Assessment of "stress tests" conducted on the French banking system

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During the first quarter of 2004, the General Secretariat of the Commission bancaire *(SGCB) and the Directorate General Economics and International Relations (DGEI) of the Banque de France conducted an assessment of the stability of the French banking system and its capacity to withstand a set of macroeconomic and financial shocks, as part of a broader evaluation of the French financial system carried out under the auspices of the IMF's Financial Sector Assessment Program (FSAP). The assessment employed a macro-prudential approach which seeks to quantify the effects of shocks to the banking system using "stress tests". The tests measured the impact of severe shocks, deemed plausible but infrequent:* e.g.*, a recession, a large movement in interest rates, an oil price shock, a sharp drop in stock prices.*

This report discusses in detail the principal characteristics of the "stress tests" and the innovations introduced during the French FSAP, including in particular the design of coherent scenarios, which were developed using the DGEI's macroeconomic model and the SGCB's financial models for measuring risk.

The results of the assessment indicate that, given the high average solvency ratio, the French banking system is currently in a position to withstand a major macroeconomic shock, such as a prolonged recession lasting two years. This type of shock would, however, erode the quality of bank assets and reduce bank profits by 38.5% in the second year, compared with the baseline, resulting in a decline in the international solvency ratio of one percentage point (using the Basel I methodology) or two percentage points (using the new methodology proposed in the Basel II Accord). Other scenarios, such as a 32% depreciation of the dollar against the euro for two years or an increase of nearly 50% in the price of oil also for two years, would have more limited effects on net income and solvency ratios.

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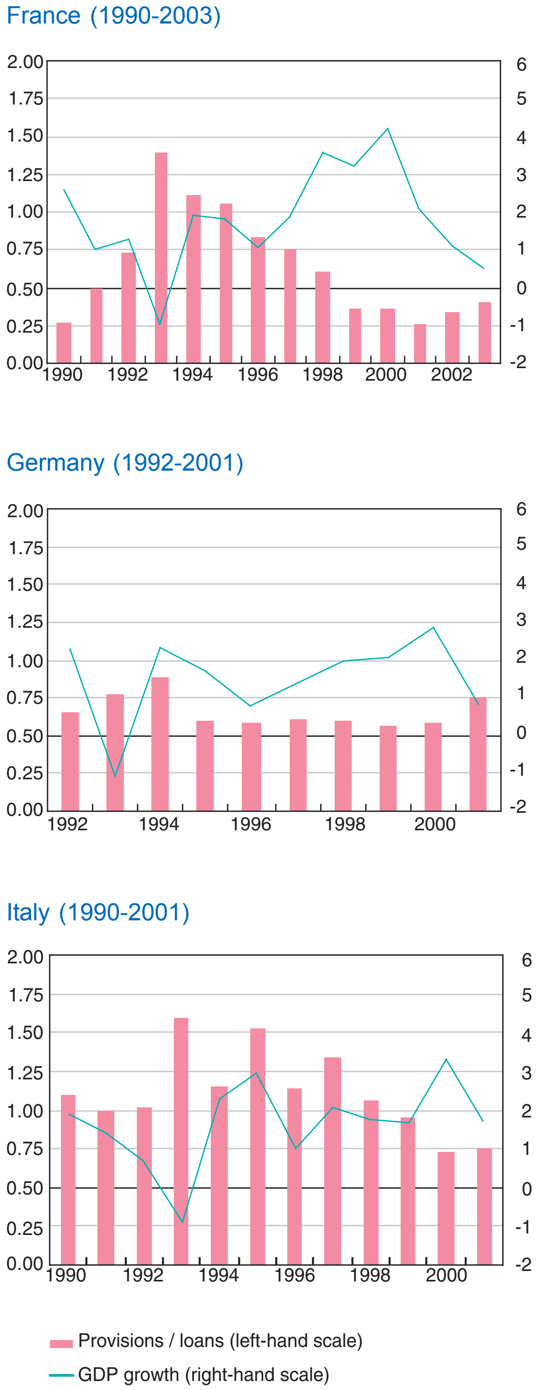
In the first quarter of 2004, the General Secretariat of the *Commission bancaire* (SGCB) and the Directorate General Economics and International Relations (DGEI) of the Banque de France undertook an examination of the stability of the French banking system and its capacity to withstand a set of macroeconomic and financial shocks. This study was conducted in conjunction with the IMF as part of a broader assessment of financial systems, known as the FSAP (Financial Sector Assessment Program). The first section of this report places this study of the effect of rare but plausible shocks ("stress tests") in the more general context of the "macro-prudential" approach, which is applied in an increasing number of countries. The second section describes the principal characteristics of the "stress tests" and the innovations introduced in the course of the French assessment. The third section presents the results of the assessment. The concluding section draws some lessons from the exercise.

Chart 1
Provisioning and GDP growth



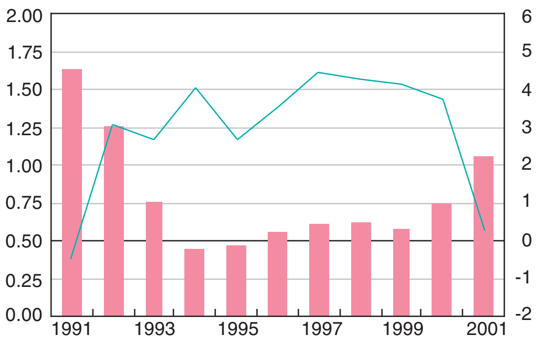
1| "STRESS TESTS"

Since the mid-1990s, central banks and the authorities responsible for bank supervision have placed increasing emphasis on the macro-prudential perspective: the study of linkages between macroeconomic trends and the stability of the financial system, and the banking system in particular. "Stress tests" constitute an important element of this approach.

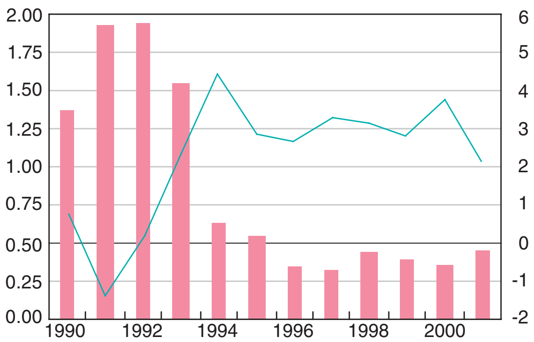
1|1 Issues of macro-prudential policy

Recent financial crises have highlighted the importance of macroeconomic analysis of the banking sector and its interactions with financial stability, which goes beyond the supervision of individual financial institutions by supervisory authorities and the macroeconomic analysis performed by central banks as part of the implementation of monetary policy.

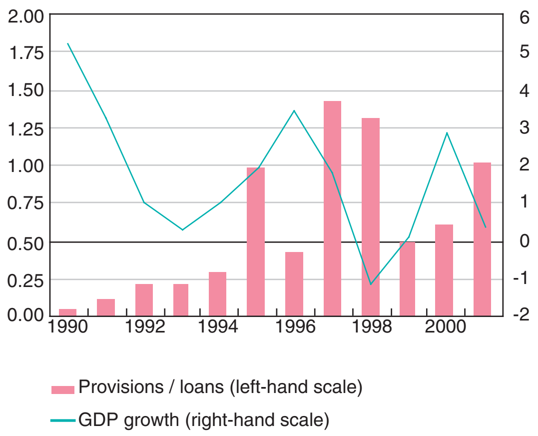
United States (1991-2001)



United Kingdom (1990-2001)



Japan (1990-2001)



Source: *Bank Profitability (OECD), Annual Report of the* Commission bancaire *(French provisions) and Economic Outlook (OECD).*

AN INCREASINGLY PRESSING NEED

The financial crises of the past decade illustrate the prominent role of macroeconomic factors in triggering crises. A variety of mechanisms can be involved, but the causal chain is usually simple: over indebtedness of households and businesses in the wake of the rapid growth in bank lending leading to a series of bankruptcies in the industrial sector, exacerbated by deterioration in the terms of trade and a drop in exports, leading in turn to an increase in the volume of loan losses and failures of banking institutions.

The Asian crisis of 1997 also showed the decisive role of deterioration in macroeconomic fundamentals in triggering crises. This conclusion has been documented in the work of Kaminsky and Reinhart (1999), using data covering a large number of emerging countries and also some developed countries. Since the 1980s, a large number of banking crises have been associated with currency crises (the peak of the banking crisis generally coming after the currency crisis). Both types of crises are generally preceded by a recession, or at least a period of economic growth below potential growth.[1]

Chart 1 shows the rate of growth in gross domestic product and the ratio of provisions for loan losses to the outstanding amount of bank loans for several countries. The charts illustrate the link between economic growth and the health of the banking system. The 1991 recessions in the United States and the United Kingdom, as well as the 1993 recessions in France, Germany and Italy, led to an erosion in the quality of portfolios and a significant increase in provisioning. Provisions were generally reduced during the rising phase of the economic cycle at the end of the 1990s, only to increase again at the beginning of the 2000s, although to a more limited extent than before.

[1] *These empirical studies confirm the conclusions of economic theory, which for a long time has emphasised the link between macroeconomic trends and the stability of the banking system. See Gorton (1988) and Jacklin and Bhattacharya (1988), using the original model of Diamond and Dybvig (1983). In Chen's model (1999), an unfavourable macroeconomic shock increases the risk of banking contagion. See also de Bandt and Hartmann (2002).*

VARIETY OF METHODS

Because of the great number of mechanisms *via* which macroeconomic developments influence the stability of the banking system, several types of tools are used to implement a macro-prudential approach, for which there is not currently a single definition. According to C. Borio (2003), the ultimate goal of the macro-prudential approach is to study the risk of a general breakdown of the financial system, and not simply the risk of failure of individual institutions. Hence the emphasis is placed on the risk of contagion and on shared exposure to macroeconomic shocks, rather than on factors specific to particular financial institutions. By monitoring relevant macroeconomic indicators and developing leading indicators of banking crises ("early warning systems"), it is possible to assess the probability that the financial system will be affected by unfavourable financial or macroeconomic shocks. "Stress tests" measure the effects of such shocks on the stability of the banking system. In FSAP missions, this analysis is often complemented by an assessment of the risk of contagion in financial systems, which are increasingly interdependent (analysis of exposures).

Monitoring relevant macroeconomic indicators

At both national and multilateral levels (IMF), certain quantitative indicators are closely monitored by the authorities responsible for financial stability. These include both microeconomic aggregates relating to asset quality, profitability, sensitivity to market risks, and capital standards; and macroeconomic indicators: economic growth and the volatility of inflation rates, interest rates, and exchange rates.[2] These indicators have been selected by virtue of their influence on the level of loan losses, earnings, and bank capital. For a given country, a subset of these indicators can be the object of "stress tests". The macro-prudential indicators make it possible to determine the relevance of the "stress" scenarios at a given moment in time.

Leading indicators

More specifically, macro-prudential indicators can be used as forecasting tools, to predict the likelihood of future banking crises. The choice of leading indicators of banking crises has been the subject of extensive research. However, the analysis by Berg, Borensztein and Patillo (2004) of different econometric models indicates that their actual performance in terms of forecasting has been disappointing. It thus appears difficult, for the time being, to focus only on a small number of indicators to predict banking crises.

Analysing the risk of contagion

A final dimension is often reserved for the most developed countries, whose banking and financial systems are the most sophisticated. The analysis of the risk of contagion is an essential component of the supervision of financial conglomerates. In the French FSAP, only bank-insurance combinations were considered relevant as far as the possible risk of contagion is concerned. But this risk turns out to be of limited magnitude (see below). However, if the risk of contagion is large, the "top down" approach favoured by the macro-prudential perspective (*i.e.* the stability of the financial system taken as a whole) can produce results that are different from those produced by the "bottom-up" approach, *i.e.* the financial stability of individual institutions (see below).

1|2 Growing use of "stress tests"

To date, more than ninety "stress test" exercises have been completed by the IMF or are on the way to being completed. Initially conceived for emerging countries, where they have been used in nearly three-quarters of the exercises already completed or in the process of completion, "stress tests" are now increasingly used by developed countries. Following Japan in 2001, the United Kingdom in 2002, and Germany in 2003, France is now the fourth major G10 country to use these large-scale simulations to assess the soundness of its banking and financial systems. This trend should become more pronounced in the future, due in part to the incorporation of "stress tests" in the new Basel II Accord governing capital standards for banking institutions.

2 *See IMF (2000)*

2| CHARACTERISTICS OF FRENCH "STRESS TESTS"

Several types of innovation were introduced in the course of the French "stress tests":

• to begin with, as indicated above, the IMF chose for the first time, because of the importance of *bancassurance* in France, to analyze the impact of certain scenarios on banks and insurance subsidiaries together. Information on the effects on insurance subsidiaries was provided by the French Insurance Commission (*Commission de contrôle des assurances*), which was responsible for conducting the FSAP in this sector;

• in addition, several quantitative tools for assessing the sensitivity of bank exposures to macroeconomic developments were employed;

• to ensure consistency between the simulations carried out by the SGCB and those carried out by banks, the macroeconomic "stress" scenarios were illustrated with key parameters drawn from the Mascotte macroeconomic model of the Banque de France, such as the rate of growth in bank loans, and provided to credit institutions;

• furthermore, the macroeconomic "stress" scenarios were implemented using both the Mascotte model (for France) and the NiGEM model (to take into account the effect of international shocks);

• finally, the effect of the shocks on solvency ratios was calculated using the methodologies of Basel I and Basel II.

Major market institutions participated actively in these simulations. Along with the simulations carried out by supervisors, "stress tests" were conducted independently by the seven largest banking groups in terms of share of the French banking system (representing more than 60% of the net banking income of the French banking system and 80% of total assets in 2003).

2|1 Testing strategies

DYNAMIC *VERSUS* STATIC SCENARIOS

The strategy chosen to carry out the FSAP simulations was sensitivity analysis. This is the simplest approach to operationalise, given the current state of the art, and is generally used in the majority of the large developed countries which have already carried out this exercise. In agreement with the IMF, the "feedback" effect on the real economy of an initial shock affecting the banking and financial system was not considered. In addition, there was no detailed analysis of systemic risk in the narrow sense of the term, *i.e.* the propagation of shocks between individual institutions. The emphasis is instead on market shocks and exposure to macroeconomic shocks.

The sensitivity analysis comprises a static analysis and a dynamic analysis.

The static sensitivity analysis focuses on the instantaneous impact of shocks to monetary and financial markets, including foreign exchange markets. These shocks are large in magnitude but limited in time, and their impact is transmitted through instruments quoted in various markets (interest rate, exchange rate, stock market index, etc.). The calibration of these instantaneous shocks generally corresponds to the 99th percentile of the historical probability distributions observed over the past thirty years. These shocks are mainly univariate (single-factor), although multivariate scenarios combining several factors have also been carried out. They produce a price effect on banks' portfolios, which is evaluated instantaneously. Also included in this category are certain shocks of a "systemic" nature affecting credit risk (such as a sudden flight to liquidity), or sectoral shocks: for example, deterioration in credit spreads in the TMT (Technology Media-Telecommunications) sector.

There are two principal reasons for carrying out a more dynamic analysis of the impact of "stress" events.

• The first stems from the fact that credit risk is still the principal risk borne by banks. Since the credit cycle is relatively long and closely linked to the economic cycle, the overall effect of the "stress" event is poorly captured by a static analysis, which focuses on very short term effects.

• The second relates to the weak economic credibility of factor scenarios, in which a shock is assumed to affect only a single economic or financial variable, with other variables remaining fixed; or possibly several variables but with arbitrary assumptions concerning their possible correlation. This explains why this type of scenario is generally credible only for instantaneous shocks.

In contrast, dynamic sensitivity analysis is global and macroeconomic in character. It considers a scenario in which an exogenous shock to the French economy is propagated over time, impacting the banking system through two mechanisms: an increase in risk and an income effect stemming from a possible contraction in economic activity. This type of scenario requires the use of a macroeconomic model; the French FSAP utilised the Mascotte model to simulate the impact of several macroeconomic shocks.[3] It was employed in conjunction with the NiGEM model in order to take into account the impact on France's international environment of shocks of a "global" nature.

Simulation horizon of dynamic scenarios

The simulation horizon used in these scenarios is two years. This corresponds to an estimate of the average maturity of bank portfolios and represents the maximum period of time for which the assumption that banks do not restructure their portfolios is acceptable.

The scenarios of macroeconomic "stress" were constructed in two stages. The "baseline" corresponds to the OECD's forecast for 2004 and 2005 issued in the autumn of 2003 (*OECD Economic Outlook*): estimated French GDP growth of 1.7% in 2004 and 2.5% in 2005. The macroeconomic "stress" scenarios are then simulated using various exogenous shocks specified by the IMF (Box 1).[4]

For each "stress" scenario, measurements were made of the effect of the shock on a set of macroeconomic variables: GDP and its components, loans extended to businesses and households, and corporate failures. The variants obtained were distributed to the banks participating in the exercise (the "bottom-up" approach – see below) and were also used in the "top-down" approach conducted by supervisors.

In addition to providing these variants to the banks, they were given the option of developing alternative variants using their own internal economic models. Only one bank took advantage of this option.

2|2 Consistency of "top-down" and "bottom-up" approaches

Reference scenarios

In the so-called "bottom-up" approach, each bank was asked to simulate the reference scenarios and to measure the impact on the variables of interest (listed below) on the basis of its consolidated accounts.[5] For its part, the SGCB conducted a "top-down" approach, incorporating the results of the shocks on the macroeconomic variants in its own financial models.

Variables of interest

The results of the "stress tests" were measured in terms of three different indicators, which constitute the presumed variables of interest for the banking system. These are also the variables used in the macro-prudential approach described in the first section of this article, namely:

• profitability;
• exposures;
• and capital, *i.e.* the solvency ratio.

3 *See Baghli* et al. *(2003 et 2004)*
4 *Downward shocks to property prices were not considered explicitly, due to the absence of wealth effects on consumption in the current version of the Mascotte macroeconomic model. This type of risk was nevertheless taken into account indirectly by means of sectoral shocks to credit risk.*
5 *Priority was given to the stability of the French financial system, and thus the macroeconomic scenarios measure the impact of shocks on the French economy. International shocks can, in principle, partly be transmitted* via *the international activities of French banking groups. However, the impact of shocks on macroeconomic trends in other countries was not studied in detail.*

Box 1

Reference scenarios

Single- and multi-factor shocks (frequency of occurrence: 1% over the past 30 years)

F1 *Flattening of the yield curve due to an increase in interest rates: increase of 150 basis points (bp) in overnight rates, increase of 50 bp in 10-year rates, with interpolation for intermediate maturities.*

F2 *Steepening of the yield curve due to a decrease in interest rates: decrease of 50 bp in overnight rates; no change in 10-year rates, and interpolation for intermediate maturities.*

F3 *Parallel shift upwards of 300 basis points of the entire yield curve. "Stress" limited to the insurance sector.*

F4 *General deterioration in counterparty credit quality: downgrade by one "notch" on the Standard and Poor's reference scale in the quality of all counterparties; downgrade by two notches on the same scale in the quality of counterparties in specific sectors: energy, transport, telecommunications and commercial property.*

F5 *Share price decline of 30% in all stock markets.*

F6a and F6b *Appreciation/depreciation of 15% in the euro relative to major currencies (USD, JPY).*

F7 *Downgrade by two notches in the credit quality of emerging-country counterparties for exposures representing 50% of all emerging-country exposures.*

F8 *Increase of 30% in volatility in all markets: interest rate, exchange rate, financial markets, etc.*

F9 *Flattening of the yield curve (increase of 150 basis points in overnight rates, increase of 50 bp in10-year rates) together with a 30% drop in stock markets.*

Macroeconomic scenarios (the probability of occurrence of the shock during the period 1978-2003 – quarterly data – is shown in parentheses)

M1 *(1%) Twenty-per-cent decline in global demand for two years: simulation of a sharp contraction in global demand resulting in a reduction in outlets for domestic production destined for export markets. This leads to a sharp decline in economic activity in France: zero growth in 2004 and 2005 (decline in personal consumption and investment) combined with a deficit in the balance of trade (contraction in exports), with the consequence for banks of a decline in lending to households and businesses coupled with an increase in failures.*

M2 *(1%) Increase to USD 40 in the price per barrel of Brent crude for two years (an increase of 48% compared with USD 27 per barrel in the baseline case), without any reaction from the central bank; the increase in the price of oil leads to an increase in the general rate of inflation and a decline in economic activity in France together with a drop in global demand.*

M3 *(<1%) Increase to USD 40 in the price per barrel of Brent crude for two years, with a reaction from the central bank. This scenario repeats the assumptions of the previous scenario, accompanied by a reaction of the central bank as postulated in the NiGEM model (increase in key interest rates to try to reduce inflationary pressures and counter "second-round" effects on wages). While such a rate increase has the potential to further slow French economic activity, worsening the scenario in the short term, it permits a steepening of the yield curve which is favourable to banks.*

M4 *(5%) Depreciation of the dollar against European currencies (euro, Swiss franc, Pound sterling, etc.) averaging 32% for two years. This scenario leads to a decline in the competitiveness of the euro area, and of France in particular, leading to reduced growth in France and in the euro area.*

For each of the variables of interest, the results of the "stress" simulations were expressed in terms of the cumulative change in net income on the one hand, and capital and solvency ratios on the other hand, at the specified time horizon (instantaneous for single-factor and multi-factor shocks and one to two years for macroeconomic shocks). These effects were felt *via* changes in loan losses and net provisions for credit shocks.

For the macroeconomic scenarios projected over a two-year horizon, the effect on net income took account of a tax depreciation of 33%, corresponding to the deductibility of losses from the corporate tax base.

Synthetic measure of impact

The different measures of impact produced by the simulations were summarised and compared in terms of their overall impact on the solvency ratio, with a distinction being made between Basel I (Cooke ratio) and Basel II definitions. While profits generally appear to be the first cushion for absorbing the losses generated by unfavourable situations, they can be insufficient to cover unexpected losses in "stress" situations. In this case, the mobilisation of capital is necessary.

Thus the solvency ratio $CAR_t = K_t / RWA_t$ relates capital K_t to risk-weighted assets RWA_t. The numerator of the ratio includes the change in net earnings due to the "stress" scenario. In the Basel I simulations, the denominator (RWA_t) takes into account only the variation in capital requirements due to the volume effect, while in the Basel II simulations it takes into account both the volume effect and the deterioration in assets. Thus, in the latter approach both the numerator and denominator of the solvency ratio are affected.

The choice of a Basel II measure of the solvency ratio appears logical. In the first place, it anticipates the adoption of the new solvency standards, particularly under the heading of Pillar 2 of Basel II, which calls on supervisors to incorporate measures of "stress" in their capital requirements. In the second place, the Basel II measure does not limit the impact of a "stress" –in particular, a macroeconomic "stress" – to likely failures, but also captures the general deterioration in the quality of bank portfolios which is expected to result.

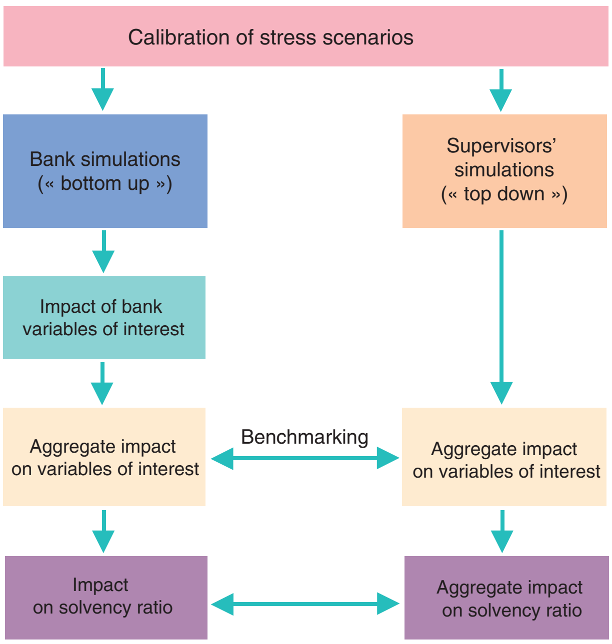
In addition to the value of having a synthetic measure which aggregates in a single indicator the simulated impacts on exposures, profitability and capital, this approach also provides more consistency in macroeconomic "stress" scenarios, since it incorporates the volume effect of the activity on exposures. This analysis is therefore more relevant in the context of dynamic macroeconomic scenarios.

Comparison of approaches

All of the bank results were aggregated on the basis of the reference scenarios and the variables of interest.

At the same time, simulations of single-factor credit shocks and macroeconomic "stress" scenarios were carried out by the SGCB, with the goal of providing a "benchmark" for the simulations carried out by banks. These simulations used a "top-down" approach, employing aggregated models, applying the same scenarios described in Box 1.

Chart 2
Operationalisation of the "bottom-up" and "top-down" approaches



In the absence of a feedback effect on the real economy, or externalities linked to a series of bank failures (genuinely "systemic" shocks), one would expect the aggregation of the results of individual banks to be consistent with the results obtained using a more macroeconomic "top-down" approach.

This consistency was in fact observed (see Box 2, comparing the banks' and the SGCB's estimates). This provides an *ex post* confirmation of their robustness.

The aggregated models used to simulate the impact of different "stress" scenarios are described in the Appendices, distinguishing between the demand for bank loans (Appendix 1), expected profitability (Appendix 2) and exposures and capital requirements (Appendix 3).

3| RESULTS OF THE SIMULATIONS

The aggregated results of the "stress" simulations are summarised in Box 2. For each type of "stress" scenario, results aggregated at the level of a representative sample of the banking system are presented, showing the net impact of the shocks:[6]

• on expected profitability (net of future exposures); this impact is expressed in terms of cumulative change at the specified time horizon (instantaneous for the static scenarios and two years for the macroeconomic scenarios), compared with the situation observed at the end of 2003,[7] according to the estimates of banks and those of supervisors;

• on the solvency ratio, instantaneously for market shocks and with a horizon of end-2005 (*i.e.* two years) for the macroeconomic scenarios, measured according to the definitions of Basel I[8] and Basel II, which also incorporate the impact of the "stress" event on the quality of the portfolio in the denominator of the ratio. As with profitability, this impact is expressed in relative terms in comparison with the level observed at the end of 2003 (see Table below).

Sample statistics at end-year 2003

Amounts in EUR millions

	Net income (1)	Capital (2)	Regulatory capital requirements (3)	Risk-weighted assets (4)	Solvency ratio = (2) / (4)
Banking system	12,775	152,783	107,751	1,346,887	11.34

The "stress" scenarios can be classified in three broad categories: market shocks, including liquidity shocks; credit quality shocks; and macroeconomic "stress" scenarios.

MARKET SHOCKS

Of the various market shocks, the scenarios involving a flattening of the yield curve or a drop in stock market prices (F1, F5 and F9) are the most significant in terms of their instantaneous impact on banks. The immediate price effect on bank portfolios of a flattening of the yield curve is an average loss amounting to slightly less than 4% of 2003 profits, or less than 0.05 point in the solvency ratio. The average solvency ratio of the banking system would decline from 11.34% to 11.30%. The scenario of a drop in stock market prices ratio would lead to an average loss corresponding to roughly 21% of 2003 profits, or 0.3 point in the solvency ratio. The combination of these two scenarios would reduce profits by 30% relative to 2003 and lower the solvency ratio by 0.40 point. These shocks appear on the whole relatively benign for banks, seriously threatening neither their profitability, which would remain on average strongly positive, nor their solvency. Considering the substantial margin that banks maintain above the regulatory minimum of 8%, these results suggest that the banking system has ample capacity to withstand these types of shocks.

With the exception of scenario F3 – a parallel upward shift in the yield curve for all maturities (short, medium, and long), the shock being specific to the insurance sector – and scenario F4 – a deterioration in the quality of loan portfolios – the

6 *The results are presented only as averages, because of the limited heterogeneity of individual results.*
7 *The net consolidated income of French banking groups accounted for nearly 1.2% of French gross domestic product in 2003.*
8 *For the Basel I simulations, only the effect of the "stress" event on expected losses was taken into account in the numerator (the impact on expected earnings was not taken into account), due to the fact that the deterioration in asset quality was not taken into account in the denominator.*

Box 2

Results of "stress tests" for the French banking system

(average in percentage points)

		Impact on net income percentage change end-2003	Impact on solvency ratio Cooke method in ratio points end-2003	Impact on solvency ratio Basel II method in ratio points end-2003
Single- and multi-factor sensitivity tests				
Bank estimates (except F3)				
F1	Flattening of the yield curve	-3.8	-0.05	ns
	Of which: due to the impact on insurance subsidiaries	-0.6	-0.01	ns
F2	Steepening of the curve through a decrease in short-term rates	0.6	0.01	ns
F3	Parallel shift in the yield curve (insurance sector)	-35.7	-0.34	ns
F4	General deterioration in credit quality	-44.5	-0.56	ns
F5	Stock market decline	-21.4	-0.30	ns
	o/w: due to the impact on insurance subsidiaries	-0.6	-0.01	ns
F6a	Appreciation of the euro against major currencies	–	–	ns
F6b	Depreciation of the euro against major currencies	1.6	0.02	ns
F7	Deterioration in credit quality in emerging markets	-7.1	-0.10	ns
F8	General increase in volatility	2.0	0.03	ns
F9	Combination of F1 and F5.	-30.1	-0.40	ns
	o/w: due to the impact on insurance subsidiaries	-5.0	-0.05	ns
Commission bancaire estimates				
F4	General deterioration in credit quality	-56.5	-0.72	
Macroeconomic scenarios				
Bank estimates				
M1	Drop in global demand	-23.6	-1.06	-2.10
M2	Oil price increase	2.0	-0.83	-0.15
M3	Oil price increase with monetary reaction	8.7	-0.84	-0.10
M4	Depreciation of the dollar	-4.4	-0.77	-0.80
Commission bancaire estimates				
M1	Drop in global demand	-26.0	-1.09	-2.10
M2	Oil price increase	7.0	-0.79	-0.11
M3	Oil price increase with monetary reaction	13.2	-0.80	-0.05
M4	Depreciation of the dollar	-9.2	-0.73	-0.83
Memo: Baseline (*Commission bancaire* estimate)		12.5	0.00	0.16

Tests of liquidity

Commission bancaire estimates	(average % 1999-2003)	
Regulatory liquidity ratio less than 100%	< 100%	100% - 120%
Number of banks as a percentage of all banks	1.4	4.0
Size of banks as a percentage of all assets in the banking system	0.5	15.4

See Box 1 for definitions of the scenarios
The upper part of the table displays the impact of instantaneous shocks (single- and multi-factor sensitivity tests) relative to levels at the end of 2003. The lower part displays the impact of dynamic shocks (macroeconomic scenarios) at the end of 2005. The "bank estimates" represent the aggregation of individual simulations ("bottom up" analysis), while the "Commission bancaire *estimates" are generated directly at the macroeconomic level using the models described in Appendices ("top-down" analysis).*
ns: not significant

market shocks have only a marginal effect on the profitability and solvency of banks. These findings are in line with observations in other countries that have carried out an FSAP, and where market shocks appear on the whole to be handled well by banks.

Finally, it should be noted that no liquidity "stress test" was conducted, strictly speaking, to analyze the risk of propagation of failures in the inter-bank market (exposure channel). Indeed, current regulations impose a strict standard in order to constantly avert the possibility of a liquidity crisis. The standard takes the form of the ratio of disposable liquid assets to short-term liabilities; this ratio must be greater than 100%. Historical statistics indicate that this standard has been breached in the past by only 1.4% of the institutions in the French banking system, accounting for only 0.5% of all assets in the French banking sector; *i.e.* only this very small number of institutions have allowed their balance of liquid assets to fall below 100% of total short-term liabilities.

In the F3 scenario, the yield curve undergoes a 300-basis-point shift upwards. This particularly large shock was conceived specifically to test the resilience of the insurance sector. Portfolio securities in this sector are generally held in very long maturities. They have recorded significant unrealised capital gains as a result of the decline in interest rates over the past few years, which would be dissipated only if there were to be a very large upward shift in the yield curve, particularly in the long-term segment of the curve. Assuming full consolidation of the losses of insurance subsidiaries at the level of the banking group, the shock would represent approximately 36% of 2003 bank profits and would lead to a decline of 0.34 point in the solvency ratio. The banking system appears to be easily capable of withstanding this extreme shock.

General deterioration in the quality of loan portfolios

Scenario F4, a general deterioration in the quality of loan portfolios, is intended to simulate periods of sudden pressure on credit ratings during episodes of flight to the highest-quality borrowers (flight to quality). While this type of phenomenon is plausible for securities portfolios, its spread to loan portfolio would appear to be an extreme case. The objective here is rather to simulate a shock of a systemic nature.

The "stress" was calibrated to be equivalent to a downgrade of one level (specialists speak of one "notch") in the average rating of loan portfolios on the Standard and Poor's reference scale (with the exception of certain sensitive sectors such as telecommunications, transport, energy, and commercial property, for which the shock is equivalent to a two-level downgrade). The calibration corresponds to an average increase of approximately 25% in the probability of default on a national scale. As with the other sensitivity tests, the probability of such an event occurring is estimated at 1%.

The instantaneous impact of this shock indicates the percentage of claims likely to fall rapidly into default in the event of a systemic crisis. This impact appears to be significant, with the requirement for new provisions representing on average (according to bank estimates) nearly 45% of 2003 profits and approximately 0.56 point in the solvency ratio.

This shock was also simulated by supervisors using the SAABA expert system,[9] which allows supervisors to observe the distribution of exposures in banks' loan portfolios. The supervisors' simulations are slightly more pessimistic, with an instantaneous impact estimated at 56% of 2003 profits and 0.72 point in the solvency ratio.

The results of both simulations appear relatively consistent and suggest that the impact on the solvency ratio, while significant, is entirely bearable for French banks.

Finally, the deterioration in credit spreads for emerging-country counterparties, equivalent to a two-notch rating downgrade (scenario F7), has only a limited impact on French banks, estimated at approximately 7% of 2003 profits and 0.10 point in the solvency ratio.

[9] *An "expert system" developed by the SGCB for early detection of troubled banking institutions*

MACROECONOMIC "STRESS" SCENARIOS

While dynamic macroeconomic "stress" scenarios compensate for the weaknesses of single- and multi-factor scenarios, they are on the other hand more complex to analyze. In this regard, benchmarking the "bottom-up" and "top-down" approaches – the former aggregating the results of banks' implicit models and the latter being based on explicit models of transmission – has the advantage of highlighting potential channels for transmitting a "stress" event in the real economy to the banking system.[10]

Results of "bottom-up" simulations

In the "bottom-up" approach, banks simulated the macroeconomic "stress" scenarios at a horizon of two years using their own internal models. The impact of the scenarios on net projected profitability is shown in Box 2.

According to the banks' simulations, scenario M1 – a drop in global demand leading to zero GDP growth in 2004 and 2005, using baseline economic assumptions – has the greatest impact, leading to a decline of approximately 24% in net profitability at the 2005 horizon compared with the level observed at the end of 2003.

Scenario M4 – depreciation of the dollar for two years – appears to be less unfavourable with an average decline in expected profitability of only 4.4% in 2005 compared with the level at the end of 2003.

The scenarios involving an increase in the price of oil, with or without a monetary policy reaction, on the other hand, have a modest impact on expected profitability, or even a slightly favourable impact in the former case. An interpretation of these results is suggested below, in the comparison with the supervisors' models.

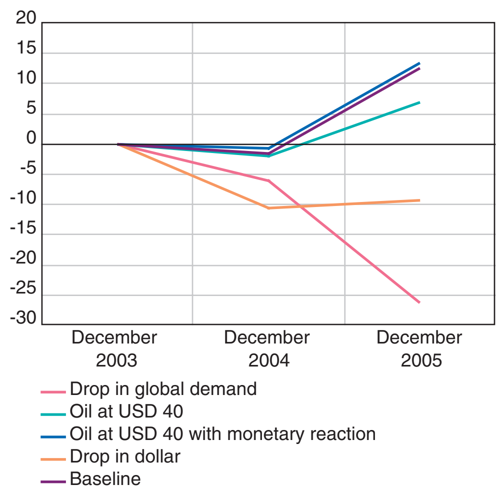
The banks did not directly simulate the impact on the solvency ratio. It was calculated by the SGCB from the banks' results. According to these calculations, the impact on the solvency ratio appears significant for the scenario of a drop in global demand, with a one-point average decline in the solvency ratio based on the Basel I standards currently in force. If the calculation is based on Basel II, the impact on the solvency ratio exceeds two points at the 2005 horizon, reflecting a large increase in the denominator of the ratio due to the deterioration in exposures (see below).

Results of "top-down" simulations

The results of the "top-down" simulations were obtained in parallel, using the methodology and the models described above. Their simulated impact on the net average expected profitability of the banking system appears to be relatively in line with the aggregate results of the banks (Chart 3).

For example, the model estimates that the scenario of a drop in global demand and a recession in France leads to a 26% average decline in profits from 2003 levels, as opposed to a 24% decline in the banks' simulations. The impact is also slightly less favourable for the foreign exchange scenario, with a 10% decline from levels at the end of 2003 (as opposed to 5% for the banks); and more favourable for the oil price increase scenarios M2 and M3 (+7% and +13% respectively as opposed to +2% and +9% for the banks).

Chart 3
Net profitability after a shock according to the SGCB estimations
(as a percentage)



The chart displays the change in banks' net income in 2004 and 2005 for the different scenarios relative to net income at the end of 2003. The baseline and the scenarios are drawn from the spread model (Appendix 2) using macroeconomic data furnished by the Mascotte model.

[10] *It should, however, be noted that the variants corresponding to "extreme" shocks, in the sense that their probability of occurring is less than 5%, do not correspond to the usual application of macroeconomic models, that are used to measure small deviations from a baseline. Large deviations can produce non-linearities associated with changes in behavior. Such an exercise can nevertheless provide a first approximation of the impact of the shocks under consideration.*

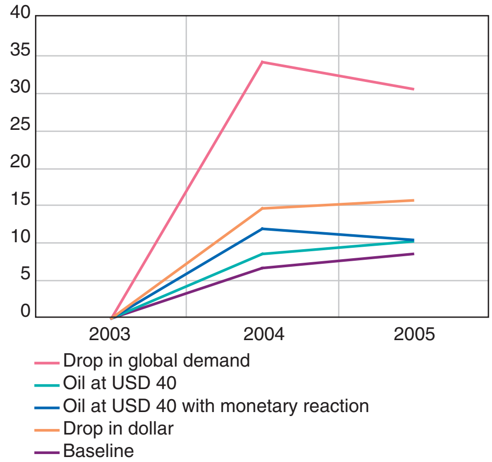
Because the econometric model used in the "top-down" approach enables changes in net income to be linked explicitly to the economic context (risk, slope and volatility of interest rates, volume of credit), it is possible to confirm the economic robustness of their results.

In the first place, as might have been expected, all of the "stress" scenarios (except the supervisors' scenario M3) forecast profitability at the end of 2005 to be less than the baseline forecast, which represents the normal economic trend. The baseline forecast, which is based on the OECD's autumn 2003 projections of French GDP growth for 2004 and 2005, is that bank profitability will increase by approximately 12.5% by the 2005 horizon. The "stress" events definitely have an unfavourable effect: the scenario of an increase in the price of oil leads to a smaller increase in expected profitability (7% instead of 13% for scenario M2). Interestingly, scenario M3, which includes a monetary reaction, contributes to restoring bank profitability (net income increases by 13.2% compared to 2003, as opposed to 7% in the absence of a monetary reaction and 12.5% for the baseline scenario). Measured against the baseline, the impact of the scenario of a drop in global demand appears to be even more severe, since it reduces the net income in 2005 by 36% according to the banks' estimates and by 38.5% according to the SGCB.

In particular, the Mascotte model provides a better understanding of the transmission mechanisms for the most unfavourable scenario (M1). The drop in global demand, leading to two years of stagnation in economic activity in France, results in a sharp decline in the demand for domestic credit and an increase in the failure rate for businesses. The scissor effect of the decline in economic activity and revenues and the increase in risk explains the observed contraction in earnings.

Scenario M3 assumes a reaction on the part of the European Central Bank according to Taylor's Rule, with an initial increase in key rates triggered by monetary authorities in order to contain the inflationary pressures resulting from the increase in the price of oil (second-round effects). The standard reaction embedded in the NiGEM model results in this case in an increase in the slope of the yield curve at the end of two years, which improves banks' performance *via* their transformation activity.[11]

Chart 4
Increase in risk-weighted assets (Basel II) according to SGCB estimates
(as a percentage)



The chart displays relative changes in risk-weighted assets (RWA) for the different scenarios, compared with the level at the end of 2003; these changes would result in additional capital requirements.

Chart 4 illustrates the effects of the different scenarios on the level of risk-weighted assets, and consequently on capital requirements, *i.e.* on the denominator, *RWA*, of the solvency ratio. Compared with the baseline, which forecasts an increase in risk-weighted assets of slightly less than 10% at the end of 2005 due to the increase in outstanding loans, the different scenarios lead to a general deterioration in the quality of portfolios, resulting in an increase in capital requirements. In the recession scenario, the strong growth in capital requirements (denominator) combined with the downward impact on profitability and capital (numerator) explains the two-point change observed in the solvency ratio, which is by far the most unfavourable. However, even in this case, the ratio remains above the regulatory minimum of 8% due to the high initial level of the solvency ratio of French banks.

The other scenarios appear to have a more modest impact, with a maximum 15% increase in capital requirements due to deterioration in exposures at the two-year horizon.

[11] *According to NiGEM, shocks to long-term rates are more persistent than shocks to short-term rates, so that a temporary increase in short-term interest rates has a more durable effect on long-term rates and temporarily increases the slope of the yield curve.*

Several lessons can be drawn from this "stress test" exercise, concerning the results obtained, the methodology used, and future work.

Concerning the results, the different "stress" scenarios applied to the French banking system, on the basis of 2003 reports and predicted performance in 2004 and 2005, indicate French banks' strong capacity to withstand shocks. Among the shocks studied, zero growth in the French economy for two years as the result of a slowdown in global demand appears to be the most severe. This shock would lead to an average 35% reduction in bank earnings compared with the baseline forecast for the end of 2005, and a decrease of one point (Basel I) to two points (Basel II) in the solvency ratio. The main French banking groups, which have an average ratio close to 12%, have a sufficient margin of solvency to absorb such a shock.

Concerning the methods used, the implementation of "stress tests" is now tried and tested, given the number of exercises already carried out at the international level and the experience acquired previously in France. The use of the Banque de France's *macroeconomic model and the development of financial models for measuring risk were particularly useful in ensuring the consistency of the French exercise. Certainly, the absence of a common, standardised conceptual framework for the macro-prudential approach made it necessary to tackle the question from a number of different angles. Nevertheless, the overall consistency in the results obtained from the "bottom-up" approach (based on individual banks' accounts) and the supervisors' "top-down" approach tends to confirm their robustness.*

Concerning future work, the FSAP has served as a catalyst for the development of tools for assessing aggregate risk. In addition to pursuing the calibration of the instruments, the next phase of work should aim at integrating the different approaches, currently in partial equilibrium (credit market, bank capital market, etc.), in a unified conceptual framework, while also seeking to incorporate more systematically the international dimension of banking activity.

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APPENDIX 1

Demand for credit in the private sector

Work currently in progress at the Banque de France modeling demand for credit in the private sector, as a complement to the Mascotte model, emphasises the link between the demand for credit in the private sector, investment demand on the part of household and businesses, and interest rates. The model presented in this Appendix deals only with household demand for credit. Since the rapid growth in bank lending at the end of the 1980s may have caused a change in regime, the estimate begins in 1985.

In the long term, lending is a function of consumption and investment. In addition, real interest rates have a negative effect on the demand for credit. The near-unit elasticity of credit to inflation signifies that the demand for credit adapts rapidly to any surprises in terms of inflation.

$$\Delta \ln L^H_t / L^H_{t-4} = \underset{(0.0033)}{0.0027} - \underset{(0.05)}{0.17}(\ln L^H_{t-1} / L^H_{t-5} - 0.61 \ln P^H_{t-1} I^H_{t-1} / P^H_{t-5} I^H_{t-5} - 0.41 \ln P^C_{t-1} C^H_{t-1} / P^C_{t-5} C^H_{t-5})$$

$$- \underset{(0.0014)}{0.0039}(tx\_bond_t - 100 * \ln P^C_t / P^C_{t-4}) + \underset{(0.0044)}{0.0176} DU851874 + \underset{(0.06)}{0.17} \Delta (\ln I^H_t / I^H_{t-4}) + \underset{(0.33)}{0.99} \Delta \ln (P^C_t / P^C_{t-4})$$

$R^2 = 0.37 \quad DW = 1.85$

Estimation period 1985: Q1 - 2001: Q4

where L^H_t represents the nominal outstanding amount of credit to households, I^H_t is total investment by households (at 1995 prices), p^H_t is the price of household investment (base = 1995), tx_bond_t is the yield on long-term government securities, C^H_t is the volume of household consumption (at 1995 prices), P^C_t is the price deflator for household consumption and *DU851874* is a dummy variable for financial deregulation, with a value of one from 1985: Q1 to 1987: Q4 and zero thereafter.

In addition, over the past 15 years, a fairly strong correlation has been observed between household demand for credit and property prices. This leads us to introduce a variant in the previous equation in which property prices are included in the short-term dynamic. The causality is considered here as running from property prices to credit, although the reverse causality is also possible.

$$\Delta \ln L^H_t / L^H_{t-4} = \underset{(0.0076)}{0.0173} - \underset{(0.05)}{0.18}(\ln L^H_{t-1} / L^H_{t-5} - \underset{(0.17)}{0.661} \ln P^H_{t-1} I^H_{t-1} / P^H_{t-5} I^H_{t-5})$$

$$- \underset{(0,0015)}{0.0032}(tx\_bond_t - 100 * \ln P^C_t / P^C_{t-4}) + \underset{(0.0047)}{0.0173} DU851874 + \underset{(0.07)}{0.15} \Delta (\ln I^H_t / I^H_{t-4}) + \underset{(0.18)}{0.34} \Delta \ln (P^{RE}_t / P^{RE}_{t-4})$$

$R^2 = 0.36 \quad DW = 1.89$

Period of estimation 1985: Q1 - 2001: Q4

where P^{RE}_t represents the index of property prices for all of France, published by INSEE. Such an equation makes it possible for "stress" testing to generate credit forecasts consistent with the selected macroeconomic scenarios.

APPENDIX 2

Benchmark model of profitability

The model of interest income generation in banks is the result of work carried out at the SGCB to extend the model of profitability originally proposed by Flannery (1981), which suggests that net interest income is partly a function of the business cycle, measured in terms of the level and volatility of interest rates and the variation in the demand for credit; and partly a function of the composition and quality of bank portfolio, measured respectively by inertia (the auto-regressive term) and the associated cost of risk.

The model of profitability used is a dynamic panel model calibrated for all banks using the Commission bancaire's BAFI (database of financial agents) data for the period 1993-2003 (4,160 bank observations x year). The model employs the unbiased estimator of Anderson-Hsiao (1982) using a second-order lagged endogenous variable as the instrumental variable. (See Goyau, Sauviat and Tarazi, 2002, for a similar approach, which however employs a different econometric approach and uses data for the period 1988-1995).

$$M_{i,t} = 0{,}64 + \underset{(17{,}99)}{0{,}68}\, M_{i,t-1} + \underset{(10{,}19)}{0{,}35}\, p^*_t - \underset{(-\,4{,}96)}{0{,}59}\, \sigma^{*\,2}_{p,t} + \underset{(15{,}34)}{0{,}29}\, p^*_t \Delta L_{i,t} - \underset{(-0{,}65)}{0{,}20}\, \pi_{i,t} + \varepsilon_t$$

adjusted R^2 = 0.83

$M_{i,t}$ = net interest margin of bank i at time t

p^*_t = difference in riskless (credit risk) interest rates : 5 years - 3 months

$\sigma^*_{p,t}$ = volatility of the slope : 5 years - 3 months

$\Delta L_{i,t}$ = nominal rate of growth in lending for bank i at time t

$\pi_{i,t}$ = cost of risk expected by bank i at time t

Student statistic in parentheses

This model was used to simulate the profitability of banks for the FSAP exercise. "Stress" scenarios constructed with the aid of the Mascotte macroeconomic model of the Banque de France were used to simulate exogenous changes in the factors of the spread model at a 2005 horizon, and to estimate the impact of the propagation of shocks on bank profitability.

APPENDIX 3

Model of variation in risk-weighted assets and capital requirements (Basel II)

An important development in risk analysis introduced by the Basel II reforms is the consideration of changes in the quality of bank portfolios as a function of the business cycle. Henceforth, capital requirements will be set as a function of the credit quality of the borrower. Credit quality is approximated by a rating, which may be public (for example, AAA on the Standard and Poor's rating scale) or internal to the bank. Several levels of rating or credit quality are defined. A certain fraction x of the exposures assigned to rating grade i $(i = 1, \ldots N)$ in period $t\text{-}1$ will receive the same rating in period t. The complementary fraction $(1\text{-}x)$ will "migrate" to another rating grade. If one proceeds in this fashion for all rating grades, one obtains a matrix of dimension $N \times N$. This transition matrix represents a statistical summary of the probabilities that exposures will move or "migrate" from one credit quality level to another between time $t\text{-}1$ and time t. The transition matrix is often assumed to be invariant over time, but that is not the assumption made here. Instead, in order to model changes in credit risk as a function of the economic outlook, the sensitivity of the transition matrix to macroeconomic developments is considered. Work carried out by the SGCB has attempted to show a link between observed transition matrices and data on short-term macroeconomic variables (GDP, interest rates, etc.). The model has been designed to link the probability of migration, for each state in the matrix, to cyclical factors, according to a prescribed logistical law. The complete model, for i varying from *1 to N*, and j varying from *1 to N-1*, is:

$$z_{ijt} = \log\left(\frac{P\,(rating_t \leq j \mid rating_{t-1} = i)}{P\,(rating_t > j \mid rating_{t-1} = i)}\right) \qquad z_{ijt} = \theta_{ij} z_{ijt-1} + \alpha_{ij} + \beta'_{ij} X_t + \varepsilon_{ij,t}$$

where X_t is a vector of exogenous macroeconomic variables and ε_{ij} an error term.

The implications of this model are then expressed in terms of regulatory capital requirements. Given an initial portfolio and an economic context determined by the macroeconomic scenarios produced by the Mascotte model, this model can be used to estimate a "stressed" transition matrix, which can then be applied to produce a final "stressed" portfolio. Thus, given RWA_t, the regulatory capital requirements; RW, the vector of risk weightings according to Basel II; Z_{t-1} the initial loan portfolio; $P\,(X_t)$, the transition matrix, which is itself a function of macroeconomic factors; and υ_t, new loans extended in time period t, the dynamic behaviour of the portfolio can be represented as follows:

$$\begin{cases} Z_t = Z'_{t-1} \cdot P(X_t) + \upsilon_t \\ RWA_t = RW' \cdot Z_t \end{cases}$$

In the case where the amount of new loans υ_t is zero;[12] this reduces to:

$$dRWA_t = \frac{RWA_t\,(X_t)}{RWA_t\,(\bar{X})} = \frac{RW' \cdot Z_t}{RW' \cdot Z\,(\bar{X})}$$

where $\bar{X}$ refers to a given equilibrium. Thus, once the reference situation has been selected, it is possible to evaluate the impact of a cyclical shock on regulatory capital.

[12] *This assumption is conservative in the sense that new loans tend to bring the bank's average profitability back closer to its hurdle rate, unless the bank engages in risk-prone behavior (gambling for resurrection).*