Stress testing of banks' profit and capital adequacy

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A model system for stress testing financial stability is being developed at Norges Bank. In this article, we present two of the models in this system: a macroeconomic model and a bank model to analyse developments in banks' profit and capital adequacy under different scenarios in the Norwegian economy. We illustrate important properties of these models by studying a stress scenario for the Norwegian economy involving major shocks. The stress scenario shows that banks' profit will be considerably impaired if house prices are sharply reduced and the interest rate rises. Banks' capital adequacy will also decrease. However, banks in Norway have a solid capital base, and our analysis shows that they would be able to weather such economic developments.

1   Introduction

Over the past decades, financial stability analysis has been given an increasingly important role in many central banks as financial markets have deepened and financial crises have occurred more frequently. A number of central banks have a clear mandate to promote financial stability[2]: the situation in the financial system, i.e. financial institutions, markets and payment systems, are monitored and analysed regularly. An important element in the analysis of financial stability is to study how vulnerable the financial system is to macroeconomic shocks. This can be done by conducting stress tests.

The use of stress testing to assess vulnerability in the financial sector has become increasingly common among central banks. The methods and models used, however, are different. This is partly due to differing perceptions of what the most important elements are in financial stability analyses, but also to structural differences in financial systems across countries.

Norges Bank is developing a system comprising a number of models for stress testing financial stability. In our analyses of financial stability, considerable weight is given to assessing developments in banks, as banking accounts for most of the financial sector in Norway. Banks play a key role in credit provision and payment services – and they differ from other financial institutions in that their activities are largely funded by customer deposits.

The next section provides a brief description of the complete model system used for stress testing. Two of the models are then presented in more detail: a macroeconomic model for the analysis of financial stability and a bank model for analysing developments in banks' profit and capital adequacy. Section 3 contains an example showing how the two models are used to assess developments in bank's profit and capital adequacy in two different scenarios for the Norwegian economy, a benchmark scenario and an alternative scenario involving major shocks. Section 4 provides a summary.

2   A system for stress testing

The model system[3] for stress testing of financial stability comprises a macro model, a micro model for default probabilities among households, a micro model for default probabilities among non-financial enterprises, and a bank model for banks' profit and capital adequacy. The models can be simulated independently or as an integrated system.

The macro model is a model for the Norwegian economy expanded to include important variables for financial stability analysis. The model is used to describe alternative scenarios for the Norwegian economy in which the economy is exposed to extreme, negative shocks. These are shocks that are likely to have a negative impact on households, enterprises and banks.

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[2] See for example Ferguson (2002)

[3] For a more detailed description of the model system used in stress-testing analyses, see Andersen et al. (2008a).

The micro model for households is a model for predicting default probabilities in individual households. However, there is no information about which households default on their loans. We therefore introduce an indicator for default probabilities by estimating a measure of household financial margins. Household financial margins are defined as income after tax minus interest expenses, loan repayments and normal living expenses. Outstanding debt in households with negative margins is classified in the model as debt at risk. For a more detailed description of the household model, see Vatne (2006).

The micro model for enterprises is a model for predicting default probabilities for all Norwegian limited companies. Default probabilities are derived from an estimated model for bankruptcy probabilities (SEBRA), which is based on key variables from the enterprises' accounts, including earnings, liquidity and financial strength. Idiosyncratic variables are also included, such as industry and the size and age of the enterprise. Default probabilities for the individual enterprises are multiplied by the enterprise's outstanding debt and can be interpreted as that enterprises' debt at risk. The sum of risk-weighted debt for all enterprises will constitute debt at risk in the corporate sector. For a more detailed description of the corporate sector model, see Bernhardsen and Larsen (2007).

The bank model comprises three main components: profit and loss account, balance sheet and capital adequacy calculation. This model can be applied to individual banks or groups of banks, depending on the purpose of the analysis.

Chart 1 illustrates the interplay between components in the model system. The structure of the system is recursive, with the macro model's projections of key macroeconomic variables being used in the micro part of the system, illustrated by the solid arrows. This enables us to conduct consistent analyses where macroeconomic developments are the same for all the models.

In the micro part of the system, i.e. the household, corporate sector and bank models, the profit from the macro model are used as exogenous input, either directly or in derived form. In the bank model, we also use calculations of debt at risk grouped by industry from the corporate sector model. This enables us to assess the risk associated with each bank's portfolio composition. As illustrated by the broken arrow in the chart, it is also possible to use this approach for the household sector.

Banks' loan losses are a key variable when we estimate banks' profit and capital adequacy in the bank model. The system is designed to provide two alternative possibilities for estimating loan losses. In this analysis, banks' loan losses in the years ahead are estimated on the basis of the macro model's projections of problem loans[4]. Another alternative is to use the micro model's projections of default probabilities and debt at risk.

In the rest of this section, we will give an account of the structure and properties of the macro model and the bank model.

2.1 The macro model

In connection with the development of the model system for stress testing, Norges Bank has developed a macroeconomic model designed for financial stability analysis, see Box 1 below. The model is used to describe macroeconomic scenarios. For a more detailed review of the relationships in the macro model, see appendix 1 in Andersen et al. (2008a).

We have used as our basis an existing model of the Norwegian economy, see Bårdsen and Nymoen (2008) and Chapter 9 in Bårdsen et al. (2005). The model has been expanded by including relationships for variables are that are central to financial stability analysis, including house prices, household debt, housing investment and banks' problem loans in the household and corporate sector. In addition, the original model was altered somewhat by including a financial accelerator. House prices and credit influence each other and have an impact on developments in economic activity, represented by mainland GDP.

The macro model is an equilibrium correction model

Chart 1 Norges Bank's system for stress testing

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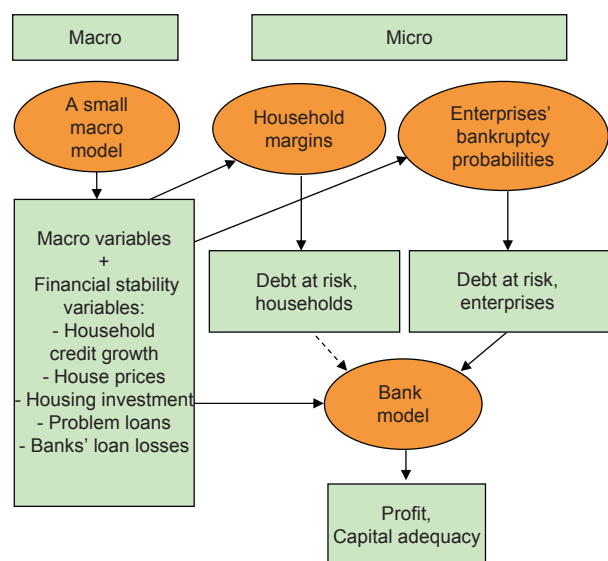
[4] Problem loans are defined as the sum of non-performing loans and non-delinquent loans which the banks consider to be particularly doubtful.

for the Norwegian economy, and comprises estimated relationships on quarterly data for, for example, mainland GDP, unemployment, wages, prices, import prices, nominal exchange rate, house prices, housing investment, household credit growth and problem loans in banks. In addition, the model contains a Taylor-type interest-rate reaction function for money market rates.

The model has a number of features that are of particular interest in analyses of financial stability. First, developments in house prices and debt have repercussions on the real economy through aggregate demand. Total activity, i.e. mainland GDP, is in the long-term a function of the interest rate, exchange rate, household credit growth and public consumption, all variables measured in real terms (see relationship (1.1)). Public consumption, house prices and growth in credit to both households and enterprises also have short-term effects on the level of activity. Both the short- and long-term effects of credit growth are assumed to represent frictions in credit markets, for example because borrowers are rationed. With higher house prices and higher credit, aggregate demand and output in the economy will increase. Higher house prices result in increased wealth for homeowners, who may want to realise a share of the gain in the form of debt-financed consumption. At the same time, new residential construction projects become profitable when house prices rise relative to residential construction costs. This leads to higher housing investment. Higher house prices will also push up household indebtedness. The model thus embodies the correlation between the level of economic activity, house prices and household debt growth.

In addition, the model contains relationships for banks' problem loans to the household sector and the corporate sector respectively, where problem loans comprise non-performing loans and other doubtful loans. Problem loans are determined by developments in macroeconomic variables and enable us to assess banks' vulnerability and the risk of loan losses under different macroeconomic scenarios. The relationships for problem loans[5] in (1.12) and (1.13) are modelled based on debt-servicing capacity and willingness among households and enterprises respectively. The probability of default is represented by factors such as income, interest rate, unemployment, competitiveness and oil prices. Competitiveness for Norwegian enterprises is reflected in the real exchange rate, while oil prices reflect the petroleum sector's particular significance for developments in demand in the Norwegian supplier sector.

The exchange-rate model is presented in relationship (1.2). In the long term, the real exchange rate reflects the difference between the domestic and the global real interest rate, and oil prices. In the long term uncovered interest-rate parity holds in real terms.

Import prices in relationship (1.3) are a homogeneous function of the nominal exchange rate and foreign producer prices measured in foreign currency. But in addition, import prices rise if the real exchange rate (measured by consumer prices) appreciates.

Unemployment, wages and consumer prices in relationship (1.4)–(1.6) are based on the assumption of imperfect competition and a model for negotiations between trade unions and employers. Trade unions are concerned about both wage developments and unemployment. In the long term, changes in consumer prices and productivity feed through fully to wages. The wage level also depends on the bargaining power of trade unions, which is reflected in the level of unemployment. Consumer prices are determined in the long term by production costs, reflected in labour costs per person-hour and import prices. In the short term, price developments are also affected by developments in mainland GDP.

The money market rate in relationship (1.7) is a Taylor-type interest-rate reaction function that depends on how much inflation deviates from the inflation target, the level of unemployment and global money market rates. This relationship is partly estimated and partly calibrated on historical data.

The bank lending rate in relationship (1.8) is the sum of the money market rate and an exogenously determined lending margin.

Household credit growth is given in relationship (1.9). Credit growth depends on household income, interest rates on loans and house prices. Household debt-servicing capacity increases with higher incomes and lower interest rates, which makes banks willing to provide more credit to households and results in higher household demand. Most household debt is secured on the borrower's own dwelling. Higher house prices lead to higher collateral values for banks, which thereby become willing to increase loans secured on dwellings. Household housing wealth also increases when house prices rise, and by increasing the loan-to-value ratio, households can realise some of the increase in wealth in the form of higher consumption.

House prices and housing investment in relationship (1.10) and (1.11) are modelled based on a stock flow model. First, house prices are modelled, defined as a demand function given the supply, i.e., given the housing stock. The reason for this approach is that the hous-

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[5] For a more detailed review of problem loans in banks, see Berge and Boye (2007).

ing stock is a lagged variable that it takes time to change via housing investment. Then housing investment is modelled, i.e. the change in the supply, on the basis of profitability considerations among residential building contractors.

Corporate credit growth is exogenously determined in this analysis.

2.2 Bank model

Banks face a number of risk factors. The purpose of the bank model is to analyse how vulnerable banks are to these risk factors. Loans to households and enterprises account for approximately two-thirds of Norwegian banks' assets.[6] It is important, therefore, that the bank model can be used to analyse how changes in credit risk affect banks' profit and financial strength. It should also be possible to use a bank model to analyse the effects of liquidity risk, market risk and operational risk on banks' profit and financial strength.
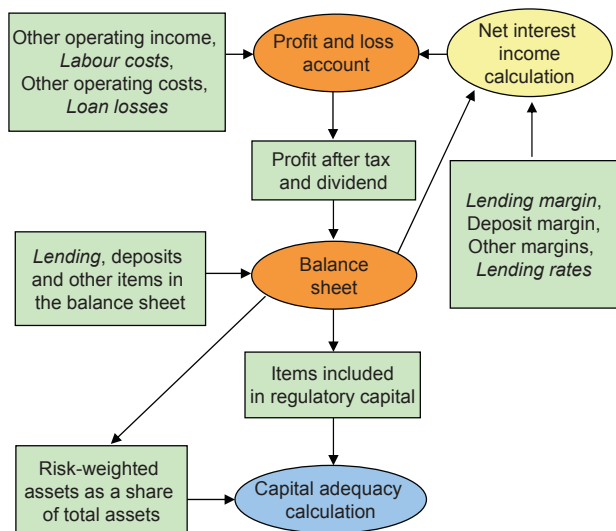
The bank model is a non-behavioural model and consists of three main components: profit and loss account, balance sheet and capital adequacy calculation (see Chart 2).

The profit and loss account and the balance sheet have a reciprocal effect on each other. Banks' profit after

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[6] All banks in Norway except branches of foreign banks in Norway.

Chart 2 Bank model

tax and dividends directly affects banks' equity capital that is included in the balance sheet. At the same time, net interest income, which is included in the profit and loss account, is determined by the size of the assets and liabilities in the balance sheet.

The balance sheet affects the capital adequacy calculation. Equity capital is an important item in the calculation of regulatory capital included in the capital adequacy calculation. The balance sheet also affects the risk-weighted assets for capital adequacy calculation.

The bank model's projections make use of the output from the macro model on lending to households, lending rates, loan losses and labour costs (see italicised text in Chart 2). The model may be used for individual banks or groups of banks, depending on the purpose of the analysis. A detailed presentation of the model follows.

2.2.1 Banks' profit and loss account

Banks' profit after tax and dividends is calculated in the following manner:

$$PRO = NII + OOI - OOC - LL - T - DIV \qquad (2.1)$$

where profit after tax and dividends (*PRO*) depends on net interest income (*NII*), other operating income (*OOI*), other operating costs (*OOC*), loan losses (*LL*), tax (*T*) and dividends (*DIV*).

Net interest income (*NII*) which is included in the calculation of banks' profit after tax and dividends (see equation 2.1), is calculated as follows:

$$NII = ((L_{-1} + L)/2) \cdot LR + ((OA_{-1} + OA)/2) \cdot ROA$$
$$- ((D_{-1} + D)/2) \cdot RD - ((OL_{-1} + OL)/2) \cdot ROL \qquad (2.2)$$

where the subscript *–1* indicates that the variable is from the previous quarter. Net interest income (*NII*) depends on net lending (*L*), average lending rate (*LR*), other interest-bearing assets (*OA*), average interest rate on other interest-bearing assets (*ROA*), deposits from customers and other financial institutions (*D*), average interest rate on deposits from customers and other financial institutions (*RD*), other interest-bearing liabilities (*OL*)[7] and average interest rate on other interest-bearing liabilities (*ROL*). An increase in the average interest rate on loans and other interest-bearing assets increases in isolation net interest income, whereas an increase in the average interest rate on deposits and other interest-bearing liabilities has the opposite effect. In addition, growth in total assets will increase net interest income if the marginal interest rate is higher on interest-bearing assets than on interest-bearing liabilities. Net interest income as a share of banks' total operating income has fallen over the past ten years, although the share was nonetheless 67 per cent at end-2007. It is therefore especially important that the projections for this income item are accurate.

Other operating income (*OOI*) which is included in the calculation of banks' profit after tax and dividends (see equation 1), is calculated as follows:

$$OOI = FEE + SD + NGS + NGFE + NGD + OGI \qquad (2.3)$$

where other operating income is the sum of fee income (*FEE*), share dividends (*SD*), gains/losses on securities (*NGS*), foreign exchange (*NGFE*) and derivatives (*NGD*), as well as other gains and income (*OGI*).

Fee income (*FEE*), which is included in the calculation of other operating income (see equation 2.3), is calculated using an error correction model estimated on quarterly data:

$$\Delta\ln(FEE) = -4.82 - 0.37\ln(FEE_{-1}) + 0.60\ln(GDP_{-1})$$
$$+ 1.51(R5Y - R3M)_{-1} - 0.003\Delta FORB$$
$$+ 0.94\Delta\ln(GDP) + 0.23\Delta\ln(FEE_{-4}) \qquad (2.4)$$
$$+ 0.02S1 + 0.01S2 - 0.001S3$$

where ln designates the logarithm of the variable, the subscript −1 indicates that the variable is from the previous quarter and Δ designates the first difference, i.e. $\Delta\ln(FEE) = \ln(FEE) - \ln(FEE_{-1})$. Banks' fee income is estimated using GDP (*GDP*), the yield differential between 5-year government bonds (*R5Y*) and 3-month money market rates (*R3M*), and the market share of branches of foreign banks (*FORB*). The equation also contains the effects of seasonal variations (*S(i)*). See Andersen et al. (2008b) for a more detailed description

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[7] Other interest-bearing liabilities include short-term paper, bonds, subordinated loans and other debt.

of the equation. At the end of 2007, fee income was the largest item in other operating income, accounting for 55 per cent of the total.

Other operating costs (*OOC*) include labour costs, commission costs, electronic data processing costs and other costs. Labour costs represented the largest item, accounting for 55 per cent of other operating costs in 2007.

Loan losses (*LL*) have been very low in recent years, but may increase considerably if the financial position of borrowers deteriorates. During the Norwegian banking crisis in the period 1988–1993, loan losses were very high, and in 1991 loan losses were higher than other operating costs. Projected loan losses are derived from the macro model's calculations of problem loans and estimated loan-loss ratios for these loans. However, exposure to credit risk in different industries varies across banks. The bank model therefore uses the projected distribution of loan losses across different industries from the corporate sector model.

Tax (*T*) is set at 28 per cent of profit before tax and dividends. The average share of tax that banks have charged to income during the past five years is slightly less than 28 per cent, but the share varies from year to year.

Banks' dividends (*DIV*) are assumed to be 50 per cent of after-tax profit. A dividend is not paid if banks record a negative profit.

2.2.2 Banks' balance sheets

A bank's balance sheet consists of an asset column listing the bank's assets and a liability column indicating how the assets have been funded. The assets in the balance sheet comprise the following items:

- loans to households and enterprises
- securities and deposits in other financial institutions
- other assets

Loans, accounting for 67 per cent of banks' total assets in 2007, represented the dominant asset on the balance sheet.

Liabilities comprise the following items:

- customer deposits
- market funding
- other debt
- subordinated loans
- equity capital

Deposits, accounting for 62 per cent of banks' total liabilities, represented the dominant liability on the balance sheet. Market funding comprises bonds, short-term paper and loans from other financial institutions.

2.2.3 Banks' capital adequacy

The calculation of banks' capital adequacy is based on projections of regulatory capital and the risk-weighted assets for capital adequacy.

Banks' regulatory capital is the sum of Tier 1 capital and subordinated debt. It is impossible, however, to identify all components of Tier 1 capital. Therefore, a residual, i.e. the difference between the last reported figure for Tier 1 capital and the sum of the Tier 1 capital items in the balance sheet, is also projected.

The risk-weighted assets for capital adequacy are based on an assumption that growth in the risk-weighted assets is equivalent to growth in total assets. It is assumed therefore that the risk parameters and the composition of the portfolio remain unchanged during the estimation period. A number of empirical studies find, however, that the value of the risk parameters estimated by banks will increase during a downturn. In isolation, this will reduce capital adequacy when the risk of bankruptcy increases among the banks' loan customers.

A natural extension of the model will thus be to approximate the risk-weighted assets based on bankruptcy probabilities for enterprises and households with loans. Through this, bankruptcy probabilities for enterprises could be obtained from the SEBRA model while projections of household margins could be used to calculate bankruptcy probabilities for households.

2.2.4 Risk factors that can be analysed using the bank model

The bank model can be used to analyse the effect of several different risk factors on banks' profit and financial strength. *Credit risk* affects banks' loan losses (*LL*). Credit risk is therefore included in the bank model through the effect of estimated loan losses on banks' profit (*PRO*) and capital adequacy.

Liquidity risk affects banks' funding costs. In the bank model, the deposit rate (*DR*) and the interest rate on other interest-bearing liabilities (*ROL*) can be adjusted as a result of changes in liquidity risk. Changes in the interest rate that banks pay for funding affects estimated net interest income (*NII*) as well as banks' profit (*PRO*) and capital adequacy.

Market risk affects dividends (*DIV*) and gains/losses on securities (*NGS*), foreign exchange (*NGFE*) and derivatives (*NGD*). Changes in market risk are thus important to other operating income (*OOI*), which is

included in the calculation of banks' profit (*PRO*) and capital adequacy.

Banks can incur considerable losses as a result of *operational risk*. In the bank model, costs resulting from operational risk are included in other operating costs (*OOC*). Losses due to operational risk will thus lead to higher costs, lower profits (*PRO*) and a reduction in capital adequacy in the bank model.

3 Simulations of the system

In this section, we examine an alternative stress scenario for the Norwegian economy that involves major shocks as from 2008. A weakening of households' expectations with regard to their own financial situation and the Norwegian economy leads to a sharp fall in house prices. Consumer price inflation increases as a result of both higher domestic price pressures and increased imported inflation. Moreover, we assume that banks' risk willingness declines in pace with heightened liquidity and credit risk in the Norwegian and global economy.

The bank model is used to project banks' profit and capital adequacy up to and including 2011 based on the baseline scenario for the Norwegian economy presented in *Monetary Policy Report* 1/08. Developments for banks in that scenario are then compared with an alternative stress scenario. Such a stress scenario is not necessarily the most likely alternative to the baseline scenario for the Norwegian economy, but rather an analysis of a possible scenario that could entail problems for banks.

3.1 Macroeconomic scenario

House prices fall markedly in the alternative stress scenario (see Chart 3). In 2010, house prices are close to 35 per cent lower than at the end of 2007. By comparison, house prices fell by about 30 per cent between 1988 and 1992 in connection with the banking crisis. House prices edge up towards the end of the simulation period. With higher consumer price inflation in the alternative stress scenario, the interest rate rises rapidly over the next two years. Lower house prices and higher borrowing rates in banks (see Chart 4) result in lower corporate and household credit demand and weaker economic growth compared with the baseline scenario.

As a result of a change in the macroeconomic outlook and increased loan defaults, we assume that banks tighten lending standards by reducing new loans to both households and enterprises. Under the alternative stress scenario, household and corporate debt growth drops sharply over the next two years (see Chart 5).
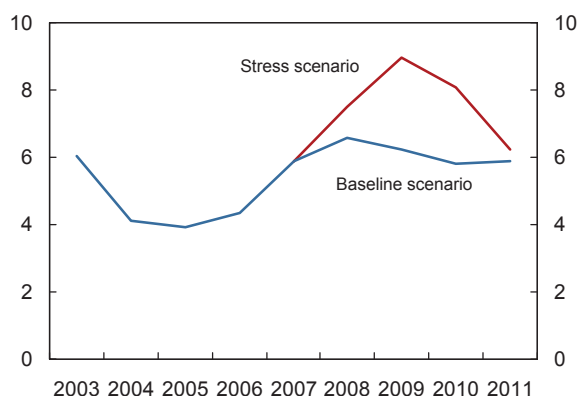
Chart 3 House prices. Annual rise. Per cent[1]
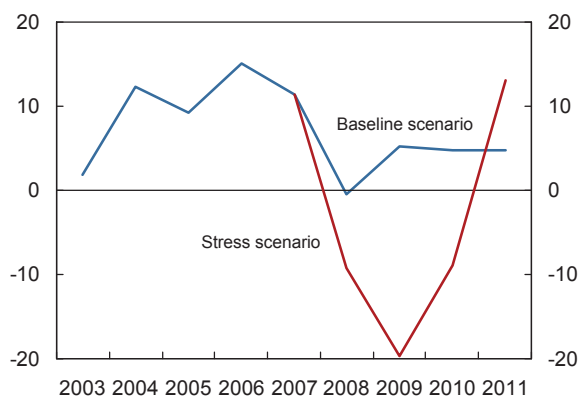
[1] Projections for 2008 – 2011

Sources: Norwegian Association of Real Estate Agents, ECON Pöyry, Finn.no, Association of Real Estate Agency Firms and Norges Bank
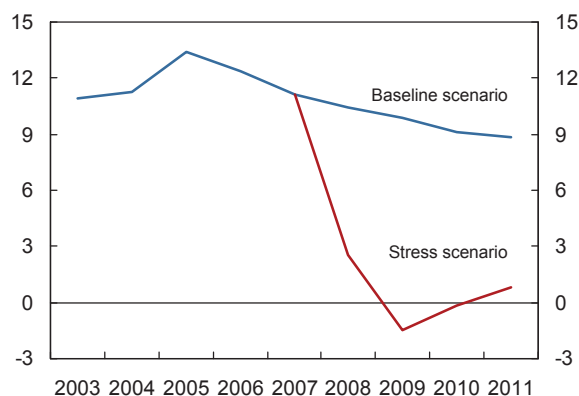
Chart 4 Banks' lending rates[1]

[1] Projections for 2008 – 2011

Sources: Statistics Norway and Norges Bank

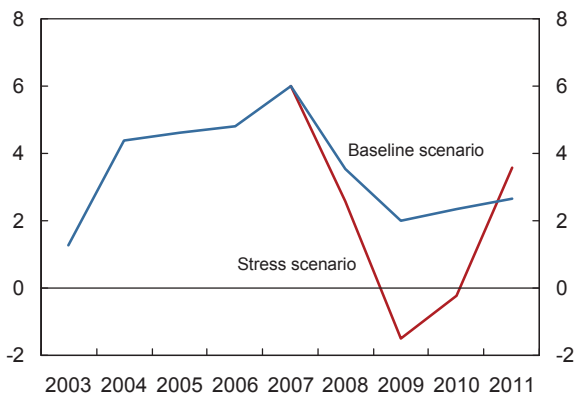**Chart 5** Credit to households (C2). Annual growth[1]. Per cent[2]

[1] Change in lending at year end
[2] Projections for 2008 – 2011

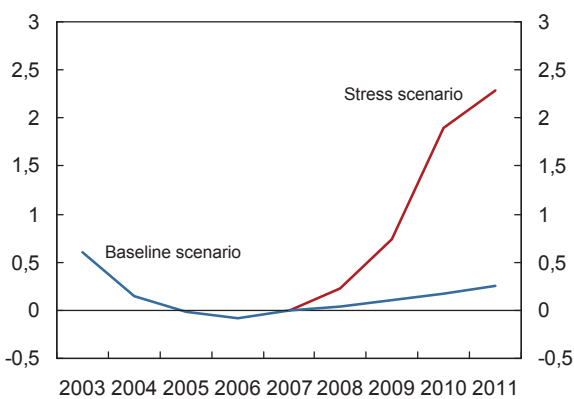Sources: Statistics Norway and Norges Bank

Chart 6 Mainland GDP. Annual growth. Per cent[1]

1) Projections for 2008 – 2011
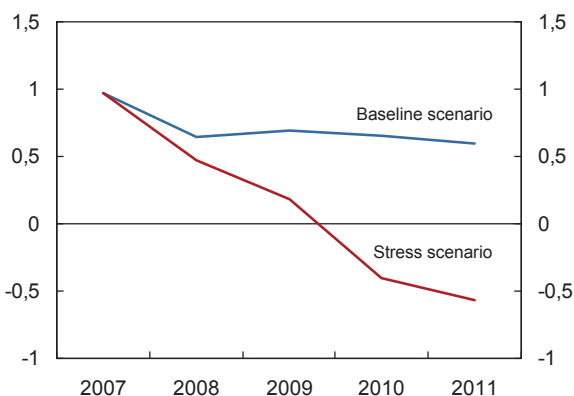
Sources: Statistics Norway and Norges Bank

Chart 7 Banks' losses. Percentage of gross lending. Annual figures[1]

1) Projections for 2008 – 2011

Source: Norges Bank

Chart 8 After-tax profit for the five largest Norwegian banks[1]. Percentage of average total assets. Annual figures[2]

1) DnB NOR Bank (excl. branches abroad), SpareBank 1 SR Bank, Sparebanken Vest, SpareBank 1 Nord-Norge and SpareBank 1 SMN
2) Projections for 2008 – 2011

Source: Norges Bank

Lower property prices and lower household and corporate debt growth lead to slower growth in aggregate demand and output (see Chart 6). GDP growth is negative in two of the years. By comparison, mainland GDP fell by 1 per cent in 1988 and 1½ per cent in 1989. In 2011, unemployment rises to just above 5 per cent, or about 2¼ percentage points higher than in the baseline scenario.

Weaker macroeconomic developments and higher borrowing rates in banks reduce borrowers' debt-servicing capacity. This results in a larger number of problem loans, particularly in the corporate sector. At the end of the simulation period, corporate problem loans account for almost 10 per cent of total corporate loans. By comparison, the share of problem loans was about 16–17 per cent towards the end of the banking crisis in the 1990s. For households, the increase is less dramatic. Nevertheless, the share of problem loans is more than double the share in the baseline scenario.

The share of problem loans that banks will have to record as losses depends to a large extent on collateral values. Bank loans are normally secured, largely on residential and commercial property. To simplify, we assume that commercial property prices follow developments in residential property prices. A fall in residential and commercial property prices results in higher loan losses. We assume that loan losses increase to 55 per cent of problem loans in 2011. Such a high loan-loss ratio has not been recorded since the early 1990s, i.e. towards the end of the last banking crisis. With such a loan-loss ratio, losses constitute 2¼ per cent of total loans at the end of the projection period (see Chart 7).

3.2 Banks

Using the bank model, we project the profit and capital adequacy of the five largest Norwegian banks[8] up to end-2011. The bank model uses loans to households, lending rates, loan losses and labour costs from the macro model. The bank model uses loans to the corporate sector and the distribution of loan losses across different industries from the corporate sector model.

Chart 8 shows banks' after-tax profits. In the baseline scenario for the Norwegian economy, banks' profit is expected to decline somewhat the first year and then constitute approximately 0.7 per cent of average total assets during the remainder of the projection period. In the alternative stress scenario, banks' after-tax profit as a percentage of average total assets will fall substantially in 2009 and be negative as from 2010. The most

[8] DnB NOR Bank, SpareBank 1 SR-Bank, Sparebanken Vest, SpareBank 1 SMN and SpareBank 1 Nord-Norge

Chart 9 Capital adequacy for the five largest Norwegian banks[1]. Per cent. Annual figures[2]
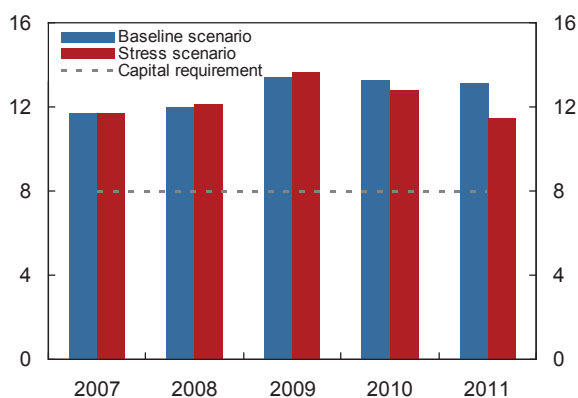
[1] DnB NOR Bank (excl. branches abroad), SpareBank 1 SR Bank, Sparebanken Vest, SpareBank 1 Nord-Norge and SpareBank 1 SMN

[2] Projections for 2008 – 2011

Source: Norges Bank

important reason for the weaker profit in the alternative stress scenario is the marked increase in loan losses. In addition, banks' market funding rates increase somewhat more than their deposit rates. This reduces banks' net interest income in the stress scenario.

In spite of banks' weaker profit in the alternative stress scenario, capital adequacy will be higher compared with the baseline scenario in the first two years (see Chart 9). This is because we assume that lending growth is slower than in the baseline scenario and that this contributes to curbing the rise in capital requirements. Negative profit in 2010 and 2011 will lead to weaker capital adequacy both in terms of level and compared with the baseline scenario. The average capital adequacy of the five banks in the alternative stress scenario will nevertheless be well above the minimum requirement of 8 per cent, but the capital adequacy of one bank will fall below the minimum requirement. In such a situation, banks can try to increase capital adequacy by raising new equity and subordinated debt. Banks will probably also increase lending margins more than assumed in the stress scenario when loan losses are at nearly 2 per cent in 2010 and 2¼ per cent in 2011.

3.2.1 Profit and loss account

In the projections of *net interest income*, lending and deposit rates are assumed to develop in pace with the lending rate from the macro model. The effect of higher liquidity risk is incorporated in the model by increasing the price premium for market funding. In the alternative stress scenario, the interest rate on other interest-

bearing liabilities is assumed to increase by 20 basis points more than the deposit rate in both 2008 and 2009. Subsequently, this interest rate falls 10 basis points compared with the deposit rate in both 2010 and 2011. The difference between these two interest rates is thus 20 basis points higher in 2011 than in 2007. This interest rate difference changes gradually since it takes time to refinance the entire stock of market funding. Section 3.2.2 describes the projections of balance sheet variables included in the calculation of net interest income.

As a cross-check, we compare estimated net interest income with estimated net interest income from the error correction model which is estimated using macro variables (GDP and three-month money market rates).[9] This comparison is made to ensure that the estimation of net interest income is in line with the macroeconomic scenarios for the Norwegian economy. The comparison shows that the estimation of net interest income represents a plausible development given the macroeconomic scenarios.

Other operating income contains several components that are exposed to market risk. With the exception of fee income, developments in the components included in other operating income are assumed to be identical in the two scenarios. Dividends on shareholdings in 2008 are assumed to be at the same level as in 2007 and 20 per cent lower for the remainder of the projection period. Banks' net losses on securities charged as a cost during the first quarter of 2008 are included in the projections for other operating income. Net losses/gains on securities are set at zero for the rest of the projection period. Net gains on foreign exchange and derivatives are not assumed to be cyclically sensitive. These income items are therefore set at the same level as in 2007 for the entire projection period. In the fourth quarter of 2007, DnB NOR recorded a NOK 1.4 billion gain on the sale of property. Since this is a one-time gain, other gains and income are adjusted down by an approximately equivalent amount from 2007 to 2008. Other gains and income rise in pace with the inflation target, i.e. 2.5 per cent per year, for the remainder of the projection period. The projections for fee income are calculated using the error correction model, where developments in GDP and interest rates are extracted from the macro model (see equation 2.4 in Section 2.2.1).

Other operating costs excluding labour costs are assumed to increase at the same pace as the inflation target in both scenarios. In spite of Norwegian banks' high lending growth, annual growth in other operating costs has only been about 0.5 per cent during the past five years. The potential for further cost cuts may, how-

[9] For en more detailed description of the equation, see Andersen et. al. (2008b)

ever, be limited. Banks' labour costs are increasing at the same rate as the labour costs (including changes in both employment and wages) from the macro model in both the baseline scenario and the alternative stress scenario.

The projections for *loan losses* are obtained from the macro model's calculations of the baseline scenario and the alternative stress scenario. The corporate sector model is used to predict the distribution of loan losses across different industries. In this way, the bank model uses information about the individual bank's exposure to different industries as well as the corporate sector model's estimated credit risk in these industries.

3.2.2 The balance sheet

Assets in banks' balance sheets are projected as follows:

Loans to households are based on projections from the macro model. *Loans to the corporate sector* are projected on the basis of the corporate sector model. The macro model predicts a marked increase in losses on loans to the corporate sector in the alternative stress scenario. Both the supply of loans to enterprises and enterprises' demand for loans are assumed to decline due to problems in the corporate sector.

Securities and other assets are assumed to grow at the same rate as total lending. This assumption ensures that the composition of banks' assets remains unchanged in the projection period. This is also consistent with the assumption that the risk-weighted assets as a share of total assets remain constant during the projection period.

Liabilities in banks' balance sheets are projected as follows:

As a simplification, *growth in deposits* is set equal to growth in labour costs from the macro model. The increase in *equity* is determined endogenously from the profit after tax and dividends. Growth in *other interest-bearing liabilities* (bonds, short-term paper, loans from other financial institutions, subordinated debt and other debt) are set as a residual, so that the sum of all liabilities is equal to the sum of all assets.

While growth in total assets is higher than growth in deposits (and growth in labour costs) in the baseline scenario, the opposite is the case in the alternative stress scenario. Due to the above assumptions, growth in market funding is higher than growth in deposits in the baseline scenario. This is in line with growth in market funding, which has been higher than growth in deposits over the past ten years for Norwegian banks. In the

alternative stress scenario, the need for market funding is much lower as a result of the low level of lending growth. As a result of the above assumptions, growth in market funding is lower than growth in deposits in the alternative stress scenario.

4   Summary

In this article, we have presented parts of Norges Bank's system for stress-testing financial stability. The bank model in the system is used to analyse developments in profit and capital adequacy for the five largest Norwegian banks in two different macro scenarios for the Norwegian economy – one baseline scenario where the Norwegian economy develops in line with *Monetary Policy Report* 1/08 and an alternative stress scenario where house prices fall sharply, the interest rate rises and banks' risk willingness declines. In the stress scenario, banks' profit deteriorates considerably and is negative as from 2010. Average capital adequacy for the five banks is nevertheless well above the minimum requirement of 8 per cent. The banks are basically financially sound, and the analysis shows that they will be able to weather such macroeconomic developments.

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Appendix

Table. Stress scenario. Percentage change on previous year (unless otherwise specified). Baseline scenario[1] in brackets

	2007	2008		2009		2010		2011	
CPI	0.8	3¾	(3)	3¾	(2¾)	3½	(2½)	3½	(2¾)
Annual wages	5.6	6¾	(6)	7	(5½)	6¼	(5)	5¼	(4¾)
Mainland GDP	6.0	2½	(3½)	−1½	(2)	−¼	(2¼)	3½	(2¾)
Registered unemployed[2]	1.9	2	(2)	2½	(2¼)	4½	(2¾)	5¼	(3)
Bank lending rates (per cent)	5.9	7½	(6½)	9	(6¼)	8	(5¾)	6¼	(6)
House prices	11.3	−9¼	(−½)	−19¾	(5¼)	−8¾	(4¾)	13	(4¾)
Credit to households	11.1	2½	(10½)	−1½	(9¾)	−¼	(9¼)	¾	(8¾)
Credit to non-financial enterprises	18.9	2¾	(10½)	0	(7)	¾	(5½)	1	(5)
Share of problem loans[3], households	0.7	¾	(½)	¾	(½)	1¼	(½)	1¼	(½)
Share of problem loans[3], non-financial enterprises	1.1	1½	(1½)	2¾	(1¾)	6½	(2¾)	9¼	(3¼)
Bank losses, percentage of total lending	0.0	¼	(0)	¾	(0)	2	(¼)	2¼	(¼)

[1] Baseline scenario for CPI, annual wages and mainland GDP are from MPR 1/08
[2] As percentage of labour force. Baseline scenario for registered unemployment obtained by using the same percentage change as in baseline scenario for LFS unemployment in MPR 1/08
[3] Non-performing loans and other particularly doubtful loans, as a share of banks' total lending