Stress testing credit risk: experience from the Italian FSAP *

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1. Introduction

Stress tests are defined as a set of techniques to measure the sensitivity of a portfolio to a range of extreme but plausible events. In other words, a stress test is an estimate of the change in value of a portfolio of assets when huge variations in a set of financial variables or risk factors are assumed.

Stress testing techniques have been applied at the individual level by large, internationally active banks since the early 1990s. They are generally used in the context of banks' overall risk management and capital allocation, in order to complement the estimates derived by internal models.

A strong incentive to develop such techniques has been provided by financial regulation, whereas banks and investment firms have been required to develop stress tests of their internal models for the calculation of capital adequacy for market risks. More recently, the new Capi-

tal Accord and the EU Directive on capital adequacy have required intermediaries to use stress testing techniques also for credit risk.

In addition to being applied at the level of individual financial institutions' portfolios (micro level), stress testing techniques have recently assumed an important role as a component of the tools available to public authorities in financial stability (macro-prudential) analysis. An aggregate stress test can be defined as a measure of the risk exposure of a relevant set of institutions to exceptional but plausible stress events. The main goal of macro-stress testing is to identify structural vulnerabilities in the financial system and to assess its resiliency to shocks. In this respect, aggregate stress tests can usefully complement the financial stability toolbox, mostly because they provide forward-looking information on the impact of possible extreme events.

In the context of the Financial Sector Assessment Program (FSAP), the IMF and World Bank have increasingly used macroeconomic stress tests; likewise, central banks and supervisory authorities in industrialized countries have recently developed econometric models combining micro and macro data for the assessment of threats to systemic stability.

A wide number of countries have participated in the FSAP. The Program is essentially made of three components: *a*) a quantitative analysis of the factors that may influence financial stability, evaluated through a range of indicators and stress tests concerning the whole financial system and a representative sample of intermediaries; *b*) the analysis of the conformity of the financial system with respect to the standards and codes established by the international standard setting bodies (Reports on the Observance of Standards and Codes – ROSC); *c*) the evaluation of other factors which are at the core of a well-functioning financial system (transparency and accountability of supervisory authorities, corporate governance, crisis management procedures, safety nets, etc.). The participation to the FSAP provides countries with an independent external opinion on the soundness of their financial systems.

To date, more than a hundred stress-test programmes have been completed by the IMF. While they were originally conceived for emerging countries, where they have been extensively used, stress tests have been increasingly employed also by developed countries. Since 2001, nearly all G-10 countries have used these large scale simulations to assess the soundness of financial systems. This trend is likely to be-

come even more pronounced in the future, also in relation to the requirements introduced in the new Basel Capital Accord regarding the conduct by banks of macroeconomic stress-tests for credit risk. In order to assess the ability of banks to maintain their capital adequacy also in stress situations, it is therefore necessary that these types of exercises are incorporated in the toolkit of supervisory authorities.

The implementation of macroeconomic stress-testing programmes such as those underlying the IMF's FSAP has undoubtedly advanced the development of internally consistent frameworks for assessing the resilience of financial systems to adverse disturbances. Indeed, with respect to the micro-prudential evaluations derived from the analysis of the stress tests realised by individual institutions, aggregate stress tests entail a macroeconomic perspective, an overall evaluation of the financial system and a uniform approach for the analysis of the risk exposures of intermediaries.

These techniques have also some inherent limitations, such as the inability of macro-stress tests to take into account potential second-round effects (feedback), the difficulty to associate confidence intervals to the losses related to certain specified scenarios or to consider non-linearities in macroeconometric models. As a consequence, the most pragmatic way to achieve a sound financial stability assessment is to use a variety of approaches, drawing upon input from a wide range of data, indicators and models. As it is better explained later on, this approach has also been used in the Italian FSAP stress tests.

In this article, we analyse the stress tests performed on the Italian banking system. The rest of the article is organised as follows. In paragraph 2, we shortly describe stress tests within the broader framework of financial stability analysis; in paragraph 3 we describe the credit risk stress tests performed, in terms of the approaches chosen and hypotheses tested. Paragraph 4 reports the results obtained with both top-down and bottom-up approaches. Finally, paragraph 5 draws some conclusions.

2. Financial stability assessment and stress tests

There is consensus on the fact that the banking sector is particularly prone to financial fragility, contagion and, thus, systemic crises. Ac-

cording to de Bandt and Hartmann (2000), there are three characteristics that explain the vulnerability of the financial systems and their exposure to systemic risk: *a*) the structure of banks' balance sheets; *b*) the interrelations among financial institutions; *c*) the intertemporal features of financial contracts, which may entail credibility problems. In general, the episodes of financial instability are the consequence of the overall fragility of the economy and the external shock simply ignites the crisis: the more fragile the financial system, the more severe the effects of a crisis.

Therefore, it is important to evaluate the linkages between the conditions of the macroeconomy and the stability of the financial system. This is the main purpose of macro-prudential analysis. The first step in such assessment is the evaluation of the current state of health of the banking and financial system. This is typically done using both aggregated micro-data and macroeconomic indicators, called macro-prudential (or financial soundness) indicators by practitioners. The second step is the assessment of the resilience of the banking system, i.e. its ability to remain sound in the future and absorb potential exogenous shocks. This is done by conducting stress testing exercises. With respect to the analysis of macro-prudential indicators, the stress testing approach allows a more forward-looking perspective and enriches the assessment of financial sector stability (Hilbers, Krueger and Moretti 2000; Blaschke *et al.* 2001; Committee on the Global Financial System 2000).

When setting up the framework for stress testing exercises, it is necessary to identify the kind of risks that have to be considered and the range of factors to be included. In the first place, stress tests can be used to analyse the impact of changes in a single risk factor (sensitivity test) or the effect of a simultaneous change in several risk factors (scenario analysis). It is also important to determine whether the exercise should be based on historical scenarios, assuming that past shocks may happen again, or rather on hypothetical scenarios, that is, on extreme but plausible changes in the external environment regardless of the historical experience.

There is certainly a trade-off between simplicity/manageability on the one hand, and complexity/realism on the other. An appropriate cost-benefit analysis should help supervisors in tailoring the stress-testing exercises.

Specific methodological issues arise when aggregate stress tests have to be carried out in order to identify structural vulnerabilities and the overall risk exposure of the banking system. In principle, two solutions are available for the aggregation rule: 1) supervisors can define the macroeconomic shock, letting the intermediaries evaluate its impact on their balance sheets and then aggregate the bank-level outcomes in order to get the overall effect (bottom-up approach); 2) supervisors can directly apply the shock to some sort of banking system-level portfolio and analyse its aggregate effect (top-down approach). Of course, the bottom-up methodology is more precise, since each bank will reflect the shock on its own portfolio more accurately. However, the issue of comparability is quite relevant since each intermediary may employ different methodologies and modelling assumptions, making the aggregation and cross-sectional comparisons less reliable. Conversely, the top-down approach enhances the comparability of results, but it is by definition more approximate and is typically based on historical relationships.

Given the advantages and disadvantages of the two approaches, it is useful to employ both in practice. In fact, cross-checks, benchmarking procedures and comparisons are crucial in guaranteeing consistent results and reliable policy conclusions.

3. Stress tests in practice: the FSAP experience

During 2005, the IMF has undertaken an extensive assessment of the soundness of the Italian banking system and its ability to deal with extreme external shocks.[1] This analysis has been carried out as part of the FSAP for Italy. In the following sections, some of the methodologies developed and employed in the broader context of the FSAP are described, as well as the main results of the stress test simulations regarding credit risk.

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[1] For details see IMF (2006)

3.1. *Which risks?*

Banks are vulnerable to several risks. An overall assessment of their soundness must therefore take into account all the different potential sources of fragility. In this section we describe the hypotheses on the different risk factors underlying the stress tests performed during the FSAP for Italy.

For credit risk, the sensitivity exercise has been realised considering a 60% increase in the probability of default (PD) for all domestic exposures. This figure is larger than the largest change historically observed (54% increase in PD in 1993, after the EMS crisis).

A similar shock has been used for assessing the resilience of the banking sector to sovereign risk. The shock is a three-notche downgrade of the banks' largest exposures to emerging markets (exposures to foreign countries amounting to 50% of banks' exposures to emerging markets), and a two-notche downgrade of the rest of the exposures. The three- and two-notche downgrades are equivalent to a 100% and a 45% increase in PD, respectively.

These are clearly very simple frameworks, in which PDs increase under a *ceteris paribus* assumption. In order to remove such an assumption, along with single factor stress tests, scenario analyses have also been carried out.[2]

For market risks, sensitivity analyses have been conducted on the basis of the following shocks: equities –30%; forex market ±15%; volatilities ±30%; interest rates ± parallel (up to ±70 basis points) and ± tilt (up to 110 basis points). A stronger shock has been assumed for interest rate risk in the banking book (200 basis points parallel shift, following the recommendation of the new Basel Capital Accord). For liquidity risk, the shock combines a funding liquidity shock and a decrease in market liquidity modelled in terms of market prices. Overall, the size of the shocks to assess market risks, sovereign risk, interest rate risk in the banking book and liquidity risk is in line with those applied in other FSAPs for the euro area countries, while the credit risk shock exceeds the largest historical shock.

In the rest of the paper we focus on credit risk, particularly on scenario analyses, for two reasons. First, credit risk represents the most relevant risk banks deal with. Second, while stress-tests proce-

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[2] See section 3.3.

dures and sensitivity analyses for market risk are relatively better developed, there are not standardized methodologies for measuring the evolution of credit risk under stress scenarios.

3.2. *Which approach?*

For the Italian FSAP, the stress testing exercise has been performed using both bottom-up and top-down methodologies. The 6 largest limited company banks and 3 large cooperative banks have conducted the stress tests using internal methodologies to generate results in the bottom-up approach. For the top-down approach, stress tests have been conducted at the aggregate level and also on a bank by bank basis for the banks belonging to the 9 banking groups, which represent 62% of banking system's assets. Stress tests have been typically performed on consolidated balance sheets. However, in the top-down exercise, individual bank data have been used when the information detail was higher than that of the consolidated reports.

The stress tests have been performed applying the shock to bank exposures as of December 2004; top-down results have been updated with data as of June 2005; the time-horizon adopted has always been of two years. This time-period is the minimum needed if one wants to fully capture the impact of the business cycle on the credit cycle, which is generally quite long. Since the use of infra-annual data may require approximations, we prefer focussing on end-year results. June 2005 results are therefore reported, but they are generally not commented.

For the scenario analyses, banks have performed their simulations between January and March 2005 using a baseline macro-scenario available at the beginning of 2005 as the benchmark for the assessment of the before-stress losses. The same baseline scenario has been used for the top-down exercises, as well as an updated and more conservative one.

Given an exogenous shock, its impact on domestic macroeconomic variables has been estimated through the Bank of Italy Quarterly Model (BIQM). The output of the macroeconometric model has been then employed as an input for a reduced-form econometric model linking macro and bank-specific variables, in which the probability of default is the dependent variable and the macroeconomic indicators

the regressors. The substitution of the stressed figures for the latter variables allows estimating the stressed PDs in a given time-horizon. Starting from the stressed PDs it is possible to quantify the increase in expected losses (EL) using the following formula: EL = (stressed PD – before-stress PD) × LGD × EAD, where *LGD* is the loss-given-default and *EAD* is the exposure at default.

The logical steps of the stress test simulations can be summarized as in Figure 1.

FIGURE 1

STRESS TESTING THE BANKING SYSTEM
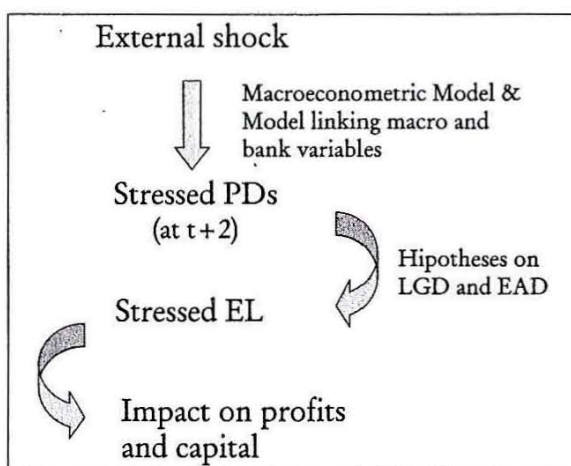
We note that, given the lack of more specific data for the top-down methodologies, it has not been possible to use a complete Basel II framework in the simulations. In other words, consistently with the macro stress tests performed in the FSAPs of other industrialized countries (UK, Germany[3]), we estimated a stressed expected loss, while we did not estimate a stressed unexpected loss. However, the severity of the shocks on the expected loss allowed to produce conservative results.

The losses or gains resulting from the stress test exercises have been measured in terms of *i*) percentage of after tax profits, *ii*) percentage of capital buffer (i.e. bank capital in excess of the mandatory regulatory capital) and *iii*) new solvency ratio calculated according to Basel I prudential regulations, allowing for losses to be initially covered by before tax profits.

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[3] See Hoggarth and Whitley (2003) and Deutsche Bundesbank (2004).

It is worth noting that the impact of the macroeconomic scenario on the banking system is propagated through two different, though not independent, mechanisms: an increase in portfolios' riskiness and a contraction of profits. In the scenario analyses, the simulations have explicitly taken into account the latter mechanism by assessing the impact of the stressed expected losses on estimated stressed profits (Casolaro and Gambacorta 2004). This also allows to incorporate the impact of market risks – as a result of changes in interest rates, equity and foreign exchange prices due to the macroeconomic shocks – in the scenario results.

3.3. *Which scenarios?*

Macroeconomic stress scenarios, possibly resulting from the combination of more than one elementary shock, have been simulated. The three scenarios are the following:

1) a 70% oil price increase from the level observed in the fall of 2004 combined with a sudden global equity price decline of 30%;

2) a confidence shock in the US that triggers a 20% appreciation of the euro with respect to the US dollar;

3) a confidence crisis triggered by a large corporate failure in Italy, that implies a 35% decline in stock prices combined with a 200 basis point increase in corporate spreads.

The effects of these shocks on the Italian economy have been computed using the macroeconometric quarterly model. The simulations of the macroeconomic shocks, arising from changes in exogenous variables, have generated deviations with respect to a baseline projection over a two-year horizon.[4]

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[4] The model is Keynesian in the short run and neoclassical in the long run. In the short run the level of economic activity is determined by aggregate demand, while the long run follows Solow's model of exogenous growth. In the short run, the dynamics of the model is characterized by stickiness of prices and wages, inflation surprises and a putty-clay nature of the production process. On the contrary, in the long run, along the steady-state growth path, the dynamics is driven by capital accumulation, productivity growth, foreign inflation and demographics. In equilibrium, the model describes a full employment economy where output, employment and capital stock are consistent with an aggregate production function, relative prices are constant and inflation equals the exogenous growth rate of foreign prices.

Under the first macroeconomic scenario, oil prices jump to USD 85 per barrel in the first quarter. At the same time, stock prices fall by 30% and their impact on the macroeconomy goes through two channels: *i*) the private sector wealth is eroded proportionally thus implying a downward revision of households' consumption plans and *ii*) firms face a higher cost for external financing. The effects for the Italian economy under this scenario are sizeable in terms of both reduction in the GDP growth and decrease in households' consumption and gross fixed investments. The increase in consumer prices causes an aggressive reaction of monetary policy to the inflation induced by the oil price shock.

Under the second scenario, the USD depreciation implies that the euro effective exchange rate appreciates. The competitiveness of Italian commodities reduces markedly. Two years after the depreciation of the USD, the Italian GDP growth is slightly lower than the baseline, while the cumulated fall in consumer prices is not relevant. For all the other variables, the impact of the depreciation is likewise quite modest.

The third scenario is built under the assumption that the cost of financing for Italian firms increases by 200 basis points in the first quarter, remaining at this new level for up to 8 quarters. In addition, it is assumed a further stock market price shock with prices falling by 35% that implies a sizeable drop in households' wealth. This is a typical scenario identifying a combination of idiosyncratic shocks that only hit the Italian economy. Thus, there are no implications for the euro-area monetary policy and the exchange rates. The increase in corporate spreads heavily affects firms' investment behaviour, so that two years after the beginning of the shock total investment growth drops. At the same time, the cumulated drop in GDP growth is substantial. The total employment decreases, while domestic prices experience only a moderate decline.

3.4. *Top-down methodologies*

In this section, we describe some tools that have been developed in order to carry out credit risk stress tests.[5] They are typically reduced-

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[5] See Quagliariello (2005). For an international perspective see Sorge (2004).

form econometric models, which are designed to estimate the impact of external macroeconomic shocks on banks' riskiness. In some cases, different statistical procedures may have similar or even overlapping goals (e.g., the estimation of future loan losses): this is a further explicit acknowledgement that cross-checks are an essential part of stress testing and a prerequisite for policy implementation.

A first possible way to estimate the relevant econometric relationships is the use of panel data techniques. As an example, Quagliariello (2004) estimates the reduced-form relationships between the loan loss provision ratio and the default rate,[6] on the one hand, and the business cycle indicators, on the other. The sample employed for the estimation includes over 200 Italian banks and covers the period 1985-2002. The sample is huge and represents around 90% of Italian banking system's consolidated total assets.

The main goal is to verify whether banks' performance is linked to the general economic climate and to understand the timing of banks' reactions to economic changes. The starting set of regressors is selected according to the insights provided by economic theory. In particular, the macroeconomic regressors include the real GDP growth, the long-term real interest rate, the loan-deposit spread and the stock exchange index changes. The lag structure of the explanatory variables is selected trading off parsimony with the need to account for the plausible delay with which macroeconomic shocks affect banks. The results of such a model can then be employed to carry out stress tests, mainly single factor stress tests. As an example, it is possible to set GDP growth at its lower historical value, *ceteris paribus*. The main shortcoming of this approach is that any potential second round effect or policy response is neglected. Moreover, if the set of regressors includes many bank-specific variables, it is not very realistic to keep them constant.

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[6] The default rate used here and in the following works is built up as the ratio of the amount of loans classified as bad debts in the reference period to the performing loans outstanding at the end of the previous one. In order to improve the reliability and timeliness of such indicator, the 'adjusted' bad debts as signalled by the Central Credit Register are used. Adjusted bad loans are those outstanding when a borrower is reported to the Central Credit Register: *a*) as a bad debt by the only bank that disbursed credit; *b*) as a bad debt by one bank and as having an overshoot by the only other bank exposed; *c*) as a bad debt by one bank and the amount of the bad debt is at least 70% of its exposure towards the banking system or as having overshoots equal to or more than 10% of its total loans outstanding; *d*) as a bad debt by at least two banks for amounts equal to or more than 10% of its total loans outstanding.

Binary choice models may also be used in order to estimate borrowers' probability of default. For instance, Chionsini, Fabi and Laviola (2005) estimate the probabilities of default for all the corporate borrowers of Italian banks on the basis of a scoring model that employs several logit specifications. Exploiting the databases available at the Bank of Italy, balance-sheet data and Credit Register information are used to assess the probability of each firm of being recorded as defaulted. Two separate multivariate logistic models are estimated, respectively for the firms recorded in the balance-sheet register and for those recorded in the Credit Register; the results generated by each model are then combined in order to obtain the final estimation. With respect to previous releases,[7] this methodology has the advantage that it is possible to exploit fully the higher frequency and the detailed information content of Credit Register data, in principle available monthly (quarterly data are used in the estimation), with respect to balance-sheet data, available only once a year. The model based on credit register information uses 5 variables out of about 20 ratios examined; the financial model employed separate functions for the main sectors of economic activity (manufacturing, trade, construction and services), in order to capture the specificities of the different segments. Six variables out of the 15 examined have been selected, which refer to the main economic and financial profiles of the firms.

The authors have used the estimated PDs in order to carry out a stress testing aiming at evaluating the impact of an adverse macroeconomic environment on the credit quality of the aggregate loan portfolio of Italian banks and on the overall capital buffer (that is, the amount of capital above the minimum solvency requirement) of the banking system. The exercise has tried to replicate the adverse circumstances of the economic recession experienced in Italy at the beginning of the 1990s. To this purpose, the default probabilities have been computed using information on credit relations and balance sheet indicators related to the years 1993-94. The 'historical stress scenario' has been used to compute the average credit quality of the aggregate loan portfolio under the above-mentioned adverse scenario and the consequent increase in the capital requirement.

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[7] An earlier and partially different version of the model, with some applications, is contained in Fabi, Laviola and Marullo Reedtz (2004).

Finally, the impact of the business cycle on bank borrowers can be estimated using a vector autoregression (VAR) approach.[8] With respect to cross-sectional or panel techniques, VAR allows to fully capture the interactions among micro- and macroeconomic variables, providing a better framework for capturing possible feedback effects. This enables to perform a more comprehensive assessment for financial stability purposes. Again, the estimated relations may be easily employed for carrying out stress testing exercises in order to assess the resilience of the banking system in the presence of sudden unfavourable macroeconomic shocks.

The VAR methodology has been used for the stress tests following Marcucci and Quagliariello (2005). These authors build their VAR from a small-scale macroeconomic model enriched with a micro equation that describes the behaviour of Italian banks' default rates. The macroeconomic model comprises an IS curve, a Phillips curve that corresponds to a backward looking AS curve, an uncovered interest rate parity and a modified Taylor rule. Therefore, their VAR includes the following variables: *i*) bank borrowers' default rate, *ii*) output gap, *iii*) inflation, *iv*) three-month interest rate and *v*) real exchange rate. The authors use a recursive identification scheme where the default rate and the output gap are assumed to react quite slowly to financial and monetary shocks. Their results show that the Italian default rates follow a cyclical pattern, falling in good macroeconomic times and increasing during downturns. They also document that feedback effects do operate.

3.5. *Bottom-up practices*

The new capital Accord and the revised EU Capital Requirements Directive (CRD) contain requirements with regard to stress testing in terms of risk management and for the assessment of capital adequacy. Notwithstanding the huge amount of analyses on stress tests, at this stage, it is commonly acknowledged that there is no single correct stress testing procedure. As a matter of fact, each individual institution should consider the range of risks it is exposed to, the complexity of its operations, the past experience of extreme events. As it is well under-

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[8] Marcucci and Quagliariello (2005).

lined in the *fora* for international supervisory cooperation, what is adequate for the individual institution should be assessed on the basis of proportionality considerations. Indeed, the level of complexity of stress testing is expected to vary with the size and level of sophistication of institutions.[9]

The Committee on the Global Financial System (2005) conducted two different surveys on intermediaries' practices regarding stress tests and found that G10 banks increasingly use stress test methodologies for internal purposes ranging from risk management and capital allocation to strategic planning. The last survey, published in 2005, analysed 64 banks and investment firms. The results suggest that, while most large and complex institutions already have stress testing arrangements in place, overall, the use of a broad range of stress tests as a complement to existing risk management tools is not very widespread. In general terms, the stress testing of market risks is at a more advanced stage than for other kinds of risk. In particular, stress tests continue to be developed mostly for the trading portfolio, with reference to the more common types of risk (interest rate, foreign exchange, equity, commodity risk). The survey reveals that stress tests concerning the risk of abrupt changes in interest rates are the most frequent (357 tests), followed by that regarding foreign exchange (116) and equities (130). As regards the type of stress exercises, according to the survey results historical scenarios and sensitivity analyses are performed more frequently (respectively 92 and 74% of the total number of tests is performed at least once a month) than hypothetical scenarios (50% of the total cases with a monthly frequency, 25% of the cases with an annual frequency), due to the higher complexity and specificity of the latter.

As far as Italy is concerned, according to a survey carried out jointly by the IMF and the Bank of Italy, methodologies are different across Italian banks. In particular, this survey has showed that stress tests for market risks are well developed. Regarding credit risk, internal ratings models have been developed in most cases while, in some cases, stress tests are used in the context of the broader activity of risk management. While sensitivity analyses are quite straightforward to implement once an adequate internal rating system has been put in place, in the scenario analysis the main technical challenge to be solved

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[9] See, for example, CEBS (2006).

concerns the so-called macro-link, that is, the possibility to estimate PDs (and LGDs) conditional to macroeconomic conditions.

For the FSAP, consistently with the goals and the spirit of the exercise, banks have assessed the impact of the macroeconomic scenarios using internal estimations. Overall, some banks used their internal portfolio models under the unfavourable macroeconomic scenarios described above; the majority of the banks have either developed econometric models in order to link their internal PDs to relevant macroeconomic variables or simply applied the changes of the default rates estimated by the Bank of Italy to their portfolios.

4. Stress test results

4.1. *Credit risk*

4.1.1. Top-down simulations

As mentioned above, the credit risk shock consists in a 60% increase in the probability of default (PD) of all banks' borrowers.

In the top down-approach, the PD is measured as the flow of new 'adjusted' bad debts over the stock of performing loans in the previous period. With respect to Basel II rules, this is a narrower definition of PD since it does not include past-due exposures, but it is the only one for which long-time series are available (see also footnote 6). For this reason, the increase in the PD translates in provisioning increases assuming a quite conservative loss given default (LGD), equal to 60% for the whole portfolio, independently of any collateral and guarantees held, and, consistently with Basel II, an exposure at default (EAD) equal to the drawn amount of the performing loan portfolio plus 75% of the undrawn credit lines.

The assumed LGD is the average loan loss provisioning rate on bad loans reported by the largest banking groups, which is considerably higher than the average 40-45% LGD reported by G-10 countries in the third Quantitative Impact Study of the Basel Committee.

The effects of the macroeconomic scenarios on the probabilities of default are reported in table 1. As mentioned above, in the top-

down simulations the profits themselves are affected by the shock and reduced/increased accordingly. The results refer to the simulations carried out using the updated baseline.

TABLE 1

SUMMARY OF MACROECONOMIC STRESS TESTING SCENARIOS

	Scenario 1 Oil price increase and global equity prices decline by 30%	Scenario 2 USD depreciation	Scenario 3 Increase in credit spreads and decline in Italian equity prices
Effect of changes in macroeconomic variables on banks operating profits and borrowers' PDs (percent change after two years)			
Banks operating profits end-2004	–14.0	7.4	–17.9
Probability of default end-2004	98	42	58
Banks operating profits June 2005	–5.8	17.2	–11.2
Probability of default June 2005	83	52	71

According to the simulations carried out using the VAR model described in the previous section, in the worst scenario (scenario 1) the probabilities of default of banks' borrowers increase by 98 and 83% with respect to end-2004 and June 2005 respectively. In this scenario, the banks' operating profits decrease by 14 and 6% for the two dates (compared with 18 and 11% in scenario 3).

Table 2 shows the impact of the extra-provisions that banks need to make under stress in terms of after-tax profits and capital buffers.

With reference to the first scenario, on average, for the nine banking groups, the losses under stress represent 74% of the stressed after-tax profits and 17% of the capital buffers. The solvency ratio, calculated allowing for losses to be covered by before-tax profits, remains virtually unchanged. The update of the top-down simulations for June 2005 shows a lower loss for the first scenario (Table 3). In this case, the new solvency ratio has been calculated not allowing for losses to be covered first by before-tax profits. As the table shows, the capital adequacy ratio decreases, remaining comfortably above the minimum required level.

It is worth noting that these simulations employ quite extreme hypotheses. Moreover, the indeed severe shocks are applied to a baseline scenario in which GDP growth is close to zero. This suggests a strong resilience of the Italian banking system to adverse macroeconomic conditions.

As far as country risk is concerned, the impact of the assumed rating downgrade is limited. With respect to the baseline, the expected loss increases by roughly 8% of the after-tax profits and 2.3% of the capital buffers. Overall, there are no visible effects on capital adequacy levels.

TABLE 2

STRESS TEST RESULTS*

	Loss as percentage of end-2004 after-tax profits		Loss as percentage of capital buffer at end-2004[1]		New CAR[2]	
	Weighted average	Largest loss	Weighted average	Largest loss	Weighted average	Min.
Sensitivity to sovereign risk[3]						
Top-down	7.6	7.6	2.3	4.2	11.1	9.2
Bottom-up	10.2	19.5	3.1	5.9	11.1	9.2
Sensitivity to credit risk[4]						
Top-down	35.5	79.6	10.6	24.1	11.1	9.2
Bottom-up	36.4	94.9	10.9	36.4	11.1	9.2
Macroeconomic scenario tests						
Top-down						
Scenario 1[5]	73.8	171.5	17.3	39.4	11.0	9.2
Scenario 2[6]	22.2	49.6	7.4	16.9	11.1	9.2
Scenario 3[7]	47.5	111.6	10.3	23.3	11.1	9.2
Bottom-up						
Scenario 1[5]	33.3	104.3	10.0	40.0	11.1	9.2
Scenario 3[7]	16.6	45.9	5.0	17.9	11.1	9.2

* Top-down results refer to the updated baseline scenario.
[1] Gains or losses as percentage of the capital in excess of the regulatory capital as of end 2004.
[2] Risk-weighted capital adequacy ratio, allowing for losses to be covered first by before-tax profits.
[3] A three-notch downgrade of claims on emerging markets countries that comprise at least 50% of banks' total exposure to emerging market, and a two-notch deterioration applied to all others.
[4] A 60% increase in the probability of default of all credit exposures, except interbank exposures.
[5] The price of oil increases to 85 USD per barrel and global equity prices decline by 30%.
[6] Sustained 20% depreciation of the USD with respect to the major currencies.
[7] Italian corporate spreads increase by 200 basis points and Italian equities decline by 35%.

TABLE 3

STRESS TEST RESULTS – JUNE UPDATE – TOP-DOWN

	Loss as percentage of June 2005 (annualized) after-tax profits		CAR after stress[1]	
	Weighted average	Largest loss	Weighted average	Min.
Sensitivity to sovereign risk[2] Top-down	15.3	178.0	10.8	8.8
Sensitivity to credit risk[3] Top-down	24.3	94.4	10.7	8.5
Macroeconomic scenario tests Top-down				
Scenario 1[4]	35.8	144.7	10.6	8.4
Scenario 2[5]	17.9	63.4	10.8	8.6
Scenario 3[6]	32.6	137.7	10.6	8.5

[1] Risk-weighted capital adequacy ratio, not allowing for losses to be covered first by before-tax profits.
[2] A three-notch downgrade of claims on emerging markets countries that comprise at least 50% of banks' total exposure to emerging market, and a two-notch deterioration applied to all others.
[3] A 60% increase in the probability of default of all credit exposures, except interbank exposures.
[4] The price of oil increases to 85 USD per barrel and global equity prices decline by 30%.
[5] Sustained 20% depreciation of the USD with respect to the major currencies.
[6] Italian corporate spreads increase by 200 basis points and Italian equities decline by 35%.

4.1.2. Bottom-up simulations

Banks have performed sensitivity analyses and two out of three scenario analyses. In the bottom-up approach, the PD is generally defined as the sum of bad and substandard loans. With respect to the top-down simulations, this is a broader definition, although it is not completely compliant with the new Capital Accord definition. For the LGD, most banks have employed values equal or close to regulatory LGDs; some of them have used LGDs obtained from internal calculations. The exposure at default is typically equal to the credit exposures used plus a certain percentage of the difference between exposures committed and granted, guarantees, etc.

Table 4 provides a summary of the different definitions of PD, LGD and EAD used in the top-down and bottom-up approaches.

TABLE 4
COMPARISON OF TOP-DOWN AND BOTTOM-UP DEFINITIONS

	PD	LGD	EAD
Top down	Narrower	Higher	Higher
Bottom up	Broader	Lower	Lower

Results for the bottom-up simulations are also reported in table 2. Consistently with the top-down results, the first scenario has the greatest impact on banks' profits and capital buffers. For the nine banking groups, the extra provisions arising from the worst stress scenario represent, on average, 33% of the after-tax profits and 10% of the capital buffers. The after-stress solvency ratio, calculated allowing for losses to be covered by before-tax profits, is unchanged.

It is worth reminding that top-down and bottom-up simulations are not directly comparable since the baseline scenario is not the same. However, a direct comparison of different results can be made using the sensitivity analyses (Table 5).

TABLE 5
SENSITIVITY ANALYSIS: COMPARISON OF TOP-DOWN
AND BOTTOM-UP RESULTS

	Average		Minimum		Maximum	
	TD[1]	BU[2]	TD[1]	BU[2]	TD[1]	BU[2]
After-tax profits	35.5	36.4	19.4	15.8	79.6	94.9
Capital buffers	10.6	10.9	5.3	6.2	24.1	36.4
New CAR	11.1	11.1	12.0	12.0	9.2	9.2

[1] TD = Top-down approach.
[2] BU = Bottom-up approach.

The comparison between top-down and bottom-up results is encouraging. The choice of PD, LGD and EAD definitions has ensured consistency of the results across different approaches. Regardless of the metrics, the impacts are on average similar, although there are differences when one looks at the range between minimum and maximum values.

A further check of the consistency between the results emerging from different approaches is provided in table 6. The table reports the ranking of the banks according to the impact on capital buffers.

SENSITIVITY ANALYSIS: COMPARISON OF TOP-DOWN
AND BOTTOM-UP BANKS' RANKING
(impact on capital buffers)

Ranking / BU²	TD¹	1	2	3	4	5	6	7	8	9
1				B3						
2						B4				
3		B7								
4					B6					
5			B5							
6								B9		
7									B1	
8							B2			
9										B8

¹ TD = Top-down approach.
² BU = Bottom-up approach.

Banks in (or close to) the main diagonal are ranked in a similar way by the top-down and bottom-up methodologies. As an example, the impact on bank 3 (B3) is ranked as the third most relevant impact according to the top-down approach and the first according to the bottom-up one. Overall, top-down and bottom-up approaches show an acceptable convergence in classifying the banks on the basis of their vulnerability to credit risk under stress hypotheses.

All in all, the comparison reveals that top-down exercises provide, on average, reliable signals on the resilience of the banking system and of the single intermediaries in the event of very unfavourable macroeconomic shocks. Since bottom-up simulations are resource-intensive and expensive for banks, this suggests that top-down stress tests can be a relatively cost-effective approximation for periodical assessments of financial stability.

5. Concluding remarks

In this paper we describe the methodologies that can be used for stress testing credit risk providing some applications to the Italian banking system.

Stress testing techniques have been applied at individual level by large, internationally active banks since the early 1990s. A strong incentive to develop such techniques has been provided by the financial regulation, since banks and investment firms have been required to develop stress tests of their internal models for the calculation of capital adequacy for market risks. More recently, the new Capital Accord and the EU Directive on capital adequacy have required intermediaries to use stress testing techniques also for credit risk.

In addition to being applied by financial intermediaries, stress testing techniques have recently been adopted by central banks and supervisory authorities in order to assess the stability of the financial system and its ability to cope with extreme external shocks. With respect to other tools, stress tests provide forward-looking information on the impact of possible negative events.

Setting the stage for adequate stress testing procedure is not an easy task. In fact, the level of complexity tends to increase very rapidly when many variables and risk factors are moved together. A certain degree of simplification and some discretionary assumptions are therefore needed in order to keep the simulations at a manageable level. Furthermore, most of the statistical techniques that are commonly used have some inherent limitations, such as the inability to take into account potential feedback effects, the difficulty to associate confidence intervals to the losses associated to certain specified scenarios or to consider non-linearities in macroeconometric models. As a consequence, the most pragmatic way to achieve a sound financial stability assessment is to use a variety of approaches, drawing upon input from a wide range of data, indicators and models. In that respect, expert judgements may somehow help when data availability and statistical methods are not sufficient.

Within the FSAP for Italy, stress tests examined the impact of a variety of shocks on the nine major Italian banking groups. The tests were performed using both top-down and bottom-up approaches, which provided comparable results. For the sensitivity analysis, the

size of the shocks to assess market risk, sovereign risk, interest rate risk in the banking book and liquidity risk was in line with those applied in other FSAPs for euro area countries, while the credit risk shock exceeded the largest historical shock. In addition, the impact of various adverse macroeconomic scenarios has been assessed. Specifically, an adverse macro scenario in which oil prices reach USD 85-90 per barrel causing a global slow down and global equity prices decrease by 30% has the largest impact. Overall, stress test results suggest that the Italian banking sector is resilient to shocks. Profits appear in most cases sufficient to cover losses arising from the shocks calibrated. Existing capital buffers remain comfortably above the minimum regulatory solvency ratios.

The implementation of macroeconomic stress-testing programmes such as those underlying the FSAPs has advanced the development of internally consistent stress testing procedures. However, the state of the art is still evolving and further work in this field will allow relaxing less realistic assumptions, further improving the methodologies and making results more reliable.

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