measure is a short-term liquidity ratio which assesses banks' liquidity buffers under stressed scenarios to cover unexpected outflows over three months.** Unexpected cash outflows arise as a result of a dry-out in wholesale markets, deposit withdrawals, and a draw-down of unused credit lines. As regards the calibration of the shocks, a haircut of 50 percent was applied to the liquidity reserves. The test assumed deposit runs on retail and small and medium-sized enterprise (SMEs) deposits of 10 percent and on corporate deposits of 25 percent. Moreover, 50 percent of issued securities maturing within three months were assumed not to be refinanced, while 10 percent of committed credit facilities were assumed to be drawn. The assumptions are summarized in Table 3. RB's short-term liquidity ratio is calculated as:

$$SLR = \frac{Adjusted\ \ liquity\ reserve}{3-month\ stressed\ \ cashflow}$$

In this test, a bank with a high share of liquid assets, which can easily be converted into cash to cover the assumed cash outflows over a period of three months, fares better than a bank with no such liquidity reserve buffers.

22. **The second measure is a structural long-term one, which relates the weighted average of liabilities to the weighted average of assets.**[8] For example, on the assets side, cash was allocated a zero weight, while loans were allocated an 85 percent weight. On the liabilities side, equity capital and liabilities maturing in less than a year were allocated a weight of 100 percent, while short-term market funding was allocated a zero weight. The

[7] For details, see RB's Financial Stability Report 2010:2, pp. 77-83.

[8] The weights of assets are based on liquidity while those of liabilities on stability of funds.

assumptions are summarized in Table 4. RB's structural liquidity ratio was estimated as follows:

$$SLR = \frac{\sum_{i=1}^{k} Funding_i \times factor_i}{\sum_{j=1}^{k} Assets_j \times factor_j}$$

In this test, a bank which is funded at longer maturities and has more liquid assets in its balance sheet fares better than a bank funded at shorter maturities and has a larger share of illiquid assets (e.g., mortgage loans).

23. **Liquidity stress test results show that banks lag in both liquidity metrics (short-term and structural) behind other European banks owing to their heavy reliance on short-term market funding (Figure 8).**[9] The short-term liquidity measure is significantly less than 100 percent, suggesting that banks do not have sufficient liquidity reserves to cover modeled cash outflows for a period of three months. The weakness in the structural measure reflects the heavy reliance on nonstable, short-term market funding to finance relatively illiquid assets. This reflects the large share of banks' assets in mortgages, which in Sweden are kept in banks' balance sheets (not securitized).

C. Large Exposures and Contagion Risk

24. **Contagion and large exposure risk stress tests were carried out by RB owing to data confidentiality.** RB conducted the tests, using its existing framework,[10] and presented the results to the mission team.

25. **Contagion stress tests evaluated the impact of interbank exposure defaults associated with unsecured lending, securities, and derivatives.** Interbank exposure data were not available due to confidentiality reasons. Hence, the RB runs the contagion-risk stress tests. Contagion-risk stress tests evaluated the impact of interbank exposure defaults associated with unsecured lending (deposits and overnight loans), securities (including both gross positions and positions net of risk mitigants), and derivatives. Banks' largest interbank exposures were found to be securities holdings.

26. **Concentration risk stress tests evaluated the impact of defaults of banks' largest counterparties.** The test was based on banks' 15 largest counterparty exposures, which the RB compiles quarterly, and assumed an LGD of 60 percent.

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[9] This technical note can only present the results of the structural stress test using Liquidatum data due to copyright restrictions.

[10] For details, see RB Financial Stability Report 2010:2, p. 84.

27. **Contagion and concentration risk stress test results suggest that banks could withstand the default of a major bank, but not the joint default of their three largest exposures (Table 6).** The contagion test indicates that banks could withstand the failure of another bank: the Tier 1 ratio of the most affected bank would fall to about 8 percent.[11] However, the default of the three largest exposures would result in a bank reaching a low 4.4 Tier 1 ratio.

IV. Conclusions and Recommendations

28. **While the banking sector appears resilient to credit risk stress tests, pockets of vulnerabilities remain.** The stress testing results using both the FSAP and RB methodologies show that banks should be able to maintain adequate capital in the face of severe credit risk shocks, owing to high profits and capital buffers, and high-quality loan portfolios. Several structural factors explain the continued high credit quality of mortgage loans, which constitute an important share of banks' loan portfolios. These include the nonspeculative nature of mortgage borrowing in Sweden, full recourse from lenders, generous social and unemployment benefits, and, so far, stable housing prices**.** Nevertheless, the performance of mortgage and property companies' loans should be monitored closely, including by regularly collecting supervisory data on these sectors (e.g., PDs, LGDs, default rates, and NPLs) and conducting regular stress tests on them. Against the backdrop of continuing house price increases, the high and rising indebtedness of households, increasing loan-to-value (LTV) ratios, and the significant share of housing related loans in banks' portfolios, the recently introduced regulatory cap on the LTV ratio of 85 percent is a good start. However, the authorities should continue to closely monitor the situation and be prepared to tighten this cap if house prices and LTV ratios continue their upward trends. In the event LTV cap proves insufficient, the authorities could explore other macro prudential measures.

29. **Liquidity stress test results show some concerns due to banks' heavy reliance on wholesale funding to finance mortgage lending.** The shortfalls exhibited by the liquidity stress test results reflect banks' heavy reliance on wholesale funding, in particular short-term, to finance relatively illiquid mortgages in SEK. In fact, banks' current funding structure exposes them to dislocations in the various segments of the wholesale market, including money markets, bonds, or swaps. Disruptions could lead to an increase in banks' funding costs with an impact on banks' profits and solvency if the increase cannot be passed through to borrowers. This could occur in particular if the latters' balance sheets deteriorate in a scenario of high unemployment, combined with a sharp and sustained decline in housing prices, and may force banks to deleverage.

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[11] Apart from direct spill-over effects working through bilateral exposures as shocked in the contagion stress tests, banks have also more complex interconnections. Based on the joint movement in market prices, the Banking Stability Index (Segoviano, 2006 and Segoviano and Goodhart, 2009) indicates that, if any one of the four banks were to fail, it is likely that another bank also would fail (Figure 4).

30. **While the RB has made significant strides in its stress-testing capacities, enhancements are warranted.** In-house methodologies used for top-down stress tests are fairly advanced and appropriate. However, these could be further enhanced by using supervisory bank data for credit and liquidity stress tests once the data are validated by the supervisor. If the results cannot be published in the financial stability report, they could be used for internal financial risk assessments. Moreover, stress tests of mortgage loans and housing prices should be regularly conducted. Such stress tests could first test households' debt service capacity, assuming lower housing prices and higher LTV ratios and unemployment rates (or other relevant factors), which can then be linked to banks' solvency. Default data and NPL ratios by sector (in particular, mortgage and property developer loans) and geographical allocation should be collected and monitored on a regular basis to verify reported credit risk measures by banks (e.g., PDs and LGDs). Reported credit risk measures should be verified by the supervisor (for example cross-checked against actual defaults[12]) and consistent methods of calculation and reporting should be ensured to enhance comparability across banks. Market risk stress tests (including interest rate and foreign exchange) should be introduced. In addition to the four major banks, stress tests should also cover smaller banks. Furthermore, the authorities should calibrate the macroeconomic scenarios based on macroeconomic models as conducted by the FSAP (instead of reverse engineering the macro shocks). Stressed profits and RWA should also be modeled and used in the stress tests. Moreover, since solvency and liquidity risks interact strongly in crisis periods, the authorities may need to consider extending their framework, which currently links solvency and liquidity stress tests through the funding cost channel.[13]

[12] UC AB, a private credit registry with granular loan information, might be used for this purpose.

[13] In the current setup, external shocks increase funding costs, which in turn have a negative impact on capital through profits. Incorporating the link that lower capital pushes up funding costs would be a valuable extension.

Table 1. Sweden: The Core Set of Financial Soundness Indicators for Banks, 2003–10

	2003	2004	2005	2006	2007	2008	2009	2010
Capital Adequacy								
Regulatory capital to risk-weighted assets 1/	10.5	10.6	10.5	10.5	10.2	10.7	13.0	12.6
of which: Four major banks	10.0	10.1	10.1	10.0	9.8	10.2	12.7	12.2
Regulatory Tier I capital to risk-weighted assets 1/	8.0	8.3	7.7	7.8	7.5	8.1	10.9	10.8
of which: Four major banks	7.4	7.6	7.0	7.1	7.0	7.6	10.5	10.4
Capital as percent of assets (leverage ratio)	5.1	4.8	4.8	4.8	4.7	4.6	5.0	4.5
of which: Four major banks	5.0	4.8	4.8	4.9	4.7	4.7	5.0	4.6
Asset quality and exposure								
Nonperforming loans to total gross loans	2.0	1.2	0.9	0.8	0.6	1.1	2.0	2.0
of which: Four major banks	1.9	1.1	0.8	0.8	0.6	1.0	2.0	2.0
Nonperforming loans net of loan-loss provisions to capital	11.9	4.8	3.1	4.3	3.4	7.4	10.7	10.4
of which: Four major banks	11.5	4.0	2.7	3.9	3.1	6.5	11.0	10.6
Loan-loss provisions to nonperforming loans	49.4	66.2	69.7	56.1	58.3	49.1	55.4	45.0
of which: Four major banks	50.3	70.6	73.6	58.0	60.4	47.1	53.7	44.7
Sectoral distribution of bank credit to the private sector (percent)								
Sweden	57.2	56.7	53.8	54.0	52.7	44.0	46.1	49.4
Nonfinancial corporations	24.3	23.2	21.8	20.6	20.9	19.1	18.3	18.7
Households	21.5	22.1	20.6	20.6	19.0	18.1	20.4	21.5
Small personal companies	6.5	6.6	6.4	6.3	6.1	5.6	6.1	6.7
Insurance companies	0.4	0.4	0.5	0.5	0.6	0.2	0.2	0.3
Others	4.6	4.3	4.5	6.0	6.1	1.0	1.2	2.2
Outside Sweden	42.8	43.3	46.2	46.0	47.3	55.4	50.3	47.0
Geographical distribution of loans to total loans								
Sweden	63.6	47.4	45.8	48.0	48.1	48.5	48.7	50.1
Nordic countries	11.9	26.7	28.2	24.4	25.9	25.4	27.8	27.9
Denmark	6.3	12.6	13.3	8.6	9.0	8.4	10.3	11.6
Finland	2.4	8.0	8.2	8.3	7.8	8.4	7.9	7.5
Norway	3.3	6.1	6.8	7.5	9.1	8.6	9.6	8.9
Baltic countries	2.2	2.0	3.3	5.2	5.0	5.4	4.9	4.1
Estonia	1.1	1.0	1.6	1.9	1.9	2.1	1.8	1.6
Latvia	0.4	0.4	0.8	1.7	1.5	1.6	1.4	1.2
Lithuania	0.7	0.6	0.9	1.5	1.6	1.8	1.6	1.3
Other	22.3	23.9	22.6	22.5	21.0	20.6	18.6	17.9
Large exposures as percent of tier 1 capital	26.4	11.1	17.5	18.3	13.4	34.1	12.3	19.4
of which: Four major banks	22.2	12.4	12.0	13.3	6.5	30.9	8.1	16.1
Earnings and profitability								
Return on assets (Net income as percent of average total assets)	0.6	0.7	0.8	0.8	0.8	0.5	0.3	…
of which: Four major banks	0.6	0.7	0.7	0.8	0.8	0.6	0.2	0.1
Return on equity (Net income as percent of average equity capital)	12.5	15.9	18.1	19.9	18.5	12.7	13.0	…
of which: Four major banks	13.3	16.0	18.7	21.0	19.7	14.3	5.4	2.6
Net interest income as percent of gross income	64.4	58.9	52.4	49.2	52.4	55.2	56.8	…
of which: Four major banks	64.6	59.2	52.6	49.4	52.7	56.9	57.7	56.5
Trading income and foreign exchange gains (losses) to gross income	3.0	5.1	9.6	10.5	8.3	8.6	11.7	…
of which: Four major banks	3.5	5.4	10.0	11.2	9.6	9.8	13.6	12.2
Personnel expenses as percent of noninterest expenses	54.0	53.7	56.0	57.4	57.1	55.0	53.2	…
of which: Four major banks	55.9	55.7	58.4	60.3	60.0	59.2	57.1	57.5
Liquidity								
Liquid assets as percent of total assets	4.4	5.2	5.0	5.0	5.0	4.0	6.3	4.4
of which: Four major banks	4.4	5.3	4.6	5.1	5.4	4.3	6.7	4.8
Liquid assets as percent of short-term liabilities	29.3	30.6	31.6	32.1	34.1	23.6	43.6	38.0
of which: Four major banks	32.1	34.7	33.3	37.5	43.8	30.5	54.7	49.7
Customer deposits as a percent of total (non-interbank) loans	50.6	52.6	50.2	53.8	51.4	46.1	47.1	46.2
of which: Four major banks	49.1	50.8	49.1	53.4	51.3	45.5	45.3	44.9
Noninterbank loans to noninterbank deposits	142.6	130.8	137.4	135.7	139.8	139.6	144.8	155.0
of which: Four major banks	150.2	139.6	145.1	143.1	148.4	149.7	156.1	165.6
Foreign exchange risk								
Foreign currency-denominated loans as percent of total loans	19.1	18.2	21.5	23.4	26.1	28.1	27.8	26.3
Foreign currency-denominated assets as percent of total assets	23.9	26.9	28.9	28.9	31.4	32.5	31.0	30.2
Foreign currency-denominated liabilities as percent of total liabilities	25.2	23.4	26.1	24.4	25.4	21.8	20.0	19.6
Exposure to derivatives								
Gross asset position in derivatives as percent of Tier 1 capital	152.6	176.7	164.7	110.7	132.0	336.8	210.8	327.7
Gross liability position in derivatives as percent of Tier 1 capital	168.2	188.5	165.2	117.3	136.1	320.7	198.9	326.8

Sources: Financial Supervisory Authority, Riksbank, and IMF staff estimates.

1/ From 2007, the calculation of capital base follows rules under Basel II.

2/ On consolidated basis

Table 2. Sweden: Funding Cost and Other Earnings Assumptions

(In percent)

	Short term market funding that need to be refinanced with long term funding	Outflow of deposits that need to be refinanced with long term funding	% of increased funding cost that can be transferred to customers	A decrease of net commission and other income	A decrease of variable staff cost
Adverse scenario 1	5%	2%	95%	5%	20%
Adverse scenario 2	10%	5%	85%	10%	40%
Adverse scenario 3	15%	10%	80%	15%	60%

Source: Riksbank.

Table 3. Sweden: Assumptions for Short-Term Liquidity Measure

	Factor	Example of balance sheet	Adjusted reserve and stressed cash outflow	Ratio
Liquidity reserve	Decrease 50%	400	200	200/200= 100%
Withdrawal of deposits by private individuals and small and medium-sized companies	10%	800	80	
Withdrawal of deposits by large companies	25%	160	40	
Issued securities that will mature within three months	50% cannot be refinanced	150	75	
Credit facilities used	10%	50	5	
Total stressed outflow			200	

Source: Riksbank.

Table 4. Sweden: Assumptions for Structural Liquidity Measure

Funding		Assets	
Item	Factor (in percent)	Item	Factor (in percent)
Tier 1 and Tier 2 capital Liabilities with remaining maturity > 1 year Derivatives	100	Cash Loans to financial institutions remaining maturity < 1 year Insurance assets Pension assets	0
Deposits and borrowing from private customers and nonfinancial small corporate customers with remaining maturity < 1 year	90	Securities	5–50
Deposits and borrowing from nonfinancial large corporate customers remaining maturity < 1 year	50	Loans to private individuals and companies irrespective of maturity	85
Repos	5	Credit and liquidity facilities Reverse repos	5
All other liabilities or capital not mentioned above	0	All other asset, including derivatives	100

Source: Riksbank.

Table 5. Sweden: Summary of Macro Stress Testing Results, 2011–15

(n percent)

	Adverse 1					Adverse 2					Adverse 3				
Bank 1	**2011**	**2012**	**2013**	**2014**	**2015**	**2011**	**2012**	**2013**	**2014**	**2015**	**2011**	**2012**	**2013**	**2014**	**2015**
Profits before Loan Losses	-3.6	-3.7	-3.5	-3.4	-3.4	-10.1	-11.4	-11.3	-12.3	-13.2	-6.6	-13.9	-19.6	-20.4	-28.9
Loan Losses	21.2	47.5	30.3	15.9	0.0	43.7	101.0	63.2	32.5	0.0	17.5	91.9	97.6	78.3	59.4
RWA	7.5	15.8	10.5	5.6	0.0	14.7	30.9	20.6	11.0	0.0	6.7	28.5	29.8	24.1	18.4
Tier 1 ratio	10%	9%	9%	10%	11%	9%	8%	8%	9%	10%	10%	8%	7%	8%	8%
Total CAR	12%	11%	12%	13%	14%	11%	10%	10%	12%	13%	12%	10%	9%	10%	11%
Bank 2															
Profits before Loan Losses	-4.9	-4.9	-4.5	-4.5	-4.5	-12.7	-14.0	-13.4	-14.5	-15.5	-25.1	-28.9	-28.1	-30.7	-32.9
Loan Losses	21.3	48.7	31.3	16.5	0.0	43.9	103.7	65.3	33.7	0.0	16.9	94.0	101.7	82.4	63.1
RWA	8.2	17.7	11.8	6.4	0.0	16.2	34.6	23.2	12.6	0.0	7.1	31.8	33.8	27.6	21.5
Tier 1 ratio	10%	9%	10%	11%	12%	9%	8%	9%	10%	11%	10%	8%	8%	8%	9%
Total CAR	12%	11%	11%	12%	13%	11%	9%	10%	11%	13%	12%	9%	9%	10%	10%
Bank 3															
Profits before Loan Losses	-8.2	-8.2	-7.8	-7.7	-7.5	-21.1	-22.7	-22.1	-23.5	-24.7	-41.1	-45.5	-44.6	-47.7	-50.3
Loan Losses	21.6	49.1	31.5	16.6	0.0	44.5	104.5	65.6	33.9	0.0	17.3	94.8	102.0	82.6	63.1
RWA	9.5	20.4	13.6	7.4	0.0	18.7	40.1	26.7	14.5	0.0	8.3	36.8	39.0	32.0	24.9
Tier 1 ratio	12%	11%	11%	13%	14%	11%	9%	10%	12%	14%	12%	9%	8%	9%	10%
Total CAR	12%	11%	11%	13%	14%	11%	9%	10%	12%	14%	12%	9%	9%	10%	10%
Bank 4															
Profits before Loan Losses	-4.7	-4.7	-4.5	-4.6	-4.6	-11.8	-12.8	-13.0	-14.2	-15.2	-22.6	-25.8	-26.6	-29.4	-31.7
Loan Losses	20.7	46.5	29.7	15.5	0.0	42.7	98.9	61.9	31.8	0.0	17.1	89.9	95.7	76.7	58.2
RWA	7.5	16.4	10.9	5.8	0.0	15.0	32.8	21.7	11.4	0.0	6.6	30.0	32.0	25.6	19.6
Tier 1 ratio	11%	10%	10%	11%	12%	10%	8%	9%	10%	12%	11%	8%	8%	9%	9%
Total CAR	13%	12%	12%	14%	15%	12%	10%	11%	13%	14%	13%	10%	10%	11%	11%

Source: Riksbank and IMF staff estimates.

Notes: This table presents the results of the macro stress tests based on the mission's credit risk model. Profits before loan losses, loan losses, and RWA are presented in percent deviations from baseline. Tier 1 ratios and total CARs are presented in percent.

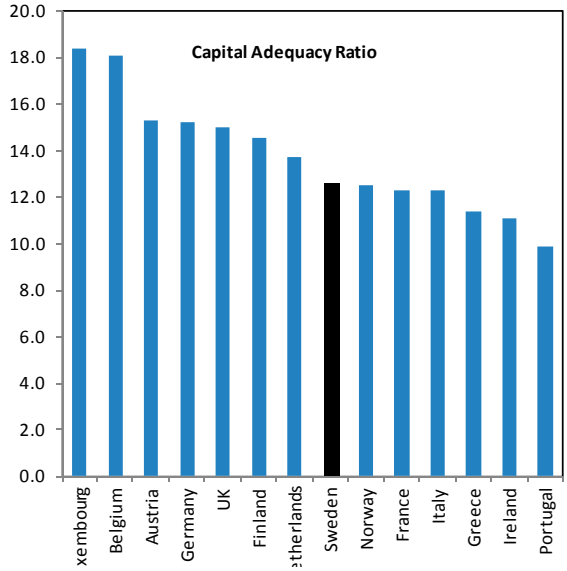
Table 6. Sweden: Concentration Risk Stress-Test Results
(In percent)

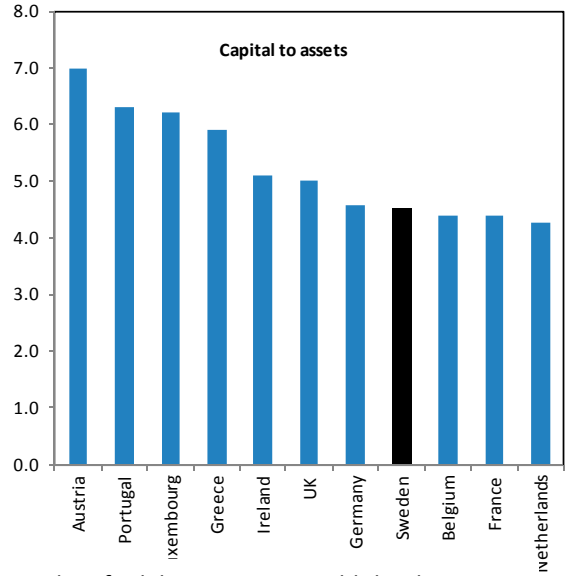
	Tier 1 Ratio
Bank 1	5.6
Bank 2	4.4
Bank 3	10.5
Bank 4	8.3

Source: Riksbank.

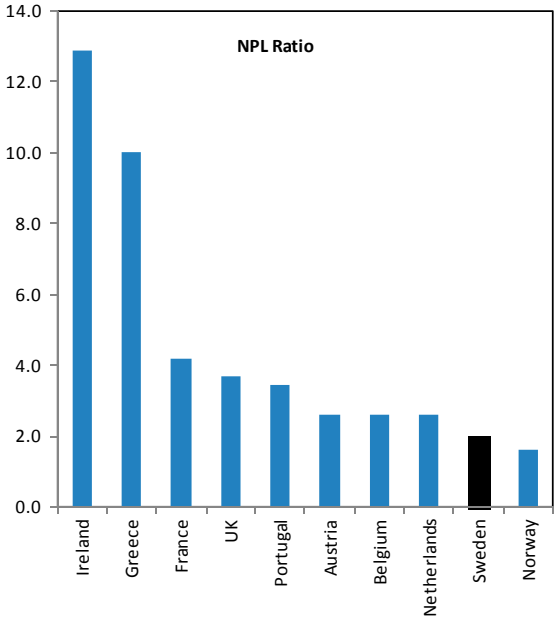
Figure 3. Sweden: Selected Western European Countries: Banking Sector Financial Soundness Indicators, 2010

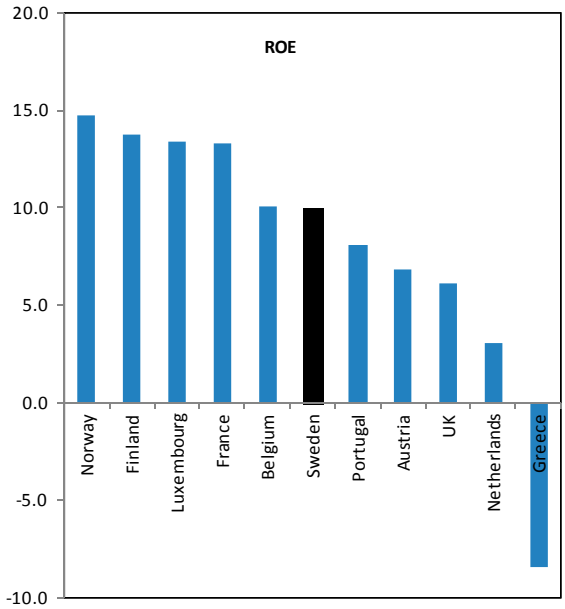
Capital Adequacy Ratio is comparable to other European Countries, while the leverage ratio is somewhat lower...





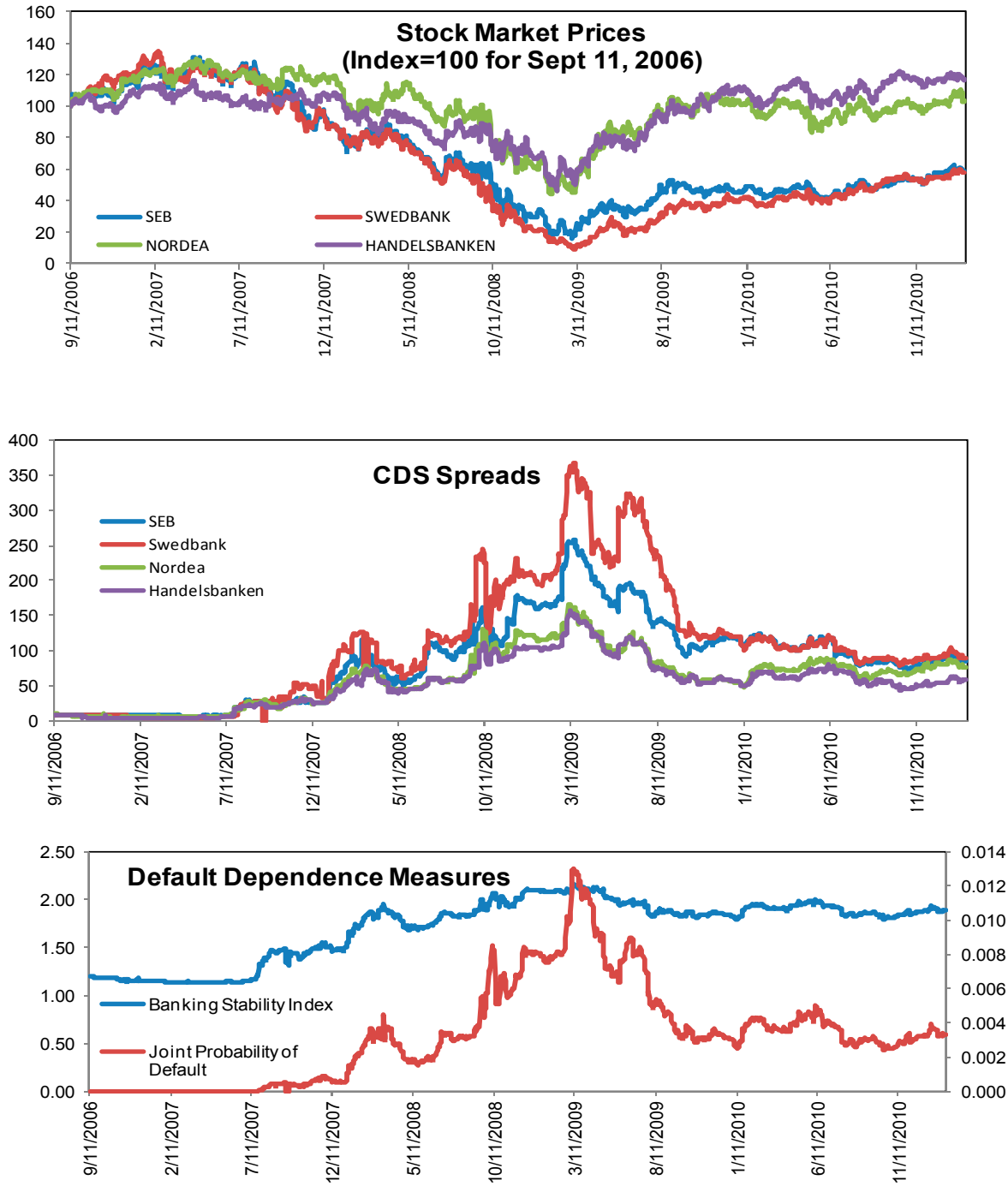
...Asset quality is among the highest in Europe and profitability is at comparable levels.





Source: GFSR

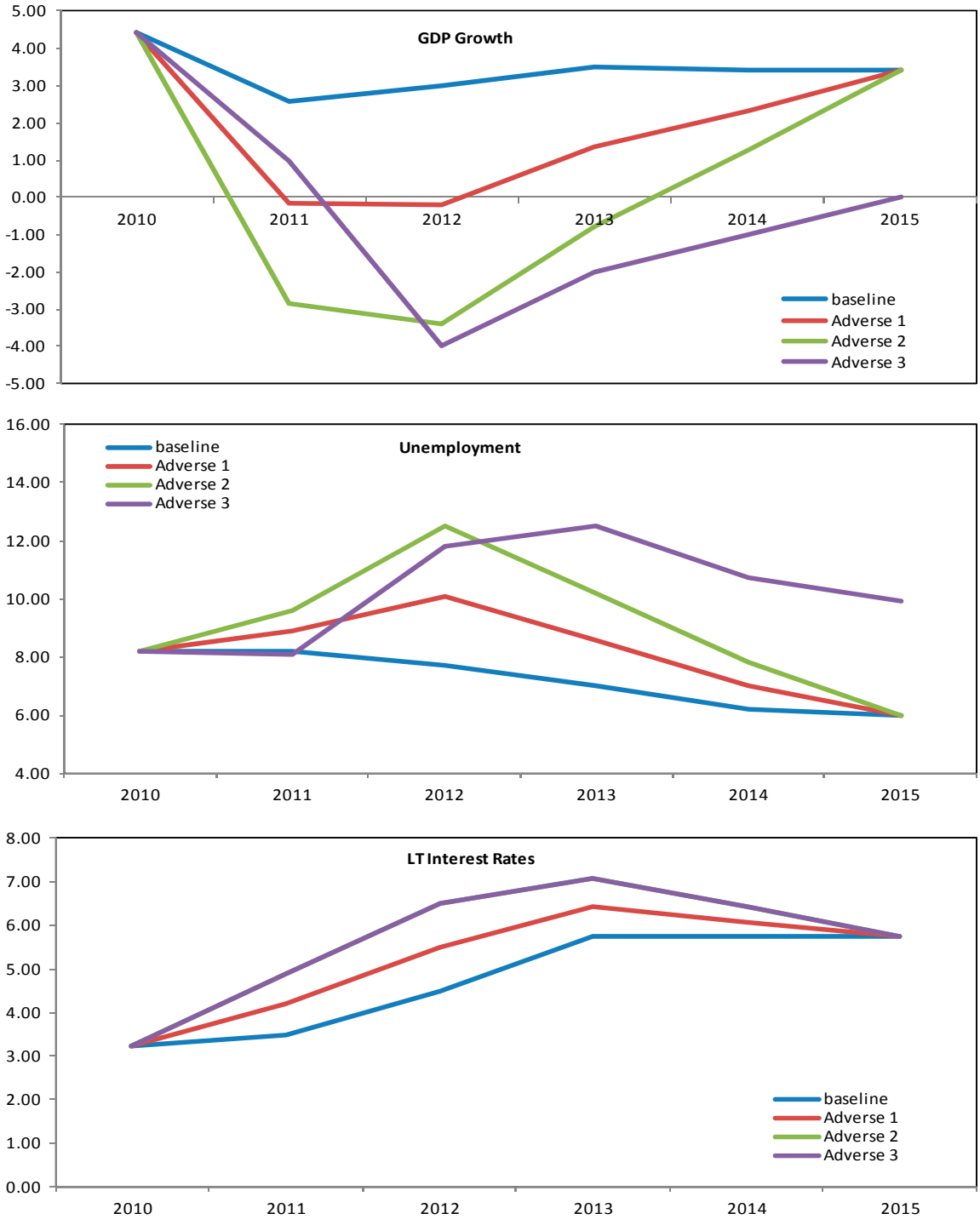
Figure 4. Sweden: Market Indicators for the Four Major Banks, 2007–10[1]



Source: Bloomberg, Markit, and IMF staff estimates

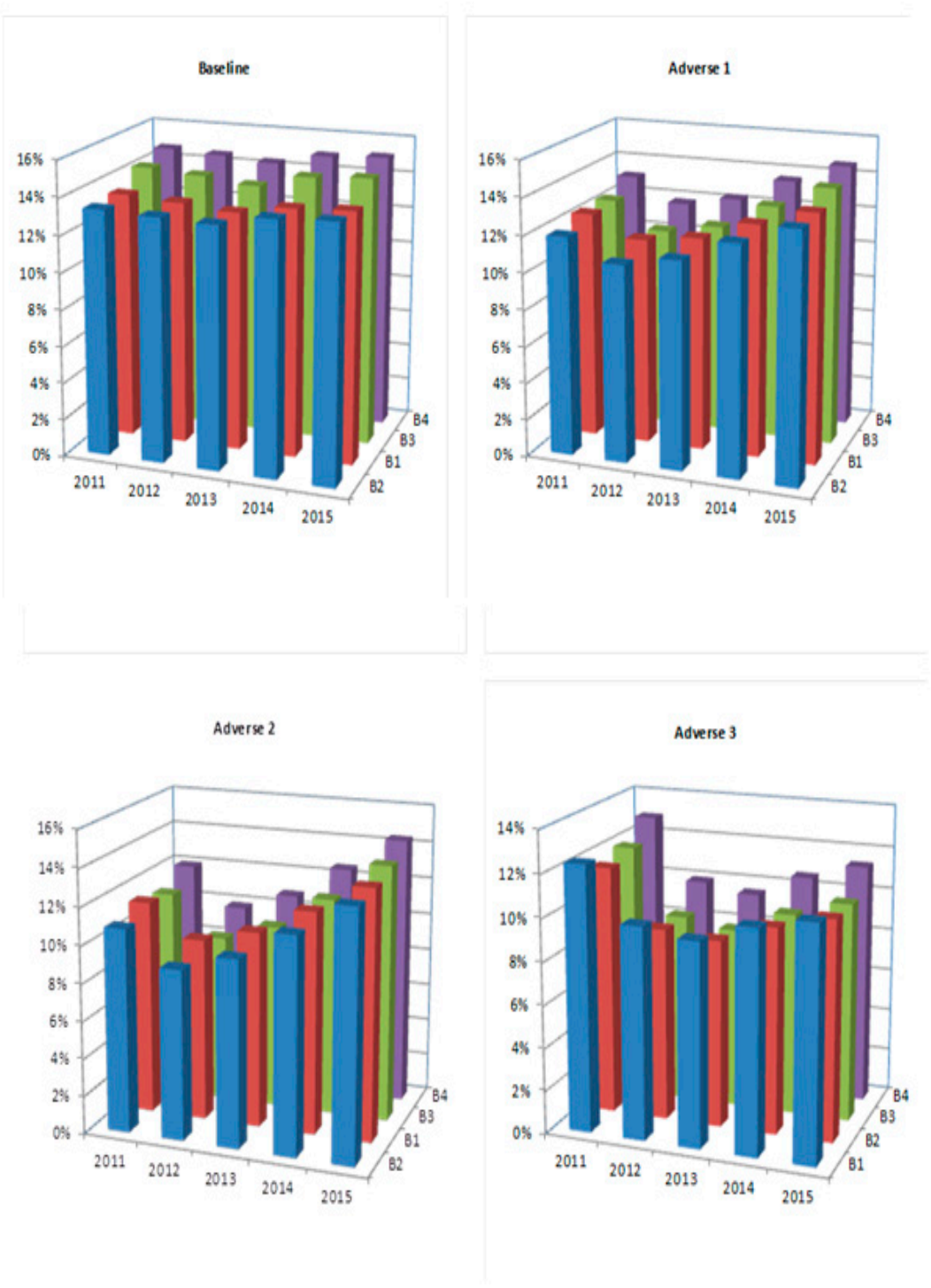
[1] The Banking Stability Index and the joint probability of default are derived using the methodology developed by Segoviano (2006) and Segoviano and Goodhart (2009).

Figure 5. Sweden: Macroeconomic Assumptions in Macro-Stress Tests 1/



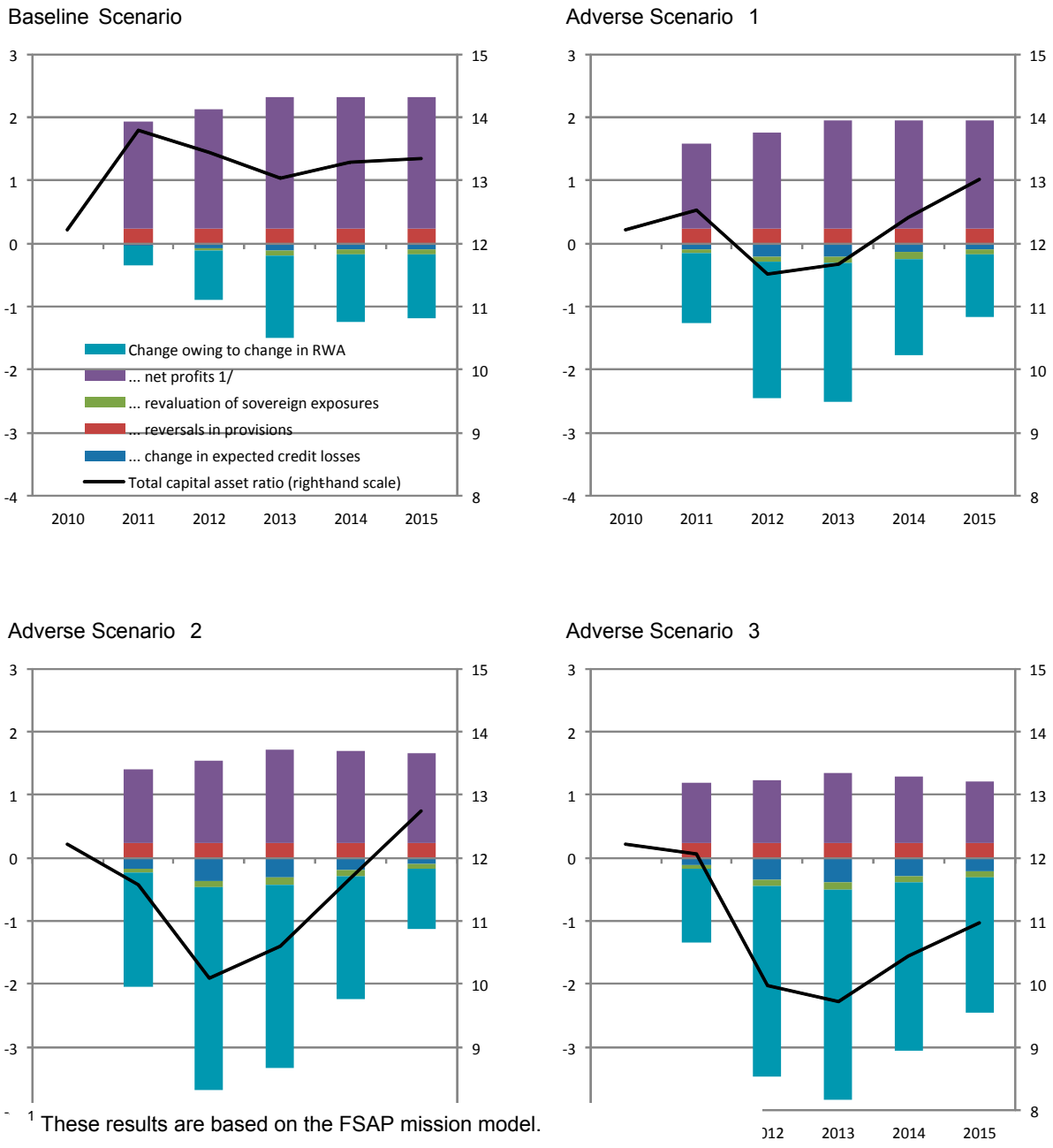
Source:Riksbank and IMF staff estimates

Figure 6. Sweden: Macro Stress-Test Results, 2011–15[1]
Post shock CAR (In percent)



Source: Riksbank and IMF staff estimate.
[1] These results are based on the FSAP mission model.

Figure 7. Sweden: Aggregate Macro Stress-Test Results, 2010–15
Contributions to changes in the aggregate CAR (In percentage points)

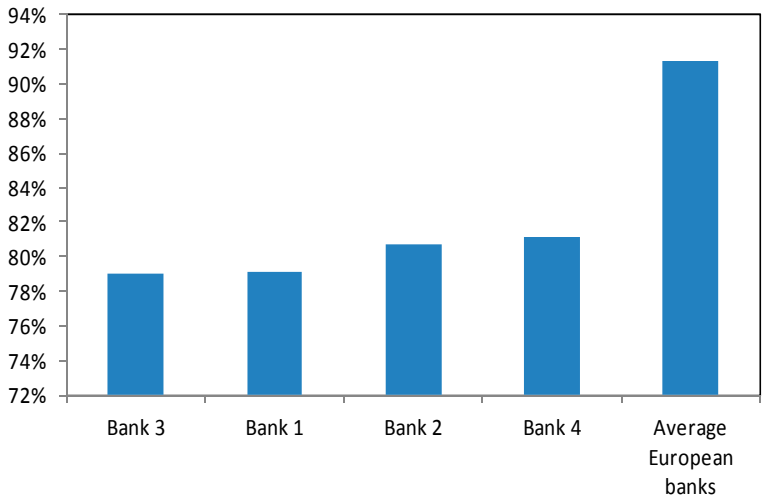


[1] These results are based on the FSAP mission model.

[1] Profits net of reversals in provisions, provisions to cover changes in expected losses, and revaluation of sovereign exposures. Results are based on FSAP mission model.

Source: IMF.

Figure 8. Sweden: Structural Liquidity Stress-Test Results, June 2010
(In percent)



Source: Riksbank.

APPENDIX I: CREDIT RISK MODELS USED FOR THE FSAP UPDATE

FSAP mission model

31. **The stress-testing framework used by the FSAP mission largely followed the methodology used in the context of the 2010 CEBS stress test exercise and other recent EU FSAPs.** As supervisory data was not available by geographical exposure, the mission team was not able to introduce a geographical dimension. Hence, in close coordination with the FSAP team, the RB devised a model which accounted for such dimension using market-implied Moody's KMV data. This model is discussed in subsequent sections.

32. **For each year, the stress-test estimates were calculated as comparative static shocks relative to the base year using the CEBS elasticities.** The base year of the stress test is 2010: Q3. The credit and sovereign bond mark-to-market (MTM) losses were estimated each year in the scenarios to reflect the cumulative stressed changes since the base year. The methodology did not model the buildup of retained earnings or bank exposures. The static nature of this stress-test methodology is broadly consistent with approaches used in some recent European FSAPs. Let base-year bank-specific advanced internal-ratings-based (AIRB) PD and LGD values be represented by $PD_{i,0}$, $LGD_{i,0}$, and S_0, C_0, B_0, M_0, and RR_0 represent total bank exposures to sovereign, corporate, banking and financial institutions, mortgage, and revolving retail loans, respectively. It is our understanding that the exposures data S_0, C_0, B_0, M_0, and RR_0 represent each bank's total initial exposures at default (EADs) to each credit-risk category, including on- and off-balance sheet exposures, and that PD and LGD data exclude already-defaulted exposures. Let RWA_0 represent a bank's actual reported initial regulatory total RWA, and GDP_t, UN_t and LR_t the level of real GDP growth, unemployment rate and long-term interest rate in stress scenario year *t*, respectively. Stress scenario PDs and LGDs were linked to changes in three macroeconomic variables in each stress period and each scenario using the CEBS elasticities. The model which links PD_0 and LGD_0 with PD_{it} and LGD_{it} is summarized as follows:

$$PD_{i,t} = \frac{PD_{i,0}}{PD_{i,base}}(PD_{i,base} + \alpha_{i,1}\Delta GDP_t + \alpha_{i,2}\Delta UN_t + \alpha_{i,3}\Delta LR_t)$$

$$LGD_{i,t} = \frac{LGD_{i,0}}{LGD_{i,base}}(LGD_{i,base} + \beta_{i,1}\Delta GDP_t + \beta_{i,2}\Delta UN_t + \beta_{i,3}\Delta LR_t)$$

where

$$\Delta GDP_t = GDP_t - GDP_0, \quad (1)$$

$$\Delta UN_t = UN_t - UN_0,$$

$$\Delta LR_t = LR_t - LR_0.$$

$PD_{i,base}$ and $LGD_{i,base}$ are country-specific, base-year values that were provided by the CEBS in the context of the stress test exercise in 2010 to calibrate country-specific elasticities.

33. **The expected stress losses from each loan portfolio (corporate, banking, mortgage, and revolving retail) exposure were estimated for the base year and each stress year as follows:**

$$\begin{aligned} EL_{C,t} &= C_0 PD_{C,t} LGD_{C,t} \\ EL_{B,t} &= B_0 PD_{B,t} LGD_{B,t} \\ EL_{M,t} &= M_0 PD_{M,t} LGD_{M,t} \\ EL_{RR,t} &= RR_0 PD_{RR,t} LGD_{RR,t} \end{aligned} \tag{2}$$

Total stress losses in any stress year were estimated as total losses from these exposures, i.e., $EL_t = EL_{C,t} + EL_{B,t} + EL_{M,t} + EL_{RR,t}$. The stress-scenario change in the expected loss relative to the base year is $\Delta EL_t = EL_t - EL_0$. Let LLP_0 represent the base-year loan-loss provisions from banks' income statements. The stress test loan-loss provisions in stress year *t* were estimated as follows:

$$LLP_t = LLP_0 + \Delta EL_t \tag{3}$$

34. **RWA were estimated as bank base year total reported RWA in 2010: Q3, adjusted by an estimate of changes in RWA for bank, corporate, mortgage, and retail exposures in each of the shock years using stressed PDs, LGDs, and AIRB functions.** Let $IRB_i(PD_{i,t}, LGD_{i,t}, m_0)$ represent the Basel II advanced approach RWA value for exposure *i*, based on inputs $PD_{i,t}, LGD_{i,t},$ and $m_{i,0}$ ($m_{i,0}$, the maturities, are assumed fixed over the stress test).[14] The base year and stress scenario total RWA for the sum of corporate, banking, mortgage and retail credit risks are estimated as follows:

$$\begin{aligned} RWA_t^A = {} & IRB_C(PD_{C,t}, LGD_{C,t}, m_{C,0}) + IRB_B(PD_{B,t}, LGD_{B,t}, m_{B,0}) \\ & + IRB_M(PD_{M,t}, LGD_{M,t}) + IRB_{RR}(PD_{RR,t}, LGD_{RR,t}) \end{aligned} \tag{4}$$

The cumulative stressed change in RWA relative to the base year is estimated as follows:

$$\Delta RWA_t = RWA_t - RWA_0^A \tag{5}$$

[14] For more details and regulatory formulae see, "International Convergence of Capital Measurement and Capital Standards," Basel Committee on Banking Supervision, June 2006.

The estimate of bank RWA that is used in the stress test to estimate regulatory capital ratios was then calculated as follows:

$$RWA_t^S = RWA_0 + \Delta RWA_t \quad (6)$$

35. **The stress tests maintained the Basel II floors throughout the entire stress-testing period.** Under current Basel II rules, a bank's RWA calculated under the AIRB approach are subject to a floor which requires that banks may not report an RWA value that is less than 80 percent of their RWA value calculated under the 1988 Basel Accord rules. This transitional floor will remain in place until end-2011. The initial stress-test scenario RWA used banks 2010: Q3 regulatory reported RWA, which include the 80 percent floors. These floors were kept by the FSAP mission throughout the stress period.[15]

36. **Equations (3) and (6) estimate stress-scenario loan-loss provisions and RWA as the sum of a bank's initially reported values plus the changes in expected loss and RWA (respectively), where these changes are calculated relative to the base-year Basel II EL and RWA prescriptions.** This approach is necessary because, in many cases (perhaps all), bank balance sheet provisions and RWA are not equal to the Basel formula in the initial period, i.e., $LLP_0 \neq EL_0$, and $RWA_0 \neq RWA_0^A$.[16]

37. **There are some important considerations that need to be noted when using this methodology.** The static nature of the approach used in this exercise means that there is no information gained by running a long stress test scenario. The stress-scenario results do not compound across subsequent years, as the outcomes are calculated as a series of comparative static results (relative to the base year) and so the stress-test capital adequacy outcome is essentially determined by the single worst year of the test.

38. **Another important consideration is the character of the model's multipliers, which are applied to a bank's initial PDs and LGDs to produce stress PDs and LGDs.** These multipliers are determined by the magnitudes of the macroeconomic shocks and the model parameters. The resulting multipliers are independent of the level of bank's reported PDs and LGDs. This raises the issue of whether more conservative banks in terms of credit risk reporting (higher PDs and LGDs) would be facing larger stress scenarios in this model than underreporting ones. Hence, it was important to use expert judgment from banking sector experts at the RB and FI to fine-tune the results.

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[15] The Swedish Government has presented a bill that proposes extending the floors regulation until further notice and the Riksdag is expected to decide on the issue in June 2011.

[16] This could be due to the more granular data available to and used by banks in their calculations.

39. **Finally, the mission model does not account for the geographic allocation of loan exposures.** While the main strength of this approach is that it uses bank-by-bank actual supervisory data, it does not account for the geographical allocation of the loan portfolio. This caveat is somewhat mitigated by the predominance of loan exposures in Sweden and other Nordic countries with similar macroeconomic conditions. Nevertheless, this caveat was recognized and motivated the use of a complementary model, which was devised by the RB in collaboration with the FSAP team to corroborate the overall solvency results.

The Riksbank's credit risk model

40. **The RB designed a credit risk stress-testing methodology in close collaboration with the mission team prior to the mission.**

41. **The RB base their stress tests on market-implied Moody's KMV default data.** The authorities argue that (i) the results of stress tests based on supervisory data could not be published for confidentiality reasons; and (ii) the results of stress tests based on market implied data are more comparable across banks. Hence, RB derives PDs and LGDs from available market-implied Moody's KMV data for listed companies in the Nordic countries, Germany, and the United Kingdom. The loan breakdown used in the RB's models includes property companies, other nonfinancial companies, financial institutions, and households. The geographic breakdown includes Sweden, other Nordic countries, Baltic countries, Germany, the United Kingdom, and the rest of the world (Table 9). NPL ratios are used as proxies for corporate loan PDs in the Baltic countries, and household loan PDs in all countries.

42. **Stress scenario PDs are estimated using elasticity estimates from the RB's in-house satellite models, while LGDs are held constant.** To describe the RB's satellite models, it is important to introduce some notations first: let $PD^{C}_{i,t}$ be corporate loan PDs in the Nordic countries, U.K., and Germany; $PD^{H}_{i,t}$ be household loan PDs in the Nordic countries, United Kingdom, and Germany; and $PD^{B}_{i,t}$ be household and corporate loan PDs in the Baltic countries. The RB satellite models can be summarized in equations (7)–(9):[17]

$$PD^{C}_{i,t} = c_i + \alpha_{i,1} PD^{C}_{i,t-1} + \alpha_{i,2} \Delta GDP_{i,t} + \alpha_{i,3} SR_{i,t} \quad (7)$$

$$PD^{H}_{i,t} = b_i + \beta_{i,1} \Delta UN_{i,t} \quad (8)$$

[17] Equation (7) is a reduced form VAR model, equation (8) is a simple projection where the percentage change in PD is explained by the percentage change in the unemployment rate, and equation (9) is a dynamic panel with fixed effects.

$$PD_{i,t}^{B} = d_i + \delta_{i,1} PD_{i,t-1}^{B} + \delta_{i,2} \Delta GDP_{i,t} + C_i \tag{9}$$

where,

$$\Delta GDP_{i,t} = \frac{GDP_{i,t}}{GDP_{i,t-1}} - 1$$

$$\Delta UN_{i,t} = \frac{UN_{i,t}}{UN_{i,t-1}} - 1$$

C_i : crisis dummy

43. **In the baseline scenario, credit growth is forecasted using the RB satellite models.** For corporate lending, investments are deemed to be the main driving factors behind credit growth, while disposable income and short-term interest rates are considered to be the main explanatory variables for retail credit growth. Let CI be corporate loan exposures in Nordic countries, United Kingdom, and Germany; CB be corporate loan exposures in the Baltic countries; HI be household loan exposures in the Nordic countries, United Kingdom, and Germany; and HB be household loans exposures in the Baltic countries. Let $I_{i,t}$ be investments in country *i* and year *t*, $DI_{i,t}$ be disposable income, $SR_{i,t}$ be short-term interest rates, and C_i be a crisis dummy.

The RB's credit growth satellite models are summarized in equations (10)–(13).[18]

$$\Delta CI_{i,t} = c_i + a_{i,1} \Delta CI_{i,t-1} + a_{i,2} \Delta I_{i,t} \tag{10}$$

$$\Delta HI_{i,t} = c_i + b_{i,2} \Delta HI_{i,t-1} + b_{i,2} \Delta DI_{i,t} + b_{i,3} SR_{i,t} \tag{11}$$

$$\Delta CB_{i,t} = c_i + d_{i,1} \Delta CB_{i,t-1} + d_{i,2} \Delta I_{i,t} + d_{i,3} SR_{i,t} + d_{i,4} C_i \tag{12}$$

$$\Delta HB_{i,t} = c_i + e_{i,1} \Delta HB_{i,t-1} + e_{i,2} SR_{i,t} + e_{i,3} C_i \tag{13}$$

where,

$$\Delta CI_{i,t} = \frac{CI_{i,t}}{CI_{i,t-1}} - 1,\ \Delta I_{i,t} = \frac{I_{i,t}}{I_{i,t-1}} - 1,\ \Delta HI_{i,t} = \frac{HI_{i,t}}{HI_{i,t-1}} - 1,\ \Delta CB_{i,t} = \frac{CB_{i,t}}{CB_{i,t-1}} - 1,\ \Delta HB_{i,t} = \frac{HB_{i,t}}{HB_{i,t-1}} - 1$$

The increments estimated in equations (10)–(13) are then added to the initial exposures in each year to derive the EAD for each loan portfolio, such as:

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[18] Equations (10)–(13) are dynamic panel models with fixed effects.

$$CI_{i,t} = CI_{t-1} \times (1 + \Delta CI_{i,t}) \quad (14)$$

$$HI_{i,t} = HI_{t-1} \times (1 + \Delta HI_{i,t}) \quad (15)$$

$$CB_{i,t} = CB_{i,t-1} \times (1 + \Delta CB_{i,t}) \quad (16)$$

$$HB_{i,t} = HB_{t-1} \times (1 + \Delta HB_{i,t}) \quad (17)$$

Using equations (7)–(17), and fixed LGDs, loan losses are then calculated for each loan portfolio and geographic allocation as follows:

$$LLP_{i,t} = PD_{i,t} \times LGD \times EaD_{i,t}$$

44. **The total loan loss in each bank is then estimated as the sum of loan losses in each loan portfolio and geographic allocation after accounting for anticipated reversals and using expert judgment from banking and macro prudential staff at the RB to fine-tune the results.** Loan losses are then deducted from RWA at the end of the year. Additional risk migration was assumed, associated with an ad hoc increase in RWA of 3 percent, 4 percent, and 5 percent for adverse Scenarios 1, 2, and 3, respectively.

45. **Important considerations should be mentioned when using this model as well.** While the model has the important advantage of accounting for the geographic allocation of the loan exposures, it is based on market-implied data. While such data is useful in the satellite model estimations given its long time-series nature, actual/supervisory bank data should be used as the initial values of credit-risk measures in the stress tests. EDF data are based on a Merton-type model, which assumes efficient markets where stock market prices reflect firm fundamentals. EDFs infer PDs from equity prices, which are typically volatile during periods of crisis. Moreover, nonlisted firms are excluded from this model, which could leave out an important share of banks' loan portfolios from the credit risk stress tests.

Table 7. Sweden: Geographic and Loan Portfolio Allocation Used in Riksbank's Credit-Risk Models

Geographic Allocation	Loan Portfolio
Sweden	Non financial companies
	Property Companies
	Financial companies and credit institutions
	Households
Norway	Non financial companies
	Property Companies
	Financial companies and credit institutions
	Households
Denmark	Non financial companies
	Property Companies
	Financial companies and credit institutions
	Households
Finland	Non financial companies
	Property Companies
	Financial companies and credit institutions
	Households
Germany	Non financial companies
	Property Companies
	Financial companies and credit institutions
	Households
United Kingdom	Non financial companies
	Property Companies
	Financial companies and credit institutions
	Households
Estonia	Corporate
	Households
Latvia	Corporate
	Households
Lithuania	Corporate
	Households
Rest of the world	Corporate
	Households

Source: Riksbank.

APPENDIX II: SOVEREIGN HAIRCUT CALCULATIONS

46. **The mission broadly followed a discounted cash flow (DCF) methodology in the calculation of bond haircuts under the four scenarios.** Five-year bonds were assumed to be representative of the maturities of banks' bond holdings. Bonds for which market quotes from Bloomberg were available, with maturities between 4.5 and 6.5 years, were included similar to the CEBS exercise. Bond prices for each year under each scenario were calculated based on a DCF method using coupon payments, coupon frequency, maturity dates, redemption value, and yield-to-maturity under the four scenarios as follows:

$$P_{b,t} = \sum_{k=1}^{n} \frac{c}{(1+r_t)^k} + \frac{f}{(1+r_t)^n} \ ,$$

where $P_{b,t}$ is the price in year stress year t of bond b, c is the coupon payment, f is the face value, and r_t is the yield to maturity in each year.

47. **Corresponding haircuts were calculated for each bond from changes in bond prices relative to the base year under the three scenarios.**

$$\Delta P_{b,t} = 100\left(\frac{P_{b,t}}{P_{b,0}} - 1\right) \tag{7}$$

where $P_{b,0}$ is the bond price in the base year.

48. **The haircut for each sovereign at each stress date, $haircut_t^c$, was calculated as the weighted average change in the price of all bonds of that sovereign for the scenario date, where the weights are the amounts outstanding of the included sovereign bonds, as follows:**

$$haircut_t^c = \sum_{b=1}^{k} \frac{\Delta P_{b,t} \times Amt_b}{\sum_{b=1}^{k} Amt_b} \tag{8}$$

where $\Delta P_{b,t}$ is the haircut on bond b, and Amt_b is the outstanding amount of bond b.

49. **The sovereign bond losses of a bank were estimated as follows:**

$$Losses_t = \sum_{c=1}^{m} haircuts_t^c \times \exp osures_{0,c} \tag{9}$$

Where $exposures_{0,c}$ represent banks' total sovereign-bond exposures to country *c* in the banking and trading books as of March 2010.[19] Sovereign-exposure gains, should they materialize, were ignored for stress-test purposes.

[19] More recent data on banks' sovereign bond exposures were not available to the mission.

APPENDIX III: BASEL III NEW CAPITAL REQUIREMENTS

Table 8. Sweden: Overview on the Basel III Minimum Capital Requirements

Annex 2: Phase-in arrangements (shading indicates transition periods)
(all dates are as of 1 January)

	2011	2012	2013	2014	2015	2016	2017	2018	As of 1 January 2019
Leverage Ratio	Supervisory monitoring		Parallel run 1 Jan 2013 – 1 Jan 2017 Disclosure starts 1 Jan 2015					Migration to Pillar 1	
Minimum Common Equity Capital Ratio			3.5%	4.0%	4.5%	4.5%	4.5%	4.5%	4.5%
Capital Conservation Buffer						0.625%	1.25%	1.875%	2.50%
Minimum common equity plus capital conservation buffer			3.5%	4.0%	4.5%	5.125%	5.75%	6.375%	7.0%
Phase-in of deductions from CET1 (including amounts exceeding the limit for DTAs, MSRs and financials)				20%	40%	60%	80%	100%	100%
Minimum Tier 1 Capital			4.5%	5.5%	6.0%	6.0%	6.0%	6.0%	6.0%
Minimum Total Capital			8.0%	8.0%	8.0%	8.0%	8.0%	8.0%	8.0%
Minimum Total Capital plus conservation buffer			8.0%	8.0%	8.0%	8.625%	9.25%	9.875%	10.5%
Capital instruments that no longer qualify as non-core Tier 1 capital or Tier 2 capital			Phased out over 10 year horizon beginning 2013						
Liquidity coverage ratio	Observation period begins				Introduce minimum standard				
Net stable funding ratio		Observation period begins						Introduce minimum standard	

Source: International Convergence of Capital Measurement and Capital Standards," Basel Committee on Banking Supervision, June 2006.

Table 9. Sweden: Individual Bank Minimum Capital Conservation Standards

Common Equity Tier 1 Ratio (In percent)	Minimum Capital Conservation Ratios (In percent of earnings)
4.5-5.125	100
>5.125-5.75	80
>5.75-6.375	60
>6.375-7.0	40
>7.0	0

Source: International Convergence of Capital Measurement and Capital Standards," Basel Committee on Banking Supervision, June 2006.

Table 10. Sweden: Individual Bank Minimum Capital Conservation Standards, When a Bank is Subject to a 2.5 Percent Countercyclical Requirement

Common Equity Tier 1 Ratio (Including other fully loss- absorbing capital)	Minimum Capital Conservation Ratios (In percent of earnings)
4.5-5.75	100
>5.75-7.0	80
>7.0-8.25	60
>8.25-9.5	40
>9.5	0

Source: International Convergence of Capital Measurement and Capital Standards," Basel Committee on Banking Supervision, June 2006.

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